Article ▸ Binocular Measurements in a Nonselected Group of Non-strabismic Patients 8-35 Years Old, in Sweden

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ABSTRACT

Background: To investigate binocular findings in a nonselected group of patients examined in optometric practice, and in this group to analyze the frequency of meeting the criteria for convergence and accommodative insufficiency.

Methods: In this national multi center study, 159 patients that voluntarily made appointments for visual examination and were found to meet the inclusion criteria, were examined following a specified protocol that included answering a questionnaire, a series of tests with the habitual correction, followed by refraction and specified sequence of binocular measurements.

Results: Mean values and standard deviation for all measurements were compared with expected values according to commonly used optometric norms. The binocular findings closely followed Morgans norms of expected values. The frequency of meeting the criteria for convergence insufficiency and accommodative insufficiency was analyzed for the total group and for three age groups. For convergence insufficiency the frequency was 9.4% for the total group (n=159), 11.9% for 8-15 years of age (n=42), 6.6% for 16-25 years of age (n=61) and 10.0% for 26-35 years of age (n=56). For accommodative insufficiency the frequency was 17.6% in the total group (n=159), 50.0% for 8-15 years of age (n=42), 9.0% for 16-25 years of age (n=61) and 2.0% for 26-35 years of age (n=56).

Conclusion: The frequency of meeting the criteria for primary convergence insufficiency and accommodative insufficiency was found to be high in the examined population, compared to other studies. For patients 8-15 years of age, positive relative convergence for near (40cm), negative relative accommodation and accommodative amplitude were below expected values and the criteria for accommodative insufficiency was significantly more met in the group ($p<0.001$).

Keywords: accommodative insufficiency, binocular vision, convergence insufficiency

Introduction

It is estimated that the majority of primary examinations of eyes and vision in Sweden are performed by optometrists.[1] The symptoms of visual problems may be due to different causes, including deficiencies in binocular vision. The Convergence Insufficiency Treatment Trial (2005) evaluated symptoms in children with convergence insufficiency before and after different regiments of treatment. Several international studies[2-6] describe the prevalence of binocular vision dysfunction. In these studies, that use different criteria for convergence and accommodative insufficiency, the reported prevalence of convergence insufficiency and accommodative insufficiency reported are in the range 3.6%-6.0% and 2.4%-15.0% respectively when comparing similar criteria for the diagnoses respectively.

One of the studies,[2] found the prevalence of convergence and accommodative insufficiency were the most common, with 5.% and 11.4% respectively. Another study[3] looked at convergence insufficiency in 5th and 6th graders, and found that when using criteria for definitive convergence insufficiency (at least 3 of 4 signs being present), 4.2% were defined as having convergence insufficiency and that among them, accommodative insufficiency was present in a majority of them (78.9%). In a study[4] that looked at clinically significant convergence insufficiency in patients 8-12 years of age, the prevalence for convergence insufficiency was 17.6%. Association between symptoms and convergence insufficiency and accommodative insufficiency in children 8-15 years of age was analyzed in one study[5] and in this study convergence insufficiency and accommodative insufficiency was 4.6% and 10.5% respectively and it was found that both diagnoses are associated with increasing symptoms. One study[6] examined the frequency of convergence and accommodative insufficiency in a group of patients with a mean age of 21.3 years, but the range of age was not reported in the study. In the study, the frequencies for convergence and accommodative insufficiency was 3.6% and 2.4% respectively.

In the Nordic countries there are, to our knowledge, no reports based on a comprehensive optometric examination. However, in Sweden, there is one study[7] of some binocular findings in patients with dyslexia compared to a control group.

Another Swedish study[8] described orthoptic findings and asthenopia in a group of 260 school children aged 6-16 years.

Since previous studies indicate that binocular problems are common, and since optometry is a primary health care profession, it is important for the optometrist to follow procedures that includes a protocol that identifies, among other things, binocular vision problems and to correctly manage them.

In Sweden, evaluation of binocular status is often not included in the standard procedure (anecdotal information). No Swedish study on the importance of a comprehensive examination including binocular tests in the normal examination routine exists.

The purpose of this study was to investigate binocular vision findings in a group of patients 8-35 years in age. The subjects voluntarily made appointments for visual exams using a protocol often used in normal clinical practice to specifically analyze the frequency of convergence and accommodative insufficiency. The goal is to highlight the importance of including tests for and examinations of binocular vision in the standard optometric examination procedure.

Methods

A group of experienced optometrists in Sweden were invited to participate in examining patients 8-35 years old, beginning at the end of September 2014 until the end of December 2014. The practitioners where presented a detailed protocol, as described later, that had to be followed, before they decided if they wanted to participate in the study. The optometrists where not informed that signs of convergence and accommodative insufficiency was to be examined, only that they had to follow the inclusion criteria, and to follow the examination protocol. Optometrists at eight different sites agreed to participate in the study. The examinations made by each optometrist were performed on consecutive patients, not excluded according to the exclusion criteria. The patients included should have voluntarily contacted the optometrist for a regular optometric examination. No specific selection other than specified in the exclusion criteria, was made. All patients, including first-time visits and follow-up visits, scheduled for examination starting at the end of September 2014. No patient was asked to participate before they had made an appointment. Patients were included until the end of December 2014. Each optometrist examined the patients following the detailed protocol, and in the specified order.

Inclusion criteria:

- Patients 8 – 35 years of age, that voluntarily had made an appointment for a visual exam

Exclusion criteria:

- Patients under 8 years of age or over 35 years of age
- Any suspected underlying pathological condition
- History of treated strabismus, including patching and surgery
- Corrected visual acuity below 20/25 in either eye
- Lack of binocular vision
- Suppression of either eye
- Any manifest strabismus including microtropia
- Inability to participate in examinations using a phoroptor
- Medication that may affect binocular vision

Each participating examiner was responsible for deciding if the patient should be included in the study, keeping the exclusion criteria in mind, and that the specified protocol was followed.

Abbreviations used:

CI	Convergence Insufficiency
AI	Accommodative Insufficiency
CISS	Convergence Insufficiency Symptom Survey
CITT	Convergence Insufficiency Treatment Trial
NPC	Near Point of Convergence
BAF	Binocular Accommodative Facility
MAF	Monocular Accommodative Facility
OD/OS	Right Eye / Left Eye
CPM	Cycles Per Minute
NRC	Negative Relative Convergence
PRC	Positive Relative Convergence
NRA	Negative Relative Accommodation
PRA	Positive Relative Accommodation
AC/A	Accommodative Convergence/ Accommodation ratio
Sheard	Sheards criterion

Examination protocol

Prior to being examined, each patient was asked to answer a questionnaire. The questionnaire used in this study, is the same type of questionnaire used in the study "Convergence Insufficiency Treatment Trial, 2005"[9] . The questionnaire (CISS, Convergence Insufficiency Symptom Score) has 15 questions to be answered with No (0p), Rarely (1p), Sometimes (2p), Often (3p) or Always (4p). The sum of all questions was noted.

Nearpoint of convergence was examined with the habitual correction, with a small (accommodative) object that was slowly moved toward the nose until diplopia was noted by the patient or when the examiner could observe divergence of one eye. Immediately after this, the object was slowly moved outward until it could again be seen as one. The number of cm for break and recovery was noted.

Accommodative facility was examined with the patient's habitual correction, first binocularly (BAF) and thereafter monocularly (MAF). In both cases with a flipper of +2.00D/-2.00D was used for testing. The patient was asked to focus on a text corresponding to font size 6 at 40cm. The flipper was held in the right hand starting with the plus lenses in front of the eyes. Immediately when the patient could see the text clearly,

Table 1. Examined population. All and per age group.

	All (n=159) Mean (±Std-Dev)	8-15 yrs (n=42) Mean (±Std Dev)	16-25 yrs (n=61) Mean (±Std Dev)	26-35 yrs (n=56) Mean (±Std Dev)
Age	21.5±7.7	11.4±2.2	20.7±2.8	30.0±2.7
Female	22.2±7.7	11.8±2.3	20.8±2.4	30.1±2.8
Male	20.8±7.7	11.0±2.1	20.6±3.2	30.0±2.6

the flipper was turned so the minus lenses were in front of the eyes. Again, when the text was clear, the flipper was turned. The test was carried out for 1 minute. MAF was examined in a similar manner with only the left eye closed when MAF right eye was examined and thereafter, with only the right eye closed, when MAF left eye was investigated. The number of cycles per minute (CPM) was noted for BAF, MAF OD and MAF OS. 1 cycle equals 2 turns.

Convergence/vergence facility was examined with the patient's habitual correction, with a flipper with 12 prism diopters base out/ and 3 prism diopters base in. The patient was asked to focus on a small accommodative object at 40cm. The flipper was held in right hand starting with 3 prism diopters base in in front of the eyes. As soon as the object could be seen single, the flipper was turned to the side with 12 prism diopters base out in front of the eyes. Again, when the object could be seen single the flipper was turned. This was repeated for 1 minute. The number of cycles per minute (CPM) was noted. 1 cycle equals 2 turns.

Subjective refraction at 6m was determined using fogging technique, to reach the end point using the principle of maximum plus for maximum visual acuity. The result was noted as sphere, cylinder, axis and the best visual acuity was noted for each eye.

Measurement of phorias was performed using the von Graefe method for distance (6m) and near (40cm). Horizontal measurements were performed introducing 6 prism diopters base up in front of the right eye (OD) to create vertical diplopia. 12 prism diopters base in was then introduced in front of the left eye (OS), to move the images apart. The object used was a vertical line of single letters when measuring horizontally, and a horizontal line of letters when measuring vertically. The amount of prism in front of the left eye (OS) was reduced until the first time the lines were above each other (measuring horizontally) or at the same height (measuring vertically). Measurements were performed with the subjective distance correction both for distance (6m) and for near (40cm). The result was noted in prism diopters. Vertical measurements were noted in prism diopters base down and for which eye it was measured.

Negative relative convergence (NRC) and positive relative convergence (PRC) was measured for distance (6m) and for near (40cm). Smooth vergence was measured, using Risley prisms in front of both eyes. The object used was a vertical line of single letters. Measurements were performed with the subjective distance correction both for distance (6m) and for near (40cm). When NRC was measured, prism base in was slowly increased until first blurring of the letters, and then increased further until diplopia occurred. After this the amount of prism was slowly reduced until the object again was seen single. The total amount of prism (OD+OS) was noted for each result. Conversely when PRC was measured, but with prism base out. The total amount of prism (OD+OS) was noted for each result.

Negative relative accommodation (NRA) and positive relative accommodation (PRA) was measured for near (40cm). The object used was text corresponding to a visual acuity for near of 0.8 (20/25 or 6/7.5). When NRA was measured, plus was added binocularly to the subjective distance correction until first blurring of the text. The amount of diopters added was noted. When PRA was measured, minus lenses were added binocularly to the subjective distance correction until first blurring of the text. The amount of diopters added was noted.

Accommodative amplitude was measured in the phoroptor, using the subjective distance correction, first monocularly, then binocularly. The object used was text corresponding to a visual acuity for near of 0.8 (20/25 or 6/7.5). The text was moved closer until first blurring of the text. If needed, when the accommodative amplitude was high, -3.00 diopters was first added in front of each eye before the measurement. The amount in diopters was noted as accommodative amplitude.

Analysis

The refractive status for OD and OS was calculated as spherical equivalent, as the sum of the spherical component and 50% of the measured cylinder. To determine the refractive status of the patients, the result in the eye with the highest numerical value was noted and the patient was classified as being hyperopic, myopic or emmetropic. An equivalent spherical error of zero was noted as emmetropia, even if the eye was astigmatic.

The amount of astigmatism in the eye with highest value was noted. (Table 1) All findings were compared with expected values. Expected values used were Morgans norm values.[10,11] Findings not specified in Morgans normative values, were compared with normative values as specified in Table 2.

Phoria was evaluated for distance (6m) and for near (40cm) using Sheards criterion, stating that the opposite relative vergence must be at least twice the phoria, for the phoria to be considered compensated. The blur point was used if it was noted or reported, if not, the break point was used (Table 3). Results of measurements of phoria hyper at distance (6m) and at near (40cm) are not included in this table since the findings were not significantly outside expected values.

The AC/A was calculated as the total amount of prism diopters converged from distance to a viewing distance measured from the rotational center of the eye to 40 cm from the spectacle plane, divided by the assumed amount of accommodative effort for the same distance. An interpupillary

Table 2. Findings total population and per age group.

	Expected >12 years (8-12 years)	All (n=159) Mean (±Std Dev)	8-15 yrs (n=42) Mean (±Std Dev)	16-25 yrs (n=61) Mean (±Std Dev)	26-35 yrs (n=56) Mean (±Std Dev)
CISS Score	<21	15.8±10.1	18.5±10.4	12.8±9.2	17.1±10.1
NPC Break	5±2.5	6.1±3.8	7.5±4.5	5.2±2.9	5.9±3.7
BAF	10.0±5.0 (5.0±2.5)	7.9±4.1	6.6±4.2	9.1±3.7	7.6±4.1
MAF OD	11.0±5.0 (7.0±2.5)	9.1±4.4	7.8±4.2	10.3±3.8	8.8±4.8
MAF OS	11.0±5.0 (7.0±2.5)	9.0±4.7	7.8±4.6	10.6±4.0	8.0±5.1
Vergence facility	15.0±3.0	11.7±5.2	9.9±6.0	13.1±4.8	11.7±4.5
Phoria 6m horisontally	1.0±2.0	0.2±2.9	0.8±2.4	0.0±2.4	-0.1±3.6
Phoria 6m hyper	0±0.50	0.1±0.3	0.1±0.3	0.1±0.3	0.1±0.4
NRC 6m Break	7.0±3.0	9.3±3.5	9.5±4.4	9.6±3.0	8.9±3.3
NRC 6m Recover	4.0±2.0	6.0±3.5	6.0±4.0	6.3±3.1	5.8±3.5
PRC 6m Blur	9.0±4.0	11.7±5.9	9.9±4.9	12.2±5.6	12.7±6.9
PRC 6m Break	19.0±8.0	17.8±8.5	16.3±8.1	19.0±7.3	17.8±9.8
PRC 6m Recover	10.0±4.0	10.1±7.2	9.3±7.3	10.9±5.4	10.0±8.8
Phoria 40cm horizontally	3.0±3.0	2.0±6.1	3.0±5.7	1.0±5.1	2.3±7.4
Phoria 40cm hyper	0±0.50	0.1±0.4	0.1±0.3	0.1±0.3	0.1±0.3
NRC 40cm Blur	13.0±4.0	12.5±4.4	12.3±5.4	12.6±4.1	12.5±4.2
NRC 40cm Break	21.0±4.0	18.1±5.1	16.9±5.5	18.0±4.6	19.3±5.1
NRC 40cm Recover	13.0±5.0	13.0±5.0	12.1±4.9	12.6±4.6	14.1±5.0
PRC 40cm Blur	17.0±5.0	16.2±7.6	11.8±6.7	17.4±6.3	19.3±7.7
PRC 40cm Break	21.0±6.0	21.0±8.0	16.8±7.3	23.0±7.0	21.8±8.5
PRC 40cm Recover	11.0±7.0	12.1±7.3	8.7±5.2	13.7±6.5	13.0±8.7
NRA	2.0±0.50	2.1±0.5	1.9±0.6	2.3±0.4	2.1±0.4
PRA	-2.37±1.00	-2.2±0.9	-2.3±0.9	-2.3±0.9	-1.9±0.7
AC/A Calculated	3.5 – 5.5	5.3±2.0	5.2±1.9	5.6±1.7	5.0±2.2
Accommodative width	18D - 0.33*age ±2.00D	11.34D±2.69	8.44D±3.21	10.55D±2.48	9.05D±2.05D

CISS=convergence insufficiency symptom score, NPC=near point of convergence cm:s, BAF=binocular accommodative facility (expected value for 8-12 years) cycles per minute, (CPM), MAF=monocular accommmodative facility (expected value for 8-12 years) CPM, NRC=negative relative convergence prism diopters (prd), PRC=positive relative convergence, prd, NRA=negative relative accommodation, diopters, PRA=positive relative accommodation, diopters, AC/A=accommodative convergence/accommodation prism diopters/diopter accommodation

distance of 60 mms was assumed for all patients when calculating AC/A (Table 2).

Accommodative amplitude was compared to the minimum expected for the patients age.

Criteria for convergence insufficiency

The criteria for convergence insufficiency in this study was defined as a situation where all of the following criteria[12-14] were met:

1. A receded near point of convergence (break >5cm)
2. An exophoria for near at least 4 prism diopters greater than at distance
3. Positive relative convergence (PRC) for near lower than expected (Table2)
4. A low AC/A-value (lower than 3.5 prism diopters per diopter)

BAF is often low in convergence insufficiency, since it is a binocular measurement and NRA may also be low. However these findings were not considered necessary to meet the diagnostic criteria for convergence insufficiency in this study.

Criteria for accommodative insufficiency

In this study, the criteria for accommodative insufficiency was defined as a situation where the following criteria were met.[15]

1. An amplitude of accommodation lower than the expected minimum value according to the expected values (Table 2)
2. At least one of MAF OD or MAF OS lower than the expected normative values (Table 2)

Convergence insufficiency with/without comorbid accommodative insufficiency

Convergence insufficiency may be either primary convergence insufficiency or it may be convergence insufficiency with a comorbid accommodative insufficiency. It can be debated which of these two diagnoses is the primary diagnose. This study does not answer this question.

Results

A total of 159 patients were examined at 8 sites in the study. The patients examined were 8 years to 35 years old, with

Table 3. Findings total population and per age group.

Finding	Examined population (n=159)	8-15 yrs (n=42)	16-25 yrs (n=61)	26-35 yrs (n=56)	ANOVA p-value
CISS Score >20	30.8% (N=49)	38.1% (N=16)	21.3% (N=13)	35.7% (N=20)	0.120
NPC	44.0% (N=70)	54.8% (N=23)	42.6% (N=26)	37.5% (N=21)	0.228
MAF OD or OS	58.5% (N=93)	69.0% (N=29)	49.2% (N=30)	60.7% (N=34)	0.123
Vergence Facility	76.2% (N=114)	76.2% (N=32)	68.9% (N=42)	71.4% (N=40)	0.722
Phoria 6m horisontally	64.8% (N=103)	66.7% (N=28)	62.3% (N=38)	66.1% (N=37)	0.875
Uncomp phoria 6m horizontally (Sheard)	9.4% (N=15)	9.5% (N=4)	6.6% (N=4)	12.5% (N=7)	0.552
NRC 6m	25.2% (N=40)	23.8% (N=10)	23.0% (N=14)	28.6% (N=16)	0.765
PRC 6m	47.2% (N=75)	57.1% (N=24)	39.3% (N=24)	48.2% (N=27)	0.205
Phoria 40cm	77.4% (N=123)	78.6% (N=33)	73.8% (N=45)	80.4% (N=45)	0.684
Uncomp phoria 40cm (Sheard)	24.5% (N=39)	33.3% (N=14)	18.0% (N=11)	25.0% (N=14)	0.209
NRC 40cm	60.4% (N=96)	76.2% (N=32)	50.8% (N=31)	58.9% (N=33)	0.034
PRC 40cm	52.8% (N=84)	78.6% (N=33)	44.3% (N=27)	42.9% (N=24)	<0.001
NRA	28.9% (N=46)	52.4% (N=22)	14.8% (N=9)	26.8% (N=15)	<0.001
PRA	62.3% (N=99)	54.8% (N=23)	55.7% (N=34)	75.0% (N=42)	0.05
Acc.width <minimum expected	26.4% (N=42)	73.8% (N=31)	16.4% (N=10)	1.8% (N=1)	<0.001
AC/A Calculated Low	15.7% (N=25)	11.9% (N=5)	9.8% (N=6)	25.0% (N=14)	0.058
AC/A Calculated High	45.3% (N=72)	45.2% (N=19)	49.2% (N=30)	41.1% (N=23)	0.683

The age groups have been analyzed by means of Chi-square and ANOVA in order to analyze whether there is any significant difference among groups and by Scheffe's post hoc test to identify the group which is significant different compared with the other groups. (Sheard)=Sheards criterion.

a mean age of 21.53 years. In the group 47.8% were male and 52.2% were female. The mean age in the male group was 20.8 years, and in the female group 22.2 years.

Mean values and standard deviation for all measurements, for the total group and for three age groups were calculated. These age groups were chosen to match age groups often used, and at the same time to be as similar as possible in size. The results are shown in Table 2.

Statistical analysis.

The data was statistically analyzed using SPSS 22. For all findings mean values and standard deviation was determined. Analysis was done for the total group (n=159) and for three age groups, 8-15 years (n=42), 16-25 years (n=61) and for 26-35 years (n=56). The data was close to normally distributed. The age groups have been analyzed by means of Chi-square and ANOVA in order to analyze whether there was any significant difference among groups and by Scheffe's post hoc test to identify the group which was significant different compared with the other groups.

Findings in relation to normative values.

When the findings were compared to the expected values (Table 2), several were found to not meet the expected values. In the age group 8-15 years, NPC Break, BAF, MAF OD, MAF OS and vergence facility were below expected values. In this group the values for NRC Break and PRC Break both for distance and near were lower than expected. This indicates a lower than expected fusional range. For the group 16-25 years as a whole, all values were close to as expected. For the group 26-35 years all values except NPC Break, BAF/MAF and vergence facility were close to as expected. For patients 8-15 years of age, findings for PRC 40cm, NRA and Accommodative amplitude were significantly lower than for other age groups (Table 2).

Frequency of meeting the criteria for convergence insufficiency and accommodative insufficiency

Using the definitions previously mentioned, a total of 9.4% (n=15) were found to meet the criteria for convergence insufficiency in the group (n=159), 7.5% (n=12) were found to meet the criteria for primary convergence insufficiency, 1.9% (n=3) were found to meet the criteria for convergence insufficiency with a comorbid accommodative insufficiency and 17.6% (n=28) were found to meet the criteria for accommodative insufficiency. For the age group 8-15 years the frequency for meeting the criteria for convergence insufficiency, primary convergence insufficiency, convergence insufficiency with a comorbid accommodative insufficiency was 11.9%, 9.5%, 2.4% and 50.0% respectively. For the age group 16-25 years the frequency that met the criteria for the different diagnoses was 6.6%, 3.3%, 3.3% and 9.0% respectively. For the age group 26-35 years the prevalence of the different diagnoses were 10.0%, 10.0%, 0% and 2.0% respectively. Chi square and ANOVA analysis of the differences between the age groups showed statistically significant higher frequency of accommodative insufficiency for the age group 8-15 years ($p<0.001$). When comparing the frequency of convergence insufficiency no significant differences was found between the age groups ($p=0.612$, Table 4).

Table 4. Frequency for following the criteria for Convergence Insufficiency (CI) and Accommodative Insufficiency (AI) respectively in the examined population (n=159)

	Total (n=159)	8-15 yrs (n=42)	16-25 yrs (n=61)	26-35 yrs (n=56)	ANOVA (p-value)
CI Totally	9.4% (N=15)	11.9% (N=5) 11.9% (N=5)	6.6% (N=4)	10.0% (N=5)	0.612
CI (without coexisting AI)	7.5% (N=12)	9.5% (N=4) 9.5% (N=4)	3.3% (N=2)	10.0% (n=5)	0.272
CI (with coexisting AI)	1.9% (N=3)	2.4% (N=1) 0% (N=0)	3.3% (N=2)	0% (n=0)	0.417
AI	17.6% (N=28)	50.0% (N=21) 35.7% (N=15)	9.0% (N=6)	2.0% (n=1)	<0.001 <0.001
Neither CI (wo/ AI) or AI	74.8% (N=119)	40.5% (N=17) 52.4% (N=22)	86.9% (N=53)	87.5% (N=49)	<0.001

Table 5. Frequency for following the criteria for of convergence insufficiency and accommodative insufficiency respectively in comparison with two other studies.[3, 4]

	8-15 yrs (n=42)	8-12 yrs (n=415)[3]	9-13 yrs (n=451)[4]
Convergence Insufficiency	11.9% (N=5)	6.0% (N=25)	4.2% (N=19)
Primary Convergence Insufficiency	9.5% (N=4)	N/A	3.5% (n=15)
Convergence Insufficiency	2.4% (N=1) 0% (N=0)	3.3% (N=2)	0% (n=0)
w/ coexisting accommodative insufficiency	2.4% (N=1)	N/A	0.9% (n=4)
Accommodative Insufficiency	50.0% (N=21)	N/A	10.0% (n=45)

Discussion

Several studies[2,4,7,9,11,13] show that the prevalence of primary convergence insufficiency and accommodative disorders are high. In this study, the frequency showed the same tendency, especially in the age group 8-15 years. In this age group the number of patients that met the criteria for either of the diagnoses was higher than in the older age groups. In this age group patients 8-12 years of age were included. The expected value for MAF OD and MAF OS for patients is 7 CPM.[11] This was taken into account when analyzing if the patients met the criteria for accommodative insufficiency. The age group 8-15 years was used in order to get age groups of similar sizes, and in this group the different expected values were used for patients 8-12 years and for patients 13-15 years (Table 3).

The number of patients that met the criteria for accommodative insufficiency was higher for 8-15 year olds. For this age group there were also significantly fewer patients with neither of the diagnoses (p<0.001, Table 4).

The number of patients that met the criteria for both convergence insufficiency and accommodative insufficiency in this age group was high compared to two other studies[3,4] with comparable age groups and criteria for convergence insufficiency and accommodative insufficiency (Table 5).

The definition used for convergence insufficiency followed the definition used by The Convergence Insufficiency Treatment Trial (CITT), but did not include symptoms as defined by the Convergence Insufficiency Symptom Score since the examined group was unselected.

A total sum of >16 was considered significant as symptoms of convergence insufficiency in the study CITT.[9] In a later study[16] it was considered that >20 was more appropriate for young adult patients, and the validity of using CISS as screening for convergence insufficiency was questioned in the same study. Using <21 as cut off, no significant difference was found between the age groups in this study (p=0.120). The findings indicate that CISS may be a tool that has insufficient sensitivity and specificity to identify patients with near vision problems in an unselected group. This needs to be further investigated before it can be answered.

This study is a national study that reflects a typical optometric population. The patients, that were all symptomatic for some reason, included in the study were examined at 8 different sites. The examined patients visited the optometrist for varying reasons, including being new patients, patients visiting for a scheduled follow up as well as patients seeking the optometrist for one or more specific symptom. Because of this, there is some uncertainty regarding the quality of the collected data, but at the same time it reflects normal optometric examination results, from which analytical decisions normally are made. Each of the participating optometrists was responsible to ensure that the exclusion criteria was considered before enrollment.

This study shows a high frequency of patients that meet the criteria for convergence and accommodative insufficiencies in the examined group. The results in this unselected group are not to be seen as prevalence data, only as a description of findings in the group. The frequency is high compared to two other studies (Table 5). This does not mean that all patients identified with either or both of the diagnoses need treatment or had troublesome symptoms. The high frequency for meeting the criteria for accommodative insufficiency indicates that accommodation is an important factor when diagnosing near vision problems. In one study[17] accommodative insufficiency was found to be the primary source of symptoms in children diagnosed with convergence insufficiency.

The mean values found in the total group closely follows Morgans tables of expected values. However, as mentioned earlier, several values in the group 8-15 years were lower than expected.

A comprehensive optometric examination must include a thorough evaluation of the patient's binocular status to

correctly identify and manage visual problems. The refractive status alone is not sufficient to make the evaluation, since it only addresses the optical performance of the eyes.

It is often stated by colleagues that vergence and accommodative disorders are more common than we realize. This study also gives this impression but the findings need to be further investigated to be better understood. If further investigations indicate that an increased prevalence of convergence insufficiency and accommodative insufficiency play a significant role in reading performance (speed and understanding) this highlights the importance of early detection and management of binocular vision problems. This is of special importance for younger patients, since school demands are increasing every year, and near vision demands play an important role in performance. The comprehensive optometric examination should follow a protocol with norms that are strict. This could result in over diagnosing problems, but it could, which would be worse, result in the opposite, if the optometrist decides to not follow the protocol, considering it to be consisting of too many details, and being to strict to follow.

Conclusion

The frequency of meeting the criteria for primary convergence insufficiency and accommodative insufficiency was found to be high in the examined population, compared to other studies. For patients 8-15 years of age, positive relative convergence for near (40cm), negative relative accommodation and accommodative amplitude were below expected values and the criteria for accommodative insufficiency was significantly more met in the group ($p<0.001$).

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Declaration of Interest

Göran Skjöld, Msc, is the distributor of HTS INet software in Sweden and Finland.

Sites / Participating Optometrists

Malmoe / Göran Skjöld, Helsingborg / Gustav Brinkby, Stockholm / Stefan Nilsson, Umeå / Per-Åke Östman, Härnösand / Olof Nesterud, Varberg / Christer Haar, Kalmar / Catarina Ericsson, Växjö / Håkan Petersson.

References

1. ECOO European Council of Optometry and Optics. http://www.ecoo.info/. Retrieved from European Council of Optometry and Optics, 2015.
2. Montés-Micó R. Prevalence of general dysfunctions in binocular vision. Annals of Ophthalmol 2001;33(3):205-8.
3. Rouse M, Borsting E, Hyman L, et al. Frequency of convergence insufficiency among fifth and sixth graders. Optom Vis Sci 1999;76(9).643-9.
4. Rouse, M., Hyman, L., Hussein, M., & et.al. (1998, February). Frequency of Convergence Insuficiency in Optometry Clinic Settings. Optometry and Vision Science, 75(2).
5. Borsting E, Rouse M, Deland P, et al. Association of symptoms and convergence and accommodative insufficiency in school-age children. Optometry 2003;74(1):25-34.
6. Hoseini-Yazdi S, Yekta A, Nouri H, Heravian J, et al. Frequency of convergence and accommodative disorders in a clinical population of Mashhad, Iran. Strabismus 2015;23(1)22-29.
7. Wahlberg-Ramsay M, Nordström M, Salkic J, Brautaset R. Evaluation of aspects of binocular vision in children with dyslexia. Strabismus 2012;20(4):139-44.
8. Abdi S, Rydberg A. Asthenopia in schoolchildren, orthoptic and ophtahlomological findings and treatment. Documenta Ophtahlmologica 2005;111(2):65-72.Scheiman M, Mitchell L, Cotter S, et al. The convergence insufficiency treatment trial: design, methods and baseline data. Ophtalmic Epidemiology 2008;15(1):24-3.
9. Morgan MW. Analysis of clinical data. Am J Optom Arch Am Acad Optom, 1944;21(12): 477–491.
10. Scheiman M, Wick B. Clinical Management of Bincocular Vision. Philadelphia, USA: Lippincott Williams & Wilkins, 2002.
11. Francisco L, Cacho P, García Á, Megías R. General binocular disorders: Prevalence in a clinic population. Ophthal Physiol Opt, 2001;21:70-74.
12. Bade A, Boas M, Gallaway M, et al. Relationship between clinical signs and symptoms of convergence insufficiency. Optom Vis Sci 2013;90(9):988-995
13. Rouse M, Borsting E, Mitchell GL, et al. Validity and reliability of the revised convergence insufficiency symptom survey in adults. Ophthalmic Physiol Opt 2004;384-90.
14. Cacho P, García A, Lara F, Seguí MM. Diagnostic signs of accommodative insufficiency. Optom Vis Sci 2002;79(9):614-20.
15. Horwood AM, Toor S, Riddell PM. Screening for convergence insufficiency using the CISS is not indicated in young adults. Brit J Ophtahlmol 2014 Published Online First: 14 February, 2014. doi:10.1136/bjop
16. Marran L, De Land P, Nguyen A. (2006, May). Accomodative insufficiency is the primary source of symptoms in children diagnosed with convergence insufficiency. Optom Vis Sci 2006:83(5):281-9.
17. Marran, L., De Land, P., & Nguyen, A. (2006, May). Accomodative Insufficiency is the Primary Source of Symptoms in Children Diagnosed With Convergence Insufficiency. Optometry and Vision Science, 83(5), pp. 281-289.

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Skjöld G, Skjöld A, Brinkby G, Cheng Y. Binocular Measurements in a Nonselected Group of Non-strabismic Patients 8-35 years old, in Sweden. Optom Vis Perf 2018;6(1):31-7.

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