VALIDITY OF USING THE GRAND SEIKO WR-5100K AUTOREFRACTOR TO MEASURE THE LAG OF ACCOMMODATION

by

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Has been approved

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ABSTRACT

PURPOSE. To investigate whether or not the Grand Seiko WR-5100K autorefractor can be used to measure the lag of accommodation. METHODS. Measurements were taken on both the right and left eyes at distance and then a near measurement of 40 centimeters was taken. RESULTS. The accommodative response minus the accommodative stimulus gave an average accommodative lag of 0.95 diopters. CONCLUSION. The Grand Seiko WR-5100K autorefractor can be used to measure accommodative responses and offers some exciting opportunities, both clinically and for research, in determining near refractive error and accommodation.

INTRODUCTION: Autorefractors are computerized instruments that measure harmless infrared light rays as they pass through the eye and estimate the eye's refractive error. The Grand Seiko WR-5100K is a new, open view binocular autorefractor that is commercially available for determining patient's refractive error. Studies have shown it to be valid and reliable with adults and children[1,2,3]. This instrument is exciting for clinicians and researchers because unlike most autorefractors that simulate a distance environment in an enclosed box, it allows the patient to view the "real world". Measurements can be made at distance and near, allowing for the possibility of near refractive error and accommodative responses. Furthermore, the patient views the target under binocular conditions which provides a more realistic representation of their "natural" environment.

The Grand Seiko WR-5100K autorefractor has three measurement modes including: autorefraction and keratometry simultaneously, autorefraction only, and keratometry only. Vertex distance can be set manually to 0, 10, 12, 13.5, and 15 mm. The instrument is capable of taking refractive error measurements of +/-22.00 diopters sphere and +/-10.00 diopters of cylinder in steps of 0.125 diopters and 1 degree for cylinder axis. In addition, keratometry measurements of 5.0 to 10.0mm for radius of curvature and 33.75 to 67.50 diopters for corneal refractive power in steps of 0.01mm or 0.12/0.25 diopters increments can be taken. The manufacturer's recommendation for minimum pupil size is 2.9mm. Refractive error is measured in two stages by imaging a ring target of near infrared radiation (850nm) that is reflected off the retina[1,2]. First, a lens is moved along a motorized track to approximately focus the ring and then the image is analyzed digitally in multiple meridians to calculate the prescription[1,2].

Accommodation refers to the process by which the crystalline lens of the eye changes shape to focus the image of a near object onto the retina. The mechanics of this process involve the radial contraction of the ciliary muscle inward, which lessens the tension on the lens zonules and thus allows the lens to assume its relaxed state. There is an increased anterior surface curvature which produces increased plus power to focus near objects. The maximum amplitude of accommodation of the eye decreases with age by the formula Amp Acc= 18D – 0.3*age in years[4]. An important fact to realize is that the eye does not focus directly in the plane of a near target, but there is a tendency for the eye to focus behind the plane of the target. The relationship between the accommodative stimulus and the magnitude of the response follows a predictable pattern. Through the linear portion of the relationship, the accommodative system responds at about 0.8 of the stimulus[5]. The difference between the accommodative stimulus and the accommodative response is defined as the lag of accommodation. Even though the eye is not focused at the plane of the object, a clear image is still projected onto the retina because of the depth of focus. The depth of focus is the variation in image distance an optical system can tolerate without incurring an objectionable lack of sharpness in focus. For a 3 mm pupil, the depth of focus is +/- 0.30 diopters[4]. The system changes focus by the minimum amount possible that will place a clear image on the retina and that is achieved be putting the object just inside the depth of focus. Any further accommodation would not serve any purpose and thus there exists a lag of accommodation.

The near lag of accommodation has a counterpart that acts at distance. This means that the accommodative response to infinity is not zero, but rather 0.25 to 0.33 diopters in front of the distant target[4]. This is referred to as the lead of accommodation and is made possible because of the depth of focus provided by the pupil.

Clinically, dynamic or near retinoscopy is performed to determine the lag of accommodation from a near target. For a 40 cm target the normal lag is approximately +0.50 diopters or 10 centimeters behind the target. The lag of accommodation provides information about how efficiently the binocular system is functioning. A large lag or "loose system" shows an inadequate accommodative response and could indicate a near esophoria, accommodative insufficiency, or uncorrected hyperopia. A small lag or "tight system" from overaccommodating could indicate a near exophoria or spasm of accommodation. The two most commonly used methods of determining the near lag of accommodation are Nott and the monocular estimate method (MEM). Both involve evaluation of the retinoscopic reflex and require an expert observer, but differ in the way that they neutralize the reflex. In Nott, the examiner neutralizes the reflex by adjusting the distance from the target, and in MEM the reflex is neutralized with lenses[6].

If the Grand Seiko WR-5100K autorefractor were capable of accurately measuring the lag of accommodation a technician or other non-expert observer could collect this useful information which would lead to more efficient examinations. Studies have shown the Grand SeikoWR-5100K to be valid and reliable in primary gaze at distance with adults and children[1,2,3], but the purpose of this study is to use the Grand Seiko WR-5100K autorefractor to measure near accommodative responses and calculate the lag of accommodation.

METHODS: This study was approved by the Human Subjects Review Committee at Ferris State University. 8 subjects participated in the study and 16 eyes were tested. After each subject signed a consent form and had an opportunity to ask questions, preliminary data was collected to determine if the subject was a candidate to participate in the study. This data included: distance visual acuities of 20/30 or better, cover test at both distance and near to rule out strabismus and clinically significant AC/A ratio (<2/1 or >6/1), normal lag of accommodation, and an initial distance autorefractor reading to verify the subject had 1.0D or less of astigmatism. The testing room was set up so that the autorefractor was aligned with a central distance fixation target. First subjects were instructed to fixate the central distance target and five measurements were taken on each eye. The average of the five readings for each eye established the baseline refraction for which the near measurements were compared. Next the patient was instructed to fixate a near Snellen acuity chart located at a distance of 40cm and ten measurements were taken again on each eye. All measurements were taken with the patient in a normal binocular state (not patched or fogged).

RESULTS: The spherical equivalent of each reading was calculated by using the following formula: Spherical Equivalent= Sphere + (Cylinder/2). The average of the spherical equivalents for all of the distance readings was -0.24 D and for the near readings it was

-1.79D. The 40 cm testing distance represents an accommodative stimulus of 2.50D for which the average accommodative response was 1.55D. The average lag was 0.95D calculated by subtracting the response from the stimulus.

Table of Results

Spherical Equivalent Average of Distance Readings	-0.24 D
Spherical Equivalent Average of Near Readings	-1.79 D
Average Accommodative Response	1.55 D
Accommodative Demand	2.50 D
Total Calculated Lag	0.95 D

Pre-test Lag Vs. Autorefractor Calculated Lag

	1	2	3	4	5	6	7	8	Avg
Pretest lag	0.5	<0.5	0.5	0.5	<0.5	<0.5	0.5	<0.5	
A/R lag OD/OS	0.97/1.11	0.59/0.34	0.58/0.63	1.33/0.93	1.19/1.06	1.05/0.90	1.08/0.73	0.68/2.08	0.95

DISCUSSION: The Grand Seiko WR-5100K autorefractor is capable of taking near refractive error measurements, so it is possible to calculate the accommodative response to a given accommodative demand. This study, because of the design, was not able to make any statement about the accuracy of the autorefractor lags. The table of pre-test lags versus autorefractor lags does not show any pattern between the two. To determine if the response versus demand calculated by the autorefractor is consistent with the clinical measurement of MEM or Nott, careful pre-testing lag values would have to be taken on a greater number of patients and then compared to the autorefractor results.

The Grand Seiko WR-5100K autorefractor could become the preferred method of determining lag for two reasons. First, the patient's lag information could be collected as part of a pre-test battery by a technician without any time being taken out of the doctor's examination. Secondly, because of the potential variability of near retinoscopy values, the autorefractor could be a more objective and reliable method of determining and tracking a patient's lag.

The Grand Seiko WR-5100K autorefractor has a near option that allows you to set a near testing distance of 25 centimeters or 40 centimeters with the implication that the instrument will measure the near refractive error. However, the only variable that is changed is the pupillary distance measurement. Regardless of the setting the measurement of the refractive error is for optical infinity and the doctor must calculate out the near demand and the refractive measurement.

CONCLUSION: There are numerous factors of the binocular system that contribute to the value of the lag of accommodation including: AC/A ratios, heterophorias, uncorrected refractive error, attention of the patient to the targets, and to a small degree pupil size[7]. Future studies should account for these factors. In answer to our original question, it has been determined that the Grand Seiko WR-5100K autorefractor is capable of measuring accommodative responses to near targets, but further study needs to be done to determine the accuracy of the lag values the instrument calculates.

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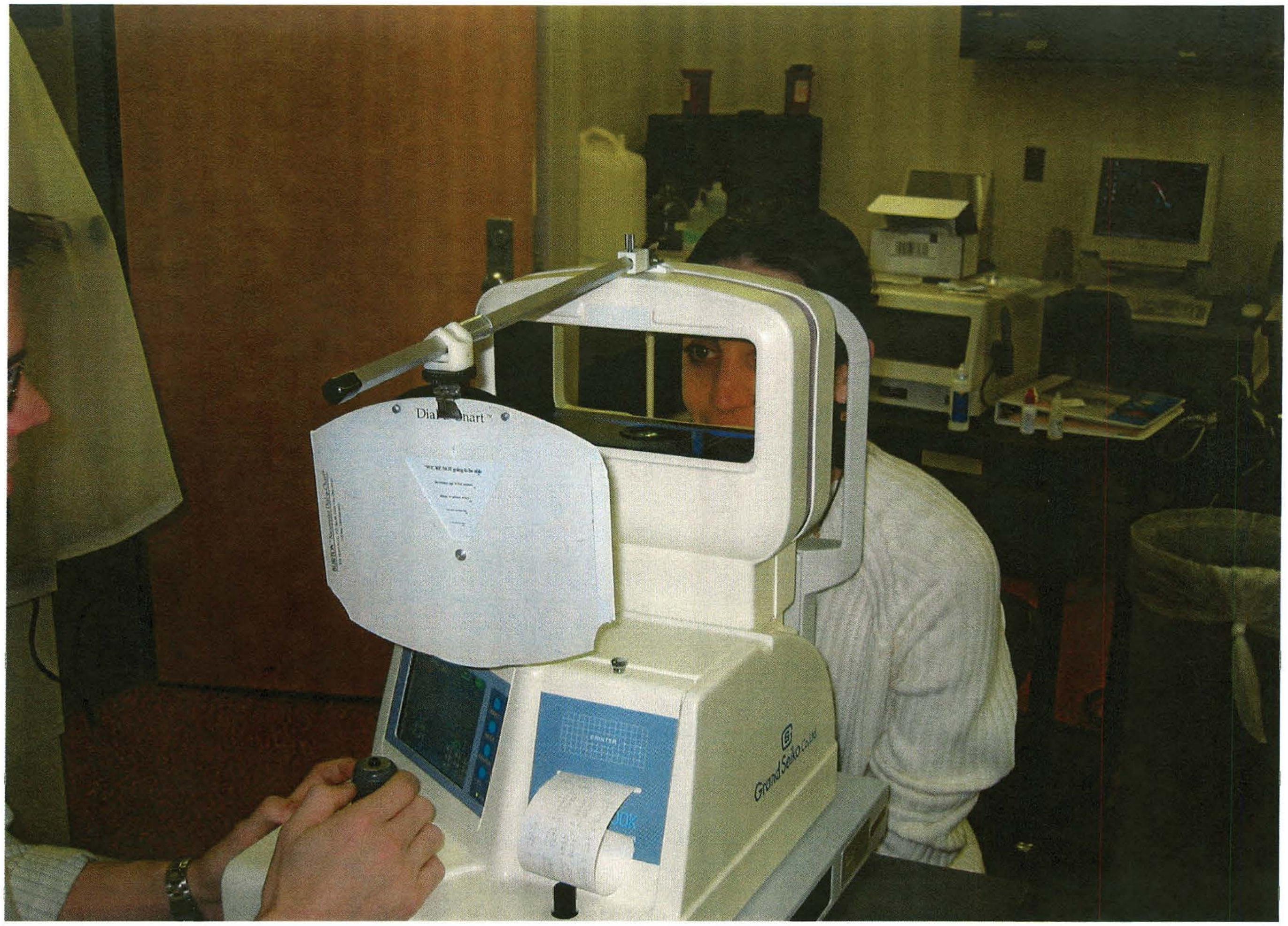
Grand Seiko