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Original Research Article

Effectiveness of HTS2 computer vision therapy for the treatment of non strabismic binocular vision disorders among young adults

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Abstract

Background: Previous studies reported that non strabismic binocular vision anomalies are mainly associated with near work. These anomalies are mainly associated with symptoms which impact the daily living activities. Therefore, diagnosis and treatment for these conditions is main concern**.**
Aim and Objective: To assess the effect of HTS2 computer vision therapy in young adults with convergence insufficiency (CI) and co-existing accommodative dysfunction.
Materials and Methods: This was a single center, prospective and experimental study. In this study, 25 subjects (age: 18-35 years) with combined (CI) and accommodative excess (n=18) or combined CI and AI (n=7) were diagnosed. Subjects were assigned to HTS2 vision therapy for 4 days per week for a period of one month. After one month of therapy, vergence parameters such as near exophoria, near point of convergence (NPC), near positive fusional vergence (PFV), vergence facility (VF) and accommodative parameters such as amplitude of accommodation (AA), negative relative accommodation (NRA), positive relative accommodation (PRA), monocular accommodative facility (MAF), accommodative response (MEM) and convergence insufficiency symptom survey questionnaire (CISS) scores using CISS V-15 questionnaire were recorded. Data analysis was performed using Wilcoxon Sign Rank Test.
Results: At baseline, there was not statistically difference in mean values of vergence, accommodative parameters and CISS scores**.** After one month of therapy, there was statistically significant difference found in the mean values of vergence, accommodative parameters and CISS scores. ($p < 0.05$).
Conclusion: HTS2 vision therapy is found to be an effective treatment for improving vergence, accommodative function and alleviating the symptoms in the patients with CI and co-existing accommodative dysfunction and is recommended when in-office exercises is not possible.

Keywords: Convergence insufficiency, Accommodative dysfunction, Office-based vision therapy, HTS2.

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1. Introduction

Convergence insufficiency (CI) is a most common neuromuscular disorder of binocular vision mostly characterized by decreased ability to converge the eyes and maintain binocularity while looking at near object leading to high exophoria at near, reduced positive fusional vergence (PFV), fusional facility and increased near point of convergence (NPC), low AC/A ratio, low negative relative accommodation (NRA).[1] Recent studies have reported that CI is mostly associated with accommodative disorders.[2] Prevalence of CI varies from 2.5% to 33%[3,4] and accommodative disorders around 2.3%-20.2% among children and adults globally.[5] A recent study done by Rizwana et al.[6] in South India reported that prevalence of binocular disorders was found to be higher in the age group of 13-17 years (36.2%) as compared to the children 7-12 years old (25.1%). The symptoms associated with these anomalies are eyestrain, headache, poor comprehension, intermittent blurring and diplopia which also affect the quality of life.[7,8] The treatment strategies for non strabismic binocular vision disorders include base-in prism,[9,10] over correcting minus lenses,[11,12] office-based VT (OBVT) or home-based VT.[13-22] Over a period of years, office-based

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exercises are most extensively evaluated.[23-29] However, these exercises are highly expensive, require more office visits and not readily available. In comparison home-based exercises require less office visit, cost effective and are easily available. Computer-based vision therapies can be used at home and the progress can be monitored online. HTS2 is a computer-based eye exercise program which is based on behavioural modification in the subject treatment model. The program uses random dot stereograms and other objective targets.[18] Only a few studies evaluated the efficacy of computer-based vision therapy particularly in children.[10,13,30] Further, no prospective studies on effectiveness of HTS2 VT in young adults with combined CI and accommodative dysfunction in India have been done so far as per our knowledge. Hence, the purpose of this study was to assess the effectiveness of HTS2 vision therapy among young adults with combined CI and accommodative disorders.

2. Aim of Study

Purpose of study was to assess effect of HTS2 vision therapy among young adults with combined CI and accommodative disorders.

3. Objectives of Study

To evaluate vergence, accommodative function & symptoms scores with in HTS2 VT group at Pre and Post intervention

4. Materials and Methods

This prospective, single centre and experimental study was conducted at local tertiary hospital from March 2024 to July 2024. The study was approved by the local human subjects ethical committee. This study followed the tenets of declaration of Helsinki and a written informed consent was obtained from all subjects. 25 Young adults of age group (18-35 years) associated with only combined symptomatic CI and accommodative excess (n=18) or symptomatic CI and AI (n=7), best corrected distance visual acuity 6/6 and near visual acuity N/6, near exophoria greater than 4 D than at the far, increased NPC (Break Point > 6 cm), PFV break < 15 Prism Diopter (PD) at near, VF < 12 cpm, AA ≤ 2 D expected Hofstetter's minimum expected (AA: 15- Age × (1/4), MAF <7 cpm, CISS Scores > 21 points were included. Subjects with history of strabismus, amblyopia, nystagmus or any other binocular disorder, previously treated with VT, refractive/ strabismus surgery, presence of ocular anomaly were excluded.[5-8]

4.1. Examination procedure

At baseline visit, demographic data of all subjects were recorded. A complete examination including best corrected visual acuity, dry refraction and cycloplegic refraction wherever it was needed, anterior and posterior segment examination were performed. In addition to it, standardized binocular vision examination procedure were also conducted as follows.[25-27]

1. Cover test at the distance and near for determining type and amount of phoria using accommodative target of 20/30 size and prism neutralization.
2. Measurement of NPC with push-up technique using a 20/30 accommodative target at 40 cm.
3. Measurement of positive and negative fusional vergence (PFV & NFV) at distance and near using prism bar.
4. Measurement of vergence facility (VF) using vergence flipper 12BO/ 3BI
5. Monocular and binocular accommodative amplitude (AA) with push-up technique.
6. Measurement of monocular and binocular accommodative facility (MAF &BAF) with ± 2 D flipper lens.
7. Measurement of lag of accommodation using monocular estimation method (MEM).
8. Measurement of NRA and PRA. (Lenses were added binocularly in increment of 0.25 D steps until sustained blur was reported).
9. Evaluation of saccade and pursuit function by NSUCO (North-eastern State University College of Optometry) test.
10. A standardized 15 item version of CISS Questionnaire (CISS-V15) (**Figure 1**) was administered in Hindi & English languages to record the symptoms. The patients were asked to choose one of the five possible answers with lowest and highest scores 0 and 4 representing the lowest and highest frequency of occurrence respectively, with 0 representing no symptoms and 4 representing highest symptoms. Symptom score was calculated by sum of answer of 15 items. A symptom score of 21or higher was considered significant.[23]

Convergence Insufficiency Symptom Survey

Name _____ DATE __/__/__

Clinician instructions: Read the following subject instructions and then each item exactly as written. If subject responds with "yes" - please qualify with frequency choices. **Do not give examples.**

Subject instructions: Please answer the following questions about how your eyes feel when reading or doing close work.

		Never	(not very often) Infrequently	Sometimes	Fairly often	Always
1.	Do your eyes feel tired when reading or doing close work?					
2.	Do your eyes feel uncomfortable when reading or doing close work?					
3.	Do you have headaches when reading or doing close work?					
4.	Do you feel sleepy when reading or doing close work?					
5.	Do you lose concentration when reading or doing close work?					
6.	Do you have trouble remembering what you have read?					
7.	Do you have double vision when reading or doing close work?					
8.	Do you see the words move, jump, swim or appear to float on the page when reading or doing close work?					
9.	Do you feel like you read slowly?					
10.	Do your eyes ever hurt when reading or doing close work?					
11.	Do your eyes ever feel sore when reading or doing close work?					
12.	Do you feel a "pulling" feeling around your eyes when reading or doing close work?					
13.	Do you notice the words blurring or coming in and out of focus when reading or doing close work?					
14.	Do you lose your place while reading or doing close work?					
15.	Do you have to re-read the same line of words when reading?					
		__x 0	__x 1	__x 2	__x 3	__x 4

TOTAL SCORE _____

Figure 1: Convergence insufficiency symptom survey questionnaire

4.2. Therapy protocol

25 subjects were assigned HTS2 vision therapy for 4 days/week for a period of one month. The subjects using this program performed fusional convergence, divergence, accommodative and ocular movement therapy by using random dot target and other objective targets. The HTS2 software program was used for 20-25 minutes daily.

4.3. Subjects characteristics

A total of 25 subjects with combined symptomatic CI and accommodative excess or combined CI and AI were recruited in the study and allocated to HTS2 vision therapy. Four subjects were not compliant to therapy and three subjects did not participate in study. Only 18 subjects were analysed after the therapy. (**Figure 2**). There was total 5 males and 20 females. Mean age was 17 ± 1.02.

4.4. Outcome measures and success criteria

Vergence parameters like near exodeviation, NPC, near PFV, VF and accommodative parameters: AA, MAF, BAF, MEM, NRA, PRA and CISS scores were the outcome measures of this study which assessed post one month of therapy. We used the set of criteria to define subjects as "cured" or "improved" on the basis of previous literatures.[23] Subjects who achieved NPC break of ≤ 6 cm, normal PFV measurement 15 PD break or greater on PFV amplitudes at near, VF >12 cpm, expected AA based on Hofstetter's formula, accommodative facility >7 cpm and CISS scores <21 was considered cured. Subjects who achieved the normal values in either of vergence, accommodative parameters and CISS scores were considered improved.

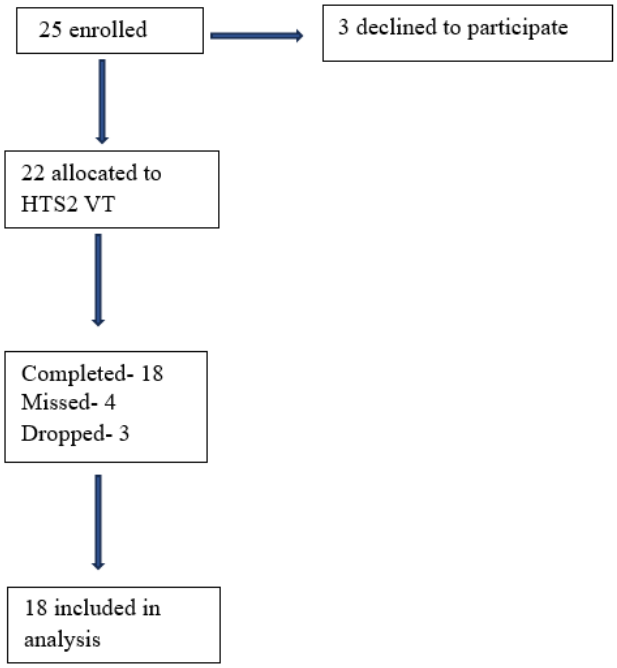

Figure 2: Flow chart of allocation of treatments and analysis of participants

4.5. Data analysis

After the data collection, the data was analysed using SPSS version 30 with confidence interval 95% and 80% power. Normality of data was assessed with Kolmogorov-Smirnov test which showed that data was normally distributed ($p > 0.05$). Wilcoxon sign rank test was used to compare the mean values of vergence and accommodative parameters and CISS scores between baseline visit and post one month of therapy.

5. Results

The mean and standard deviations for vergence parameters, accommodative parameters and CISS score at baseline and post one month of therapy are summarized in **Table 1**.

The mean baseline near exophora, NPC, PFV and VF was 6.29±1.32, 11.57±1.9**,** 11.00±1.0, 5.14±2.1 respectively and mean baseline AA(RE), AA(LE) BAF, MAF, NRA, PRA, MEM was 8.4±1.8, 8.5±1.7, 4.5±0.94, 4.9±1.2, 4.7±1.1, 1.57±0.34, -1.82±1.3, 0.53±1.1, 0.58±1.1 respectively and mean CISS scores was 31.14±4.1. There was no statistically significant difference in mean values of vergence, accommodative parameters and CISS scores at baseline. ($p > 0.05$)

After one month of therapy mean near exophoria improved from 6.29±1.32 to 5.07±0.99, mean NPC from 11.57±1.9 to 6.14±1.8, mean PFV from 11.00±1.0 to 23.29±3.9, 5.14±2.1 to 12.36±1.2 and mean AA in right eye improved from 8.4±1.8 to 9.79±0.6, in left eye from 8.5±1.7 to 10.07±0.4, mean BAF from 4.5±.94 to 10.93±0.99, mean MAF in right eye improved from 4.9±1.2 to 12.29±2.4, in left eye from 4.7±1.1 to 12.86±2.1, mean NRA from 1.57±0.34 to 2.39±0.23, mean PRA from -1.82±1.3 to -2.41±0.15, mean MEM in right eye from 0.53±1.1 to 0.45±1.3, in left eye improved from 0.58±1.1 to 0.43±1.2 and mean CISS improved from 31.14±4.1 to 15.29±6.4.($p<0.05$).

Table 1: Comparison of vergence, accommodative parameters and CISS scores at baseline visit and post VT

Clinical Parameters	At baseline (Mean ± SD)	Post VT (Mean ± SD)	p-value
Near exophoria	6.29±1.32	5.07±0.99	0.04
NPC Break	11.57±1.9	6.14±1.8	<0.01
Near PFV	11.00±1.0	23.29±3.9	<0.01
VF	5.14±2.1	12.36±1.2	<0.01
AA (RE)	8.4±1.8	9.79±0.6	0.01
AA (LE)	8.5±1.7	10.07±0.4	0.01
BAF	4.5±.94	10.93±0.99	<0.01
MAF (RE)	4.9±1.2	12.29±2.4	<0.01
MAF (LE)	4.7±1.1	12.86±2.1	<0.01
NRA	1.57±0.34	2.39±0.23	<0.01
PRA	-1.82±1.3	-2.41±0.15	0.05
MEM (RE)	0.53±1.1	0.45±1.3	<0.01
MEM (LE)	0.58±1.1	0.43±1.2	<0.01
CISS scores	31.14±4.1	15.29±6.4	<0.01

There was significant difference found in vergence, accommodative and CISS scores after one month of therapy. ($p<0.05$)

5.1. Success criteria

After one month of therapy, out of 18 subjects, 15 (60%) achieved cured criteria and 2 subjects (40%) were in improved criteria. Only 1 subject did not show any improvement in vergence, accommodative parameters and CISS scores. (**Table 2**)

Table 2: The success criteria at the end of the 1 month of therapy

Success Criteria Achieved	No. of Subjects
Cured	15 (60%)
Improved	2(40%)
Failed	1(10%)

6. Discussion

Convergence insufficiency is inability to maintain eye coordination during near task and is characterized by high exophoria at near, decreased positive fusional convergence amplitude (PFV), reduced fusional facility and decreased near point of convergence (NPC), low AC/A ratio, low

negative relative accommodation (NRA) and Low monocular estimation method (MEM) are the signs of CI.[2-5]

Patient with CI tend to suffer from following symptoms: eyestrain, headache, intermittent blur, intermittent diplopia, poor comprehension, difficulty in maintaining concentration.[6,7] However, some patient with CI might be asymptomatic due to suppression of eye, high discomfort threshold, avoidance of near work or covering of one eye at near.[8] Symptoms reported in patients with accommodative dysfunction are blurred vision, headache, intermittent blurring, difficulty in maintaining the concentration during near activities and difficulty in changing focus from near to distance or distance to near.[9]

Comparison of therapy at baseline and post one month of therapy is shown in **Table 1**. In this experimental study, the results obtained statistically and clinically in the means of vergence, accommodative parameters and CISS scores at baseline and post one month of VT for HTS2 vision therapy were found significant. ($p<0.05$)

In our study, HTS2 proved to be effective in treating combined CI and accommodative disorders as 60% subjects showed successful outcome. This compared the data in study done by Cooper in which 40% subjects were cured.[18]

6.1. Comparison of present study with previous studies with respect to number of patients achieved success criteria at end of vision therapy

We also compared our study with previous studies with respect to number of patients achieved success criteria at end of vision therapy, the improvement in symptoms was much larger than reported in previous studies. In our study, HTS2 treatment showed a cure rate of 80%, and the improvement rate of 26%. We compared the data with CITT study in which 49% were cured, and improved rate was 73%, Cooper and Feldman study in which cure rate was 40% and improved rate was 55% and Shin HS, Park SC & Maples WC in which cure rate was 60% and improved rate was 77%. In our study, HTS2 treatment showed a cure rate of 80%, and the improvement rate of 26% **(Table 3).**

Table 3: Comparison of present study with previous studies with respect to no. of patients achieved success criteria at end of vision therapy

Study	Treatment Group	Cured	Improved
CITT Clinical Trial[25]	HTS2+ Pencil Push up Office-Based VT	17% 49%	38% 73%
Cooper and Feldman[13]	HTS2	40%	55%
Shin HS, Park SC & Maples WC[30]	HTS2	60%	77%
Current Study	HTS2	80%	26%

6.2. Comparison of present study with previous studies with respect to number of sessions in achieving PFV criteria

In this study, comparison was also made between studies with respect to number of sessions achieved normal PFV criteria. Skjöld G, Lewis P. reported that average number of session 67 required to achieve training goals. In study of Cooper and Feldman,[13] maximum no. of patients achieved normal positive fusional vergence amplitude by 14 sessions. In our study, maximum no. of patients achieved positive fusional vergence by 8 sessions.

Although standardized diagnostic and treatment procedures were used in our study but there are limitations also to this study such as small sample size, no masking and no control or placebo group.

7. Conclusion

There are various treatments for non strabismic binocular vision anomalies of which the traditional VT is extensively evaluated and is considered as most preferred treatment. However, it is not always practical as it is time consuming (45-60 min.), require more office visits (12 to 24 or more), expensive (1 session cost: INR 500 approx.) and not availability of equipment readily in India. Moreover, less compliances rate is associated with traditional based vision therapy.

The software-based VT as compared to the traditional VT can be a popular choice of treatment due to its easy accessibility and financial constraints and can also be used for home-based VT which require less office visits.

In conclusion, HTS2 vision therapy was found to be an effective treatment for improving vergence, accommodative function and reducing the symptoms scores in patients with CI and co-existing accommodative dysfunction. It may also be used as a first line of treatment or additional treatment with traditional based exercises in the young adults diagnosed with non strabismic binocular vision disorders.

8. Future Recommendations

The foremost shortcoming of home-based VT can be such as the subject's procrastination, making excuses and getting tired at times leading to the break in exercise there by resulting in flawed results.

More randomized clinical trials with longer follow-up and large sample size should be conducted to validate the results of the study.

9. Source of Funding

None.

10. Conflict of Interest

None.

11. Ethical Approval

Ethical No.: IHEC/DHR/CU/PB/23/199.

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