Real-time wavefront aberrometry in subjects with accommodative excess

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Abstract. The purpose of this study was to use real-time wavefront aberrometry to detect accommodative excess (AE) and to analyse the optical quality of the eye in subjects with this dysfunction. AE was detected from the accommodative response obtained by real-time wavefront aberrometry. These subjects had a significant accommodative lead to all stimuli and had difficulty relaxing accommodation. The root mean square (RMS) of high order aberrations (HOA) was higher in subjects with AE for lower stimulus and for disaccommodation than in the control group. However, the subjects with AE showed a decrease in the RMS of HOA with an increase in accommodative response. Primary spherical aberration tended to become more negative with accommodation in both subjects and there was no difference between the groups. Real-time wavefront aberrometry can be used as an objective method to detect accommodative excess.

1 Introduction

In order to see a clear image on the retina at near distances, it is necessary to increase the power of the crystalline lens, a process called ocular accommodation. [1] However, some subjects exceed the amount of accommodation needed for a particular stimulus and may not be able to relax it. This condition, called accommodative excess (AE), causes various symptoms and is common in university students. [2]
The aberrations present in the optical components of the eye determine its optical quality, and it is known that these aberrations change during accommodation. Furthermore, previous studies have shown that wavefront aberrations, especially spherical aberration, can influence the precision of the accommodative response. [3]
The aim of this study was to use real-time wavefront aberrometry to detect accommodative excess and to analyse the optical quality of the eye in subjects with this condition.

2 Methods

2.1. Participants

The study included 8 subjects with AE and 8 subjects without accommodative dysfunction (control). Visual acuity was 20/20 or better and there was no history of ocular pathology, refractive surgery or orthokeratology. The study adhered to the tenets of the Declaration of Helsinki and was approved by the Ethical Sub-Committee of Life and Health Sciences of the University of Minho.

2.2 Experimental set-up

The system used to measure wavefront aberrations in real time was an in-house Shack-Hartman aberrometer (Thorlabs WF150-7AR) with a resolution of 1280x1024 with 39x31 lens lets working with a frequency of 15Hz. The power of the super luminescent diode, used to generate the optical beam, was 12µw at the eye and had a spectral maximum at 830 nm.

2.3 Data collection

The subjects had to fixate a target and keep it as clear as possible while negative lenses were placed in front of the eye to stimulate the accommodation and measure in real-time the wavefront aberrations until the 6th order. The accommodative stimuli were: 0D, -1.00D, 0D, -2.39D, 0D, 4.56D and 0D, alternating in accommodation and disaccommodation.
Accommodative response (AR) was calculated by defocus aberrations (Z_2^0) for a pupil radius of 2.25mm (r):

$$AR = (-4\sqrt{3}Z_2^0)/r^2 \quad (1)$$

Primary spherical aberrations and root-mean-square (RMS) of high order aberrations (HOA) were analysed and compared between subjects with AE and the control group.

2.4 Statistical analysis

Statistical analysis was performed using version 4.1.3 of the R software.

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The normality of the data was tested using the Shapiro-Wilk test, and the values of subjects with AE and controls were compared using the t-test and the Mann-Whitney test for parametric and non-parametric data, respectively. Data were considered statistically significant when $p < 0.05$.

3 Results

The accommodative response over time for the different stimuli of the subjects with AE is shown in Figure 1. It is possible to observe that the accommodative response was higher than for all the stimuli. It is also possible to observe that accommodation was not completely relaxed after the stimulus, i.e. a certain amount of accommodation is still present when the negative lens is removed. This effect increases as the value of the accommodative stimulus increases.

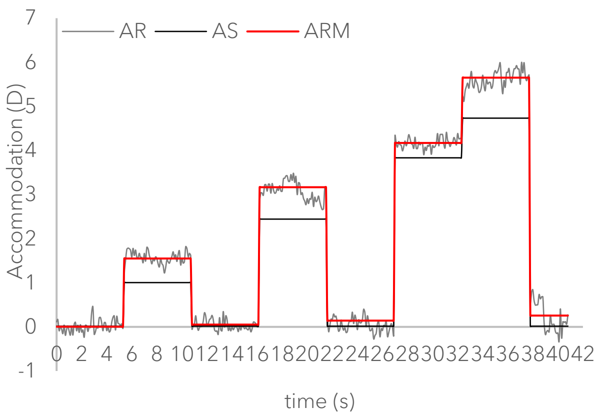

Figure 1. Real-time accommodative response (AR) and its mean (ARM) for different accommodative stimuli (AS) of the subject with AE.

The RMS of HOA for all accommodative stimuli and disaccommodation of the subject with AE and control are shown in Figure 2.

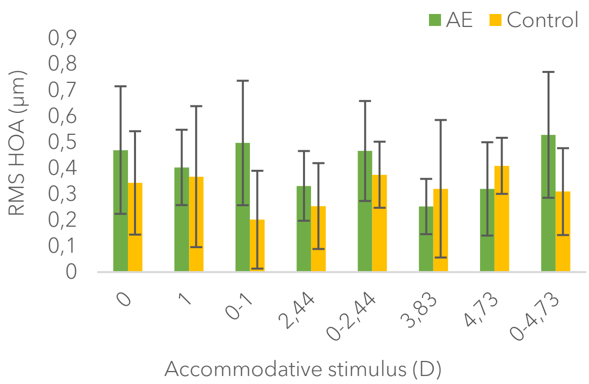

Figure 2. RMS of HOA for the different accommodative stimuli for subjects with AE and control.

The RMS HOA is higher in the subject with AE than in the control for most of the accommodative and disaccommodative stimuli, except for the highest stimuli, 3.7D and 4.56D. The subjects with AE have a lower RMS HOA for these high stimuli than for lower stimuli. However, all these differences were not statistically significant, but this could be due to the small sample size. There were no differences in primary spherical aberration between subjects with AE and controls (Figure 3). Furthermore, it became more negative with the accommodative level in both groups, as expected from previous studies [2,3].

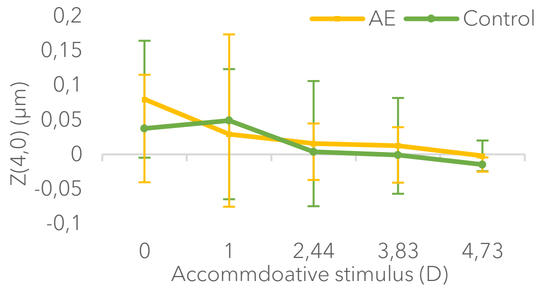

Figure 3. Changes of primary spherical aberration (Z(4,0)) with accommodation for the subjects with AE and control.

4 Conclusion

Real-time wavefront aberrometry was an efficient method to detect accommodative excess. It is possible to observe the accommodative response of these subjects to different accommodative stimuli and how they disaccommodate. Subjects with AE seemed to have higher RMS values of HOA than the control group for lower stimuli and during disaccommodation. However, the optical quality of these subjects increases for higher accommodative stimuli, which could lead them to accommodate more than expected to find the best image quality.

References

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