Article • CISS Symptom Score Change After Vision Therapy Using HTS2 in a Cohort of Swedish Patients

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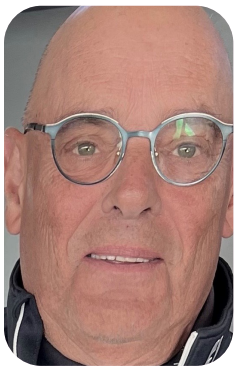

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ABSTRACT

Background: Binocular vision problems have been shown to be successfully treatable using tailored therapy. The purpose of this study was to investigate the effect of therapy with the HTS2 computer-based therapy program on symptoms and the number of therapy sessions required to achieve the therapy goals.

Method: The effect of vision therapy for binocular dysfunctions was determined with the CISS questionnaire. The number of training sessions required to complete the therapy was recorded for each patient.

Results: For patients who completed the therapy, a significant improvement in CISS symptom scores ($p<0.0001$) was achieved. An average of 67.7 training sessions, over a period of approximately three months, was needed to achieve the training goals.

Conclusions: The study confirms that HTS2 is effective in relieving symptoms in patients with binocular vision dysfunctions. Therapy needs to be continued for a period of approximately three months to achieve the therapy goals.

Keywords: binocular vision, binocular vision therapy, CISS, HTS2

Introduction

Binocular vision dysfunction is common. The prevalence of different types of binocular vision dysfunctions has been reported to be high. In a clinical trial of 1679 subjects aged 18-38 years, a prevalence of 34.4% for accommodative dysfunction and 21.7% for vergence dysfunction was reported.[1] A study of fifth and sixth graders reported a prevalence of highly suspected and definitive convergence insufficiency of 12.8%.[2] A retrospective study of 415 patients aged 8-12 years reported a prevalence for highly suspected and definitive convergence insufficiency of 17.6%.[3] In a study of the prevalence of vision and ocular disease conditions in a clinical pediatric population, aged 6 months to 18 years, a prevalence of 9.5% for accommodative dysfunction and 20.4% for vergence dysfunction was reported.[4] Patients are most likely to visit their optometrist to examine the cause of symptoms affecting their vision. A recent Swedish study showed a high incidence of findings associated with common binocular vision dysfunction in patients examined by optometrists, such as abnormal NPC, accommodative and vergence facility, and fusional ranges.[5]

Symptoms related to binocular vision problems can be graded using various methods. One example is the Convergence Insufficiency Symptom Survey (CISS) questionnaire, which is often used to grade vision-related problems associated with near work. The questionnaire was developed for and used in the Convergence Insufficiency Treatment Trial (CITT) to measure the type and frequency of symptoms, and as an outcome measure following treatment, in patients with convergence insufficiency.[6] The CISS questionnaire has been evaluated for use in both children and adults.[7,8]

Binocular vision problems have been shown to be successfully treatable using tailored therapy

programmes.[9] Traditional methods, including simple exercises such as "pen-to-the-nose" push-ups, Brock string, and Hart charts, as well as more advanced methods like Tranaglyphs, can be implemented. When using these methods, the patient is either trained in-office, given exercises to be performed at home, or a combination of both. The CITT study showed that in-office treatment was significantly more successful than home-based therapy. One obvious disadvantage of home-based therapy is that compliance becomes more difficult to control due to difficulties in monitoring therapy sessions and/or the results of the therapy.

Over the past twenty years, computer-based vision therapy systems have been developed, including systems that can be used online via the Internet. One such system is HTS (Home Therapy System), which was relaunched as an online vision therapy program at the end of 2019 and allows a practitioner to follow a patient's progress remotely. The effectiveness of computer-based home binocular vision therapy has previously been demonstrated,[10,11] and these systems allow for more flexible therapy programs and the ability to monitor patients closely.

Treatment with HTS is indicated when in-office treatment is not possible and is well documented as an effective method for the treatment of binocular vision problems.[12-18] HTS therapy is conducted at home by the patient, and their progress is monitored remotely by the doctor via an online clinical platform. HTS runs on common browsers and can be used on PC, Mac, or tablet with landscape format and a minimum screen width of 7.5 inches. HTS is designed to provide lasting therapy results through a standardized therapy protocol, with therapy procedures that have defined therapy goals.[19]

HTS includes several procedures for training of binocular vision functions. The procedures included in HTS are presented in a specified order; these are described in more detail in the Methods section below. The difficulty level increases depending on the performance and progress of the patient. As a training incentive, "stars" are awarded as the therapy goals are achieved. Once a patient has received all of the stars for a given procedure, this is automatically removed from the daily protocol and replaced with a more difficult procedure.

The purpose of this study was to investigate the effect of therapy with HTS2 (the version used in this study) on symptoms, as measured with the CISS questionnaire, and to investigate the number of therapy sessions required to achieve the therapy goals. The purpose was not to compare HTS2 to other types of therapy for binocular vision dysfunction.

Methods

Five experienced optometrists working actively with HTS2 in Sweden were invited to participate in the study during the period of January 1 to May 31, 2021. They were requested to identify and to recruit any symptomatic patient, regardless of age, with binocular vision dysfunction of any kind, that they decided could be treated with HTS2. There were no requirements to follow a specified protocol. Each optometrist followed the protocol that they normally used in practice. It was up to the discretion of each optometrist to decide whether the patient was eligible for therapy with HTS2. It was not the purpose of this study to influence the clinician's decision making.

To assess patient symptoms, a translated Swedish version of the Convergence Insufficiency Symptom Survey (CISS) was used. The CISS questionnaire consists of 15 questions, which should be answered with either "Never" (0 points), "Rarely" (1 point), "Sometimes" (2 points), "Often" (3 points), or "Always" (4 points). The question scores are totaled, resulting in a possible CISS score of between 0 and 60. The patient's score is compared with an age-dependent maximum value, which is indicative of significant symptoms. The significant CISS score limit used in this study was as follows: for <19 years, 16 points or more, and for >18 years, 21 points or more. Patients for whom binocular vision dysfunction was identified, and where symptoms were deemed significant according to the CISS score limit values, were included in the study.

For each patient treated with HTS2, CISS scores were obtained on two occasions: 1) prior to commencement of treatment and 2) following completion or termination of treatment. In addition, the number of therapy sessions performed was recorded, as well as whether the patient had participated until prescribed therapy goals were met (i.e., all of the stars for each procedure had been attained).

Red/blue filter glasses were provided as part of the patient training kit. A flipper set containing three flippers, which allowed for six varying levels of difficulty in accommodative exercises, was also used when required during therapy sessions.

Google Forms was used by the participating optometrists to report results at the completion of therapy. Patient details remained anonymous; name, age, gender, or other information that could be linked to them was not recorded.

GraphPad Prism 9 was used for statistical analysis. The Kolmogorov-Smirnov test was used to assess normality, and the non-parametric one-tailed Wilcoxon matched-pairs signed rank test, with an α level of 0.05, was used to test for any significant improvement in CISS scores following therapy.

The procedures included in HTS2 and prescribed during this study are described below.

- Pursuit involves training the ability of the eyes to follow a fixed object. Pursuit is trained 3 minutes daily until the training goals are achieved. The goal of pursuit is increasing difficulty until 80% correct responses with an average response time of 950 ms is obtained.
- Saccadic involves training the ability of the eyes to coordinate fixation changes from one object to another. Saccadic is trained 3 minutes daily until the training goals are achieved. The goal of saccadic is increasing difficulty until 80% correct responses with an average response time of 950 ms is obtained.
- Divergence involves training coordinated eye movements where the eyes are forced to diverge. Divergence is trained daily for 7 minutes until the training goals are achieved. The goal for divergence is increasing divergence until >13 prism diopters base in is achieved.
- Convergence involves training coordinated eye movements where the eyes are forced to converge. Convergence is trained daily for 7 minutes until the training goals are achieved. The goal for convergence is increasing convergence until >35 prism diopters base out is achieved.
- Jump Duction involves training with alternating divergence and convergence. In order for the procedure to be presented, both divergence and convergence must be fully completed; i.e., all stars have been achieved for both. Jump Duction is trained 7 minutes daily until the training goals are achieved. The goals of Jump Duction are >13 prism diopters base in and >35 prism diopters base out.
- Jump Random involves training with random divergence and convergence. For the procedure to be presented, all of the stars for Jump Duction must be achieved. Jump Random is trained daily for 7 minutes until the training goals are achieved. The goal of Jump Random is increasing difficulty until >80% accurate responses for both divergence and convergence have been achieved.
- Accommodative Rock involves training functions to stimulate and to maintain focus and is trained 5 minutes daily until the training goals are achieved. The exercise is carried out with a flipper of increasing difficulty level, which is held in the left hand. The goal of accommodative rock is to complete the exercise with flipper level 6.

The daily therapy program with HTS2 is called Today's Assignment. It presents the patient with the exercises to be performed, as well as the duration of each exercise. At the beginning of therapy, the patient starts the exercises, which are then automatically presented in the order shown above. As the Jump Duction procedure requires both divergence and convergence goals to be attained, the daily assignment may contain only one of these until it is completed, after which Jump Duction is presented. Similarly, Jump Random requires Jump Duction to be completed in order to be presented. The treatment goals for the prescribed procedures listed above are that they shall be continued until all stars have been achieved. Each procedure is performed for the duration specified in HTS, 3-7 minutes for the procedures that are included.

A typical daily session, including the accommodative component, lasts 25 minutes. The daily training program can be modified after an initial assessment by the prescribing clinician, if necessary. In most cases, no modification is required, but one can choose to exclude one or more steps from the daily program or to keep one procedure in the daily assignment despite all stars being attained for the given procedure. This study did not impose any specific requirements regarding any of these modifications; these were decided on an individual case basis by each clinician, respectively.

HTS2 includes a standard 100 therapy sessions at the commencement of therapy. The clinician can follow the number of therapy sessions used/remaining for each patient. The number of therapy sessions used equals 100 minus the number shown in the clinician software.

Results

Nineteen patients started therapy with HTS2. Of these, 17 completed the therapy until all therapy

Table 1. Descriptive Statistics for CISS Scores Before (CISS Pre) and After (CISS Post) Therapy and Change in CISS Score (CISS Change)

	CISS Pre	CISS Post	CISS Change
Number of values	17	17	17
Minimum	17.0	0.0	-40.0
Median	26.0	16.0	-13.0
Maximum	54.0	30.0	7.0
Mean	29.4	15.2	-14.2
Std. Deviation	10.0	7.2	12.2
Std. Error of Mean	2.4	1.7	3.0
Lower 95% CI	24.3	11.5	-20.5
Upper 95% CI	34.6	18.9	-7.9
Skewness	1.14	-0.03	
Kurtosis	0.88	0.67	

goals were achieved (Tables 1 & 2). Two patients did not complete the full therapy plan with HTS2. Sixteen of the 17 patients completed all therapy procedures, including accommodative procedures. One of the 17 patients completed all procedures except the accommodative procedures, after a decision by the optometrist. Two patients did not complete the full therapy plan with HTS2. Nevertheless, one of those saw an improvement in their CISS score from 16 points to 10 points. A possible reason for this could have been that the symptoms were reduced to a level where the patient felt no reason to continue the treatment. The second patient discontinued therapy after 2 weeks. Results from these two patients were not included in further analysis, and the reasons for discontinuation were not disclosed in the two cases.

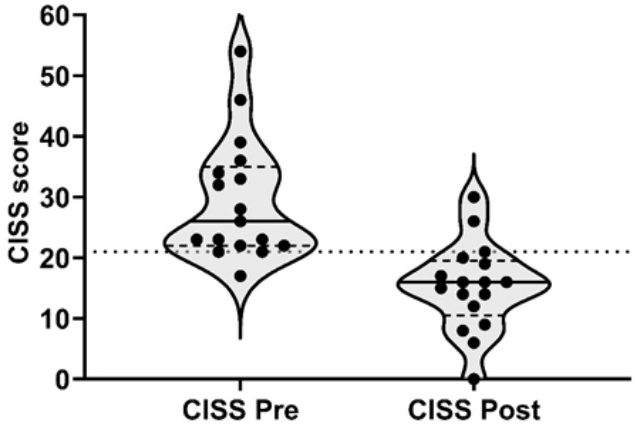

Figure 1. Violin plots showing distribution of CISS scores before (CISS Pre) and after (CISS Post) therapy. The horizontal dashed line at 21 points indicates the cut-off for significant symptomatic CISS scores for patients 19 and older. The solid line within the violin plot represents the median CISS score, and dashed lines, the upper and lower quartiles for the group as a whole.

Table 2. Individual CISS Scores, Change in CISS Score after Completed Therapy, and Number of Therapy Sessions Required to Achieve all HTS2 Therapy Goals (Results are arranged from largest to smallest changes in CISS scores; negative values represent a deterioration.)

Patient	CISS Pre	CISS Post	CISS Change	Sessions Performed
1	54	14	40	60
2	32	0	32	72
3	46	17	29	38
4	36	9	27	83
5	26	8	18	58
6	22	6	16	47
7	34	19	15	61
8	33	20	13	68
9	39	26	13	70
10	28	15	13	58
11	23	12	11	100
12	22	14	8	92
13	21	16	5	43
14	21	16	5	56
15	23	21	2	100
16	17	16	1	92
17	23	30	-7	53
Avg.	29.4	15.2	14.2	67.7

A Kolmogorov-Smirnov-test showed that the CISS scores were not normally distributed (p=0.0448) prior to commencement of therapy (CISS Pre); however, they had become normally distributed (p>0.1) after completed therapy (CISS Post). These changes can be visualized in the violin plots shown in Figures 1 and 2.

Prior to starting therapy with HTS2, the average CISS score for these 17 patients was 29.4 points (range 17 to 54). After completing therapy with HTS2, the average CISS score for these patients was 15.2 points (range 0 to 30). The average improvement

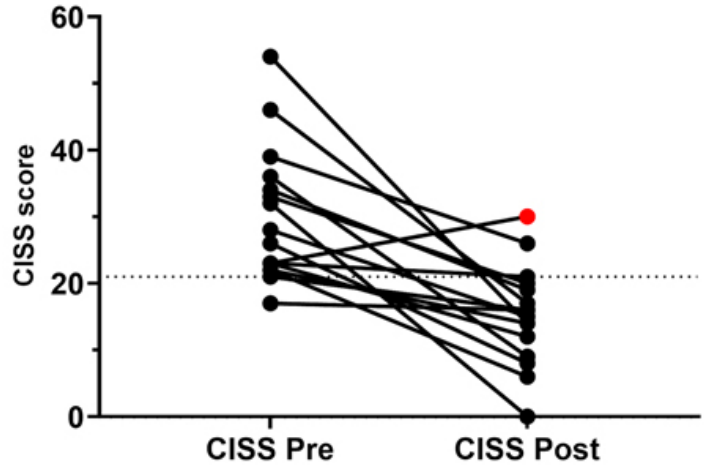

Figure 2. Individual CISS scores before (CISS Pre) and after therapy (CISS Post). The red data point indicates an increase in CISS score following therapy.

in CISS score was 14.2 points (range +7 to -40). The improvement in CISS scores was significant (Wilcoxon matched pairs signed rank test). Twelve of the 17 patients achieved an improvement in CISS scores of 8 points or more.

An average of 67.7 (range 43 to 100) therapy sessions, corresponding to 13.5 weeks of therapy (range 8.6 to 20), with 5 training sessions per week was used to achieve all HTS therapy goals (Table 2).

Discussion

To achieve significant results with HTS2, it is important that therapy is continued until all HTS therapy goals have been achieved.[17] The results of this study show a significant reduction in symptoms as measured with the CISS questionnaire in the majority of those treated with HTS2.

The CITT study compared the efficacy of 12 weeks of different treatment regimens for convergence insufficiency and found that in-office treatment was significantly more successful than home-based therapy. The results of this small study reflect results in cases where it was decided to prescribe home vision therapy with HTS2 and cannot be compared with the results of the CITT study that included a significantly higher number of patients. The average change of -15.2 points in CISS scores was greater in those treated than the results reported for home-based therapy (-6.0 points) and comparable to the results for office-based therapy (-14.8 points) in the CITT study.[19] This may be due to the design of HTS2, where the patient is usually treated with a combination of training of eye movements, vergences, and accommodation, and that treatment is monitored remotely, thus providing opportunities for greater compliance. HTS2 therapy in this study was ongoing until all therapy goals were achieved, on average for 13.5 weeks, compared with the therapy period of 12 weeks for patients in the CITT. The results thus suggest that HTS2 can be an effective tool for home treatment of binocular vision dysfunctions and that therapy needs to continue for approximately 3 months to fulfill all HTS training goals. This average training period resulted in a significant self-reported improvement in symptoms according to results on the CISS questionnaire.

This study only addresses subjective experiences of completed binocular vision therapy with HTS2, graded with the CISS questionnaire. As such, questions may be perceived differently by the respondents. One of the patients who completed the therapy reported a subjective improvement in reading ability but nevertheless had an increase in CISS score from 23 points to 30 points; both scores are above the expected level. One reason for this could be a difference in the avoidance of near vision tasks pre- and post-treatment with HTS2. It could also indicate that the questions in the CISS form were perceived differently at the follow-up. However, since only totals have been reported by the individual investigators, it is impossible to determine the exact cause. In order to ascertain objective changes in the binocular vision functions, the collection of data covering specific aspects of binocular visual function, such as phorias, vergences, and accommodative function, is required. As this study did not collect this data from the individual clinicians, it is not possible to provide answers to objective changes and how these affect therapy outcomes. This is a limitation to the study, since it was not possible to evaluate diagnoses made in each case. Another limitation is that this study did not include a control group for comparison.

Conclusion

The study confirms that when binocular vision dysfunction is treated with HTS2, significant symptom improvement can be achieved and that therapy will have to be continued for approximately three months to attain all the HTS2 therapy goals.

Declaration of conflict of interest

Göran Skjöld is the distributor of the HTS2 computer program in Sweden, Denmark, and Finland via the company HB Sekon. HTS2 is used at Linnaeus University for patients seen by students both at Bachelor- and Master-level courses.

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