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Research Article,

Effects of Home-Based Convergence Insufficiency Vision Therapy on Accommodation among School Going Children

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Abstract:

Background: Convergence and accommodation are always yoked together and any adjustment on the former affects the later. The most effective treatment for convergence insufficiency (CI) is vision therapy.

Aim/Purpose: To determine the effects of home-based vision therapy on accommodation in school-going with CI attending the Masinde Muliro University Academic Vision Center in Kenya.

Methods: A clinical experimental design involving 23 participants with the mean age of 14±2.4 years, were recruited into the study, however, only 18 were assessed after the therapy. The study took 9 weeks thus majority lost contact while others moved out of the town. Home-based vision therapy which is undertaken at home using a pencil or broke strings. During the therapy, accommodative values were monitored which were; negative relative accommodation, positive relative accommodation, dynamic accommodation, accommodative facility and near point of accommodation. Paired t-test used to compare mean values before and after the therapy.

Results: The mean value of negative relative accommodation (NRA) before and after home-based therapy was statistically significant (p=0.01). However, the mean values before and after home-based therapy for the near point of accommodation (NPA), dynamic (Lag), relativity (PRA) and facility (MAF) showed no difference (p> 0.05). The mean value of the NRA before and after office-based vision therapy was statistically significant (p=0.01).

Conclusion: The use of home-based vision therapy for the patients with CI had significant effects on accommodation changing from a lower limit to average after the therapy.

Keywords: Convergence insufficiency, Accommodation, Home-based vision therapy.

Introduction:

Convergence insufficiency (CI) is the most common binocular vision anomaly (Scheiman *et al.*, 2011; Singh *et al.*, 2017; Sreenivasan & Bobier, 2015) and is as a result of the failure of the vergence system to maintain binocular vision due to intense near work activities. The vision has to keep up with constantly shifting directional stimuli (Ukai & Howarth, 2008). Failure to adjust during such changes will result in CI due to a conflict between vergence and accommodation, resulting in visual discomfort. The prevalence of CI ranges from 2.5%-8.35% among children and adults globally (Cooper and Duckman, 1978; Lara *et al.*, 2001; Rouse *et al.*, 1999). School going children, between the ages of nine and 18, are mostly affected by CI because they spend most of their time reading and engaged in other near related activities. Home-based vision therapy, as the name suggests, is the procedure that is carried at home by the patients themselves and has fewer office visits (Scheiman, 2016). The patient is given proper instruction on how to carry out the procedure at home, followed by reinforcement

through daily phone calls to the caregivers. In most cases, the patients with CI who underwent vision therapy using pencil push up showed marked improvements in symptoms after six weeks (Vasudevan *et al.*, 2009). Momeni-Moghaddam *et al.* (2015) carried out a study on 60 students and younger adults than 19 years with manifest CI. The researcher used home-based vision therapy with pencil push up compared with office-based vision therapy. The study results showed that both home-based and office-based therapies were statistically significantly comparable in terms of efficacy. In both cases, the study combined both accommodative and vergence manipulations; hence the measure of vergence was quantified while the components of accommodation were not monitored despite their treatment.

Methodology:

The study was carried out in Masinde Muliro university academic vision center (MMUST/AVC) in Kaka mega County, Kenya. Twenty three (23) children who were previously diagnosed with convergence insufficiency were recruited into the study. This was experimental study design where the school going children aged nine to eighteen years were recruited into the study. The inclusion criteria were: patients between 9 and 19 years of age, exophoria at near 4PD greater than distance, reduced positive fusion vergence at near that was defined as less than 20PD, failure to meet Sheard's criteria, receded NPC (breakpoint of 6cm and higher using a near target), meet the convergence insufficiency symptom survey, had the best-corrected vision of 6/6 at distance and 20/20 at near. Those with diseases that are known to affect vergence and accommodation, those with the previous history of strabismus surgery, those who had a difference in NPC above 20cm in either eye, those with primary vertical heterophoria greater that 1PD and distance or near exophoria greater than 10PD were excluded from the study.

Subject's treatment:

Home based pencil push-up vision therapy participants were given clear instructions to carry out the treatment. The written instructions were given to the subjects on the procedure to do pencil push-up. Before the initiation of the therapy, the investigator conducted practice sessions with the participants and guided them through the instructions. Other details were discussed during the weakly therapy appointment sessions and subsequent phone calls. The weekly visits and communication entailed emphasis on compliance and correction of any problems that arose. The study took nine weeks to complete and was divided into two phases. During this period, the groups visited the clinic once a week to measure accommodative components and monitor the progress of the therapy. The forms used to collect data were issued to the patients at the beginning of the research and explained the procedures to be followed. These forms were from the convergence insufficiency trial treatment group (CITT) and modified to suit the local conditions.

Procedure:

The subject was to stand in front of the wall while holding a card oriented vertically and measuring 6 to 8 feet from the wall and straight from the eye level. The subject then held the pencil at arm's length directly between his/her eyes and the card from the wall. The subject reported seeing one clear letter on one pencil and two cards in the background when looking at them. The subject was asked to move the pencil slowly towards his/her nose while maintaining the eyes on the letter on the pencil and keeping in mind the two cards from the wall with the peripheral vision. The subject was requested to report when the cards were moving far apart as the pencil came closer. In case one card disappeared the subject was requested to blink and see both cards.

Treatment and follow up:

The study recruited 23 participants into the study however, only 18 were assessed after the therapy. The study took 9 weeks thus majority lost contact while others moved out of the town making follow up difficult. As shown in figure 1 below.

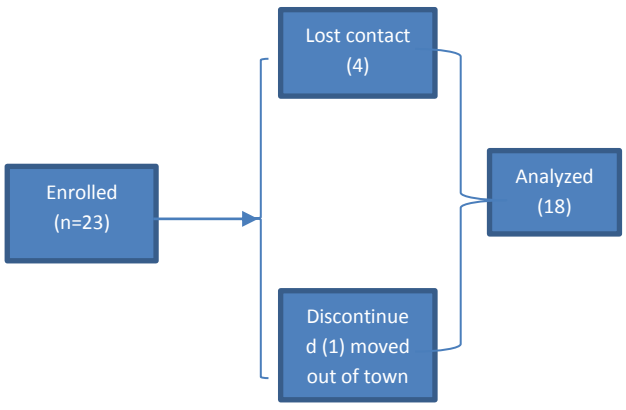

Figure 1 showing consort of treatment protocol

Logistics and Ethical Considerations:

Permission to conduct this study was obtained from Masinde Muliro University Academic Vision Center (AVC) where the tests were conducted. Ethical clearance was obtained from the Institution Ethical Research Committee (IERC) Clearance – MMUST, Kakamega and the National Commission for Science Technology and Innovation (NACOSTI).Participant Consent- Since the research was dealing with minors, participants' parents and caregivers were informed of the purpose of the study and the fact that participation is voluntary and that participation can be terminated at any time the subject deems necessary. Upon confirmation that the intended participant has understood the terms of their participation in the study, he/ she were requested to give verbal consent which was noted. Assent was also obtained from all participants. All the information about the procedures to be undertaken was explained, benefits, risks, and any relevant concerns were addressed before consent /assent was obtained.

Results:

Baseline data after completion on the therapy, the mean age of 14±2.24 having 10 females and 8 males. The mean values of the monocular accommodative facility (MAF) for the right and left eyes was 9.67 ± 2.65 cycles per minute and 9.61 ± 2.61 cycles per minute, respectively. The mean positive relative accommodation (PRA) for the right eye, 2.36 ±0.86 D and 2.36 ± 0.86 D for the left eye. The mean negative relative accommodation (NRA) for the right eye was 2.15 ± 1.03 D and 2.09 ± 0.09 D the left eye. The mean near point of accommodation (NPA) for the right eye was 9.27 ± 2.15 D and 9.22 ± 2.21 D the left eye. The mean value dynamic accommodation (lag) in the right eye was 0.50 ± 0.29 D and 0.54 ± 0.28 D in the left eye.

Table1: baseline data before commencement of the study.

ACCOMMODATION	BASELINE MEAN N= 18	SD (standard deviation)
MAFRE (CPM)	9.67	2.65
MAFLE (CPM)	9.61	2.61
PRARE (D)	2.36	0.86
PRALE (D)	2.36	0.86
NRARE (D)	2.15	1.03
NRALE (D)	2.09	0.91
NPARE (D)	9.27	2.15
NPALE (D)	9.22	2.21
Lagre (D)	0.50	0.29
Lagle (D)	0.54	0.28

Table showing the mean values and standard deviation before the therapy.

Table 2: Comparison of the treatment for the home-based before and after therapy

BEFORE TREATMENT N=18		AFTER 9 WEEKS TREATMENT N=18		
ACCOMMODATION	MEAN (SD)	MEAN (SD)	P-VALUE	Effect size
MAFRE (CPM)	9.67 (2.65)	10.22 (1.66)	0.17	0.34
MAFLE (CPM)	9.61 (2.61)	10.11 (1.67)	0.24	0.30
PRARE (D)	2.36 (0.86)	2.50 (0.56)	0.36	0.25
PRALE (D)	2.36 (0.86)	2.50 (0.56)	0.45	0.25
NRARE (D)	2.15 (1.03)	2.52 (0.66)	**0.02**	**0.56**
NRALE (D)	2.09 (0.91)	2.47 (0.54)	**0.01**	**0.70**
NPARE (D)	9.27 (2.15)	9.36 (1.05)	0.83	0.08
NPALE (D)	9.22 (2.21)	9.38 (1.03)	0.68	0.15
Lagre (D)	0.50 (0.29)	0.54 (0.28)	0.58	0.14
Lagle (D)	0.54 (0.28)	0.47 (0.18)	0.50	0.38

CPM= cycles per minute, D= diopters. MAFRE, monocular accommodation facility for the right eye, MAFLE, monocular accommodative facility for the left eye, PRARE, positive relative accommodation for the right eye, PRALE, positive relative accommodation for the left eye, NRA, negative relative accommodation for the right eye, NPARE, near point of accommodation for the right eye, NPALE near point of accommodation for the left eye. The data presented as means and standard deviation p<0.05 bolded

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The mean near point of accommodation for both right and left eye had p-value >0.05 when compared before and after treatment. Similarly, the mean difference before and after treatment was statistically insignificant (p= 0.83 and p= 0.68) for the right and left eyes, respectively. The mean MAF of the right eye before treatment was normal after treatment. The mean difference before and after treatment was statistically insignificant (p= 0.17). The mean MAF for the left eye before and after treatment was normal although the difference between mean was statistically insignificant (p=0.24). Wilcoxon signed-rank test analysis was used for negative relative accommodation as the data was not normally distributed. The mean negative relative accommodation at the beginning when compared with the end of the therapy was statistically significant (p= 0.02). Similarly, paired t-test was used to compare the mean NRA and PRA values before and after home-based vision therapy was statistically significant (p= 0.01). The mean positive relative accommodation of the right eye before and after therapy was statistically insignificant (p=0.36). The mean of the left eye at baseline when compared after therapy was statistically insignificant (p=0.45). The mean dynamic accommodative response (lag) of the right eye before and after therapy was statistically insignificant (p=0.58). The mean dynamic accommodative response of the left eye before therapy in comparison to the mean after therapy was statistically insignificant (p=0.26) as shown in ***Table 2***.

Discussion:

The comparison of participant's treatment before and after nine weeks is shown in table 2. The mean difference of the near point of accommodation before and after the therapy had a positive deviation towards normalcy and comparable to the study by Scheiman (2016). Since the mean value was within the normal values, as stated by Wajuihian (2018), there was no statistical significance. Studies by Manley (2013) and Scheiman (2016) focused on the improvement of both vergence and accommodation during treatment of convergence, but the values of near point of accommodation were not documented. The mean monocular accommodative facility of the right eye and left eye before and after treatment was low. Another study that had a similar outcome despite using accommodative flippers on training had a mean change of 1.90 (Allen *et al.,* 2010). The results of negative relative accommodation for the right and left eye showed varied outcomes. The mean difference for the right eye was statistical and clinical significance. Similarly, the mean value of the left eye depicted the same effect, having a clinical and statistical effect. In this study, the use of home-based vision therapy for the treatment of convergence insufficiency without combining accommodative therapy still had an effect. Other studies (Jang *et al.,* 2017; Manley, 2013) that conducted similar therapy used a combined method and found that accommodative exercises played a minute role. The findings from the study also indicated that the use of home-based vision therapy had no significant effect on positive relative accommodation of the right eye and left eye. These results could have been influenced by the fact that compared to normal values, they were within limits (Wajuihian, 2018). The study also established that most subjects with convergence insufficiency had normal positive relative accommodation. Other studies on positive relative accommodation showed no change before and after training, respectively (Vasudevan *et al.,* 2009). The similarities in these studies show that in cases where the subjects have low positive relative accommodation, home-based vision therapy may not be the treatment of choice. The mean dynamic accommodative response before and after therapy was statistically insignificant, suggesting that subjects with convergence insufficiency did not have problems with a lag of accommodation which was comparable with the study by Langaas *et al.,* (2008), who reported no difference between lag of accommodation between groups of similar characteristics.

Conclusions and recommendation:

This study showed that the accommodative types measured before treatment were on the lower limit of the normal values compared to Hofstetter's minimum values for the patients with CI. The baseline values were important since they were monitored for any adjustment done to either improve or reduce as the therapies were being administered. The use of home-based vision therapy for the patients with CI had significant effects on accommodation changing from a lower limit to average after the therapy. The therapy had the same effect when used with accommodative therapy on accommodation, despite showing no statistically significant difference. However, the difference was clinically significant since the values were normal at the end of the therapy. There was no significant difference between using home-based and office-based therapies, as both had the same effects on accommodation.

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