

Miopia management: è davvero possibile
controllare la progressione miopica?

Firenze 4 marzo 2022



Il ruolo del sistema accomodazione/convergenza nella progressione miopica

Fabio Casalboni

Accomodazione e visione binoculare nel miope

Indicazioni conclusive

- Ad oggi appare evidente che il ruolo dell'accomodazione e della visione binoculare nello sviluppo e nella progressione miopica non sia pienamente compreso
- Le evidenze attuali non indicano un ruolo causale sullo sviluppo e progressione miopica

Special Issue

IMI Accommodation and Binocular Vision in Myopia Development and Progression

Nicola S. Logan,¹ Hema Radhakrishnan,² Fiona E. Cruickshank,² Peter M. Allen,³ Praveen K. Bandela,^{4,5} Leon N. Davies,¹ Satoshi Hasebe,⁶ Safal Khanal,⁷ Katrina L. Schmid,⁸ Fuensanta A. ⁹

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CONCLUDING REMARKS

It is evident that, to date, the role of accommodation and binocular vision in the development and progression of myopia is not fully understood. Aspects of blur from the lag of accommodation, the impact of spatial frequency at near work, and a short working distance may all be implicated in myopia development and progression. The response of the ciliary body and its links with changes in the choroid are still being explored with respect to myopia development and progression. Researchers have not ruled out the role of the accommodative system in this field, but current methods of intervention based on this theory have not yielded significant results. Based on the evidence to date, eye care practitioners should consider assessing the accommodation and convergence system in young myopes and those at risk of myopia development to ensure they manage their patients by providing a clear retinal image. Current evidence does not point toward a role for accommodation and binocular vision in myopia development and progression.

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Keywords: accommodation, binocular vision, myopia development, myopia progression, emmetropization

Accomodazione e visione binoculare nel miope

Indicazioni conclusive

- Il professionista della visione dovrebbe comunque verificare la funzionalità del sistema accomodazione e convergenza nei giovani miopi e quelli a rischio di sviluppo miopico per garantire un'immagine retinica chiara nella visione da vicino

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Teoria dell'Uso-Abuso

L'eccessivo uso dell'accomodazione può indurre miopia

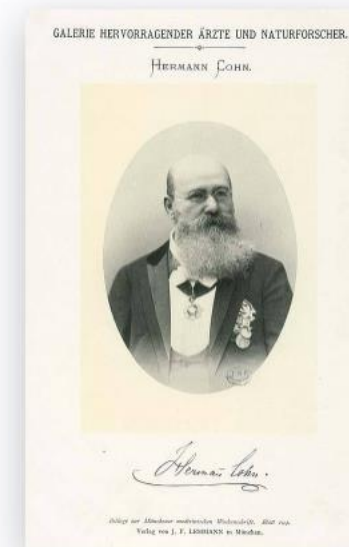
H. Cohn - 1867

The wisdom of our grandparents

The German ophthalmologist Hermann Cohn had already established in the mid-19th century that close work and too little sunlight have an influence on the progression of myopia.

In other words, what our grandparents always said to us "Do not read so much and go out to the fresh air" makes perfect sense...

Source: Wikimedia Commons



Ipotesi Strutturale

- La contrazione del muscolo ciliare produce un allungamento transitorio del bulbo oculare ed assottigliamento della coroide
- Gli occhi miopi mostrano un allungamento transitorio maggiore
- Si ipotizza che sia imputabile ad un ridotto spessore di sclera e coroide rispetto agli emmetropi

Ikuno Y, Tano Y. Retinal and choroidal biometry in highly myopic eyes with spectral-domain optical coherence tomography. *Invest Ophthalmol Vis Sci.* 2009;50(8):3876–3880.

Summers Rada JA, Shelton S, Norton TT. The sclera and myopia. *Exp Eye Res.* 2006;82(2):185–200.

Transient Axial Length Change during the Accommodation Response in Young Adults

Edward A. H. Mallen, Priti Kasbyap, and Karen M. Hampson
(*Invest Ophthalmol Vis Sci.* 2006;47:1251-1254)

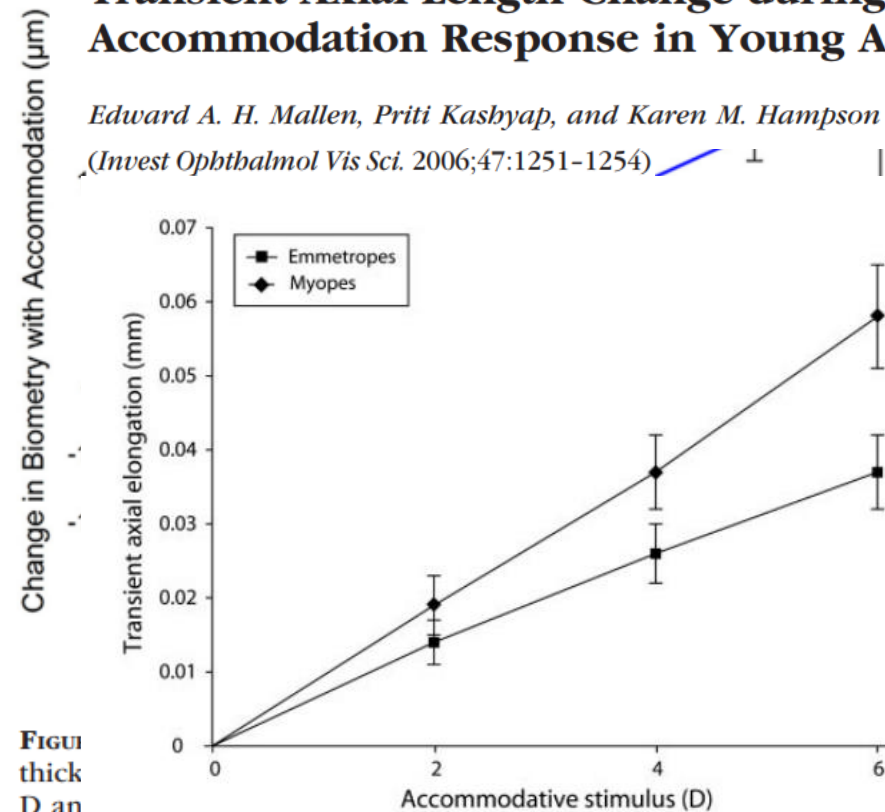


FIGURE 2. Transient axial elongation against accommodative stimulus in the emmetropic and myopic subjects.

accommodation (note that cool colors indicate a choroidal thinning with accommodation). From Woodman-Pieterse et al.¹¹⁵

Defocuf retinico e accomodazione/convergenza

Aspetti potenzialmente coinvolti

- Lag
- Nearwork Induced Transient Myopia
- Instabilità accomodativa
- Binocularità (AC/A, Foria)

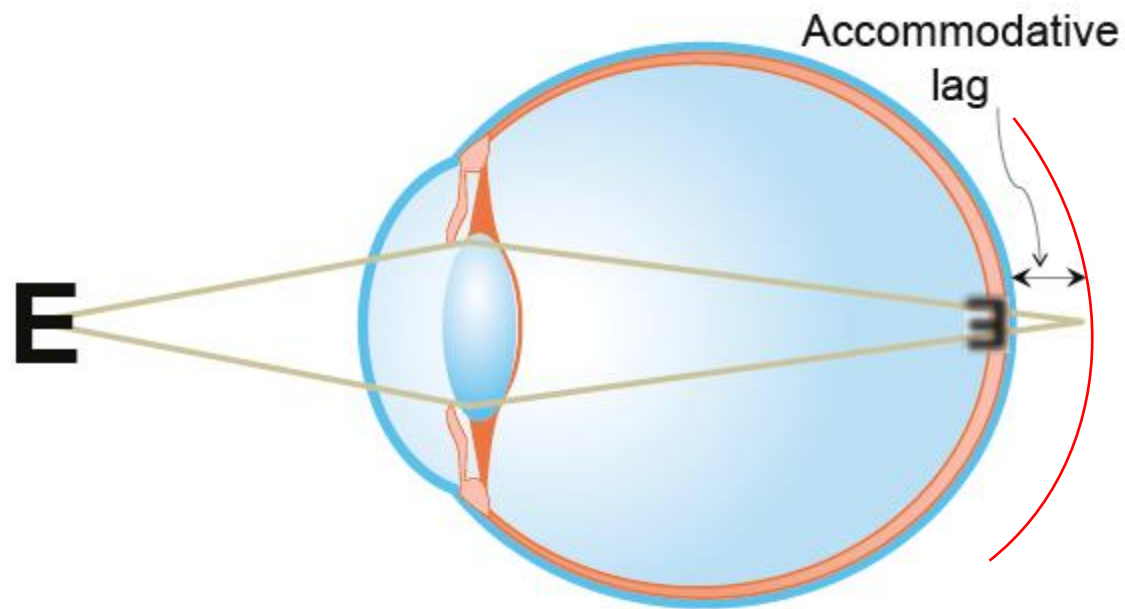
L'accomodazione è la risposta immediata al defocus...

L'emmetropizzazione è la risposta a lungo termine!

Lag accomodativo

Differenza tra stimolo e risposta accomodativa

L'occhio sottoaccomoda alle distanze prossimali (Lag=> Ritardo)



Lag accomodativo

Gli studi danno risultati contrastanti anche se emerge la presenza di un Lag più alto nei miopi adulti e bambini rispetto agli emmetropi

TABLE 1. Effect of Refractive Error and Measurement Methods on Accommodation Errors at Near Vision in Children

| Paper | Measurement Method | Accommodation Stimuli | Mode of Myopic Correction | Age, y | Refractive Groups | AE, D | Summary of Results |
|--|---|---------------------------------|-------------------------------|--------------|---------------------|--|---|
| Rouse et al. (1986) ²² | MEM dynamic retinoscopy | Monocular FV usual near demand | Habitual spectacle correction | 5-11 | Not specified | -0.50 | Relationship between age and lag |
| Gwiazda et al. (1995) ²⁶ | Canon R-1 Autorefr | Monocular FV/NL/PL 0-4 D demand | Soft contact lenses | 5-17 | EMMs MYPs EMMs MYPs | -0.50 FV -0.66 FV -0.56 NL -1.61 NL | MYPs had greater lags than EMMs. Lags were greater for NL |
| Chen and O'Leary (2002) ²⁸⁷ | Canon R-1 Autorefr | Monocular FV/NL 0-4 D demand | N/A | 3-14 | EMMs | -0.29 FV -0.69 NL | Lags greater for NL |
| McGilland et al. (2004) ²²⁷ | Not Dynamic Retinoscopy | Monocular FV 4-10 D demand | Habitual correction | 4-15 | Not specified | -0.50 at 4 D -2.50 at 10 D | Lags increased as the demand increased |
| Mutti et al. (2006) ²⁵ | Grand Seiko WRS501K or Canon R-1 Autorefr | BLV/FV 2 D and 4 D demand | Habitual spectacle correction | 6-15 | EMMs EMMs MYPs MYPs | -1.00 FV -0.91 BLV -1.12 FV -1.40 BLV | Increased lags found in MYPs after they became myopic but not in EMMs who became MYPs |
| Lanas et al. (2008) ⁴³ | Plus Optix Power Refractor 11 | Binocular FV 0.25-4 D demand | Spectacle correction | Ave 13 14 | EMMs EOMs | -0.10 -0.10 | Lags were greater at the 2 D than the 4 D viewing condition |
| Weihong et al. (2008) ¹³⁴ | Shin-Nippon Autorefr | Monocular FV 5 D demand | Spectacle correction | Ave 11 | EOMs | -0.76 | No relationship between accommodation lag and myopia progression over 1 y |
| COMET 2 (2011) ⁴⁰ | Grand Seiko WRS901K | Monocular FV 3 D demand | Spectacle correction | 8-12 | MYPs SVL MYPs PAL | -1.40 -1.47 | Both myopic groups of children exhibited larger accommodative lags. The treatment effect of the PALs was greater in children with lags greater than -1.5 D. |
| Berntsen et al. (2011) ¹³⁹ | Grand Seiko WRS901K or Canon R-1 Autorefr | BLV/FV 4 D demand | Spectacle correction | 6-14 | MYPs SVL | -1.59 | Myopic children had high lags of accommodation, but the magnitude of the lag was not related to the annual myopia progression |
| Yeo et al. (2015) ²¹⁸ | Shin-Nippon Autorefr | Binocular FV 3 and 4 D demand | Spectacle correction | 7-12 | EMMs MYPs | -0.96 -1.01 | Chinese children had high lags of accommodation when reading either English or Chinese texts |
| Han et al. (2018) ²⁸⁴ | Fused cross cyl | Binocular Phoropter 4 D demand | Spectacle correction | 9-14 | MYPs SVL | -1.0 | Orthokeratology and concentric progressive lenses reduced the lag of accommodation |
| Mu et al. (2019) ²⁸⁹ | Shin-Nippon Autorefr | Monocular FV 5 D demand | Spectacle correction | 8-12 | MYPs SVL | -1.0 | Myopic children with high lags showed reduction in lag both with in office placebo therapy and accommodation vergence training |
| Chen et al. (2019) ³⁰ | Grand Seiko WRS501K | Monocular FV 4 D demand | Spectacle correction | 8-12 | EMMs MYPs SVL | -0.20 -0.65 | Myopic children had greater lags. Lags increased in mesopic lighting conditions |

AE, accommodative error at highest demand conditions; BLV, Badal lens viewing; EMMs, emmetropes; EOMs, early onset myopes; FV, free viewing; HS, Hartmann Shack; lag, accommodation lag; MYPs, myopes; N/A, not applicable; NL, negative lens series; PAL, progressive lens wear group; PL, positive lens series; SVL, single vision lens wear group; VA, visual acuity.

IMI Accommodation and Binocular Vision in Myopia

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TABLE 2. Effect of Refractive Error and Measurement Methods on Accommodation Errors at Near Work in Young Adults

| Paper | Measurement Method | Accommodation Stimuli | Mode of Myopic Correction | Age, y | Refractive Groups | AE (D) | AEI | ASRC | Summary of Results |
|---|---|---|-----------------------------------|--------|----------------------|----------------------------------|-----|----------------------|--|
| McBrien and Millodot (1986) ⁴⁹ | Canon R-1 Autorefr | Binocular free viewing (FV) 0-5 D demand | Soft contact lenses | 18-23 | EMMs EOMs LOMs | -0.54 -0.69 -0.85 | | | EOMs and LOMs had greater lags than EMMs |
| Bullimore et al. (1992) ²⁹⁰ | Canon R-1 Autorefr | Monocular FV/NL/PL 1-5 D demand | Soft contact lenses | 19-23 | EMMs LOMs | -0.60 -0.75 | | | LOMs had greater lags for passive tasks at high demands |
| Abbott et al. (1998) ⁵⁷ | Canon R-1 Autorefr | Monocular FV/NL/PL 0-4 D demand | Soft contact lenses | 18-31 | EMMs SMs PMs | 0.01 NL -0.52 NL | | | Progressing MYPs had greater lags for NL conditions only |
| Jiang and Morse (1999) ²⁹¹ | Canon R-1 Autorefr | Monocular Badal lens viewing BLV up to 5 D demand | Soft contact lenses or spectacles | 20-30 | EMMs SMs PMs | | | 0.74 0.77 0.67 | All 3 refractive groups had similar lags |
| Rosenfield et al. (2002) ²⁹² | Canon R-1 Autorefr | Binocular FV 0-5 D demand | Soft contact lenses | 21-27 | EMMs SMs PMs | -0.34 FV -0.34 FV -0.20 FV | | 0.99 | Greater lags found in stable MYPs than initial EMMs and MYPs that progressed over a 1 y period |
| Subbaram and Bullimore (2002) ⁵⁵ | Canon R-1 Autorefr | Monocular BLV 0-4 D demand | Spectacles | 20-30 | EMMs PMs | -0.29 -0.29 | | | Small lags found in both refractive groups |
| Seidel et al. (2003) ²⁹³ | Canon R-1 Autorefr | Monocular BLV 0-4.5 D demand | Soft contact lenses | 17-26 | EMMs LOMs EOMs | | | 0.81 0.81 0.80 | All 3 groups had similar lags but greater response variability in the myopic groups |
| Hazel et al. (2005) ²⁹⁴ | Shin-Nippon Autorefr SRW 5000 Wavefront Servo or (HS) | Monocular NL 0-4 D demand | Soft contact lenses | 18-27 | EMMs | -0.72 | | | Lags greater when measured with the autorefractor when adjusted for similar pupil size |

IMI Accommodation and Binocular Vision in Myopia

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Lag accomodativo

Lag elevato produce un defocus ipermetropico nella retina centrale e periferica

- Il Lag tende ad aumentare a distanze ridotte
- Nei bambini miopi (cinesi) è stata osservata la distanza durante le attività prossimali
 - È ridotta soprattutto nei videogame tenuti in mano
 - La distanza si riduce con il passare dei minuti

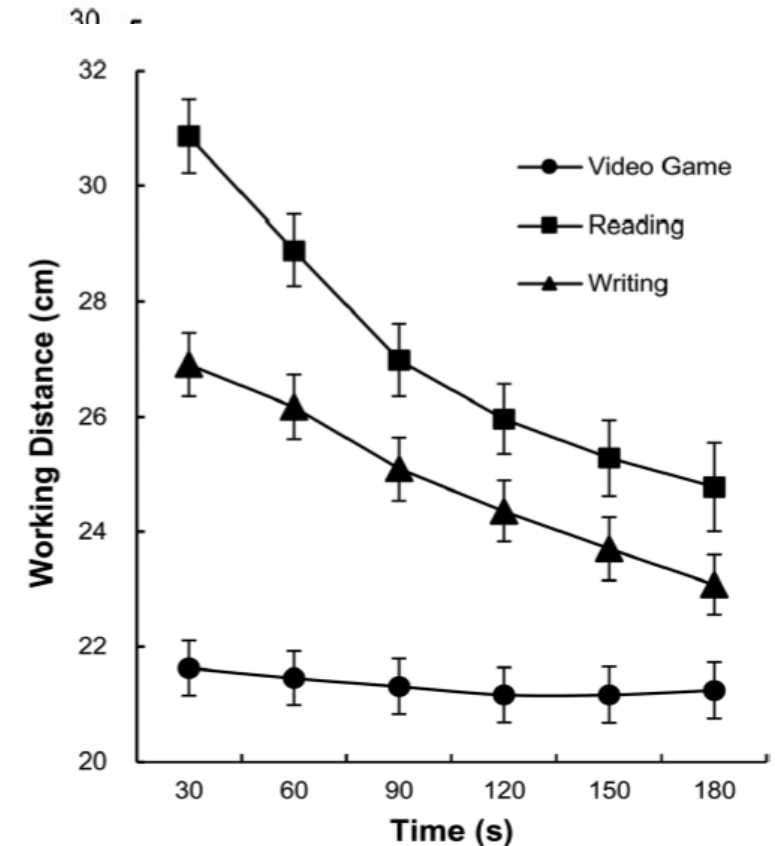


FIGURE 4.

Changes in working distance across time for each of the three tasks in 120 myopic children. The error bars indicate the standard error of the mean for each data point (video game, circles; reading, squares; writing, triangles).

Nearwork Induced Transient Myopia (NIMT)

È maggiore di entità e persistenza

- Nei miopi (EOM, LOM)
- Nei miopi adulti in progressione
- Nei bambini miopi

Effetto: tempi maggiori di sfuocamento dell'immagine retinica

Comparative Study > Invest Ophthalmol Vis Sci. 2003 May;44(5):2284-9.
doi: 10.1167/iavs.02-0373.

Nearwork-induced transient myopia in preadolescent Hong Kong Chinese

James Stuart Wolffsohn ¹, Bernard Gilmartin, Roger Wing-hong Li, Marion Hastings Edwards, Sandy Wing-shan Chat, John Kwok-fai Lew, Bibianna Sin-ying Yu

Affiliations + expand

PMID: 12714672 DOI: 10.1167/iavs.02-0373

Abstract

Purpose: To compare the magnitude and time course of nearwork-induced transient myopia (NITM) in preadolescent Hong Kong Chinese myopes and emmetropes.

Method: Forty-five Hong Kong Chinese children, 35 myopes and 10 emmetropes aged 6 to 12 years (median, 7.5), monocularly viewed a letter target through a Badal lens for 5 minutes at either 5.00- or 2.50-D accommodative demand, followed by 3 minutes of viewing the equivalent target at optical infinity. Accommodative responses were measured continuously with a modified, infrared, objective open-field autorefractor. Accommodative responses were also measured for a countercondition: viewing of a letter target for 5 minutes at optical infinity, followed by 3 minutes of viewing the target at a 5.00-D accommodative demand. The results were compared with tonic accommodation and both subject and family history of refractive error.

Results: Retinal-blur-driven NITM was significantly greater in Hong Kong Chinese children with myopic vision than in the emmetropes after both near tasks, but showed no significant dose effect. The NITM was still evident 3 minutes after viewing the 5.00-D near task for 5 minutes. The magnitude of NITM correlated with the accommodative drift after viewing a distant target for more than 4 minutes, but was unrelated to the subjects' or family history of refractive error.

Conclusions: In a preadolescent ethnic population with known predisposition to myopia, there is a significant posttask blur-driven accommodative NITM, which is sustained for longer than has previously been found in white adults.

Miopizzazione Transitoria Indotta da Attività Prossimale

(Nearwork Induced Transient Myopia)

È maggiore di entità e persistenza

- Nei miopi (EOM, LOM)
- Nei miopi adulti in progressione
- Nei bambini miopi

Effetto: tempi maggiori di sfuocamento dell'immagine retinica

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Conclusions: In a preadolescent ethnic population with known predisposition to myopia, there is a significant posttask blur-driven accommodative NITM, which is sustained for longer than has previously been found in white adults.

Instabilità accomodativa

Produce una minore nitidezza dell'immagine retinica

- È maggiore nei miopi (EOM, LOM)
- Assume il livello dell'emmetrope attraverso addizione di +2,00
- Nel Follow Up a 2 anni si evidenzia che l'instabilità accomodativa accompagna la progressione miopica ma non può essere stabilita una relazione causale

CLINICAL AND EXPERIMENTAL
OPTOMETRY

RESEARCH PAPER

Accommodative instability:
relationship to progression of early onset myopia

Clin Exp Optom 2012; 95: 153–159

DOI:10.1111/j.1444-0938.2011.00699.x

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Submitted: 28 April 2011

Revised: 30 September 2011

Accepted for publication: 9 October 2011

Background: In a previous study, we demonstrated that children with early onset myopia had greater instability of accommodation than a group of emmetropic children. Since that study was correlational, we were unable to determine the causal relationship between this and myopic progression. To address this, we examined the children two years later. We predicted that if accommodative instability was causing the myopic progression, instability at Visit 1 should predict the refractive error at Visit 2. Additionally, instability at Visit 1 should predict myopic progression.

Methods: Thirteen myopic and 16 emmetropic children were included in the analysis. Dynamic measures of accommodation were made using eccentric photorefraction (PowerRefractor) while children viewed targets set at three distances (accommodative demands), namely, 0.25 metres (4.00 D demand), 0.5 metres (2.00 D demand) and 4.00 metres (0.25 D demand).

Results: Both refractive error and accommodative instability at Visit 1 were highly correlated with the same measures at Visit 2. Children with myopia showed greater instability of accommodation (0.38 D) than children with emmetropia (0.26 D) at the 4.00 D target on Visit 1 and this instability of accommodation weakly predicted myopic progression.

Conclusions: The results presented in the present study suggest that instability of accommodation accompanies myopic progression, although a causal relationship cannot be established.

Key words: accommodation, accommodative instability, children, myopia

Visione Binoculare

La binocularità può condizionare la focalizzazione dell'immagine retinica

- Migliora la sensibilità allo sfuocamento
- Migliora la stabilità delle immagini retiniche (LOM)

> [Optom Vis Sci. 2005 Apr;82\(4\):279-85. doi: 10.1097/01.opx.0000159369.85285.21.](#)

The effect of monocular and binocular viewing on the accommodation response to real targets in emmetropia and myopia

Dirk Seidel ¹, Lyle S Gray, Gordon Heron

Affiliations + expand

PMID: 15829856 DOI: [10.1097/01.opx.0000159369.85285.21](#)

Abstract

Purpose: Decreased blur-sensitivity found in myopia has been linked with reduced accommodation responses and myopigenesis. Although the mechanism for myopia progression remains unclear, it is commonly known that myopic patients rarely report near visual symptoms and are generally very sensitive to small changes in their distance prescription. This experiment investigated the effect of monocular and binocular viewing on static and dynamic accommodation in emmetropes and myopes for real targets to monitor whether inaccuracies in the myopic accommodation response are maintained when a full set of visual cues, including size and disparity, is available.

Methods: Monocular and binocular steady-state accommodation responses were measured with a Canon R1 autorefractor for target vergences ranging from 0-5 D in emmetropes (EMM), late-onset myopes (LOM), and early-onset myopes (EOM). Dynamic closed-loop accommodation responses for a stationary target at 0.25 m and step stimuli of two different magnitudes were recorded for both monocular and binocular viewing.

Results: All refractive groups showed similar accommodation stimulus response curves consistent with previously published data. Viewing a stationary near target monocularly, LOMs demonstrated slightly larger accommodation microfluctuations compared with EMMs and EOMs; however, this difference was absent under binocular viewing conditions. Dynamic accommodation step responses revealed significantly ($p < 0.05$) longer response times for the myopic subject groups for a number of step stimuli. No significant difference in either reaction time or the number of correct responses for a given number of step-vergence changes was found between the myopic groups and EMMs.

Conclusion: When viewing real targets with size and disparity cues available, no significant differences in the accuracy of static and dynamic accommodation responses were found among EMM, EOM, and LOM. The results suggest that corrected myopes do not experience dioptric blur levels that are substantially different from emmetropes when they view free space targets.

Visione Binoculare

AC/A nel Miope

- È maggiore che nell'emmetrope
- Andamento nel bambino
 - Aumenta di entità già 4 anni prima dell'insorgenza miopica (Precursore?)
 - Rimane stabilmente più alto negli anni successivi
- È associato ad un Lag elevato ma non alla progressione miopica

Incremento di Lag => causa o effetto?

> Invest Ophthalmol Vis Sci. 2017 Mar 1;58(3):1594-1602. doi: 10.1167/iovs.16-19093.

The Response AC/A Ratio Before and After the Onset of Myopia

Donald O Mutti ¹, G Lynn Mitchell ¹, Lisa A Jones-Jordan ¹, Susan A Cotter ², Robert N Kleinstejn ³, Ruth E Manny ⁴, J Daniel Twelker ⁵, Karla Zadnik ¹, CLEERE Study Group

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PMID: 28291868 PMCID: PMC5361580 DOI: 10.1167/iovs.16-19093

[Free PMC article](#)

Abstract

Purpose: To investigate the ratio of accommodative convergence per diopter of accommodative response (AC/A ratio) before, during, and after myopia onset.

Methods: Subjects were 698 children aged 6 to 14 years who became myopic and 430 emmetropic children participating in the Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error. Refractive error was measured using cycloplegic autorefractometry, near work by parent survey, and the AC/A ratio by simultaneously monitoring convergence and accommodative response. The response AC/A ratios of children who became myopic were compared with age-, sex-, and ethnicity-matched model estimates for emmetropic children from 5 years before through 5 years after the onset of myopia.

Results: The response AC/A ratio was not significantly different between the two groups 5 years before onset, then increased monotonically in children who became myopic until reaching a plateau at myopia onset of about 7 Δ /D compared to about 4 Δ /D for children who remained emmetropic (differences between groups significant at $P < 0.01$ from 4 years before onset through 5 years after onset). A higher AC/A ratio was associated with greater accommodative lag but not with the rate of myopia progression regardless of the level of near work.

Conclusions: An increasing AC/A ratio is an early sign of becoming myopic, is related to greater accommodative lag, but does not affect the rate of myopia progression. The association with accommodative lag suggests that the AC/A ratio increase is from greater neural effort needed per diopter of accommodation rather than change in the accommodative convergence crosslink gain relationship.

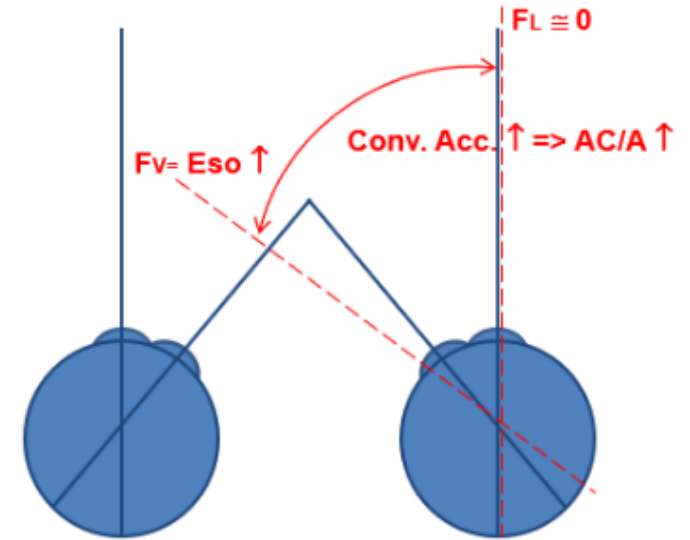
consequences of the underlying anatomy of the enlarged eye.

Ottimizzazione dell'equilibrio binoculare da vicino

L'AC/A alto può indurre eccesso di convergenza

- Tendenza Eso
- Lag Alto

| |
|---|
| Eccesso di Convergenza |
| $F_L \cong 0 / F_V = \text{Eso} \uparrow$ |
| $AC/A \uparrow$ |



Condizioni favorevoli per la prescrizione di positivo per vicino

Miopia management: è davvero possibile controllare la progressione miopica?

Firenze 4 marzo 2022



Grazie per la cortese attenzione!

Fabio Casalboni