Published in final edited form as:

Strabismus. 2013 June ; 21(2): . doi:10.3109/09273972.2013.786737.

Association Between Accommodative Amplitudes and Amblyopia

Eric Singman¹, Noelle Matta², Jing Tian³, and David Silbert²

¹Wilmer Eye Institute, Baltimore, Maryland, USA

²Family Eye Group, Vision Science Department, Lancaster, Pennsylvania, USA

³Biostatistics Consulting Center, Department of Biostatistics, Baltimore, Maryland, USA

Abstract

Purpose—To evaluate the relationship between amblyopia and accommodative ability.

Methods—The open-field Grand Seiko binocular autorefractor has become the gold standard for automated measurement of static accommodation. We measured the accommodation amplitudes in 52 children ages 3 to 14 years employing the Grand Seiko auto refractor. Children wore their glasses for this test, which was prescribed based on a cycloplegic refraction performed by one pediatric ophthalmologist. No readings could be obtained for 9 eyes (5 patients).

Results—Normal accommodation with correction utilizing full accommodative effort at 1/3 meter is 3D assuming no accommodative lag, and would generate a reading of −3.00D from the Grand Seiko auto refractor. Lack of any accommodative should give a reading of 0.00D. Accommodative gradually declined as the acuity worsened.

Conclusion—Our results suggest that amblyopic eyes do not accommodate as well as non-amblyopic eyes. Because accommodation amplitude is not subjective it may be a more sensitive indicator of regression of amblyopia than visual acuity. The Grand Seiko autorefractor could prove to be a useful tool to monitor the progress of patients with amblyopia.

Keywords

Accommodation; amblyopia; amblyopia treatment; pharmacology

INTRODUCTION

Accommodative amplitude (AA) has been shown to be reduced in amblyopic eyes.^{1–6} This result has been verified in studies using subjective and objective tests. Of these, there are manual methods of measurement including the minus lens method, the near point of convergence method employing the Prince rule, and dynamic retinoscopy, as well as automated devices such as the Hartinger Coincidence Refractometer and the infrared consensual accommodation test (iCAT). These latter tests employ infrared video cameras to document accommodative changes. The Hartinger device requires a subjective vernier alignment by the examiner while the iCAT is a custom- and purpose-built device not widely

© Informa Healthcare USA, Inc.

Correspondence: Noelle Matta, Family Eye Group, Vision Science, 2110 Harrisburg Pike, Lancaster, 17601 United States. noellematta@gmail.com.

DECLARATION OF INTEREST

The authors report no conflicts of interest.

available nor FDA approved. It has been reported that subjective methods typically overestimate true AA⁷⁻⁹ and therefore objective devices would be preferred.

In our study, we employed the Grand Seiko autorefractor (GSAR) to measure AA in children with amblyopia. Unlike other autorefractors, this device measures accommodation from below rather than from the point of fixation. By utilizing a one-way mirror, the eyes can be offered an unobstructed view of the fixation target. In addition, the fixation target can be set to any distance. Our interest was to determine how well this device would detect the known reduction of AA in amblyopic eyes. Ciuffreda¹⁰ has suggested that regression of AA may precede regression of visual acuity in patients treated for amblyopia. Therefore, it would be useful to have an automated, objected, readily available and FDA-approved device that could be used to routinely monitor patients during the treatment of amblyopia.

MATERIALS AND METHODS

Prior to starting this research we received Institutional Review Board (IRB) approval through the Lancaster General and Johns Hopkins IRB. We received a waiver of consent due to the low risk of this research and followed appropriate Health Insurance Portability and Accountability Act of 1996 guidelines.

Fifty-two children had their AAs measured on the GSAR at 1/3 of a meter wearing their optimal glasses correction as part of a pediatric ophthalmology examination. Of 108 eyes, 99 had a reading obtained. Children were between the ages of 3 and 14 years (average age 7 years). All children had a comprehensive pediatric ophthalmologic examination including subjective best-corrected visual acuity (BCVA) and a cycloplegic refraction (performed that day or within the past 6 months).

RESULTS

Table 1 displays the BCVA ranging from 20/20 to 20/ 100 and the number of eyes at each BCVA. Normal accommodation with full accommodative effort at 1/3 meter is 3D, which should generate a reading of -3.00D from the GSAR, while complete lack of any accommodation should give a reading of 0.00D. Graph 1 shows the AA for each eye and its corresponding visual acuity. The intercept was calculated at 0.46. When the BCVA ration equals zero, the GSAR would theoretically read 0.46 for the AA. The slope of the line, or BCVA-Ration Term, is -2.52. This means that when the BCVA ratio increases by 1, the GSAR reading will decrease by 2.52. Using the generalized estimating equation (GEE) model, we determined that there was a significant correlation between AA and BCVA ration ($p < 0.0001$). In simpler terms, this result indicates a negative correlation between BCVA and AA, such that the worse the vision, the lower the AA.

We tested the correlation between AA and BCVA. To do this, we transformed the BCVA into a ratio (eg, 20/20 = 1, 20/40 = 0.5, etc) and then used the GEE model to test whether this ratio was correlated to AA (Figure 1). There is a significant correlation between AA and BCVA. Eyes with acuity of 20/20 had a median AA reading of -1.939 and eyes with acuity of 20/100 had a media AA of +0.625.

DISCUSSION

Our results are in concert with previous studies demonstrating that AA is reduced in amblyopic eyes. In addition, we demonstrate a novel finding in that AA seems to progressively worsen with the degree of amblyopia. Considering the concern that reduction of AA may precede loss of BCVA in patients being treated for amblyopia, the ability to measure AA may be a useful application for monitoring the progress of AA patients. It

would be reasonable to offer this evaluation to patients, particularly after therapy has been discontinued, so as to be able to detect regression as early as possible.

The GSAR provides a unique method of measuring AA. It is a rapid, reliable,⁸ completely objective, automated, and FDA-approved device that is readily available and simple to use without special training. We believe that further studies should explore the utility of monitoring AA during and after treatment for amblyopia and the GSAR could be helpful in this effort.

References

1. Wood IC, Tomlinson A. The accommodative response in amblyopia. *Am J Optom Physiol Opt.* 1975; 52:243–247. [PubMed: 1130487]
2. Kirschen DG, Kendall JH, Riesen KS. An evaluation of accommodation response in amblyopic eyes. *Am J Optom Physiol Opt.* 1981; 58:597–602. [PubMed: 7282872]
3. Ciuffreda KJ, Hokoda SC, Hung GK, et al. Static aspects of accommodation in human amblyopia. *Am J Optom Physiol Opt.* 1983; 60:436–449. [PubMed: 6881274]
4. Hokoda SC, Ciuffreda KJ. Measurement of accommodative amplitude in amblyopia. *Ophthalmic Physiol Opt.* 1982; 2:205–212. [PubMed: 7177646]
5. France LW. Dull faces: exoteric and esoteric facts and theories relative to amblyopia. *Am Orthopt J.* 2003; 53:60–74. [PubMed: 21149075]
6. Maheshwari R, Sukul RR, Gupta Y, et al. Accommodation: its relation to refractive errors, amblyopia and biometric parameters. *Nepal J Ophthalmol.* 2011; 3:146–150. [PubMed: 21876588]
7. Wold JE, Hu A, Chen S, Glasser A. Subjective and objective measurement of human accommodative amplitude. *J Cataract Refract Surg.* 2003; 29:1878–1888. [PubMed: 14604706]
8. Win-Hall DM, Ostrin LA, Kasthurirangan S, Glasser A. Objective accommodation measurement with the Grand Seiko and Hartinger coincidence refractometer. *Optom Vis Sci.* 2007; 84:879–887. [PubMed: 17873774]
9. León AA, Medrano SM, Rosenfield M. A comparison of the reliability of dynamic retinoscopy and subjective measurements of amplitude of accommodation. *Ophthalmic Physiol Opt.* 2012; 32:133–141. [PubMed: 22268597]
10. Ciuffreda, KJ.; Levi, DM.; Selenow, A. *Amblyopia: basic and clinical aspects.* Boston, MA: Butterworth-Heinemann; 1991. p. 83-88.

FIGURE 1.
Visual acuity plotted against accommodative amplitude.

TABLE 1

Number of eyes at each level of BCVA.

BCVA	Frequency
20/100	1
20/20	36
20/25	21
20/30	17
20/40	15
20/50	9
20/60	3
20/80	2