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Nearwork-induced changes in lenticular thickness in different refractive groups

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Abstract

PURPOSE: The aim of this study was to directly measure lenticular thickness and its additivity after 1 and 2 hours of continuous reading at near in myopic and emmetropic young adults.

METHODS: Thirty-five subjects consisting of 12 early-onset myopes, 11 late-onset myopes, and 12 emmetropes were tested. Axial lenticular thickness was measured in the right eye using A-scan ultrasonography before and immediately after 1 and 2 hours of continuous reading at near (35 to 40 cm).

RESULTS: Group mean (±SD) changes in lenticular thickness from baseline values after the first and second hours of reading were 0.025 ± 0.011 and 0.035 ± 0.017 mm, respectively. The group mean increase in lenticular thickness after the second hour was significantly larger than after the first hour, with subsequent subgroup analysis indicating that this was found in the myopes only.

CONCLUSION: The lenticular increase was additive in nature, but only in the late-onset and early-onset myopes. This confirmed and extended objectively earlier studies that suggested increased nearwork accommodative susceptibility of a primarily lenticular nature in myopes.

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A growing body of evidence from both cross-sectional[1,2] and longitudinal[3-5] studies addresses factors that can influence myopia development and its progression.[6,7] These factors are broadly categorized as either environmental or genetic. For example, results from the COMET study[8,9] showed the influence of both factors in a population of myopic children. This has been confirmed recently by Jones et al.[10] A meta-analysis of all relevant studies suggested the interplay of both environmentally based factors (such as nearwork[11]) and genetic history (such as parental myopia[12]) in the overall development of myopia.[13-15]

Myopes are commonly categorized based on the age of receiving their initial distance refractive correction. They are classified as early-onset myopes (EOMs) if they received their myopic correction before the age of 14 years, whereas they are classified as late-onset myopes (LOMs) if they received their myopic correction after the age of 14 years.[16] Early literature suggests that genetic influences had a primary influence in EOMs, whereas environmental factors had a primary influence in LOMs.[17] However, more recent evidence suggests that both myopic subgroups are similarly susceptible to short-duration nearwork accommodative aftereffects,[18-21] such as nearwork-induced transient myopia (NITM).

NITM refers to the transient, pseudomyopic shift in the accommodative far point of the eye after a period of

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sustained nearwork.[11,13] It has been presumed to reflect an inability of the crystalline lens to reduce its power appropriately and rapidly, thus representing a lenticular-based accommodative hysteresis phenomenon.[11,13-15] In the normal, asymptomatic young adult population, the mean initial NITM magnitude is sufficiently small (approximately 0.3 diopters [D]) to remain within the eye's depth of focus,[13,22,23] and thus there is no transient perception of blur.

NITM has been a source of investigation for nearly a century. The first effort to study the phenomenon was conducted in 1914 by Lancaster and Williams.[24] They found that in both school-age children and in young adults, NITM magnitude could be considerable, as large as 1.5 D with persistence for up to 15 minutes after a substantial accommodative focusing demand. Other more recent studies have found the typical NITM magnitude to range from 0.25 to 0.60 D.[13,14] Several investigations have reported NITM to be of greater magnitude, frequency, or duration in myopes than in other refractive groups.[18,19,15] Furthermore, both Vera-Diaz et al,[25] and Vasudevan and Ciuffreda,[21] have reported that progressing myopes were more susceptible to NITM than were stable myopes. This is consistent with the clinical findings of Mei and Rong[26] in young Chinese children. However, this notion remains debatable[27] and deserves future longitudinally based investigation.

A recent investigation[21] found that NITM was additive in nature but in myopes only. NITM increased from 0.22 D to 0.29 D in EOMs and from 0.14 D to 0.20 D in LOMs after the first and second hour of continuous nearwork, respectively, in conjunction with more prolonged decays. However, in the emmetropes (EMMs), NITM only increased from 0.14 D to 0.15 D, with normal decay durations. Furthermore, it has been speculated that any nondecayed NITM after subsequent nearwork may be an additional environmental factor to consider in myopic refractive error development.[28] Hence, future longitudinal investigations in this important area are warranted.

Although the overall optical aspects of NITM have been measured in several earlier studies using objective open-field autorefractors (for a review, *see* Chen et al.[14]), lenticular changes have been assumed to be the sole/major factor producing the resulting NITM.[11,13] However, this has never been directly and objectively determined. Hence, using a standard NITM paradigm,[21] the aim of this investigation was to assess, directly and objectively, changes in human crystalline lenticular thickness, and its additivity, via high-resolution A-scan ultrasonography after 1 and 2 hours of continuous nearwork in myopic and emmetropic young adults.

Methods

Subjects

Thirty-five visually-asymptomatic optometry and graduate students were recruited from the SUNY State College of Optometry. None reported any ocular or neurologic dysfunction. Subjects included EMMs (N = 12), EOMs (N= 12), and LOMs (N = 11) with an age range between 21 and 35, 21 and 28, and 22 and 28 years, respectively. They comprised a large subgroup of subjects from an earlier related study in our laboratory.[21] Noncycloplegic refractive error of each subject was obtained using conventional subjective refraction. This was confirmed using an objective, open-field, infrared autorefractor (Canon R-1, Lake Success, New York)[29]; the difference was never greater than 0.37 D. Myopes were categorized as either EOMs or LOMs based on direct query of their age at receiving their initial distance refractive correction.[16] LOMs spherical equivalent refraction ranged from −0.5 D to −3.00 D, with a mean (±SD) of −1.87 ± 1.29 D; EOMs spherical equivalent refraction ranged from −2.25 to −7.75 D, with a mean (±SD) of −4.12 ± 2.95 D; and EMMs spherical equivalent refraction ranged from +0.5 to −0.25 D, with a mean (±SD) of +0.15 ± 0.20 D. The cylindrical component was no greater than −1.00 D in any of the subgroups, with a mean of −0.64 D. The mean cylindrical components were −0.58 D, −0.74 D, and −0.42 D in the EOMs, LOMs, and EMMs, respectively. The mean differences in myopic refractive error (spherical equivalent) between the EOMs and LOMs are expected, i.e., EOMs have higher degrees of myopia than do LOMs. EOMs are more genetically predisposed and have a myopic progression that starts early in life, whereas the LOMs have had a myopic progression that begins much later in life. All subjects were corrected with either spectacles or contact lenses to obtain a distance and near visual acuity of 20/20 or better monocularly and binocularly. Informed consent was obtained from each subject after the nature and possible consequences of the study were explained. The research followed the tenets of the Declaration of Helsinki and was approved by the college's internal review board.

Instrumentation

Measurement of axial lenticular thickness was obtained using A-scan ultrasonography (Sonomed 5500; Sonomed Inc., Lake Success, New York). It incorporates a low-noise probe using direct corneal contact.[30] This instrument provides temporary storage of up to 5 sequential measurements in rapid succession (every 2 seconds).

Procedure

Calibration. Instrument calibration was performed according to the instructions of the manufacturer before the testing of each subject.[30] In addition, 4 sets of A-scan measurements were obtained from a 65-year-old absolute presbyope on 4 different occasions over 2 days, with absence of any residual accommodative ability being confirmed objectively using a WAM-5500 open-field autorefractor (AIT Industries, Bensenville, Illinois). This control subject was asked to fixate the same distance target as used in the study. The ultrasound measurements were repeated 5 times at