

Relating asthenopic symptoms to optometric measures and parameters of binocular vision

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Introduction

Asthenopic symptoms (e.g., headaches, ocular pain and soreness) are related to problems in binocular vision (heterophoria, vergence and accommodative problems)¹ and are an important clinical criterion in the assessment of binocular problems. In a previous study, we showed, that binocular eye movements during reading (vergence drift and fixation durations) are related to an overall symptoms score, but optometric measures did not significantly add to the explained variance of asthenopia.² Therefore, the aim of this study was to extract specific aspects of the overall asthenopic symptoms score and to relate them to parameters of binocular vision and optometric measures in order to predict asthenopic symptoms in more detail.

Methods

We tested 64 participants with normal binocular vision (mean age: 25 ± 3.6 years; 29 males) during a reading task and a typical optometric session and collected data as follows:

- **Binocular eye movements during reading:** objective heterophoria, saccade disconjugacy, vergence drift, fixation disparity and fixation duration (Figure 1)
- **Optometric measures:** heterophoria, vergence and accommodative facility, AC/A-ratio, near point of convergence (NPC)
- **Asthenopic symptoms:** Convergence Insufficiency Symptom Survey (CISS)

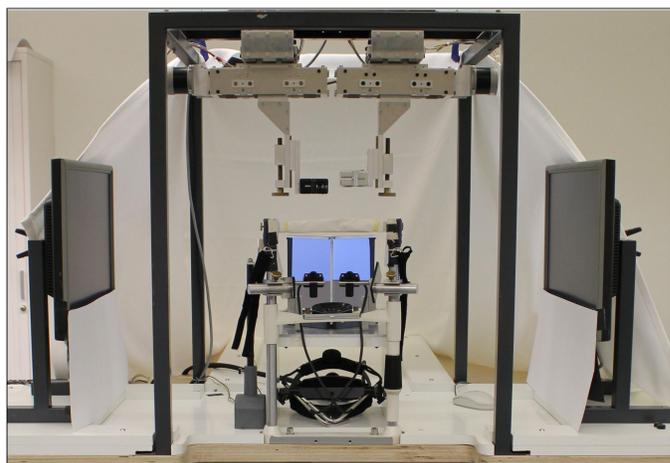


Figure 1: Set-up (EyeLink II) for the measurement of binocular eye movements during a reading task at 60 cm.

Inclusion criteria were: monocular uncorrected visual acuity of 0.8 or better at 60 cm, no strabismus, no vertical heterophoria > 1 pdpt, no wearing of prismatic correction.

Statistical analysis:

We performed a factor analysis of the CISS identifying independent symptom factors. A linear regression analysis was then used to explain the single symptom factors by parameters of binocular coordination during reading and / or the optometric measures (IBM SPSS Statistics 27).

With the factor analysis, we identified 4 independent symptom factors out of the 15 questions of the CISS questionnaire (Figure 2):

- Symptom factor 1: eye comfort (questions 2, 10, 11, 12)
- Symptom factor 2: reading process (questions 6, 9, 13, 14)
- Symptom factor 3: image quality (questions 7, 8, 15)
- Symptom factor 4: fatigue (questions 1, 4)

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 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 lose your place while reading or doing close work?
14. Do you have to reread the same line of words when reading?
15. Do you notice the words blurring or coming in and out of focus when reading or doing close work?

Figure 2: Convergence Insufficiency Symptom Survey (CISS).

Next, we calculated the sum of asthenopic symptoms for each symptom factor (for each participant) and related it to the parameters of binocular coordination during reading and the optometric measures (Table 1).

Objective heterophoria (b=1.1493; SE=0.4704; p=0.02) and **fixation duration** (b=0.0304; SE=0.0133; p=0.03) explained about **24%** of the variance of symptom **factor 2**, which is related to the **reading process**.

Considering the symptom **factor 4**, which is related to **fatigue**, **25 %** of variance could be explained by **fixation duration** (b=0.0159; SE=0.0073; p=0.03) and a weak tendency for objective heterophoria (b=0.2065; SE=0.2740; p=0.08) and vergence facility (b=0.0512; SE=0.0854; p=0.10).

For completion purposes the analyses of factor 1 (related to eye comfort) and factor 3 (related to image quality) are illustrated in table 1. However, none of the binocular or optometric parameters significantly explained the variance of factors 1 and 3, although there was a tendency of fixation duration and AC/A being related to the eye comfort (factor 1).

Results

Table 1: Linear regression analyses to predict symptom factors 1-4 by objective parameters and optometric measures.

R1: eye comfort			
Fixed factor	b	SE	t
(Intercept)	0	0.3100	-0.03
Objective heterophoria [deg]	0.3116	0.4356	0.72
Vergence drift [deg]	-3.5303	6.2112	-0.57
Disconjugacy [deg]	-0.7180	4.2557	-0.17
Obj. fixation disparity [deg]	-2.9471	1.7887	-1.65
Fixation duration [ms]	0.0192	0.0123	1.55
Maddox heterophoria [deg]	0.1208	0.2844	0.42
Vergence facility [cpm]	-0.0435	0.1357	0.32
Acc. facility [cpm ^{0.5}]	-0.1272	0.5558	-0.23
AC/A	-1.0237	0.5910	-1.73
NPC [cm]	0.1717	0.1290	1.33
R2: reading process			
Fixed factor	b	SE	t
(Intercept)	0	0.3347	-0.02
Objective heterophoria [deg]	1.1493	0.4704	2.44 *
Vergence drift [deg]	1.6463	6.7077	0.25
Disconjugacy [deg]	-6.3616	4.5959	-1.38
Obj. fixation disparity [deg]	-1.0978	1.9317	-0.57
Fixation duration [ms]	0.0304	0.0133	2.28 *
Maddox heterophoria [deg]	-0.4943	0.3071	-1.61
Vergence facility [cpm]	-0.0038	0.1465	-0.03
Acc. facility [cpm ^{0.5}]	-0.3329	0.6003	-0.55
AC/A	0.2684	0.6383	0.42
NPC [cm]	-0.0754	0.1393	-0.54
R3: image quality			
Fixed factor	b	SE	t
(Intercept)	0	0.1950	0
Objective heterophoria [deg]	0.2065	0.2740	0.75
Vergence drift [deg]	2.6041	3.9071	0.67
Disconjugacy [deg]	-1.4952	2.6770	-0.56
Obj. fixation disparity [deg]	-1.6801	1.1252	-1.49
Fixation duration [ms]	0.0067	0.0078	0.86
Maddox heterophoria [deg]	-0.0415	0.1789	-0.23
Vergence facility [cpm]	0.0512	0.0854	0.60
Acc. facility [cpm ^{0.5}]	0.0758	0.3496	0.22
AC/A	-0.0512	0.3718	-0.14
NPC [cm]	0.0168	0.0811	0.21
R4: fatigue			
Fixed factor	b	SE	t
(Intercept)	0	0.1829	-0.08
Objective heterophoria [deg]	0.4849	0.2571	1.77
Vergence drift [deg]	-3.3731	3.6653	-0.92
Disconjugacy [deg]	-1.8786	2.5114	-0.75
Obj. fixation disparity [deg]	-1.5164	1.0556	-1.44
Fixation duration [ms]	0.0159	0.0073	2.19 *
Maddox heterophoria [deg]	0.0091	0.1678	0.05
Vergence facility [cpm]	0.1329	0.0801	1.66
Acc. facility [cpm ^{0.5}]	-0.2967	0.3280	-0.90
AC/A	0.2123	0.3488	0.61
NPC [cm]	0.1140	0.0761	1.50

Note. †: p ≤ 0.10; *: p ≤ 0.05; **: p ≤ 0.01, ***: p ≤ 0.001

Discussion & Conclusion

While the overall CISS Score is known as an indicator of binocular asthenopic symptoms^{1,2}, breaking it up into 4 independent symptom factors, revealed an interesting pattern: only objective heterophoria and fixation durations related specifically to asthenopic symptoms associated with the reading process (e.g. slow reading, trouble remembering what was read), while overall fatigue was related to fixation duration only (with a tendency for objective heterophoria and vergence facility). We also found no relation between asthenopic symptom factors and typical optometric parameters:

neither measures of facilities nor binocular status added to our understanding of binocular asthenopic symptoms. Thus, further research is clearly needed to bridge the gap between optometric and eye movement testing in order to predict, monitor or even reduce asthenopic symptoms. Note that all 64 participants were selected from a normal cohort i.e. they had no severe problems or symptoms (M: 14.7, SD: 7.4, with the max. CISS Score being 32). In day-to-day setting, patients might consult an optometrist because of their symptoms and therefore, the range in this study is probably not reflecting a typical range for optometric practice.

Note also, that the CISS questionnaire assesses symptoms by taking an overall score over all 15 questions and that scores >21 are referred to symptomatic convergence insufficiency¹. We showed, that the CISS seems to assess different symptom factors and that an overall score may not be adequate (and therefore, less informative²), as it sums up over different independent aspects of asthenopia.

References

1. Scheiman, M., Wick, B. (2019). Clinical management of binocular vision: heterophoric, accommodative, and eye movement disorders. (5th ed, Lippincott Williams & Wilkins, Philadelphia.
2. Joss, J., & Jainta, S. (2021). Do standard optometric measures predict binocular coordination during reading?. Journal of Eye Movement Research, 13(6).

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