Accommodation stability and the progression of myopia in children

Authors
Trine LANGAAS
, 
Patricia RIDDELL

Refer this article as: Langaas, T., Riddell, P., Accommodation stability and the progression of myopia in children, Points de Vue, International Review of Ophthalmic Optics, N66, Spring 2012

Publication date :
05/2012

Introduction

The prevalence of myopia continues to be on the increase, and despite intensive research on both onset and progression of myopia over the past few decades, the aetiology is not clearly understood. Many factors have been suggested as possible causes of the development of myopia. For instance, it is generally accepted that it has a genetic component, and there are several studies demonstrating how myopia in children can be partially predicted by the myopia of their parents [2, 7, 5]. But inheritance cannot explain the substantial increase in the incidence of myopia that has occurred over the past few decades. Epidemiological studies have demonstrated the importance of environmental factors as causal agents in the development and progression of myopia. These include several that are related to the clarity of the retinal image and level of accommodative demand, such as intensive schooling and reading, under-correction and extensive computer work.

Both animal and human studies have suggested that retinal defocus (blur) may be a stimulus for axial elongation of the eyeball during myopic progression. Accurate focusing is controlled directly through accommodation of the lens in response to blur cues. Since maintenance of emmetropia appears to depend on a well focused image, abnormalities in the accommodative system could result in development of refractive errors. To provide evidence for this, research has focused on determining differences in accommodative behavior between myopes and emmetropes. Several studies have reported that late onset myopes showed greater accommodative instability when viewing a close target [13, 1, 3]. However, Day et al (2006) found less variability of accommodation in adults with early onset myopia. There are two possible relations between accommodative variability and myopia that could account for this. One interpretation is that differences between early and late onset myopes could result from a difference in the aetiology of myopia with decreased stability accounting for late- but not early-onset myopia. In this case, children who are developing myopia (early onset myopes) would not be expected to show decreased stability. The second interpretation is that differences in stability between early and late onset adult myopes could result from the time of testing in relation to the time at which the myopia begins. For instability of
Accommodation stability and the progression of myopia in children | Points de Vue | International Review of Ophthalmic Optics

Accommodation to cause myopia, it has to be present before the myopia, but does not necessarily have to persist after progression is complete. In this case, decreased stability would be found in adults with late onset myopia (whose myopia is still progressing) but might not be found in adults with early onset myopia (for whom myopic progression is complete). In comparison, children who are developing myopia (i.e. those who become early onset adults) would be expected to show decreased stability of accommodation. To test this, the studies reported here investigated accommodative stability in children with early onset myopia. In this paper, we report data from children who were tested on two occasions with two years between testing. Data from each visit was used to investigate possible causal relationships between stability of accommodation and myopic progression. We predicted that children who demonstrated accommodative instability at Visit 1 would continue to show this instability at Visit 2, especially at the nearest target distance where accommodative demand is greatest. In addition, if instability of accommodation drives myopia either directly or as a consequence of insensitivity to blur, we predicted that instability at the first visit would predict myopic progression. The results of the study reported here suggest that instability of accommodation accompanies myopic progression.

**Methods**

23 children aged 13.97 ±1.69 yrs and with a noncycloplegic refraction of at least -0.50D spherical equivalent in each eye were recruited from a local vision screening program comprised the index group. Their mean spherical equivalent was -1.54 ±1.29 and -1.39 ±0.88 for right and left eyes respectively. The control group consisted of 18 emmetropes and low hyperopes (aged 13.51 ±0.28 yrs) who were not considered to require an optical correction (mean spherical equivalent +0.37 ±0.37 and +0.43 ±0.34 for right and left eyes respectively). All children had full corrected visual acuity in both eyes. Any child with anisometropia or astigmatism greater than 1.0 D, with manifest strabismus or amblyopia or with a history of ocular health problems were excluded from the study. Experiments commenced after informed consent was obtained from parents/guardians and also from the children if they were over the age of 12 years. The experiment followed the tenets of the Declaration of Helsinki.

![Example of Emmetropic Child](image1)

![Example of Myopic Child](image2)

**Fig. 1: Examples of Dynamic Accommodation.** The individual responses over time for a control child (left) and myopic child (right). The black lines show the position of the target, and the open symbols give a representation of the variability of the response. The emmetropic child clearly shows a more stable response at each target distance, with no more variability than + 0.5 D at any target distance. The myopic child, however, shows quite large fluctuations in accommodative response by as much as + 1 D for the near target.

/article/accommodation-stability-and-progression-myopia-children
Instruments

The accommodation functions were recorded using the PlusOptix PowerRefractor II in dynamic mode of operation in which the refractive status of the eyes is recorded continuously at a frequency of 12.5 Hz. Further details of the instrumentation are described in Langaas et al. (2008). All children were corrected for distance with best subjective refraction to the nearest +/-0.25 D sphere and/or cylinder in a trial frame with full aperture lenses. The subjects were seated the required 1 meter in front of the PowerRefractor, with the head stabilized. Fixation targets consisted of printed letter charts with the letter size N5, scaled for fixation distance. There were three viewing distances, 4 m (“far”), 50 cm (“middle”) and 25 cm (“near”) distances. The subjects were instructed to look at the three targets in a set order: near; middle; far; near; far and middle so that all distances were viewed twice with variable step changes between each viewing. Accommodative response was recorded continuously during the procedure. Data was viewed on-line during collection to ensure that data were collected and that a steady accommodative response was achieved for an estimated 2-3 seconds at each target distance before change of fixation target.

Results

To investigate whether the variability of accommodation was different between myopic and control children, the standard deviation of the accommodation response was estimated at each plane of fixation. The comparison between the two groups showed a significant difference with myopes showing greater variability of accommodation than the control group. (Repeated measures ANOVA: (F (1, 37) = 13.14, p = 0.01). The myopes were significantly more variable than the controls for the near target (F (1, 33) = 15.64, p < 0.0001) and the far targets (F (1,33) = 10.33, p < 0.005) but not for the middle target.

/article/accommodation-stability-and-progression-myopia-children
The results of the first study suggest that there are differences in the variability in the plane of accommodation between early-onset myopic and control children. Myopic children were found to have significantly more variable accommodative responses for both near and far targets. This could produce higher stress in the accommodative system in myopic children resulting in an increase in retinal blur.

**Study II Introduction**

We further investigated the causal relationship between increased variability of accommodation and myopia by conducting a 2 year follow up study to investigate the predictive effect of accommodative variability on refractive status. By comparing variability of accommodation with refractive status and myopic progression measured at follow up we aimed to determine whether there is a potential causal relationship between accommodative variability and myopia in early onset myopia [9].

**Selection of participants**

In all 29 participants from the original cohort were included in the study: 13 myopes (age 16.00 ±0.68 yrs; mean spherical equivalent - 2.27 ±0.28 D) and 16 emmetropes (age 16.04 ±0.11 yrs; mean spherical equivalent 0.11 ±0.09 D). The same inclusion and exclusion criteria and experimental procedure as in the first study were used.

**Results**

Correlation analyses were used to investigate the repeatability of refractive error and accommodative variability across visits. There were significant correlations between both refractive error at Visits 1 and 2 (R^2 = 0.81 (p < 0.0001)), and between accommodative variability at Visits 1 and 2, for each target distance (Near: R^2 = 0.55, p < 0.0001, Middle: R^2 = 0.39, p < 0.0001, Far: R^2 = 0.19, p = 0.016). This suggests a high degree of stability across time for both refractive error and, more importantly, for our measure of accommodative variability.

We had predicted that refractive status at visit 2 would be related to accommodative instability measured at Visit 1 if instability accompanied myopic progression. We hence compared accommodative instability measured at Visit 1, between children who were myopic or emmetropic at Visit 2 and found a significant difference between groups. This result lends support to a relationship between accommodative instability at Visit 1 and the refractive status two years later.

Finally, to determine whether instability at the first visit could be used to predict the degree of myopic progression, we regressed the instability at Visit 1 against progression in myopia (Figure 3). This showed a small but significant predictive effect of instability on myopic progression (R^2 = 0.14, p = 0.05). Thus, the greater myopic progression was found for children who had showed the greater accommodative instability for the 25 cm target at Visit 1.

/article/accommodation-stability-and-progression-myopia-children
Accommodation stability and the progression of myopia in children | Points de Vue | International Review of Ophthalmic Optics

Fig. 3: Scatterplot showing the relationship between variability for near at Visit 1 and myopic progression. There was a significant correlation between these measures ($R^2 = 0.15$, $p = 0.046$).

Overall Discussion

In the first study it was found that a group of children with early onset myopia demonstrated greater accommodative variability than a control group of emmetropic children. It was postulated that this increase in accommodative variability could result in an increase in retinal blur and hence be a causal factor in the development of myopic refractive error. Alternatively, the increased accommodative variability might result from the myopia. A two-year follow-up study was therefore instigated to investigate whether the observed increase in accommodative variability would predict or be concurrent with myopic refractive error.

Correlation analysis of the repeatability of refractive error and accommodative variability across visits showed a strong relationship for both measures. In both studies, we demonstrated that concurrently measured accommodation variability was significantly greater for a group of early onset myopes when compared to an age matched group of emmetropic children. Further, a regression analysis looking at the relation between stability of accommodation for the near target during Visit 1 and myopic progression showed that stability of accommodation was a significant predictor of the degree to which the myopia increased over the two years between testing.

Previous studies have reported that accommodative variability is increased in adults with late-onset, but not early-onset myopia [12]. This difference could have arisen from differences in the aetiology of earlyonset versus late-onset myopia. Thus, late onset myopia could result from accommodative instability, with a different aetiology for early onset myopia. In this case, accommodative instability would not have been expected in our early onset myopes assessed while their myopia was progressing. The alternative hypothesis was that the accommodative instability is present during myopia progression, but later stabilizes so that both early and late onset myopes would demonstrate accommodative instability, but only during the time when their myopia is progressing. This latter
The hypothesis is supported by the findings reported here.

Reduced sensitivity to blur has been reported in adults with myopia [4], and this has been proposed as a possible mechanism for the development of myopia [10, 11]. According to this theory, if sensitivity to blur is reduced, accommodative accuracy is decreased, and larger errors of accommodation are tolerated. Relatively large fluctuations in accommodation might not produce sufficient changes in blur to be noticed and therefore would not be corrected, resulting in greater instability of accommodation. The increased blur resulting from greater errors of accommodation would then drive myopic progression.

**Conclusion**

The results of this study provide some support for the hypothesis that greater accommodative instability is one possible factor that may be involved in myopic progression, but further research is needed to establish any causal relationship.

**References**

Footnote page:

1. ANalysis Of VAriance: in statistics, analysis of variance (ANOVA)

References
