Effectiveness of Vision Therapy in School Children with Symptomatic Convergence Insufficiency

J Ophthalmic Vis Res. 2017 Apr-Jun; 12(2): 187–192.
doi: 10.4103/jovr.jovr_249_15
PMCID: PMC5423373
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Abstract

Purpose:

To determine the effectiveness of vision therapy among Korean elementary school children with convergence insufficiency.

Methods:

A total of 235 elementary schoolchildren, 10.13 ± 2.45 years of age, were subjected to thorough eye examination including binocular vision testing. Of them, 32 individuals with symptomatic convergence insufficiency without strabismus, amblyopia, and ocular disease were chosen to receive vision therapy via brock string, barrel card, mirror stereoscope, prism goggles, and aperture rule for a duration of 8 weeks.

Results:

The results showed that most of the participants had severe problems in near point of convergence. After the vision therapy, the average near point of convergence improved by approximately 5.48 ± 0.96 cm in all participants. Moreover, vision therapy had an effect on increasing near positive fusional vergence and decreasing exophoria. Negative relative accommodation improved to 2.54 ± 0.51 and positive relative accommodation improved to −3.10 ± 1.08 diopters. After treatment, near phoria was 4.19 ± 1.66 and distance phoria was 1.61 ± 0.71 prism diopters.

Conclusion:

Among convergence insufficiency symptoms, the following improved in particular: near point of convergence, exophoria, and near positive fusional vergence. These findings suggest that vision therapy is very effective to recover from symptomatic convergence insufficiency.

Keywords: Convergence Insufficiency, Near Point of Convergence, School Children, Vision Therapy
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INTRODUCTION

The prevalence of non-strabismic accommodative and vergence dysfunctions shows marked differences depending on the test methods, diagnostic criteria, and characteristics of study populations. However, despite varying statistics, these symptoms commonly occur in schoolchildren. Of various non-strabismic binocular dysfunctions, convergence insufficiency (CI) is defined as a binocular disorder in which eyes do not work well at near fixation. Approximately 3–5% of the general population are affected by CI, with 26% of the population with corrective spectacles affected.[1] Symptoms of CI, such as asthenopia, headache, intermittent blurriness, diplopia, excessive fatigue while reading, burning sensation, and epiphora, can deteriorate with time.[2] There are various treatment methods for CI, such as correcting refractive errors, prescribing prism, or vision therapy (VT).[3] Among these treatments, VT is considered as an effective method for treating children and adults with CI.[4,5] Aziz et al[6] proved the effectiveness of VT in 78 participants, aged 5–73 years. Indeed, after an average of 8.2 months of VT, 65 participants presented reduced symptoms, while the remaining 20 presented five prism diopters reductions in exophoria. Rouse et al[7] found that, among children aged 8–12 years, the rate of CI was as high as 17.6%. In a recent placebo-controlled and randomized multi-center clinical trial, the CI Treatment Trial (CITT) study,[8] a total of 221 children with symptomatic CI were evaluated. The experimental group that performed 12 weeks of VT demonstrated significant improvement of symptoms and clinical signs of near point of convergence (NPC) and positive fusional vergence (PFV) measures. Among these 221 participants, 121 children (55%) were associated with accommodative insufficiency even though they were included in the diagnostic criteria of CI. However, to date, no study on the effectiveness of VT in Korean schoolchildren has been carried out. Mokpo, with an area of 50.65 km^2, is a city in South Jeolla Province in Southwestern Korea. The population is approximately 241,744 (2016), and population density considered the tenth highest in South Korea. This region does not pay enough attention to vision and refractions in schoolchildren compared with other regions in South Korea. Therefore, this study aimed to investigate the efficacy of VT among Korean elementary schoolchildren in the Jeolla province in South Korea.

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METHODS

Participants

The local elementary schools in Mokpo city, South Jeolla Province, Korea were notified about the study, and schoolchildren who wanted to participate in this study were recruited from two schools. A total of 235 elementary schoolchildren, aged 8–13 years, who were in the first to sixth grade were selected. Parents of all the participants provided written agreement forms for their children's participation.

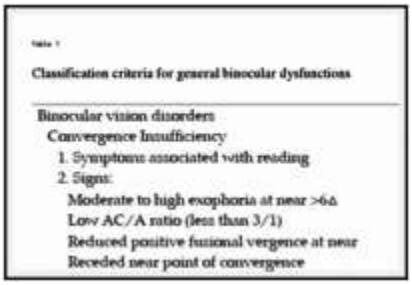
Data were collected from schoolchildren who had no history of eye injuries and who were not taking any medications. Moreover, none of the selected schoolchildren had any ocular diseases, diplopia, strabismus, or amblyopia. The VT was performed based on Scheiman and Wick's classification criteria,[2,3] while considering gender and age.

Eye Examination

Preliminary tests were included as a case history included full scope of questionnaires about symptoms were asked, in addition to the evaluation of the distance and near visual acuity, distance and near cover test, NPC (Fixation stick, Bernell, USA), distance and near pupillary distance (PD-85, Vitzro, Korea), ocular motility, fusion (Worth 4-dot, Bernell, USA), and stereopsis (Titmus stereo fly, Bernell, USA).

Refractive errors were determined using an auto-refractor (HRK-8000A, Huvitz, Korea), and subjective refraction was determined using a phoropter (DU-7000, Korea) and auto chart projector (CCP-3100, Huvitz, Korea). Subjective refraction was performed using the monocular fogging method with cross cylinder, followed by binocular balancing to a standard endpoint of maximum plus for best corrected visual acuity.

The accommodative and binocular visual systems were examined to assess the quality of the general binocular vision system. The tests were performed with the subjective refraction in place. The von Graefe technique was used to determine the distance and near horizontal heterophoria.[9] A 6-Δ base-up dissociating prism was placed in front of the right eye, and a Risley rotary prism with 12-Δ base-in was placed in front of the left eye. Positive and negative fusional vergences were measured using the prism bar method. The accommodative convergence/accommodation (AC/A) ratio was measured using the gradient method. Positive and negative relative accommodation (PRA and NRA), monocular and binocular accommodative facility were measured with ±2.00 D flipper lenses. In measuring NRA and PRA with correction, the 20/20 on a high contrast near chart at 40 cm was set as the fixation target, and we changed the accommodation using minus and plus lenses for testing NRA and PRA, respectively. The lenses were added binocularly as 0.25 D steps until first slight sustained blur which is the endpoint of the test appeared. At this point, letters are not as sharp and readable as the primary status. The total plus lenses added for NRA testing and minus lenses for PRA testing were recorded. NRA was tested before PRA to avoid any influence of accommodation on the measurements. The NPC was evaluated using the standard push-up technique, which determined abnormalities bigger than 10 cm. Eligibility criteria for determining CI were classified and compared with Scheiman and Wick's classification criteria [Table 1].



Classification criteria for general binocular dysfunctions

Binocular vision disorders
Convergence Insufficiency
1. Symptoms associated with reading
2. Signs:
Moderate to high exophoria at near >6Δ
Low AC/A ratio (less than 3/1)
Reduced positive fusional vergence at near
Receded near point of convergence

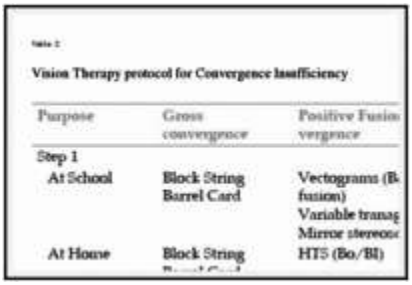
Table 1
Classification criteria for general binocular dysfunctions

Vision Therapy Program

All participants with convergence insufficiency followed an 8-week visual treatment program. During VT, they were scheduled to visit the elementary school clinic three times per week, with a

duration of 60 minutes for each treatment session. In addition, based VT was supplemented by daily home therapy sessions of 15 minutes per day.

The detailed school clinic based VT program is illustrated in Table 2, and the treatment followed three steps. Home therapy sessions comprised 5 minutes sessions, three sessions per day, while individual tasks were assigned by the school clinic. The therapy followed the program through three phases. None of the participants was discharged before 8 weeks. The progress of each participant was evaluated after they finished the first steps, and was determined before moving to the next higher phase. Instruments and manuals for VT practice methods were provided, and the participants' parents recorded daily log of the practice. Instruments included brock sting, barrel card, mirror stereoscope, prism goggle, and aperture rule; a detailed practice log is listed in Table 2. Before the VT program started, general information of binocular dysfunction, treatment options, and VT programs were explained in order to motivate the children's participation and parents' cooperation.



Vision Therapy protocol for Convergence Insufficiency

Purpose	Gross convergence	Positive Fusion vergence
Step 1		
At School	Block String Barrel Card	Vectograms (B fusion) Variable transg Mirror stereos
At Home	Block String	HTS (Bo/Bi)

Table 2
Vision Therapy protocol for Convergence Insufficiency

Success Criteria of Vision Therapy Program

The success criteria were classified based on Scheiman and Wick's[2,3] classification criteria for general binocular dysfunctions, in addition to classification criteria based on Daum[7] and Scheiman et al[10] Detailed classification criteria in this study for the children who had 8 weeks of VT sessions from school clinic and home therapy system (HTS) were as follows: (1) Symptoms were absent and (2) NPC was closer than 6 cm, while near PFV was more than twice than the amount of heterophoria, which met Sheard's criteria.[3] In addition, criteria for the improvement were as follows: (1) Symptoms were absent and (2) either NPC or PFV satisfied the normal value.

Data Analysis

Completed VT data were collected and classified based on Scheiman and Wick's classification criteria [Table 1]. Analysis were conducted, calculated with 95% confidence intervals (CIs), followed by frequency analysis, descriptive statistics, and paired *t*-test using SPSS (version 18.0 for Windows, SPSS Inc., Chicago, IL). All CIs presented are 95% CIs and the significance level was at 0.05 in all analyses.

Informed Consent and Ethical Approval for Procedures

The local Administration of the Education and School Board were contacted to request their cooperation. After securing permission to perform the study, approval was obtained from the

appropriate university ethical advisory committee. Completed consent forms were obtained from the parents or guardians of all children before the examination.

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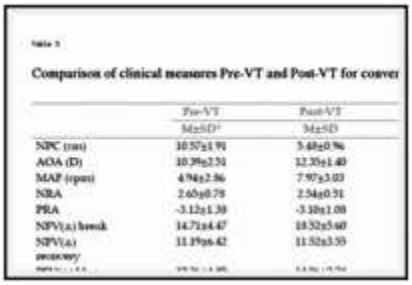
RESULTS

A total of 235 schoolchildren aged 8–13 years were subjected to eye examination; of them, 32 participants (13.61%) with symptomatic CI were enrolled in the study. During 1–2 weeks after starting the VT program, some participants complained of eyestrains, which can be the result of getting used to VT. All participants were phase 3 at the end of the 8-week program; however, a few participants were unable to reach the aim of the treatment. Table 3 summarizes the detailed results of vision therapy for CI. After 8 weeks of treatment, the mean NPC was 5.48 ± 0.96 cm. The effect of treatment on the NPC was highly significant (t = 16.386, $P < 0.001$), and NPC verged in by 5.48 cm. Moreover, PFV at near corresponded to 10.26 ± 4.89 PD initially; however, after VT practice, it was improved up to 14.06 ± 2.74PD, which was statistically significant (t = −3.644, $P < 0.001$). Moreover, negative and positive were increased up to 2.54 ± 0.51 and −3.10 ± 1.08 D, respectively. After treatment, near phoria was 4.19 ± 1.66, while distance phoria was 1.61 ± 0.71 PD. In 28 of the 32 schoolchildren, criteria of CI improved. Four students were unable to reach the goal of the treatment. The success rate of VT was 87.5% (data not shown). Figures Figures11 and and22 illustrate the NPC and PFV before and after VT practice. Moreover, NPC reached the target of 6.00 cm within 4 weeks of treatment, while PFV reached the target of 18Δ, which is in line with Sheard's criterion, within 3 weeks of treatment.



Comparison of clinical measures Pre-VT and Post-VT for conver

	Pre-VT	Post-VT
	M±SD	M±SD
NPC (cm)	10.57±1.91	5.48±0.96
AOA (D)	10.39±2.51	12.35±1.40
MAF (cpm)	4.94±2.86	7.97±3.03
NRA	2.65±0.78	2.54±0.51
PRA	-3.12±1.30	-3.10±1.08
NPV(Δ) break	14.71±4.47	18.52±5.60
NPV(Δ) recovery	11.39±6.42	11.52±3.55

Table 3

Comparison of clinical measures Pre-VT and Post-VT for convergence insufficiency

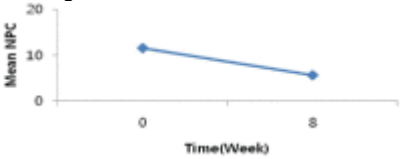


Figure 1

Mean near point of convergence (NPC) measurements after 8 weeks of treatment for convergence insufficiency group. (P<0.001).

Figure 2

Mean positive fusional vergence (PFV) measurements at near after 8 weeks of treatment for convergence insufficiency group. (P<0.001).

However, participants could spend longer periods of time reading, and symptoms of asthenopia gradually decreased.

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DISCUSSION

This study aimed to assess the effectiveness of VT in elementary school children with CI. We found that 13.61% of the participants had symptomatic CI. These frequency estimates are smaller than those reported by Rouse et al[11] (24.2% of participants with CI). The difference between the studies may be related to the number of participants and classification criteria. Indeed, classified CI used by Rouse et al[11] were low suspect CI, high suspect CI, and definite CI which was present in 62.1%[10] and 7.7%[12] in previous reports; however, these included different age groups.

In our study, after 8 weeks of treatment, the mean NPC was 5.48 ± 0.96 cm. The effect of treatment on the NPC was highly significant (t = 16.386, P < 0.001), and NPC verged in by 5.48 cm. Scheiman et al[13] compared the efficacy of VT and pencil push-up training with placebo participants. In their results, the VT group revealed statistically significant improvements; for example, NPC verged in from 13.7 to 4.5 cm.

In our study, by prescribing VT to increase the accommodative ability, not only NPC was improved, but also the degree of exophoria and PFV were improved. In a recent study,[14] 72 children with CI were prescribed base-in prism glasses for 6 weeks and the effectiveness of base-in prism glasses to treat CI was compared with a placebo group. The study found that prescribing base-in prism glasses was not effective because the treatment results did not improve clinically and symptomatically. Thus, it was proven that systematic VT is an effective method to treat CI.

Previous studies have performed a long-term tracking observation on three patients who went through VT and whose symptoms disappeared. These studies have reported that the fusional vergence improvement of the overall cure rate is 72% for 9 months after treatment, suggesting a lasting effect of VT.[15,16] However, the comparison group of four patients did not show any improvement in eye symptoms nor fusional vergence, and did not show any changes during the long-term tracking observation period. Similarly, Pantano[17] performed a 2 year observation on 207 patients with CI. Patients whose symptoms and fusional vergence recovered following VT revealed a long-lasting effect. In contrast, patients whose fusional vergence was not treated suffered from reoccurring symptoms. Grisham[15] inquired into 15 studies from 1940 to 1984, and evaluated the success rate of VT in 1,931 patients. It was reported that the accumulated cure rate was 72%, rate of improvement was 19%, and the failure rate of treatment was 9%.

The number of VT sessions can be varied depending on the degree of binocular function anomaly, participants' age, and whether or not to perform a VT program properly as classification criteria for CI.

Daum[7] suggested that 4.3 visits on average were required. In our study, the longer treatment sessions (16 school therapy sessions and home therapy) were conducted to maximize and maintain the efficacy of the therapy. Our participants were elementary school children (age 8–13) who started to have extensive amount of near work. Thus, the longer treatment sessions were necessary to ensure less chance of regression in the future.[18,14,19] Therefore, 8 weeks of therapy can be an effective method to treat CI. However, although the results were statistically significant, the small sample size limits the generalization of the efficacy of the VT program. Moreover, 8 weeks cannot be considered sufficient to improve symptoms and/or binocular functions in certain participants, and there is a possibility that improvements can be notable if the treatment sessions were longer.

It is known that PFV, PRA ability, and accommodative infacility can be improved by VT. In our study, the degree of exophoria decreased and PFV improved. Thus, our data confirm that VT is an effective method to improve CI. Therefore, well-prescribed VT programs can contribute to improve binocular functions in elementary schoolchildren in the Jeolla province in South Korea. Future studies should compare the other geographical regions of CI in Korean populations of school ages in order to gain a better understanding of their prevalence.

In conclusion, the current research emphasizes the efficacy of VT, especially with the participants' motivation to take part in the study. An intensive VT program appears to be the treatment of choice for reducing CI symptoms. Indeed, VT for CI improves symptoms by reducing NPC and degree of exophoria and increasing PFV.

Financial Support and Sponsorship

Nil.

Conflicts of Interest

There are no conflicts of interest.

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REFERENCES

1. Daftari A, Alvarez TL, Chua F, Demarco R, Ciuffreda K. The dynamics of convergence insufficiency. Bioengineering Conference 2003, IEEE 29th annual, Proceedings; 2003. pp. 41–42.
2. Mcgregor ML. Convergence Insufficiency and vision therapy. *Pediatr Clin N Am*. 2014;61:621–630. [PubMed]
3. Scheiman M, Wick B. Clinical management of binocular vision. 2nd ed. USA: Lippincott-Raven; 2002. p. 224.
4. Scheiman M, Mitchell GL, Cotter S, Cooper J, Kulp M, Rouse M, et al. A randomized clinical trial of treatments for convergence insufficiency in children. *Arch Ophthalmol*. 2005;123:14–24. [PubMed]
5. Gallaway M, Scheiman M, Malhotra K. The effectiveness of pencil pushups treatment for convergence insufficiency: A pilot study. *Optom Vis Sci*. 2002;79:265–267. [PubMed]
6. Aziz S, Cleary M, Stewart HK, Weir CR. Are orthoptic exercises an effective treatment for convergence and fusion deficiencies? *Strabismus*. 2006;14:183–189. [PubMed]

7. Rouse MW, Hyman L, Hussein M. The convergence insufficiency and reading study group (CISS). How do you make the diagnosis of convergence insufficiency?. Survey results. *J Optometric Vis*. 1998;28:91–97.
8. Convergence Insufficiency Treatment Trial (CITT) Study Group. Randomized clinical trial of treatments for symptomatic convergence insufficiency in children. *Arch Ophthalmol*. 2008;126:1336–1349. [PMC free article] [PubMed]
9. Jang JU, Park IJ. Prevalence of general binocular dysfunctions among rural schoolchildren in South Korea. *Taiwan J Ophthalmol*. 2015;5:177–181.
10. Daum KM. Convergence insufficiency. *Am J Optom Physiol Opt*. 1984;61:16–22. [PubMed]
11. Rouse MW, Borsting E, Hyman L, Hussein M, Cotter SA, Flynn M, et al. Frequency of convergence insufficiency among fifth and sixth graders. *Optom Vis Sci*. 1999;76:643–649. [PubMed]
12. Porcar E, Martinez PA. Prevalence of general binocular dysfunctions in a population of university students. *Optom Vis Sci*. 1997;74:111–113. [PubMed]
13. Scheiman M, Cotter S, Rouse M, Mitchell GL, Kulp M, Cooper J, et al. Convergence Insufficiency Treatment Trial Study Group. Randomized clinical trial of the effectiveness of base-in prism reading glasses versus placebo reading glasses for symptomatic convergence insufficiency in children. *Br J Ophthalmol*. 2005;89:1318–1323. [PMC free article] [PubMed]
14. Barnhardt C, Cotter SA, Mitchell GL, Scheiman M, Kulp MT. CITT Study Group. Symtomps in children with convergence insufficiency: Before and After Treatment. *Optom Vis Sci*. 2012;89:1512–1520. [PMC free article] [PubMed]
15. Grisham JD. Visual therapy results for convergence insufficiency: A literature review. *Am J Optom Physiol Opt*. 1988;65:448–454. [PubMed]
16. Grisham JD, Bowman MC, Owyang LA, Chan CL. Vergence Orthoptics: Validity and Persistence of the Training Effect. *Optom Vis Sci*. 1991;68:441–451. [PubMed]
17. Pantano F. Orthoptic treatment of convergence insufficiency: A two year follow-up report. *Am Orthoptic J*. 1982;32:73–80.
18. Hennessey D, Losue RA, Rouse MW. Relation of symptoms to accommodative in facility of school-aged children. *Am J Optom Physiol Opt*. 1984;61:177–183. [PubMed]
19. Scheiman M, Kulp MT, Cotter S, Mitchell GL, Gallaway M, Boas M, et al. Vision therapy/orthoptics for symptomatic convergence insufficiency in children: Treatment kinetics. *Optom Vis Sci*. 2010;87:593–603. [PMC free article] [PubMed]