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Ophthal. Physiol. Opt. Vol. 21, No. 6, pp. 470–476, 2001

0275-5408/01/$20.00

PII: S0275-5408(01)00020-5

The effects of accommodative facility training on a group of children with impaired relative accommodation—a comparison between dioptric treatment and sham treatment

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Summary

The effects of accommodative facility training were evaluated by comparing training with plano lenses and ±2.00 D lens flipper sets. Thirteen children with symptoms and signs of accommodative dysfunction were included in the study. Seven started with 2 weeks of plano lens training before proceeding to traditional dioptric flipper training; later, one patient from this group was lost to follow-up. The remaining six children used powered flipper training from the start. The positive (PRA) and negative relative accommodation (NRA) were examined every second week. During the initial training period both the PRA and the NRA decreased in the sham treatment group ($P = 0.010$ and $P = 0.102$, respectively), while the PRA and the NRA increased during the dioptric training in both groups ($P = 0.102$ and $P = 0.033$, respectively). The result of this study indicates that accommodative facility training has a real effect on the amplitude of relative accommodation in patients with impaired relative accommodation. © 2001 The College of Optometrists. Published by Elsevier Science Ltd. All rights reserved.

Introduction

The ciliary muscle of the eye is responsible for the changes in shape of the crystalline lens necessary to obtain sharp retinal images of objects at different distances. It is quite flexible and very resistant to fatigue (Berens and Sells, 1944) although symptoms of accommodative dysfunction among adults are relatively common in clinical practice (Morgan, 1944; Hoffman and Rouse, 1980; Daum, 1983; Hennessey *et al*., 1984). The amplitude of accommodation, that is, the dioptric range within which an object can be focused, continuously decreases throughout life. Rare cases of insufficiency or paralysis of accommodation in young individuals are seen in a number of pathological conditions such as infectious, toxic, and metabolic diseases (Walsh and Hoyt, 1969; Duke-Elder and Scott, 1971). Development of accommodative insufficiency in otherwise healthy young individuals is an infrequently recognized condition (Scheiman, 1996; Borsting *et al*., 1999). A syndrome of idiopathic accommodation and convergence insufficiency in seven young and neurologically intact individuals has been described (Von Noorden *et al*., 1973). The symptoms they presented were headache, asthenopia and blurred vision, in combination with an accommodative amplitude very low for their age (Rouse *et al*., 1999).

The notion that accommodative ability in children and adolescents could be affected by training in such individuals with accommodative insufficiency is controversial. There have been several reports in the optometric literature of accommodative facility training having an effect on accommodation (Daum, 1983; Hennessey *et al*., 1984; Rouse, 1987; Siderov, 1990; Siderov and DiGuglielmo, 1991; Jackson and Goss, 1991; Russell and Wick, 1993; Sterner *et al*., 1999). Most studies have focused especially on accommodative facility, which is the speed of change in accommodation. The dioptric stimulus to accommodation is alternated between two different levels, and the number of cycles between the two levels in a given unit of time is recorded by noting patient reports of clarity of vision after each lens change (Hennessey *et al*., 1984; Jackson and Goss, 1991; Zellers *et al*., 1984; McKenzie *et al*., 1987).

Received: 16 October 2000
Revised form: 23 April 2001
Accepted: 21 May 2001

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The aim of this study was to evaluate the effect of accommodative facility training by dioptric treatment on relative accommodation in a group of children with impaired relative accommodation. Orthoptic therapy is indicated when there is a spasticity in the accommodative system or the accommodative system is poorly controlled (Cooper *et al*., 1987; Siderov and DiGuglielmo, 1991). Therefore we wanted to look for an effect on the relative accommodation using accommodative facility training as used in a study by Sterner *et al*. (1999) to increase impaired relative accommodation. As part of the study a comparison was made between traditional dioptric flipper treatment and a sham flipper treatment to establish whether it was the treatment as such that affected their accommodative performance or whether additional caregiving with the children had an influence.

Methods

Patients

Thirteen Swedish children, five girls and eight boys aged 9–11 years, were included in the study. They were referred over a certain period by School Health Care for near work-related problems and complaints such as headache, blurred vision, asthenopia, loss of concentration and avoidance of near activity, and any of the symptoms listed classified the patient as symptomatic. At examination they presented subnormal negative relative accommodation (NRA) and positive relative accommodation (PRA) (both lower than ± 1.7 SD; Morgan, 1944) indicating accommodative dysfunction. Orthoptic examination revealed no vergence or motility problems in any case. All agreed to participate in the training programme. However, one child was lost to follow-up, not because of failure of the training but for personal reasons.

Before entering the training programme the patients all underwent ophthalmological examination. The examination consisted of assessment of motility and ocular alignment as well as cycloplegic retinoscopy. The visual acuity (VA) was determined at each session at a test distance of 5 m with the natural pupil using optimal distance correction. An officially approved acuity chart (Monoyer–Granström, which is an acuity chart with Monoyer built optotypes, arithmetical in letter size progression and with two extra acuity lines below decimal notation VA 1.0; 1.5 and 2.0) illuminated at approximately 700 cd/m^2 was used to determine decimal VA. Refraction was determined by retinoscopy 30 minutes after instillation of cyclopentolate (1%).

Procedure

Measurements of the relative accommodation were performed as described by Goss and Zhai (1994) and Hung and Ciuffreda (1994). To assess relative accommodation, the accommodative stimulus was binocularly decreased using positive lenses in 0.25 D steps over the distance correction, with the vergence stimulus held constant at 40 cm, to the first slight sustained blur subjectively noted by the patient. The decreased amount of accommodative stimulus at this point is referred to as the 'NRA value'. Thereafter the accommodative stimulus was increased binocularly using negative lenses in 0.25 D steps until the first slight sustained blur was again noticed. The increased amount of accommodative stimulus at this point is referred to as 'PRA'. The NRA and the PRA measurements were each an average of three measurements.

Baseline data were obtained during two test sessions prior to the start of the treatment. The interval between these two baseline test sessions varied from 2 to 5 weeks. Each patient was tested by two different examiners at each session.

Accommodative facility training by flipper lens technique

This technique makes use of a so-called 'flipper' holding one pair of minus lenses and one pair of plus lenses (e.g. ± 2.00 D). The patient focuses through one pair of lenses at a near distance object (40 cm). When the object is clearly focused, a rapid shift to the other lens pair is performed and the patient focuses again. This is then repeated (Siderov, 1990)

The patients were requested to use a flipper while focusing small text at 40 cm for 3 min at least five times a day. The training was performed by the patients at home, and the performance was controlled by a protocol recording cycles/min. Thereby the patients could see how they improved in cycles/min. The patient was interviewed and had to show this protocol at every examination to ensure a high level of compliance.

We alternatingly divided the patients into two groups: one group with seven children and one with six children, knowing which child was in which group. We were aware of the problem with experimenter bias but it was not possible to perform the study masked. The group containing seven children started with 2 weeks of training using a flipper with plano lenses. During this period we were not given any indication from any child that they realized this was a sham treatment since they had no idea what to expect. We called this group the 'sham group'. The other six children, the 'traditional training group', started treatment with a ± 2.00 D flipper. After the first 2 weeks of training the patients were re-examined. The group who had been training with plano lenses were given a flipper of ± 2.00 D to continue the training on a par with the traditional training group, who continued with their treatment. After another 2 weeks the children were again examined and the training programme repeated. An optometric examination was performed every second or third week to ensure high compliance. For patients with hypermetropia, plus lenses were prescribed after the second or third optometric

examination, for proper training of the accommodative facility. However, none of the patients wore glasses before their last optometric examination. The training continued until the patient reported that all the subjective symptoms were absent, and we did not extend the training period beyond this last examination.

Cycloplegic refraction and subjective refraction were compared. The dioptric value in the cycloplegic measure was no more than +0.25 to +0.50 D higher than that in the subjective measure.

Comparison

A comparison between the sham group and the traditional training group was made by comparing the periods of dioptric flipper lens training in both groups. Firstly, the first 2 weeks of dioptric flipper lens training were compared between the traditional training group and the sham group who had just undergone 2 weeks training with the plano flipper lenses. Secondly, the following 3 weeks of dioptric flipper lens training were compared between the two groups.

Statistics

The changes in both mean PRA and mean NRA in the two groups of patients were compared using the Student's paired *t*-test.

Results

The VA of the patients was 1.0 (decimal notation) or better at all test sessions. All patients had a slight subjective hypermetropia before the first session and were prescribed but did not use hyperopic glasses (range from +0.50 to +1.50 diopters) before the last optometric examination. In all patients, the cycloplegic refraction showed a dioptric level that was +0.25 to +0.50 D higher than the subjective refraction value. No change in subjective or cycloplegic refraction was found from the start to the end of study. Baseline data show that prior to the treatment the PRA and the NRA were subnormal in all patients. In the sham group originally containing seven children, one child was lost to follow-up.

In the sham group flipper treatment was divided into three periods, with an initial 2 weeks of accommodative facility training using a plano lens flipper as the sham treatment. This sham period had no effect on the subjective symptoms (i.e. headache, asthenopia, blurred vision) of the patients. In the following 2 weeks a ±2.00 D flipper lens set was used and by the end of this period some subjective symptoms had vanished. The period of accommodative facility training was extended until all of the patients were free from subjective symptoms. This extended period, starting in the fifth week of training, varied in length with each case. All of the sham group continued their training with the ±2.00 D flip lens until they were free from subjective symptoms. Five weeks after the start of the dioptric training programme all but one patient were free from symptoms. The last patient needed an extra 2 weeks of training with a ±2.00 D flip lens.

A question that was raised during this training period was whether the loss of subjective symptoms was dependent upon the increase of the relative accommodation value, or on the improvement of the accommodative facility, or both.

The effect of accommodative facility training on relative accommodation among the sham group is given in *Table 1*. There was a decrease in both NRA (patient 2, 3, and 6) and PRA (patient 1–6) during the first period of training when the patients used plano lenses. This is shown in *Figures 1(a)* and *(b)* (on the left of the diagrams). The box plot includes 90% of the data between the top and bottom, 50% within the box, the horizontal line inside the box describes the median value, and the square inside the box indicates the mean value. We can see that the mean NRA as well as the mean PRA decreased during this sham period. This decrease was recovered in some of the patients during the next 2 weeks when a ±2.00 D flipper was used. *Figures 1(a)* and *(b)* show how the mean relative accommodation increased at the examinations performed after 4 and 7 weeks from initial training.

The traditional treatment group who started their training with a ±2.00 D flip lens showed a increase in their mean relative accommodation at each examination (*Figures 1(a)* and *(b)*, on the right; see also *Table 2*). Their subjective symptoms vanished by the end of the 5-week training period.

The results of this study show that the first 2 weeks of dioptric training in the sham group as well as the traditional group showed an effect of the dioptric training, which continued for the whole of the training period. In concordance with this is the fact that the plano lens flipper did not have any positive effect on either the mean NRA or the mean PRA in any patient in the sham group. It is, however, difficult to explain why the PRA value actually decreased during the sham period for all the patients in the sham group (especially in patients 1 and 3). If there are any placebo effects, we should in fact expect an increase instead of a decrease in the relative accommodation values during the sham period. Despite some individual variations of the results, our data show a significant increase in both the mean NRA and the mean PRA in both the sham group and the traditional group during the dioptric training periods. We are well aware of the fact that the relative accommodation may be greater in some patients than in others; however, a change in relative accommodation was registered in all the patients. We also have no explanation as to why two patients (patient 3 and 4) in the sham group ended up with a lower PRA value than at the outset.

Nevertheless, the results show a significant overall increase in both the mean NRA and the mean PRA during the dioptric training period in both groups. Therefore these

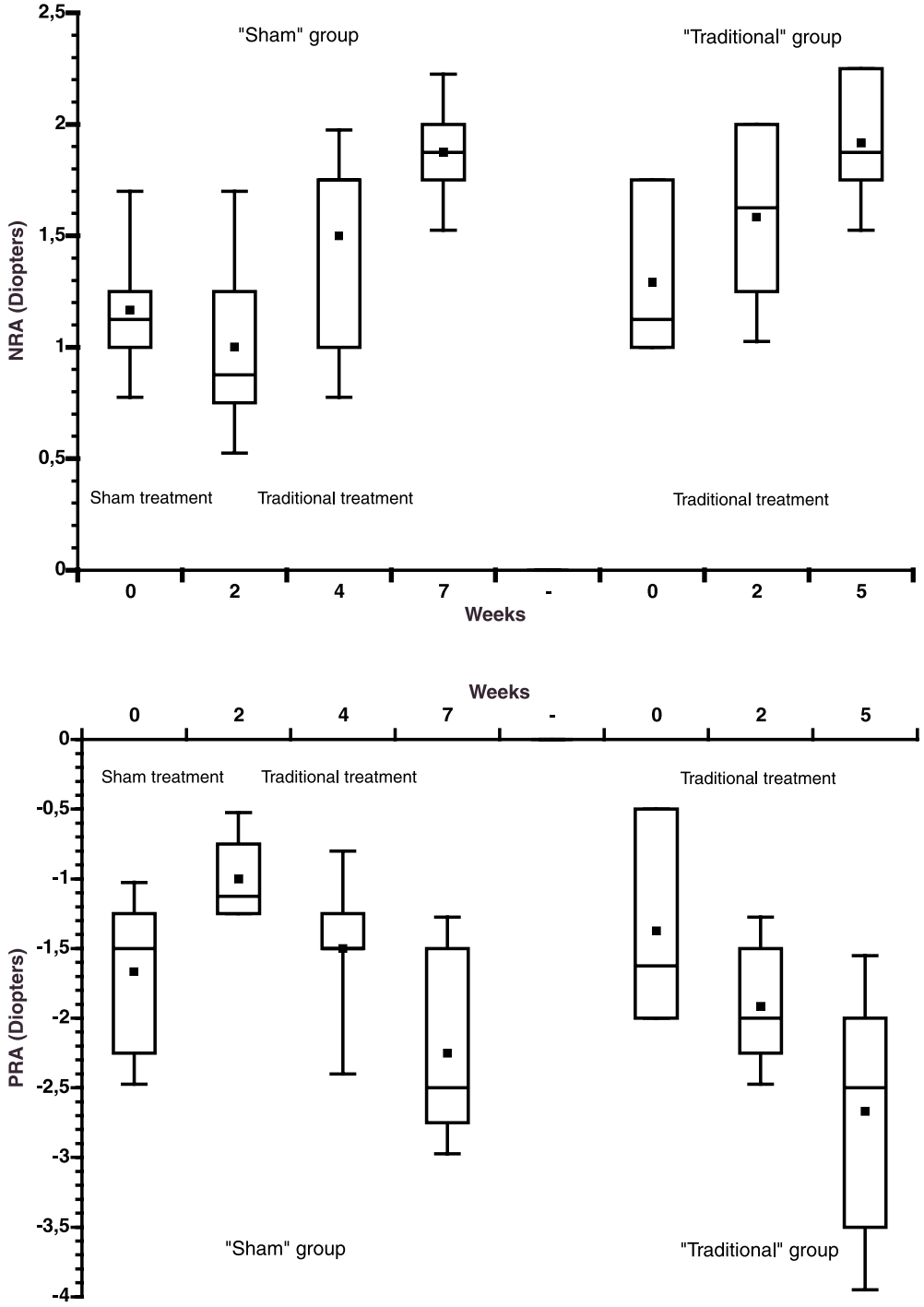

Figure 1. Box plots of the NRA value (a) and the PRA value (b) during the whole period from the initial examination to the end of training in the 'sham' and the 'traditional' groups. The patients' values at the start of the training period are marked '0'. On the left, values for the sham group after 2 weeks of training with plano lenses are marked '2'. At this point (i.e. 2 weeks) we switched to ±2.0 D flipper lenses and the box plot shows how the relative accommodation increased over the examinations performed at 4 and 7 weeks from the start of training. All six patients continued training with the ±2.0 D flipper lenses until they were free from subjective symptoms. On the right, results for the traditional training group, the group of six children who underwent traditional dioptric flipper lens training from the start, are shown at week 0, and after 2 and 5 weeks of training, respectively.

Table 1. Results of sham and dioptric training in the sham group (Patient 7 is excluded from the results because she did not complete the training)

Patients	NRA initial	NRA 2 weeks ±0.0	NRA 4 weeks ±2.0	NRA 7 weeks ±2.0	PRA initial	PRA 2 weeks ±0.0	PRA 4 weeks ±2.0	PRA 7 weeks ±2.0
Male 1	+1.25	+1.25	+2.0	+2.25	−2.25	−1.25	−1.5	−3.0
Female 2	+1.0	+0.75	+0.75	+2.0	−1.25	−0.5	−1.5	−2.75
Female 3	+1.25	+1.0	+1.75	+1.75	−2.5	−1.25	−1.5	−2.25
Male 4	+1.75	+1.75	+1.75	+2.0	−1.75	−1.25	−1.25	−1.5
Male 5	+0.75	+0.75	+1.75	+1.75	−1.25	−1.0	−2.5	−2.75
Male 6	+1.0	+0.5	+1.0	+1.5	−1.0	−0.75	−0.75	−1.25

Table 2. Results of dioptric training in the traditional group

Patients	NRA initial	NRA 2 weeks ±2.00	NRA 5 weeks ±2.00	PRA initial	PRA 2 weeks ±2.00	PRA 5 weeks ±2.00
Male 1	+1.75	+2.0	+2.25	−0.5	−1.25	−1.5
Male 2	+1.75	+1.75	+2.0	−0.5	−1.5	−3.0
Male 3	+1.0	+2.0	+2.25	−2.0	−2.0	−3.5
Male 4	+1.0	+1.25	+1.75	−1.5	−2.0	−2.0
Female 5	+1.0	+1.0	+1.5	−1.75	−2.5	−2.0
Female 6	+1.25	+1.5	+1.75	−2.0	−2.25	−4.0

Table 3. Statistics

Examination visits	NRA 'Sham'group	'Traditional'group	PRA 'Sham'group	'Traditional'group
Between initial and first revisit	$P = 0.102$	$P = 0.110$	$P = 0.010$	$P = 0.016$
Between first and second revisit	$P = 0.033$	$P = 0.002$	$P = 0.102$	$P = 0.111$
Between second and third revisit	$P = 0.107$		$P = 0.017$	

results suggest that the treatment was effective. However, there is no simple explanation for the relationship between the NRA and PRA values and the subjective symptoms.

Using Student's paired *t*-test for evaluation of the effects of training in the sham treatment group, as well as in the traditional treatment group (*Table 3*), we found the *P*-values for the sham group to be $P = 0.102$ for initial NRA and NRA at first revisit (week 2), and $P = 0.033$ for NRA at the second revisit (week 4, after training with dioptric treatment) compared with the first, and $P = 0.107$ for the second and third revisits (weeks 4 to 7). In the traditional treatment group the *P*-values for the NRA were $P = 0.110$ between initial NRA and NRA at first revisit, and $P = 0.002$ between the first and the second revisit (weeks 2–5). Corresponding values for PRA [*Figure 1(b)*] were $P = 0.010$, $P = 0.102$, and $P = 0.017$ for the sham group. In the traditional treatment group the *P*-values from week 0 to week 2 were $P = 0.016$, and, finally, $P = 0.111$ for weeks 2–5.

Discussion

The study demonstrates the effect of traditional dioptric training on relieving the symptoms of accommodative dysfunction and shows that the relative accommodation improves.

Both the mean PRA and the mean NRA increased continuously from the start of the treatment, with a marked increase in both parameters after only 2 weeks of treatment. The increase continued until the patients no longer had any symptoms and the training was completed. In general the symptoms vanished after 5 weeks of training, by which time the relative accommodation had been markedly improved. Our study therefore shows that accommodative facility training can increase relative accommodation, both positive and negative, in selected patients, as well as relieve them of their subjective symptoms. However, it is not clear whether the relief of the subjective symptoms was linked to an increase in relative accommodation or an improvement of the accommodative facility, or both.

Since the question has been posed whether it is the actual use of dioptric training that causes an increase in relative accommodation or whether non-specific caring can lead to such increase, we studied the effect of sham treatment in seven patients before they were given dioptric training. During 2 weeks of sham treatment the patients used a flipper with plano lenses. Since we used a reward system we are confident that the number of treatment sessions during this period did not differ in any significant way from the number of treatment sessions in any other given period. Although, according to interviews, the patients trained as requested no sign of improvement could be seen in the relative accommodation. This finding clearly indicates that short-term sham treatment, if anything, had a negative effect on relative accommodation and no observable effect on subjective symptoms. The lack of effect of the sham treatment with plano lenses strongly suggests that the therapeutic effect of dioptric treatment of accommodative facility is linked to the effect of the ± 2.00 D flip lenses. The focus of this test was to examine changes in relative accommodation in relation to treatment. Consequently we have had less interest in facility and change in facility speed. The fact that the effect on the relative accommodation of 2 weeks of dioptric training following the sham treatment was as marked in this group of patients as it was in the traditional training group who started directly with dioptric training, further links the positive effect on the relative accommodation to the use of the ± 2.00 flipper lenses.

The short-term findings in our present study on a minimal number of school children have been confirmed in a parallel study involving 38 children (Sterner *et al*., 1999). In that study the long-term effect of accommodative facility training on symptoms in children with slow accommodative response and reduced relative accommodation was demonstrated.

Information about the natural history of accommodative dysfunction in children is lacking, and we do not know whether the relative accommodation will spontaneously improve with age. However, even though the effect of maturation cannot be excluded from the present study design, our clinical experience is that accommodative infacility lasts for years. The dioptric training had a positive effect on both the PRA and NRA and the subjective symptoms and offers the possibility of at least shortening the period with symptoms and withdrawal from near work at school at a stage in schooling that is academically important.

The result, in terms of the dioptric treatment, in this study is in agreement with results reported in the literature (Daum, 1983; Cooper *et al*., 1987; Siderov, 1990; Russell and Wick, 1993; Sterner *et al*., 1999), although accommodative insufficiency has been more commonly reported in pre-presbyopic individuals than in school children (Hennessey *et al*., 1984; Cooper *et al*., 1987; Russell and Wick, 1993; Scheiman, 1996).

In conclusion, in this study, children with impaired relative accommodation were relieved of symptoms and both negative as well as positive relative accommodation improved as a result of dioptric training. In order to optimize the training and the diopter value of the lenses, the training intensity and the distribution of training sessions over an extended period still need further evaluation. It is also of utmost importance that children with accommodative dysfunction are properly diagnosed and that other ophthalmological problems are excluded.

Acknowledgements

This work was supported by the Swedish Medical Research Council (grant No. 02226), Kronprinsessan Margarethas Arbetsfond, Sigvard and Marianne Bernadottes Forskningsstiftelse, Stiftelsen Sunnerdahls Handikappfond, Handlanden H Svenssons Fund, Stiftelsen Karl Simsons Fund and De Blindas Vänner. We would also like to thank Stefan Michélsen for valuable discussions and advice.

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