

# Accommodative Lag by Open-field Autorefractor and Hartmann-Shack Aberrometer

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**Abstract.** The purpose of the present study was to compare an open-field autorefractor (AR) and an aberrometer for measuring the ocular accommodative lag. The measurements were. It was found higher accommodative lags when measured it with the AR specially for high accommodative stimuli. However, the differences in accommodative lag between the two instruments were not statistically significant ( $p > 0,05$ ) and were under the limits of agreement The results indicate that aberrometer may be used for measuring the accommodative lag and may be more efficient for measuring accommodative lag for high accommodative stimuli.

## 1 Introduction

Ocular accommodation is the process in which the crystalline lens changes its power to focus on the retina images of objects at different distances.[1]

One of the methods used to identify problems in the ocular accommodation is measuring the difference between the accommodative stimulus, which is presented to an eye, and the accommodative response of the subject, which can lead to a lag or lead of accommodation. This difference is typically between +0.50 D and +0.75 D. However, in the presence of an accommodative insufficiency, this value is exceeded; whereas, inferior values could indicate an accommodative excess.[1]

Accommodation response can be measured indirectly by objective methods, such as dynamic retinoscopy, and by autorefraction, aberrometry, and double-pass systems.

Dynamic retinoscopy is the method most used in clinical practice to measure the accommodative lag; however, as it is considered partially subjective [1], autorefraction and aberrometry are more used in research. [2,3] Moreover, some authors claim that subjective techniques overestimate the accommodative amplitude relative to objective methods. Whereas, autorefraction was considered a suitable instrument for measuring accommodation. [4]

Divers autorefractors were compared among themselves for measuring accommodative response, and showed no significative differences for stimulus lower than 5.00 D. [5] Furthermore, autorefraction is comparable to dynamic retinoscopy for measuring accommodative response [6], but not with minus lens technique for assessing accommodative amplitude [7].

Aberrometry has been used for determining accommodative response, and showed to be a reliable tool. [3,8]

Aberrometer and autorefractor were only compared for measuring refractive error, showing a spherical equivalent mean difference of 0.25 D. [9]

Given the importance of having precise methods to analyse the accommodative response and lag, the purpose of this study was to compare the accommodative lag measurements obtained with an open-field autorefractor and an aberrometer.

## 2 Methods

### 2.1. Subjects

Eight subjects (five females and three male) aged between 23 and 40 years-old were recruited from University of Minho.

The mean spherical equivalent was  $-0.16 \pm 0.39$  D with astigmatism less than 1D, and had no binocular and accommodative dysfunctions. Patients with any ocular pathology, previous ocular surgery or taking medication that could affect vision were excluded.

An informed consent was obtained from each subject after providing a verbal explanation of the nature and possible consequences of the study. The study was approved by the Ethics Subcommittee for the Life Sciences and Health of University of Minho.

### 2.2. Procedure

Accommodative response was measured with an open-field autorefractor (WAM-5500, Grand Seiko Co., Ltd., Japan) (figure 1.A) and an in-house Hartmann-Shack aberrometer (Thorlabs WF150-7AR) (figure 1.B). The values were first taken for the relaxed state, and then negative lenses (-1 D, -2 D, -3 D, -4 D and -5 D) were placed in front of the eye in a trial frame with a vertex

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distance of 12mm to stimulate accommodation, while patient was asked to fix a target and keep it as clear as possible. The target was a high contrast black-on- white letter.

Accommodative lag was calculated from the difference between accommodative stimulus and response.

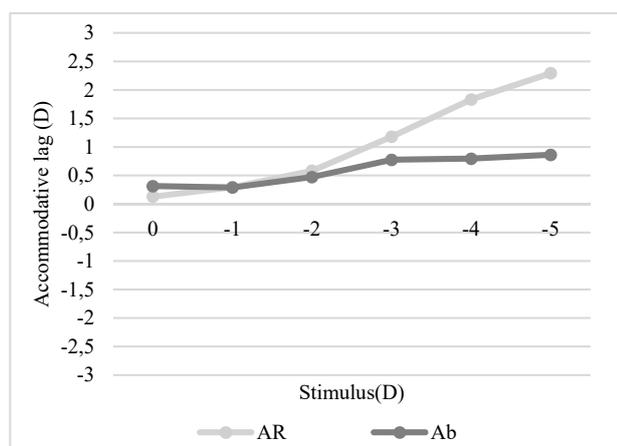


**Fig. 1.** Open-field autorefractor (WAM-5500, Grand Seiko Co., Ltd., Japan) on the left and Hartmann-Shack aberrometer (Thorlabs WF150-7AR) on the right.

The statistical analysis was performed with the software R 4.1.0. Shapiro-wilk test was used to test the normality of the data and paired t-test or Wilcoxon-test to compare the two related samples for parametric and non-parametric data, respectively. A p-value less than 0.05 was considered statistically significant.

### 3 Results

The values of accommodative lag/lead obtained from the open-field autorefractor and aberrometer for the different accommodative stimuli can be observed in the figure 2.



**Fig. 2.** The accommodative lag measured with open-field autorefractometer (AR) and Hartmann-Shack aberrometer (Ab) for the different lenses (0, -1, -2, -3, -4 and -5 D). Positive values represent accommodative lag and negative values accommodative lead.

The accommodative lag measured with AR presented values tendentially higher than with the aberrometer, especially for high accommodative stimuli (from the lens -3.00 D); However, there was no statistically significant difference for any accommodative stimulus ( $p < 0.05$ ).

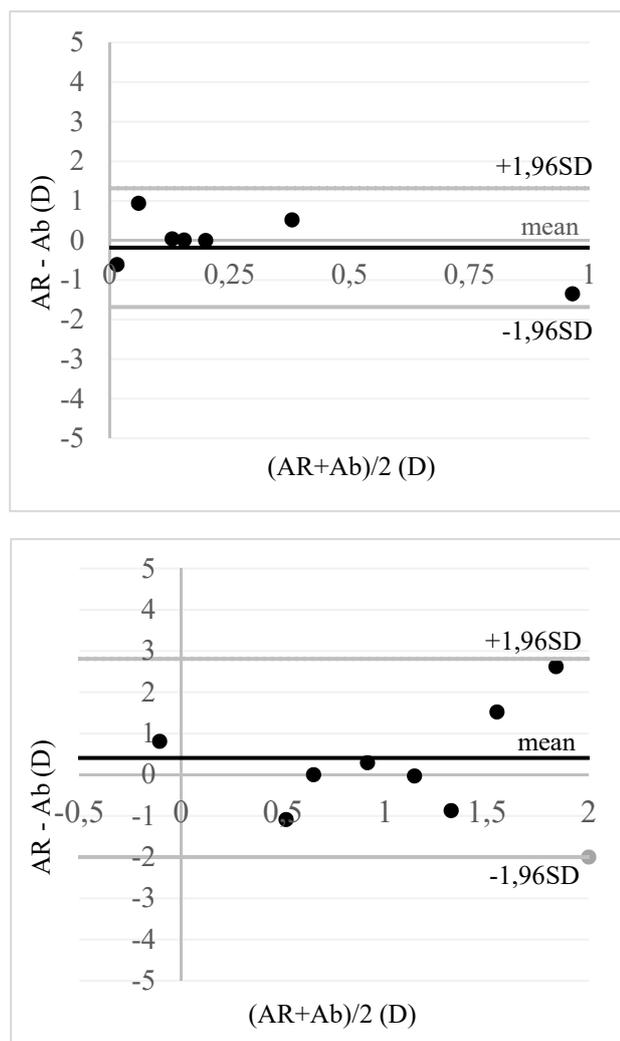
The values obtained by the AR for the higher stimuli present values above the expected, while those obtained with the aberrometer are within the expected range.

The mean, standard deviation (SD), coefficient of agreement (COA), intra-class correlation coefficient of accommodative lag (ICC), limit of agreement (LA) and p-values of the differences are shown in the table 1.

**Table 1.** Mean, standard deviation (SD), coefficient of agreement (COA), intra-class correlation coefficient of accommodative lag (ICC), limit of agreement (LA) differences obtained with AR and aberrometer, for different accommodative stimuli.

Lens (D)	0	-1	-2	-3	-4	-5
Mean (D)	-0.183	0.006	0.11	0.406	1.039	1.433
SD (D)	0.766	1.699	1.355	1.227	1.745	2.421
COA (D)	1.501	3.330	2.656	2.405	3.420	4.744
ICC	0.486	0.478	0.454	0.508	0.446	0.430
LA $\uparrow$ (D)	1.318	3.336	2.766	2.811	4.458	6.177
LA $\downarrow$ (D)	-1.683	-3.324	-2.546	-1.999	-2.381	-3.312
p-value	0.612	0.326	0.825	0.380	0.136	0.138

With Bland-Altman plots it was observed that all values were within the limits of agreement, except one, which were out of the limits with the lens -1.00 D and -2.00 D. Figure 3 shows Bland-Altman plots analysing the agreement of the measurements obtained with the two instruments for the relaxed state and for 3 D of accommodation.



**Fig. 3.** Bland-Altman plot comparing the measurements of accommodative lag in the relaxed state (up) and with an accommodative stimulus of 3D (down) obtained with the open-field autorefractor (AR) and with the Shack-Hartmann aberrometer (Ab). In the x axis is represented the average of the measures of these two instruments and in the y axis the difference between them in diopters.

## 4 Conclusion

There are no significant differences between open-field autorefractor and Shack-Hartmann aberrometer for measuring accommodative lag until 5D, although the open-field autorefractor presented values tendentially higher than with Shack-Hartmann aberrometer, mainly for high accommodative stimuli.

These preliminary results indicate that Shack-Hartmann aberrometer appears to be more effective for measuring accommodative lag in high accommodative demands than the open-field autorefractor.

In the future, it is intended to increase the sample size.

## 5 Acknowledgments

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