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Original Research Article

The Relationship between Reduced Lag of Accommodation and Rate of Myopia Progression in School Children in Kumasi, Ghana

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ABSTRACT

This paper investigated the relationship between lag of accommodation and myopia progression in children with progressing myopia. In a twelve-month longitudinal study, the accommodative response of 75 children with mean age of 12.39 ± 1.27 years (range 10 to 15 years) was measured at three visits. The mean refractive error of the children at the beginning of the study was -1.98±0.50D. Refractive error, accommodative response to target at 28.6cm and ocular biometry were measured at the visits. Refractive change was determined by cycloplegic autorefraction, accommodative response by the open field autorefractor and axial length and vitreous chamber depth by A-scan ultrasonography. Results presented were on the right eye only because Pearson correlation coefficient was 0.90 between the two eyes. The data was analyzed by paired t-test at level of significance of 5%.The results showed that myopia progression in the year was -0.37 ± 0.17D (range from 0 to -1.00D). The mean change in vitreous chamber depth and axial length was 0.17 ± 0.15mm and 0.21 ± 0.16mm respectively (p=0.11). The near lag at baseline was 0.57 ± 0.14 D and after one year it was 0.56 ±0.16D (p=0.68). There was no correlation found between lag of accommodation and myopia progression and change in ocular biometry. There was no significant difference in myopia progression and larger or smaller lag (p=0.64).In conclusion, this study failed to show a statistically significant relationship between lag of accommodation in children with progressing myopia and myopia progression. There is no evidence that larger lag of accommodation causes myopia progression in children with progressing myopia.

Keywords: lag of accommodation, myopia progression, children, undercorrection, accommodative response

INTRODUCTION

The association between myopia and near work is well established but the cause and effect relationship is still not clear. [1] For decades accommodative functions have been assumed to be involved in myopia progression and in recent times studies have focused particularly on accommodative lag. [2]

When the normal eye reads at near, the accommodative response is lower than the accommodative demand. The positive difference between these two variables is known as lag of accommodation. Myopes are found to have larger lag of accommodation than non-myopes. [3]

Studies in animals have shown that when lenses are worn the optics of the eye changes. Negative lenses focus images behind the retina (hyperopic defocus) whereas positive lenses cause myopic defocus and images focus in front of the retina. [4,5] The location of the defocus image causes a compensatory change in the position of the retina so that out-of-focus images are brought into focus. The hyperopic defocus induced by negative lenses in animals is comparable to persistent hyperopic defocus from increased lag of accommodation during reading in humans. [3,6]

Previous studies that have associated myopia progression with increased lag of accommodation have usually done so through cross sectional studies and so the cause and effect relationship has not been established yet. Longitudinal studies that investigated the relationship between myopia and lag of accommodation showed inconsistent results. [7-9] If increased lag of accommodation is a cause of myopia progression then children with larger lag should have faster myopia progression compared with those with lower lag. In addition, if progressive addition lenses (PALs) reduce lag of accommodation and rate of myopia progression then undercorrection should also reduce lag of accommodation and decrease the rate of myopia progression.

In this study we investigated the relationship between lag of accommodation and myopia progression in a longitudinal study in children with progressing myopia. The lag of accommodation of seventy five (75) children was reduced with undercorrection single vision lenses and followed up for twelve months.

MATERIALS AND METHODS

This was a twelve (12) months longitudinal study among school children aged from 10 to 15 years. This study was reviewed and approved by the Committee on Human Research, Publications and Ethics of the Kwame Nkrumah University of Science and Technology, School of Medical Sciences and Komfo Anokye Teaching Hospital. Permission was also obtained from the Ashanti Regional Health Directorate and Ghana Education Service.

Written and verbal announcements were made in four (4) purposively selected schools and children who showed interest were given parental consent forms to be given to their parents to fill and sign. One hundred and fifty five (155) children returned with completed and signed forms. These children were screened and seventy five (54 girls and 21 boys) met the inclusion criteria and were enrolled. Inclusion criteria were: healthy children aged from 10 to 15 years, spherical equivalent refractive error (SER) -1.25 to -4.50D, astigmatism ≤ -1.25D, anisometropia ≤ 1.00D, no amblyopia, and strabismus as determined by cover test at far (4m) and near (28.6cm) and free from any ocular disease. No child had parental myopia and the child should already be wearing spectacles and habitual visual acuity should be 0.2log MAR or worse. Visual acuity (VA) of log MAR 0.00 or better with full correction spectacles.

Cycloplegic refraction and accommodative response and subjective refraction were measured at first visit, 6th and 12th months. All children were refracted to an end-point of maximum plus binocular subjective refraction to best visual acuity of 0.00logMAR or better. This prescription was then adjusted by adding +0.50DS to the spherical component of the prescription to arrive at the final prescription which was fitted in spectacle frames that were chosen by the children.

Progression of myopia was evaluated as the change in cycloplegic autorefractive error. After corneal anaesthesia was achieved with a drop of proparacaine 0.5% onto the right eye, Cycloplegia was achieved by administering two drops each of tropicamide 1% and cyclopentolate 1% into the right eye of each child, five minutes apart. Autorefraction was done at least thirty minutes after administration of the second drop and when pupillary light reflex was absent. The mean of five reliable readings was calculated as the objective refractive error and written as the SER.

Myopia progression was also assessed by the change in ocular biometry, using A-scan ultrasonography (Opto US 1000 Fine) with a probe. After corneal anaesthesia ocular ten (10) reliable readings were taken. Readings were accepted when the anterior and posterior lens reflections were observed and a sharp retinal spike was seen. A-scan ultrasonography and autorefraction were performed by the same optometrist throughout the study period.

Accommodative response was measured with the open field autorefractor (the Shin-Nippon NVision K5001 autorefractor which is also marketed as Grand Seiko WR-5100K). Unlike current autorefractors, this autorefractor allows real targets to be viewed at any distance. At the first visit, children were fitted with a trial frame containing their best subjective SER with an undercorrection of +0.50 D in both eyes. The children were instructed to fixate binocularly, through the open window of an open-field autorefractor, at a 4 x4 array of alphabets of size N10 placed 28.6 cm away, and keep it clear. Five readings were taken from the right eye, and its average was recorded as the accommodative response.

Measurement of accommodative response was done by a second optometrist who was also trained on the study protocol. This was to maintain accuracy and consistency throughout the study. Children wore the trial frame or study spectacles for at least 30 minutes before measurements were done. Measurements were done in the same room throughout the study. The target was illuminated by ambient room lighting with luminance of 120 to 130 cd/m^2.

Data Analysis

Analysis was performed with Microsoft Office Excel 2010 and STATA 11. All autorefraction readings were entered into excel in the negative cylinder form and then changed into the spherical equivalence form. Spherical equivalence (SER) was calculated as the sphere + half cylindrical power.

The average of the five readings from the open field autorefractor was used to calculate the accommodative demand and response.

Effective accommodation demand =

$$\frac{1/DTE - LENS + Rx + DLE/DTE(LENS - Rx)}{1 - DLEx\,(LENS + Rx)} \quad (1)$$

$$Effective\ accommodative\ response = Rx\ /1 - (DLE\ x\ Rx) - LENS/1 - DLE\ x\ LENS - R \quad (2)$$

$$Accommodative\ lag = (1) - (2)$$

In the above equation, Rx= spherical equivalence of the subjective refraction lens. R=mean refractive value given autorefractor. DTE= distance between the accommodative target and the corneal apex (m) DLE= distance between the correcting lens and the corneal apex (0.012m) LENS = spherical equivalence of the spectacles worn. These equations correct for the effectivity of a spectacle lens worn 12mm from the eye. [3] Pearson correlation coefficient and p-values were used to test the relationship between variables. Tests of significance were 2 tailed and the level of significance was 5%.

RESULTS

The mean age of the 75 children was 12.39 ± 1.27 years (range10 to 15 years) and the SER was -1.98 ±0.50D at baseline. The mean near lag was 0.57 ± 0.14 D at baseline and 0.56 ± 0.16D after a year p= 0.80. The correlation *r* between the mean lag values at baseline and after one year was 0. 23 and the difference was not significant p=1. Measurements were done in the right eye only because Pearson's correlation coefficient was as high as 0.9 between the right and left eyes. Myopia progression in 12 months for the group was -0.37 ±0.17D for a range of zero progression to a maximum of -1.00D. There were two children whose myopia did not change after twelve months of wearing study spectacles.

The correlation between myopia progression and lag of accommodation are shown in Figure 1(a) and 1(b). Figure 1a shows a scatter plot between refractive change in 12 months and lag of accommodation at first visit(r =-0.02). Fig 1(b) shows a scatter plot between refractive change in one year and average lag of accommodation of measurements at the 6th and 12th months visits (r= -0.12).

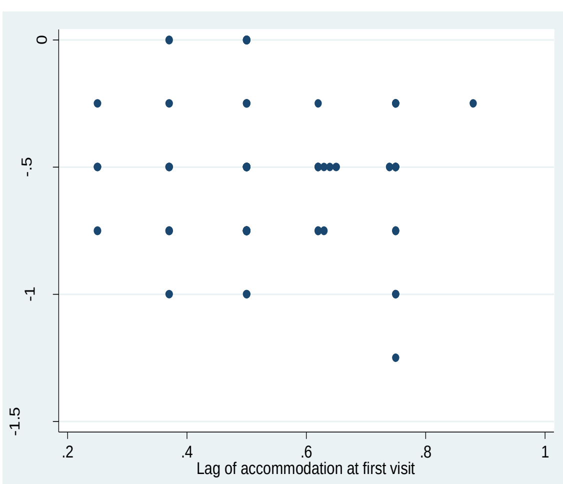

Figure 1(a). Scatter diagram between refractive change in one year and lag of accommodation at first visit.

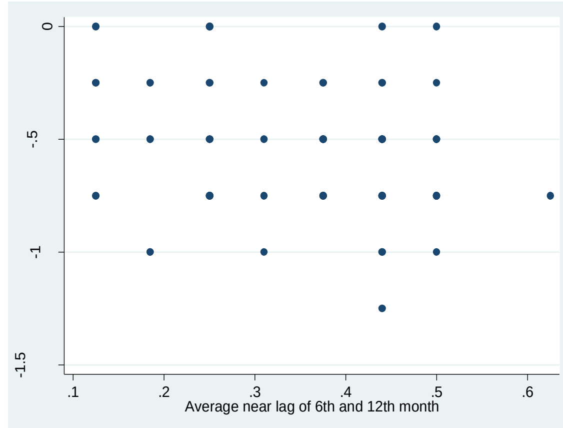

Figure 1(b). Scatter plot between refractive change in one year and average lag of accommodation between the 6th and 12thmonth visits.

Ocular biometry

Correlation between change in axial length and change in refractive error in twelve months was -0.13. The correlation between change in axial length and vitreous chamber depth was as high as 0.98. Mean change in axial length and vitreous chamber depth were 0.21 ± 0.16mm and 0.17 ± 0.15mm respectively (p= 0.11). Table 1 below shows a correlation between the change in ocular biometry and near lag of accommodation. There was no correlation in any of the paired variables.

Table 1. Correlation (r) between change in ocular biometry and lag of accommodation at 28.6cm

Outcome variable	r with lag at baseline (first visit)	r with lag at 1st year
Axial length change	-0.02	-0.03
Vitreous chamber depth	-0.03	0.00

When 0.57 D, the mean near lag at first visit is used as median lag of accommodation, larger lag is≥ 0.57 and smaller lag <0.57,then as shown in Table 2 below, the rate of progression between the two groups is significantly not different (p=0.64).

Table 2. Comparing rate of myopia progression between larger and smaller lag of accommodation

Lag of accommodation	Number of children (n)	Progression of myopia	p- value
Smaller lag < 0.57	24	-0.36±0.16	0.64
Larger lag ≥ 0.57	51	-0.34 ±0.18	

DISCUSSION

Authors of this study are not aware of any other study in Ghana that has investigated the relationship between lag of accommodation and myopia progression in Ghanaian school children. In this longitudinal study, school children aged from 10 and 15 years with progressing myopia failed to show that smaller lag of accommodation reduces myopia progression. Different studies have measured accommodative responses to blur induced by various methods. Gwiazda et al., [(3)] Abbott et al., [(10)] Nakatsuka et al., [(11)] Hasebe et al., [(12)] and Berntsen et al. [(13)] induced blur with negative lenses, positive lenses and by decreasing target distance under either monocular and/or binocular viewing conditions. The magnitude of the lag reported was inconsistent because the studies depended on different experimental methods. This present study measured the accommodative responses of children who wore habitual undercorrection and viewed real targets under binocular conditions which are the normal way by which children view the world. There was no significant difference between lag of accommodation at first visit and after twelve months of wearing study spectacles. This result is in agreement with that found by Weizhong et al., [(14)] and Berntsen et al. [(15)] Weizhong et al. [(14)] conducted their study under similar viewing conditions in China while Berntsen et al. [(15)] conducted their study among five hundred and ninety two (592) myopic children who were enrolled in the Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error (CLEERE) study in USA. This present study was done on children with progressing myopia, however, two children exhibited stable myopia and no change in refraction was measured after twelve months. The mean myopia of the group was -1.98 ± 0.50 D and the progressing rate in a year was-0.37 ± 0.17D. This yearly progression rate agrees with -0.34D found among children aged 6 to 15 years in the Houston Myopia Control Study [(16)] but is lower than -0.63 found among 6 to 15year olds in a randomized trial in Hong Kong. [(17)]

The assumption is that myopia in children with larger lag of accommodation progresses faster than those with smaller lag of accommodation. However, this study failed to find a significant correlation between lag of accommodation measured at 28.6cm and myopia progression. This result is consistent with that found by Weizhong et al. [(14)] and Berntsen et al. [(13)] but contrary to that found by Rosenfield et al. [(7)] Rosenfield et al. [(7)] found a significant but negative correlation between lag of accommodation measured on adults at 2.5D.The difference in results between this present study and that by Rosenfield et al. [(7)] is that, the latter worked on adults with stable refractive error. Abbott et al [(10)] suggested from their study on adults that the accommodative stimulus response function of stable myopia was similar to that of emmetropes. The mean myopia of the group in this study was low and progressing which probably made it possible to establish a cause and effect relationship between myopia progression and lag of accommodation.

The children in this present study were instructed to wear the undercorrection study spectacles during all waking hours and probably might have experienced blur from myopic defocus during distance vision. At near, however, undercorrection of spectacle lenses enhanced near vision by decreasing near lag but the rate of myopia progression was significantly not different when lag was divided into larger and smaller lag. This result is in agreement with that by Adler and Millodot [(18)] but is in contrast with that found by Chung et al. [(19)] and Vasudevan et al. [(20)] Adler and Millodot [(18)] did not find a significant difference in the rate of myopia progression between children, aged 6 to 15 years, who were randomly assigned to an undercorrection by +0.50 and full correction group. However, in the 24months randomized control trial by Chung et al. [19] children assigned to undercorrection by +0.75Dwere found to have statistically significant increased rate of myopia progression compared to those in the full correction group. Results shown in this study demonstrate that reduced lag of accommodation does not reduce rate of myopia progression after the onset of myopia. This result is in agreement with that found by Mutti et al. [9] Mutti et al. [9] observed increased lag a year or more after myopia had started in 1107 children and not before or during the year of onset of myopia. Mutti et al. [9] measured the accommodative response of children aged 6 to 15 year olds who wore their habitual refractive correction. Blur was stimulated whiles viewing a 4D target either in a Badal system or at 25 cm target and a 2D (Badal only) target. After 10 years follow up the team reported that lag of accommodation in emmetropic eyes and those who became myopic were not different. They therefore concluded that increased lag might be a consequence and not a cause of myopia.

CONCLUSION

In conclusion, no correlation was found between myopia progression and reduced near lag in children with mean myopia of -1.98 D. This indicates that reducing lag of accommodation in children with positive lenses will not reduce the rate of myopia progression. The relationship between reduced lag of accommodation with undercorrection single vision lenses and reduced rate of myopia progression needs to be investigated further.

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