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Accommodative facility training with a long term follow up in a sample of school aged children showing accommodative dysfunction

BERTIL STERNER, MATHS ABRAHAMSSON and ANDERS SJÖSTRÖM
Department of Ophthalmology, Göteborg University, Mölndal, Sweden

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Abstract. The primary aim of this project was to study the effect of flip lens-training on the accommodative function in a group of children with accommodative dysfunction and subjective symptoms such as asthenopia, headache, blurred vision, and avoidance of near activity. We also wanted to measure the accommodative facility among the children in comparison with a control group. Another aim of the study was whether flip lens-training increased accommodative facility, and to find out if it also had a positive effect on their asthenopia and related problems also in long term. Following the training period the accommodative facility and accommodative function significantly increased and two years after finishing the training period no child had regained any subjective symptoms and the objective findings were almost the same as at the end of facility training period. These results suggest that accommodative facility training is an efficient method built on loss of symptoms among children with accommodative infacility.

Introduction

The ability to adjust the focus of the eye by changing the shape of the crystalline lens is referred to as accommodation.

A small child is normally able to focus from infinity down to a distance close to the nose because of the child's high level of accommodative ability. This ability to accommodate slowly deteriorates through life and at the fifth decade of life insufficient accommodative ability becomes a manifest problem for the emmetrope. Reading either requires longer arms or proper optical aids [1, 2]. In order to accurately perform visually guided daily life tasks, it is necessary for the accommodative system to be dynamic, quick, and precise to ensure a well focused image on the retina.

The ability of the accommodative system is often measured by studying the accommodative amplitude or the accommodative facility. Accommodative facility tests examine the speed of changes in accommodation. The dioptric stimulus to accommodation may be alternated between two different levels, by focusing through different lenses, i.e. flip lenses, and the number of cycles between the two levels in a given time period, is recorded by noting the patients reports of clarity after each lens change [3–6]. Poor accommodative facility has been referred to as accommodative inertia [7].

The normal accommodative system is quite flexible and resistant to fatigue [8]; however, accommodative dysfunction is common among prepresbyopic and presbyopic persons in clinical practice [9, 10]. This dysfunction may result in symptoms such as blur, headaches, or asthenopia. Insufficiency or paralysis of accommodation in young individuals is infrequently seen, but may be present in a number of pathologic conditions such as infections, toxic, and metabolic conditions [10]. Development of accommodative insufficiency in otherwise healthy young individuals is said to be a very rare condition. However, asthenopic symptoms and close work related problems is commonly seen in the pediatric ophthalmology clinic. But there is no such report or figures. In 1973, von Noorden et al. [11] described a syndrome of idiopathic accommodation and convergence insufficiency in seven young and neurologically intact individuals. Before this, there were only scattered reports of similar cases. More recently, some studies have focused on accommodative inertia or on younger individuals with accommodative amplitude low for their age [3, 6, 7, 12]. It is essential to separate these patients with low accommodative amplitude from those with accommodative spasm [13]. The primary aim of this project was to study the effect of training with flip lenses on relative accommodation in a group of children with accommodative dysfunction. We also wanted to measure the accommodative facility among the children in comparison with a control group. Aims of the study were to find if flip-training increased accommodative facility, if it had a positive effect on their asthenopia and related problems and whether the training had a long term effect.

Methods

Patients

We selected thirty-eight children with an age ranging from nine to thirteen years for this study. The children were referred from School Health Care for close work related problems and they complained about headache, blurred vision, asthenopia, loss of concentration and avoidance of near activity. We only included those children with reduced negative and positive relative accommodation and/or very slow accommodative facility (see below). Before entering the training program, accommodation, cycloplegic refraction, and visual acuity at distance (decimal notation) were examined. In all children binocular vision, stereopsis and motility were tested by an orthoptist. One child was later excluded due to excessive exophoria and lack of stereopsis. The remaining 96% all carried through the whole training period with different degrees of compliance. One child was lost to follow up during the training period. Before the long term follow up examination two years after the end of accommodative facility training, all of the 38 children in the study were telephone interviewed. Twenty children accepted to participate at the follow up examination (48%).

Normative data were established using 24 voluntary controls (age 9 to 13 years). These children were recruited from two classes at two different schools in the Göteborg area. We also used 4 adult controls (age >30 years) and 4 preschool controls (age < 6 years) for comparison. For calculation of differences in relative accommodation between patients and controls only data from the 24 age matched controls were used.

Procedure

Relative accommodation

Goss and Zhai [14] and Hung and Ciuffreda [15] describe how to determine relative accommodation. In assessing accommodative flexibility, the accommodative stimulus was binocularly decreased (with positive lenses) in +0.25-D steps over the distance correction, with the vergence stimulus (at 40 cm) held constant, to the first slight sustained blur subjectively noted by the patient. The decreased amount of accommodative stimulus at this point was referred to as the negative relative accommodation (NRA) value. If the accommodative stimulus is now increased binocularly (with negative lenses) in -0.25-D steps until first slight sustained blur is again noticed, the increased amount of accommodative stimulus at this point is referred to as positive relative accommodation (PRA). In order to estimate the ability to rapidly change accommodation (accommodative facility), we measured time until a stable, clear image was obtained when the NRA value was rapidly removed and only the distance correction was left. We also measured when PRA value was rapidly removed and when NRA value was rapidly added to the distance correction.

Baseline data was obtained by two test sessions prior to the start of the treatment. The time period between the two test sessions varies from 2 to 5 weeks. During this period the patient was tested by two different examiners.

Accommodative facility training by flip lens technique

A ‘flipper’ is a holder with two minus lenses and two plus lenses. The subject focuses through one pair of lenses at an object at near distance (40 cm). When the object is clearly focused, a flip is quickly performed to the other lens pair and the subject focuses through them. This is then repeated. The children were required to use a flipper while focusing a text at 40 cm for three minutes at least five times each day. Starting with a flipper power the child almost could not focus through and then the magnitude of the lenses in the flipper increased with 0.50–D steps at a pace the child could put up with. The training was done by the child at home controlling the performance by a protocol. At the end of the treatment they used ±2.00 D flipper. An optometric examination was performed every second week to ensure high compliance. If the child shows a hypermetropia, plus lenses should be prescribed after the first or second optometric examination, for proper progression of the accommodative facility training. However, none of the children wore glasses before their last optometric examination in the training period. The length of the training period varied individually. It seemed to be more related to individual compliance than to the accommodative ability. The training continued until the child reported that the subjective symptoms were gone.

The parameters of accommodation in the study group were tested at each test session together with visual acuity testing and determination of refractive errors. Each control was tested once. We were not able to use cycloplegia in the control group. Refractive errors were determined by retinoscopy and subjectively.

Statistics

The changes in relative accommodation in the patients were compared with a paired *t*-test and comparisons between patients and controls were made by an unpaired *t*-test.

Results

In all 38 children the subjective symptoms such as headache and asthenopia decreased continuosly and disappeared during the training period. The length of the training period varied from 3 to 25 weeks, with the majority of children having a training period of less than 8 weeks.

Visual acuity

At the first examination before training started, 6 eyes had a visual acuity with subjective refraction of 0.65 or less, 15 eyes between 0.65 and 0.9 and 55 eyes had an acuity of 1.0 or better. At the end of the training all 76 eyes had an acuity of 1.0 or more.

Table 1. Mean relative accommodation (± sd) before and after training and for controls

	Before training	After training	Controls
Mean NRA	1.25 ± 0.4 D	1.8 ± 0.2 D	2.0 ± 0.3 D
Mean PRA	−1.3 ± 1.0 D	−2.4 ± 1.0 D	−3.9 ± 1.3 D

Refraction

None of the children wore spectacles, although they all, except 3 children, had a slight cycloplegic hypermetropia before the first session and were prescribed and used hyperopic glasses (ranged from +0.50 to +1.50 diopters) at the end of the training period. The cycloplegic refraction showed a higer dioptric level not greater than +0.25 to +0.50 D compared to the subjective refraction value in any child. Binocular vision, stereopsis and motility, tested by an orthoptist were normal in all children included in the study.

Relative accommodation

Baseline data for each patient were obtained through two test sessions during a 2 to 5 weeks period before the onset of the treatment. The difference in mean between NRA and PRA were 0.06 D and 0.12 D respectively. The lower numbers were in both cases from the test session, closest to the start of the treatment.

The mean for NRA as well as the one for PRA (Table 1) increased during treatment. The distributions of relative accommodation before and after training compared to the normals are shown in Figure 1a (NRA) and Figure 1b (PRA). In both cases it is evident that the post-training results are significantly lower than the data from the controls. At the first test session NRA was lower than 1.75 D in 27 cases, while after treatment there were only 6 such cases. Among these 6 cases, five had an NRA of 1.5 and one had 1.25 D. Corresponding figures for PRA show 20 cases with PRA below −1.75 D before training and 5 cases after training (ranging from −0.75 to −1.5 D). There was a statistically significant increase in both NRA ($p<0.0001$) and PRA ($p<0.0001$) during the training period, although both the parameters PRA and NRA were significantly lower than the results obtained among the controls ($p=0.024$ for NRA and $p<0.0001$ for PRA).

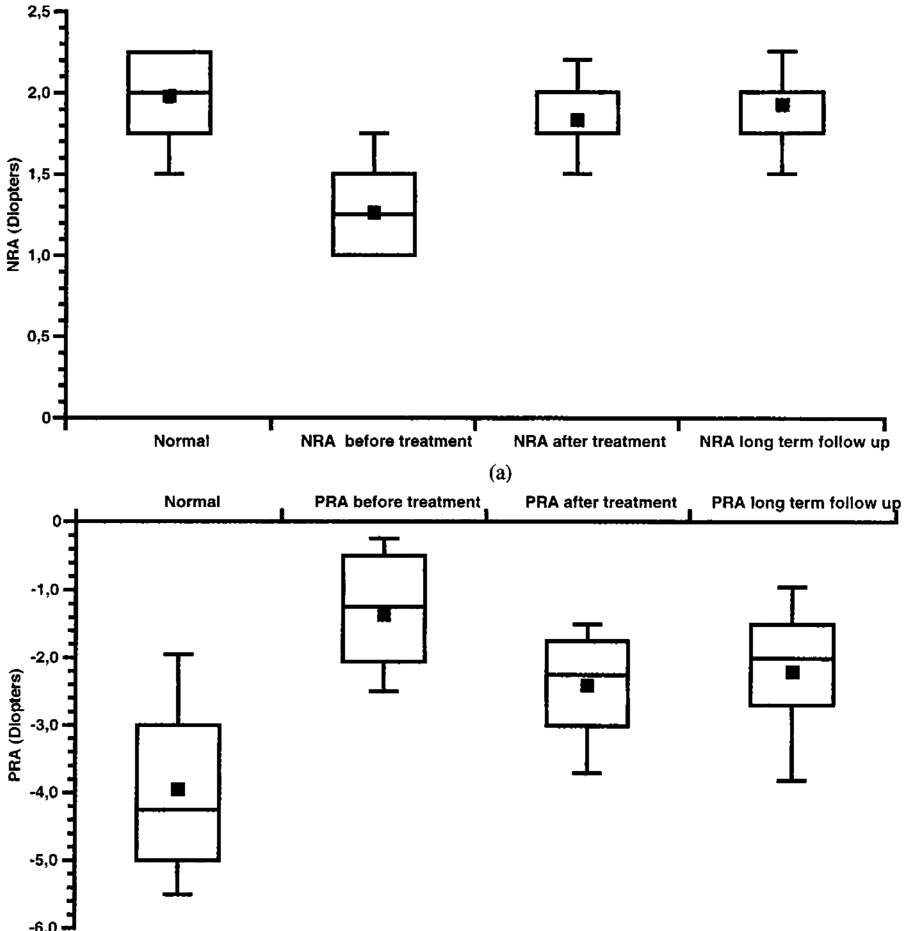

Figure 1. Figure 1 shows a box-plot of the NRA value (a) and the PRA value (b) in the control group (normal) and in the children included in the study before the flip lens training started, after finished training period and from a long term follow up examination two years after end of dioptric flip lens training.

Follow up

Two years after the last examination, a follow up examination was performed. All the children in the study group where invited but only 20 of these 38 children agreed to participate. None of the children in the follow up loss group reported any regain of subjective symptoms or lack of long-term benefits at the telephone interview. None of the 20 children agreeing to participate have had any dioptric training during the time that elapsed from the end of training to the follow up examination. The NRA (a) and the PRA (b) value before, after, and two years after finishing the dioptric flip lens training in these children is also shown in Figure 1. Both the NRA and the PRA is almost the same at the end of training as at the follow up examination and none of the children had regained any subjective symptoms.

Discussion

The children included in this study were selected from among those with problems at school that were related to near work. It was found that all of the selected children had reduced relative accommodation and the majority of them had a slow accommodative response. The study was performed to investigate the possibility to increase, or improve accommodative function as being the probable main problem of these children. We therefore tried to accomplish three goals. First, to quantitatively examine the effect of accommodative facility training on relative accommodation. Secondly, to determine whether subjective symptoms (headache, blur, asthenopia) disappeared with increased accommodative facility, and thirdly, if the dioptric training had any long term effect. None of the patients could be classified as having the syndrome called convergence and accommodative insufficiency as described by von Noorden et al. [11].

Accommodative insufficiency and accommodative facility training have been discussed in the optometric literature mainly during the last decades [3, 7, 12, 16–19], predominantly in regard to pre-presbyopic patients [4, 12, 17]. The close relationship between accommodative deficiency and visual related subjective symptoms such as blurred vision, asthenopia, loss of concentration and avoidance of near activity have been pointed out. Among the findings listed by Hoffman and Rouse [20], as indicative of accommodative difficulties when associated with symptoms, we focused on two items: when NRA and PRA were lower than $\pm$1.75 D, and when $\pm$2.00 D flipper test monocularly and binocularly showed less than 12 cycles per minute (cpm).

The proposed relationship between restricted relative accommodation and subjective symptoms was in concordance with our findings. In our study most of the children initially had a NRA of +1.75 D or less and a PRA of $-$1.75 D or less. Only a few of the children were able to obtain sharp images using a $\pm$2.0 D flipper. The results of this study to some degree support the idea that a PRA and an NRA less than $\pm$ 1.75 D [3] is related to the presence of subjective symptoms (i.e. headache, blurred vision, asthenopia, loss of concentration and avoidance of near activity).

All but three children were prescribed hyperopic correction during the training period but none of them got their glasses before the last optometric examination in their training period. Therefore, the increase in relative accommodation related to accommodative facility training in this study was statistically significant. The length of the training period varied individually, more related to the individual compliance than to the accommodative ability, until the time when subjective symptoms had disappeared. We do not know if further accommodative training would have increased the accommodative function any further. The mean of NRA increase were approximately 0.5 D and the mean of PRA increase was approximately 1.0 D. The individual changes was similar to the changes in the mean values. In all cases both NRA and PRA increased following treatment. Whether this change was an effect of accommodative facility training or an effect of time and care taking we are determining in a parallell study (Sterner et al., in preparation).

The effect of flipper training on slow accommodative responses has been shown in several studies and the relationship between slow accommodative response has been related to subjective problems [5, 12, 17, 18, 20, 21]. An effect of the training was the acceptance of hyperopic spectacles by all the children at the end of the training period.

This study clearly indicates that there is a long term effect of accommodative facility training using a dioptric flip lens tecnique. The value of the NRA and the PRA is almost the same two years after finished dioptric flip lens training as at the end of training. No child had any significant decrease in the relative accommodation value. None of the children had regained any subjective symptoms.

In conclusion, the study indicates the presence of a population of school children with a low hyperopia and accommodative insufficiency where the subjective symptoms become acute in the first school years. For these children, it is possible to increase the relative accommodation by accommodative facility training and at the same time minimize their subjective symptoms. The origin of their accommodative insufficiency is not fully understood and the mechanisms behind the effect on relative accommodation have to be further examined.

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Address for correspondence: B. Sterner, Department of Ophthalmology, Göteborg University, SU/Mölndal, SE-431 80 Mölndal, Sweden
Phone: (+46) 31 343 32 55; Fax: (+46) 31 412904; E-mail: sterner@oft.gu.se