University of South-Eastern Norway
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Master's Thesis

Study programme: Master of Optometry and Visual Science – General practice optometry

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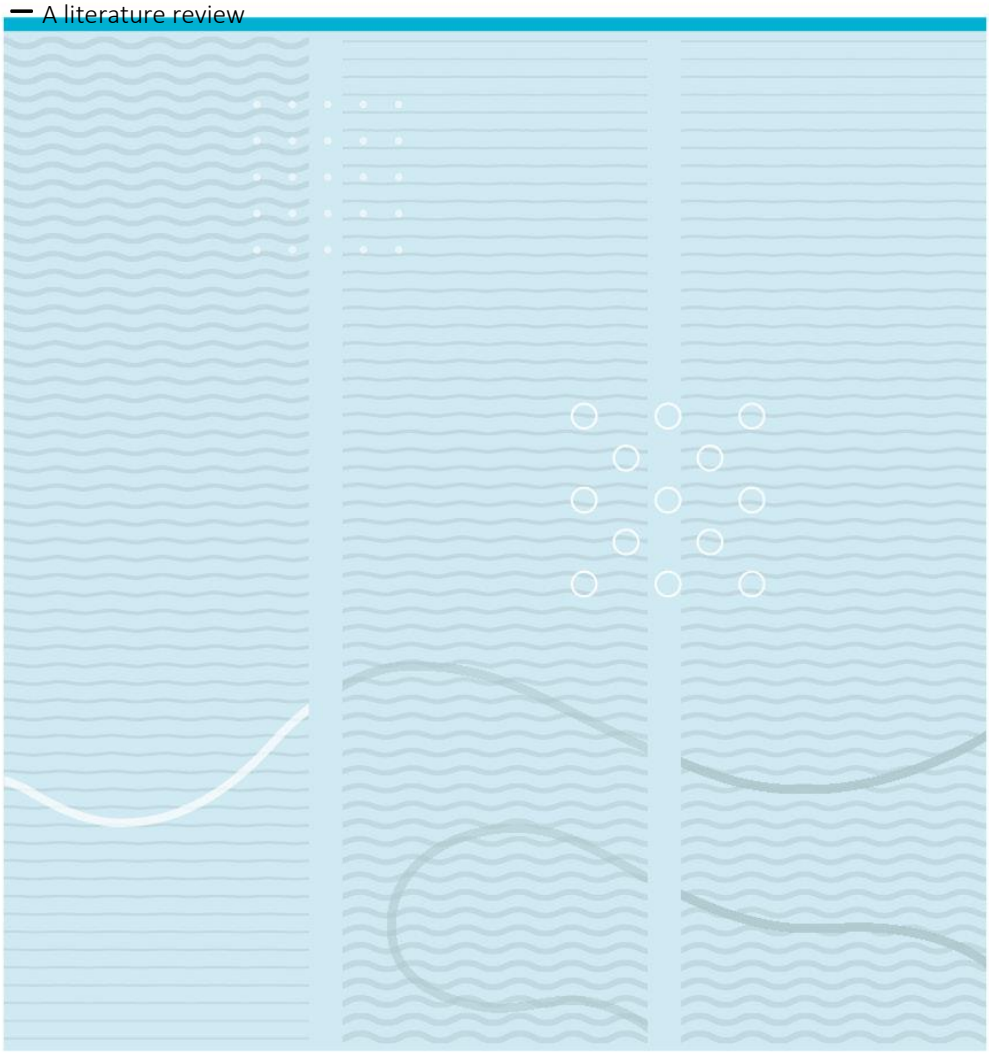
# Does vision play a role among children and adolescent with musculoskeletal complaints and headaches?

– A literature review



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This thesis is worth 30 study points

## Contents

## Abstract:

Background: Most research on musculoskeletal complaints and headaches have been conducted on the adult population and only a few of them tried to find out if there was a connection between these problems and the visual system. In recent years these problems are becoming more common in children and adolescents. This creates a need for research on the subject for this population also. The aim of this study was to review findings from the published literature about the relationship between the visual function and the musculoskeletal complaints and/or headaches in children and adolescent.

Method: Ovid was used to perform a search for potentially relevant studies in Medline and Embrase in June 2020. Publications were identified based on predefined inclusion and exclusion criteria. The data was tabulated and synthesized to produce a literature review based on a systemic review protocol. All the articles that were included examined a relationship between musculoskeletal complaints or headaches and the visual system in healthy children and adolescents. Bias risk was evaluated using checklists from CASP, Critical Appraisal Skills Program. To secure adequate number of studies for this review, both cross-sectional and cohort-studies were included since there are so few studies on the subject.

Results: The literature search yielded 2962 articles describing musculoskeletal complaints, headache, vision, children and adolescents. Out of these, 11 were finally included in this review; 2 articles about musculoskeletal complaints and 9 about headache or migraine. The different studies had different methods for data collection and measurements, there was no uniformity in the assessment of the visual system.

Conclusion: This review showed that there is a relationship between the visual system and pain or discomfort in neck, shoulders, back and/or head in the child and adolescent population. This suggests that children with complaints should have an eye examination. An eye examination is easily accessible and relatively cost-efficient solution for the problem. However, there is still a great need for more uniform research on the subject.

**Keywords**: musculoskeletal complaints, headaches, migraine, children, adolescent, vision

Word count: 11003

## Abstract – Norwegian

Bakgrunn: De fleste undersøkelser av muskel- og skjelett plager og hodepine er utført på den voksne populasjon, og bare noen få av dem prøvde å finne ut om det var en sammenheng mellom disse problemene og det visuelle systemet. De siste årene har disse problemene blitt vanligere hos barn og ungdom. Dette skaper et behov for forskning på emnet også for denne populasjonen. Målet med denne studien var å gjennomføre funn fra den publiserte litteraturen en litteraturgjennomgang om forholdet mellom syn og muskel- og skjelettplager og/eller hodepine hos barn og ungdom.

Metode: Ovid ble brukt for å søke etter mulig relevante studier i Medline og Embrase i juni 2020. Publikasjoner ble identifisert basert på forhåndsdefinerte inkluderings- og eksklusjonskriterier. Artiklene ble kritisk vurdert ved hjelp av CASP, Critical Appraisal Skills Program. For å gjennomgå artiklene ble en systematisk gjennomgangsprotokoll fulgt. Alle artiklene som ble inkludert, undersøkte et forhold mellom muskel- og skjelett plager eller hodepine og det visuelle systemet hos friske barn og ungdom. Bias risiko ble evaluert ved hjelp av sjekklister fra CASP. For å sikre tilstrekkelig antall studier for denne gjennomgangen ble både tverrsnitts- og kohortstudier inkludert, siden det er så få studier om emnet.

Resultater: Litteratursøket ga 2962 artikler som beskriver muskel- og skjelettplager, hodepine, syn, barn og ungdom. Av disse ble 11 endelig inkludert i studien; 2 artikler om muskelskjelettplager og 9 om hodepine eller migrene. De forskjellige studiene hadde forskjellige metoder for datainnsamling og målinger. Og det var ingen ensartethet i vurderingen av det visuelle systemet.

Konklusjon: Denne gjennomgangen viste at det er en sammenheng mellom synssystemet og smerte eller ubehag i nakke, skuldre, rygg og / eller hode hos barn og ungdom. Dette tyder på at barn med klager bør ta en øyeundersøkelse. En øyeundersøkelse er lett tilgjengelig og relativt kostnadseffektiv løsning for problemet Det er fortsatt et stort behov for mer enhetlig forskning på emnet.



Nøkkelord: muskel og skjelett plager, hodepine, migrene, barn, ungdom og syn

# Introduction:

## Background:

Working in optometric practice it is common to get in patients that want an eye examination because they have headaches, or migraine. Some come on their own, whilst others are referred by other health professionals. Regarding children and adolescent referrals can come both from General practitioners and school nurses. It is very rare to receive referrals for musculoskeletal complaints.

Headache is one of the symptoms that is expected to be asked about in the patient history. Discomfort or pain in neck, shoulders and back is not something that is routinely asked about by most optometrist. In Norwegian Opticians' Association's clinical guidelines chapter 1 about the routine examination the patient's history questions is listed. (Optikerforbund)

In my municipality Ipad was introduced into primary schools and junior high schools in 2018, the goal is to increase the pupil's digital skills. ("Digitaliseringsstrategi for Rana-skolen," 2018) Our schools are not the first ones to do so, and other schools will probably follow. It can be great benefits for learning if used right, but there are also a greater risk for the children's physical and visual health. (Ciccarelli, Portsmouth, Harris, & Jacobs, 2012) The frequent use of smartphones, tablets, laptops and computers may be causing an increase in visual problems and musculoskeletal complaints associated with the use of them. (Ciccarelli, Chen, Vaz, Cordier, & Falkmer, 2015) Even with well-developed policies for use and welfare for the pupils there are still a concern about the amount of exposure to technology since it is associated with musculoskeletal complaints and visual symptoms. (Straker, Harris, Joosten, & Howie, 2018) The use in schools comes in addition to screen time for leisure activities. The use for leisure activities was in one study in Norway found to be 6-7 hours in 2012. (Hysing et al., 2015) And with the development the last 8 years the time is probably higher now. It is important to facilitate so that the children can benefit of the advantages of technology without getting discomforts and problems. (Straker et al., 2018)

Therefore, it might be expected that optometrist will see more children with complaints in comparison to before iPads were introduced.

## Musculoskeletal complaints.

There are several studies about musculoskeletal complaints and headache or migraine (Mork, Bruenech, & Thorud, 2016) (Young, Trudeau, Odell, Marinelli, & Dennerlein, 2012) , but studies that investigates the relationship with the visual system are fewer.(Sánchez-González et al., 2018) Most of these studies have been done on the adult population, and there are very few studies on children and adolescent. As such it is important to summarize the knowledge in a literature review. Optometrist are probably an underutilized health profession in this context, so it is important to find the evidence that shows other health professionals that we can contribute in helping these patients.

Muscle performance and range of motion was negatively affected of accommodation dysfunction, so there are a correlation between accommodative dysfunction and neck pain.

(Sánchez-González et al., 2018) This is another reason why it is important to check accommodation, both facility and relative accommodation. There are found an association between the orbicularis oculi, the “squinting muscle”, and the trapezius blood flow and neck pain. They also found a strong relationship between blurred vision and neck pain. (Mork et al., 2016) To keep something in focus and single the accommodation and vergence system need to be coordinated. Refractive errors will make this coordination more difficult. Even small refractive errors should be corrected when patients is using electronic screens. (Rosenfield, 2011) Correct refractive correction is the foundation of everything. Symptoms in the eye-neck/scapular area were found to be positively associated to how long near work was performed. (Richter, Zetterlund, & Lundqvist, 2011) A new modern musculoskeletal term is text neck. The term was first used by Dr Dean Fishman, a US chiropractor. (institute)The angel the neck is put in whilst texting on a smartphone puts strain on the cervical spine causing degeneration. We put our neck in that position when we look at tablets and laptops also. The most painful body part after smartphone use is the neck. Flexed neck posture was associated with neck disorders.  Other wrong body position that was adapted when using a smartphone was shoulder protraction, flexed elbows, flexed hand and wrist whilst writing and hand supination to support phone, also flexion in upper and lower back, hip ant thigh, knee flexion. The study found that to reduce neck disorders the neck flexion should be decreased. (Namwongsa, Puntumetakul, Neubert, & Boucaut, 2018)

## Headache

The international classification of headache disorders divides headache in 3 main types with several subtypes. To see the full list, go to the webpage in the reference.  ("International classification of hedache disorders,")

Primary headaches are disorders by them self and not cause by other disorders. Secondary headache is a secondary symptom from another disorders. Migraine, Tension type headaches and Cluster headache are defined as primary headaches. Headaches caused by disorders by the eyes is a secondary headache and has 4 subtypes. One of them are because of refractive error, with the abbreviation HARE.

Migraine can be both without and with aura. Typical migraine headache is unilateral a pulsating with moderate to severe intensity. The headache is aggravated by normal physical activity and is associated with nausea/vomiting and/or photophobia and/or phonophobia. Tension headache have mild to moderate intensity and is typically bilateral with a pressing or tightening quality. The headache does not get worse with routine physical activity and is not associated with nausea/vomiting, although they may have photophobia and/or phonophobia.

Cluster headache is also a primary headache and have some eye related symptoms or signs, ipsilateral to the pain. Conjunctival injection and/or lacrimation, eyelid oedema and miosis and/or ptosis are the eye related symptoms and signs. The cluster headache attacks are severe. The pain is strictly unilateral which is orbital, supraorbital, temporal or any

combination of these sites.  It is normal that patients with cluster headache is restless or agitated.

Headache attributed to refractive error improves with correction of refractive error. Headache is aggravated by prolonged visual tasks at angel or distance at which vision is impaired. Headache improves when visual tasks is discontinued.

Asking the patient to keep a headache diary if they not are able to answer questions you need an answer on to make a diagnosis. There are studies that have showed that headache diaries are more accurate over time if the headaches are under 8 hours then questionnaire at examination. The study period was 16 weeks, with 4 weeks intervals. (Miller et al., 2020)

As optometrists we can in addition to provide best refractive correction also provide filter glasses to alleviate photophobia in different types of headaches and visual training with binocular disorders.

## Aim

The aim of this study was to review findings from the published literature about the relationship between the visual function and the musculoskeletal complaints and/or headaches in children and adolescent.

## Methods

This literature review followed most of the process of a systematic review.  Systematic review is the most known review type. It starts with a systematic search and the appraisal of the research follows strict guidelines, in this review CASP(Program) has been used instead of Cochrane guidelines. Critical Appraisal Skills Program is a series of checklist to help you evaluate different types of publication and studies. By using CASP checklists I also did a critical appraisal of the articles in addition to evaluating bias risk. Systematic reviews want to collect all known knowledge on a topic. In early years only a single design was included, but recent years different design has been included. Analysis tries to find out was is known, what is still unknown and come with recommendation about further research. (Grant & Booth, 2009)

The review followed Preferred Reporting Items for Systemic Reviews and meta analyses, but without the meta analyses. This because a meta-analysis is beyond the scope of at master thesis. The PRISMA flow is in Figure1.

### Eligibility criteria

To be included the articles had to examine a relationship between musculoskeletal complaints, headache and the visual system in healthy children and adolescents. Studies that did not examine a relationship between all 3 things were excluded. Several studies were excluded since it only examined a relationship between 2 of them. (Straker et al., 2018)

Illnesses, syndromes or conditions that could give musculoskeletal complaints or headaches was excluded. Migraine was included since it may come with visual aura.

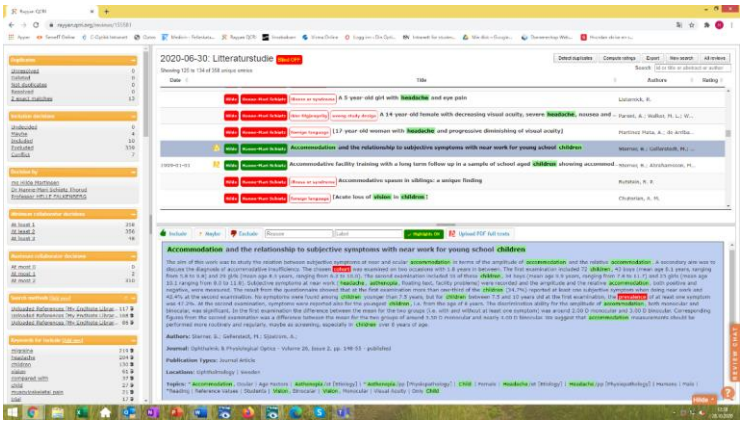
Case control studies with few patients and other reviews were excluded.

The only restriction regarding the evaluation of the visual system was that an optometrist should be able to perform it. The articles had to be in Norwegian, English or German and be full text available for USN students.

## Study Search and selection

The literature search was done in Ovid in June 2020 and included search in Embrase and Medline. Search criteria and search strategy are outlined in table 1. The writer screened the titles in Ovid and pick out articles that had a title that seemed to be relevant. These articles were transferred to Ryyan where 2 supervisors contributed in assessing the eligibility by reading the abstract. If there were a conflict the writer revaluated and took the final decision if the article should be included or not.

Ryyan is a Systematic Review web app.(Ryyan) With Ryyan it is possible to put in exclusion criteria and keep track of them. You can invite others to join the review and it is all online and there is a Ryyan app also. You can import pdf of the articles and it is possible to read them both on the web app and the phone app, which is very useful since we have our phone with us almost all the time.




Picture 1: screenshot of the Ryyan web tool

Table 1: Search criteria and search strategy entered in Ovid June 2020.

| | |
|---|---|
| 1. Population keyword 1 | 1. exp child |
| 2. Population keyword 2 | 2. exp adolescent |
| 3. Population textword 1 OR 2 | 3. (child* OR adolescent*).tw |
| 4. 1 OR 2 OR 3 | 4. 1 OR 2 OR 3 |
| 5. Selection keyword 1 | 5. exp headache |
| 6. Selection textword 1 OR 2 OR 3 | 6. (headache OR «head pain» OR «cranial pain» OR migraine).tw |
| 7. 5 OR 6 | 7. 5 OR 6 |
| 8. Selection keyword 4 | 8. «musculoskeletal complaint*» |
| 9. Selection textword 4 OR 5 OR 6 OR 7 | 9. (musculoskeletal OR «neck discomfort» OR «back discomfort» or «shoulder discomfort» OR «musculoskeletal pain»).tw |
| 10. 8 OR 9 | 10. 8 OR 9 |
| 11. 7 OR 10 | 11. 7 OR 10 |
| 12. Intervention keyword 1 | 12. vision |
| 13. Intervention textword 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 | 13. (vision OR eye OR visual OR «refractive error» OR asthenopi* OR accommodation OR convergence OR «vision screening»).tw |
| 14. 12 OR 13 | 14. 12 or 13 |
| 15. 4 AND 11 AND 13 | 15. 4 AND 11 AND 13 |

## Data extraction/collection

What visual measurements that was done or included in the articles was not the same or not in the same format in all studies, so it was not possible to extract data for analyses. Many of them stated in methods that they took cycloplegic refraction, some took 2 refractions both with and without cycloplegia, some only on those under a certain age. Some of the studies stated that they took a full ophthalmologic examination without stating what examination that included.

The different types of complaints are listed in table 1 study characteristic. Regarding the headache and migraine studies there were a difference in inclusion and exclusion criteria. Some included all headaches whilst other were more specific criteria for inclusion, both regarding type and how long they have had the complaints.

If you look at all the studies as a hole the age span of the participants is from 3 years old to 18 years old.

The different measurements of vision are listed in table 4.

## Risk-of-bias assessment

To perform the risk of bias I used checklist from Critical Appraisal Skills Program, by using these checklists I could also perform a critical appraisal. The program has 25 years of expertise and is a part of Oxford Centre for Triple Value Healthcare Ltd (3V) portfolio. CASP has several different checklists to assist white appraisal of different types of studies. (Program) The studies included in the review were cohort and cross-sectional studies. There is not a separate one for cross-sectional studies, but it is custom to use the one for systemic review.

There are questions about the studies that you must answer yes, no or unknown to.

The cohort questions are:

1. Did the study address a clearly focused issue?
2. Was the recruitment acceptable?
3. Was the exposure accurate? measured?
4. Was the outcome accurately measured?
5. Have the identified all important confounding factors?
6. Have they considered confounding factors in the design?
7. Was the follow up of subjects complete enough?
8. Was the follow up long enough?
9. What are the results of this study?
10. How precise are the results?
11. Do you believe in the results?
12. Can the results be applied into practice?
13. Do the results of this study fit with other available evidence?
14. What are the implications of this study for practice?

Cross-sectional (systemic review) questions:

1. Did the review address a clearly focused question?
2. Did the authors look for the right type of papers?
3. Do you think all the important, relevant studies were included?
4. Did the authors do enough to assess quality of the included studies?
5. If the results of the review have been combined, was it reasonable to do so?
6. What are the overall results of the review?
7. How precise are the results?
8. Can the results be applied to the local population?
9. Were all important outcomes considered?
10. Are the benefits worth the harms and costs?

Since the cross-sectional questions were indented to systematic review there will be more unknown answers on them then on cohort since it may be difficult to answer some of the questions.

The CASP answers for the included articles are presented in table 5 and 6.

### Data analysis

Quantitative data analysis was not possible since there were different measurements of the visual system in the studies.

How they published the refraction error varied. Some published the refraction error, some categories the ametropia with known criteria, some categories with unknown criteria and some just said it was a need for optical correction.

About visual symptoms some article had a collective term for symptoms, whilst others had divided them into several symptoms and how they statistically presented them was not uniform either.

## Results

The literature search was performed in June 2020 and yield 2962 articles using Ovid, searching Medline and Embrase. The 30 articles from other records that was articles found when I wrote my master thesis protocol in 2016 and another article that followed PRISMA flow for searching and screening.

After duplicates were removed the articles titles was evaluated to see if the articles should be excluded or if it was possible it could be included. This part of the screening process was difficult because Ovid access was lost after about 1 hour and I managed to screen about 100 each session and in the next session the order of the articles was changed when I logged in again. So, some articles may have been missed.

There were quite a few about adult and young adults that since some articles had put adolescents in as keyword if there were young adults in the population, like 18 years old. There is no way to exclude articles about illness, syndromes or illness so these were excluded both in the title screening and abstract screening in Ryyan.

The PRISMA chart in figure 1 shows the screening process. 62 full text were evaluated and 11 was included in the review.

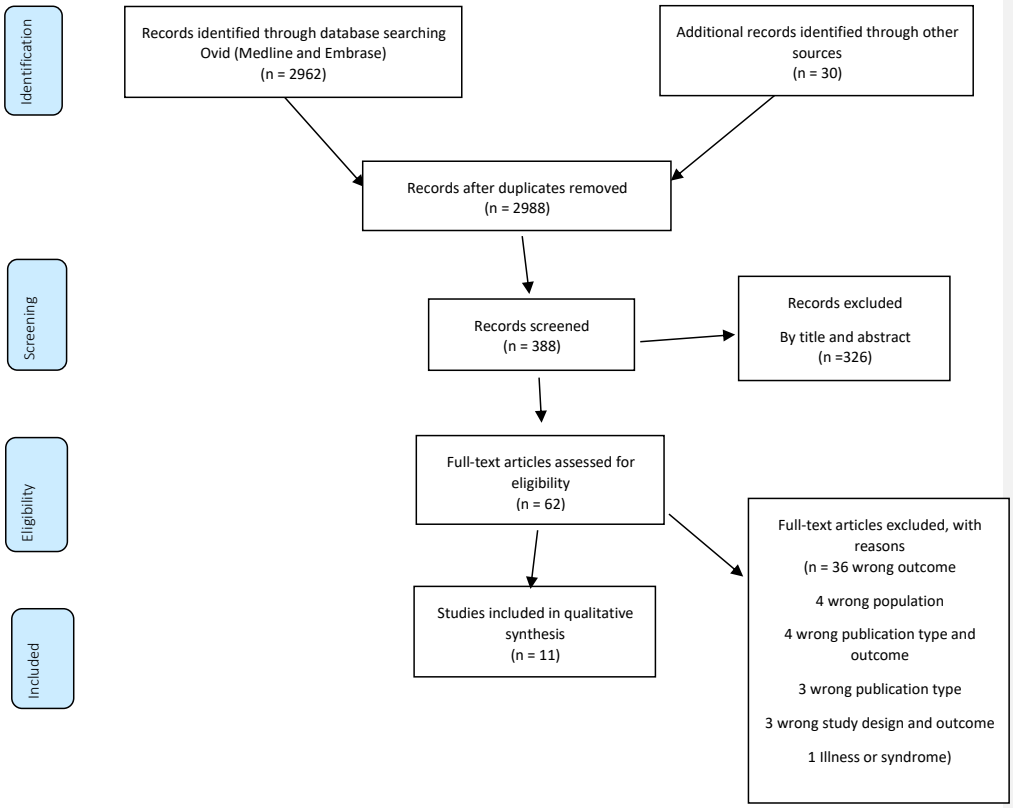



Figure 1 PRISMA flow chart of search and screening process

## Study characteristics

The 11 articles included in the review could be divided into 3 groups.

The first groups are the articles about headaches and in these studies, there are different types of headaches. (Akinci et al., 2008; Dotan, Stolovitch, Moisseiev, Cohen, & Kesler, 2014; Mehboob, Nisar, & Khan, 2019; Mishra, Sharma, Juneja, & Singh, 2013; Roth, Pandolfo, Simon, & Zobal-Ratner, 2014; Sterner, Abrahamsson, & Sjostrom, 1999; Sterner, Gellerstedt, & Sjostrom, 2006) In the second group is the one article that only included migraine patients. (Villa et al., 2009) In the last group is musculoskeletal articles. (Fares, Fares, & Fares, 2017; Toh et al., 2020) One has only neck pain,(Fares et al., 2017) while the other have different types of musculoskeletal complaints.(Toh et al., 2020) The headache studies have both cross-sectional (Akinci et al., 2008; Dotan et al., 2014; Hendricks, J, van Der Horst, Hendrikse, & Knottnerus, 2007; Mehboob et al., 2019; Mishra et al., 2013) and cohort design.(Roth et al., 2014; Sterner et al., 1999; Sterner et al., 2006) The migraine study had cohort design (Villa et al., 2009) and the musculoskeletal studies had cross-sectional design. (Fares et al., 2017; Toh et al., 2019)

The study sizes were from 16 participants to 1884 participants and the age span is 3 to 18 years. The inclusion age was primary school (grade 1 -7) and junior college (grade 8 – 10) pupils. In Norway the children start primary school the year they turn 6 years old.

Exclusion criteria was wrong age and different types of diagnosis, either systemic or eye related.

The study characteristics of the different articles are summarized in table 2.

Table 2: Study characteristics

| Headache | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Reference** | Study design | Conflict of interest | Inclusion criteria | Exclusion Criteria | Follow-up | Subjects (% boys) | N (patients) | Age (years) | Groups (n) |
| (Akinci et al., 2008) | Cross-sectional | None | Headache unknown type | Positive imaging analysis, migraine, tension headache, cluster headache etc, heterophoria, uveitis, optic neuritis, acute glaucoma | None | 47,4 | 1153 | Group 1: 8-18 Mean 13,4±2,6 Group 2: 7-17 Mean 13,9±3,1 | 1- Headache (310) 2- No headache (843) |
| (Dotan et al., 2014) | Cross-sectional | None | Headache, no abnormality beside uncorrected ametropia | Glaucoma, optic, neuritis, scleritis, known need for glasses or contact lenses, | Mean 15 months | 56 | 16 | 8-18 Mean 12 | 1- Headache (16) |
| **(Hendricks et al., 2007)** | Cross-sectional | None | 11-13 years | None | None | 48 | 487 | 11-13 | 1- Boys with glasses (32) 2- Boys without glasses (203) 3- Girls with glasses (42) 4- Girls without glasses (210) |
| (Mehboob et al., 2019) | Cross-sectional | None | Persistent headache 2-8 weeks 5-16 year | Squint, refractive error, head injury, trauma, intercranial space occupying lesions, sinusitis, migraine, prolonged drug use, epilepsy, fever, other known neurologic disease | 4-8 weeks ametropia group | 48,5 | 262 | Mean 8,9±3,16 | 1- Ametropia (56) 2- No Ametropia (2066) |
| **(Mishra et al., 2013)** | Cross-sectional | | Recurrent headache | Trauma, fever, other known causes for headache | 1 month | 55,8 | 43 | 3-17 mean 10 | 1- Migraine (26) 2- TTH (11) 3- Other (6) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **(Roth et al., 2014)** | Cohort | None | Headache, <13 year | ≥ 13 year | 6-12 months | 49,4 | 158 | 3-12 Mean 8,05 Median 8,08 | 1- Headache (158) |
| **(Sterner et al., 1999)** | Cohort | None | 9-13 year Headache Blurred vision Asthenopia loss of concentration, avoidance near activity Reduced NRA/PRA and accommodation facility | Strabismus Lack of stereovision | 2 year | Unknown | 70 | Gr 1 - 9-13 Gr 2 - 9-13 Gr 3 - > 30 Gr 4 - <6 | 1- Accommodation problems (38) 2- Controls (24) 3- Adult controls (4) 4- Preschool controls (4) |
| **(Sterner et al., 2006)** | Cohort | None | Junior level school | Amblyopia, strabismus, anisometropia, astigmatism ≥ 0,75 | 1.8 year | 59,7 – 1. exam 57.6 -2. exam | 72- 1. exam 59 – 2. exam | Boys1: mean 8,1 (5.8-9.8) Girls1: mean 8,3 (6,2-10) Boys2: mean 9,9 (7,8-11,7) Girls2: mean 8,3 (6,2-10) | 1- No Symptoms (47/34) 2- Symptoms (34/25) First exam/Second exam |
| **Migraine** | | | | | | | | | |
| **Reference** | Study design | Conflict of interest | Inclusion criteria | Exclusion Criteria | Follow-up | Subjects (% boys) | N (patients) | Age (years) | Groups (n) |
| (Villa et al., 2009) | Cohort | None | Migraine | None | None | 51,7 | 60 | Group 1- 8-12 Mean 10,8±1,5 Group 2- Mean 9,9±1,3 | 1- Migraine (30) 2- No migraine (30) |
| **Musculoskeletal complaints** | | | | | | | | | |
| **Reference** | Study design | Conflict of interest | Inclusion criteria | Exclusion Criteria | Follow-up | Subjects (% boys) | N (patients) | Age (years) | Groups (n) |
| **(Fares et al., 2017)** | Cross-sectional | None | < 18 year Neck pain | Pain associated with disease | None | Unknown | 180 | 8-17 Mean 14 | 1- Neck pain (180) |
| (Toh et al., 2019) | Cross-sectional | None | 10-18 year | None | None | 49,6 | 1884 | 10-18 Mean 13,3±2 | 1- Boys (934) 2- Girls (950) 3- Primary 5 (516) 4- Secondary 1 (530) 5- Secondary 3 (693) 6- Junior College1 (145) |

### Headache-group

For headache there were found a total of 8 studies that could be included in the review. (Akinci et al., 2008; Dotan et al., 2014; Mehboob et al., 2019; Mishra et al., 2013; Roth et al., 2014; Sterner et al., 1999; Sterner et al., 2006)Those who found a relationship found that different types of ametropia (Akinci et al., 2008; Dotan et al., 2014; Hendricks et al., 2007; Mehboob et al., 2019) and accommodation deficiencies (Sterner et al., 1999; Sterner et al., 2006), and headaches. Ametropia and compound and mixed astigmatism were the types of ametropia that had the strongest relationship with headache. (Akinci et al., 2008) What types of ametropia that gave headache differed between boys and girls, for girls it was the spherical part and for boys the cylindrical. (Hendricks et al., 2007) Accommodation dysfunction can give headaches. An accommodation amplitude below 8 monocular and 11 binocular, have a high risk of near symptoms(Sterner et al., 2006) and accommodation facility training would elevate symptoms for those with weak accommodation facility. (Sterner et al., 1999) Some studies had included primary headaches and those did not find the same relationship between refractive error and headache. (Mishra et al., 2013) The best studies were those who had a follow up to see if the new correction and visual training have had desired effect. (Dotan et al., 2014; Mehboob et al., 2019; Mishra et al., 2013; Roth et al., 2014; Sterner et al., 1999; Sterner et al., 2006)

formaterte: Norsk (bokmål)

formaterte: Norsk (bokmål)

Summaries of the eight articles is in appendix 1.

### Migraine-group

For migraine there was only one study included in the review. (Villa et al., 2009)They tested patients with migraine when they had been symptom free for at least 2 days. They found that the visual attention was reduced on some of the tests compared with the controls.

A summary of the article is in appendix 2.

### Musculoskeletal complaints

2 articles about musculoskeletal complaints were included. (Fares et al., 2017; Toh et al., 2019) They investigated if there were a relationship between musculoskeletal complaints and visual symptoms and they found some relationship, in which that some patients with musculoskeletal complaints also had visual symptoms. The studies did not include visual measurements, only questions about visual symptoms.

Summaries of the 2 articles are in appendix 3.

## Vision-measurements

Vision was measured in different ways in the different studies. What was done or included in the article and which criteria they used to define ametropia are summarized in table 3. Only 2 studies had reported their criteria for ametropia, and they had the same criteria. (Akinci et al., 2008; Dotan et al., 2014)

Table 3: Visual criteria

| **Reference** | **Headache** | | | | |
|---|---|---|---|---|---|
| | Myopia | Hyperopia | Astigmatism | Anisometropia | Miscorrection |
| **(Akinci et al., 2008)** | Mild: -0,5 to -3.0<br>Moderate: -3,0 to -6,0<br>Severe: > -6.0 | Mild: +2,0 to +4,0<br>Moderate: +4,0 to +6,0<br>Severe: > +6,0 | Mild: 1,0 to 3,0<br>Moderate: 3,0 to 6,0<br>Severe: > 6.0 | ≥ 2,0 | 0,5 |
| **(Dotan et al., 2014)** | Refraction | Uncorrected VA | Corrected VA | Same criteria as Akinci | |
| **(Hendricks et al., 2007)** | Habitual refraction – measured with correction that was used | Emmetropia -0,5 to +0,5<br>Myopia > -0,5<br>Hyperopia > +0,5<br>Astigmatism > 0,25 | | | |
| **(Mehboob et al., 2019)** | Refractive error | No Criteria stated | | | |
| **(Mishra et al., 2013)** | Correction need | No criteria or ametropia stated | | | |
| **(Roth et al., 2014)** | Refractive error | Binocular vision problems | Amblyopia | Eye disease | |
| **(Sterner et al., 1999)** | Relative accommodation | Visual acuity | Refraction | | |
| **(Sterner et al., 2006)** | Accommodation amplitude | Refraction – done, but not stated | Relative accommodation – done, but not stated | Visual acuity – done, but not stated | |
| **Reference** | **Migraine** | | | | |
| **(Villa et al., 2009)** | Visual attention | | | | |
| **Reference** | **Musculoskeletal complaints** | | | | |
| | Eye symptoms | | | | |
| **(Toh et al., 2019)** | Visual symptoms | Glasses/contacts | Type of ametropia | | |

The visual measurements from the different studies are listed in table 4. As seen in the table ametropia is stated in several different ways. Two studies had the same criteria for ametropia. (Akinci et al., 2008; Dotan et al., 2014) One study graded the ametropia (Akinci et al., 2008), another study reported the refractive power (Dotan et al., 2014), there were 2 more that reported which type of ametropia and astigmatism. (Hendricks et al., 2007; Mehboob et al., 2019), and one stated only myopia or hyperopia. (Toh et al., 2019) Two studies reported if the patients had refractive error or not, not specifying type of refractive error. (Mishra et al., 2013; Roth et al., 2014) The article about accommodation facility training reported relative accommodation and visual acuity before and after training. (Sterner et al., 1999)Visual symptoms were reported in 4 studies. (Fares et al., 2017; Roth et al., 2014; Sterner et al., 2006; Toh et al., 2019) The article about migraine reported different measurements of visual attention. (Villa et al., 2009)

Table 4: Visual measurements

| Reference (Akinci et al., 2008) | Visual measurements | | Prevalence (headache/control) | |
|---|---|---|---|---|
| | Myopia | | 20 (6,5%) / 59 (6,9%) | |
| | Mild | | 4 / 39 | |
| | Moderate | | 6 / 20 | |
| | Severe | | 10 / 10 | |
| | Hyperopia | | 25 (8%) / 72 (8,5%) | |
| | Mild | | 5 / 15 | |
| | Moderate | | 7 / 38 | |
| | Severe | | 13 / 9 | |
| | Astigmatism | | 61 (19,6%) / 69 (8,2%) | |
| | Mild | | 12 / 37 | |
| | Moderate | | 30 / 22 | |
| | Severe | | 19 / 10 | |
| | Simple | | 5 (1,6%) / 17 (2%) | |
| | Compound | | 24 (7,7%) / 37 (4,9%) | |
| | Mixed | | 32 (10,3%) / 15 (1,8%) | |
| | Total Refractive Error | | 106 (34,2%) / 200 (23,7%) | |
| | Mild | | 21 / 91 | |
| | Moderate | | 43 / 65 | |
| | Severe | | 42 / 54 | |
| | Anisometropia | | 61 (19,7%) / 21 (2,5%) | |
| | Miscorrection | | 51 (16,5%) / 17 (2%) | |
| Reference (Dotan et al., 2014) | Cyclo refraction | Refraction | Initial logMar RE/LE | Final Logmar RE/LE |
| | -1,0/-1,25*10<br>-0,5/-1,25*170 | -1,0/-1,25*10<br>-0,5/-1,25*170 | 0,6/0,2 | 0/0 |
| | -2/-0,5*0<br>-2/-0,5*0 | -2/-0,5*0<br>-2/-0,5*0 | 1,0/1,0 | 0/0 |
| | -0,75/-0,5*0<br>-0,75/-0,5*0 | -0,75/-0,5*0<br>-0,75/-0,5*0 | 0,3/0,2 | 0/0 |
| | +3/-0,25*0<br>+2/-0,25*0 | +1,5/-0,25*0<br>+0,5/-0,25*0 | 0,2/0 | 0,1/0 |
| | 0/-3,5*130<br>+0,25 | 0/-3,5*130<br>+0,25 | 0,3/0 | 0/0 |
| | -1,5<br>-1,75 | -1,5<br>-1,75 | 1,0/0,7 | 0/0 |
| | +1,5/-2,0*0<br>+2/-2,25*170 | 0/-2,0*0<br>+0,5/-2,25*170 | 0,3/0,3 | 0/0 |
| | -1,0<br>-1,0 | -1,0<br>-1,0 | 0,2/0,2 | 0/0 |
| | +4/-0,75*0<br>+2,25/-0,25*0 | +2,5/-0,75*0<br>+0,75 /-0,25*0 | 0,3/0 | 0,1/0 |
| | -1/-0,75*90<br>-0,25/-0,5*90 | -1/-0,75*90<br>-0,25/-0,5*90 | 0,1/0,1 | 0/0 |
| | -1,0/-0,25*90<br>-1,25/-0,25*90 | -1,0/-0,25*90<br>-1,25/-0,25*90 | 0,2/0,4 | 0/0 |
| | +0,5<br>+2,75 | 0<br>+2,25 | 0,1/0,3 | 0/0,2 |
| | +0,25<br>+3,50/-0,5*0 | 0<br>+3,25/-0,5*0 | 0/0,4 | 0/0 |
| | +1,25<br>+2,5 | 0<br>+1,25 | 0/0 | 0/0 |
| | -2<br>-1 | -2<br>-1 | 0,4/0,2 | 0/0 |
| | +3,5/-0,25*0<br>+4,75/-0,5*0 | +2/-0,25*0<br>+3,25/-0,25*0 | 0,2/0,3 | 0/0,1 |
| Reference (Fares et al., 2017) | Eye symptoms | | Prevalence | |
| | Eyestrain | | 21 (12%) | |
| | Dry eyes | | 12 (7%) | |
| | Myopia | | 6 (3%) | |

| Reference (Hendricks et al., 2007) | Refractive error | Prevalence (%) |
|---|---|---|
| | Right eye sphere component | Total (gr1/gr2/gr3/gr4) |
| | Myopia | 15% (37%/10%/24%/14%) |
| | Emmetropia | 73% (44%/81%/62%/73%) |
| | Hyperopia | 12% (19%/9%/14%/13%) |
| | Left eye sphere component | |
| | Myopia | 15% (41%/11%/19%/13%) |
| | Emmetropia | 76% (43%/81%/74%/77%) |
| | Hyperopia | 9% (16%/8%/7%/10%) |
| | Right eye cylinder component | |
| | Astigmatism | 33% (56%/28%/50%/30%) |
| | No astigmatism | 67% (44%/72%/50%/70%) |
| | Left eye cylinder component | |
| | Astigmatism | 36% (59%/31%/55%/32%) |
| | No astigmatism | 64% (41%/69%/45%/68%) |
| Reference (Mehboob et al., 2019) | Refractive error | Prevalence |
| | Ametropia | 56 (21,4%) |
| | Myopia | 20 (42,8% |
| | Hyperopia | 12 (21,5%) |
| | Astigmatism | 24 (42,8%) |
| | No ametropia | 206 (78,6%) |
| Reference (Mishra et al., 2013) | Refractive error | Prevalence |
| | Had prescription | 1 |
| | Got prescription | 1 |
| | No refractive error | 41 |
| Reference (Roth et al., 2014) | Visual measurements | Prevalence |
| | Refractive error | 43 (27,2%) |
| | Ophthalmologic history | 48 (30,4%) |
| | Strabismus | 19 (11,9%) |
| | Visual symptoms | 15 (9,5%) |
| | New spectacle correction | 33 (20,9%) |
| | Quit glasses | 4 (2,5%) |
| | Convergence insufficiency | 2 (1,3%) |
| Reference (Sterner et al., 1999) | Visual measurement | Prevalence |
| | VA before training ≤ 0,65 | 6 |
| | VA before training 0,65 – 0.9 | 15 |
| | VA before training ≥ 1,0 | 55 |
| | VA after training 1,0 | 76 |
| | NRA before training < 1,75 | 27 |
| | NRA after training < 1,75 | 6 |
| | NRA after training 1,5 | 5 |
| | NRA after training 1,25 | 1 |
| | PRA before training < 1,75 | 20 |
| | PRA after training < 1,75 | 5 |
| Reference (Sterner et al., 2006) | Visual measurements | Prevalence (first/second visit) |
| | Asthenopia | 26,4% / 23,7% |
| | Floating text | 11,1% / 18,6% |
| | Facility problems | 4,2% / 5,1% |
| | Accommodation amplitude mean | Value (No/yes/all) |
| | Right | (13,1/11,1/12,4) / (12,4/8,8/10,9) |
| | Left | (13,21/11,2/12,51) / (12,4/9/11) |
| | Binocular | (16,32/13,19/15,24)/15,8/11,9/14,1) |
| Reference (Toh et al., 2019) | Visual measurements | Prevalence (boys/girls) |
| | Visual symptoms | 2.0 Mean |
| | Glasses/contacts | 63,6% (58,8% / 68,2%) |
| | Myopia | 83% (79,4% / 86%) |
| | Hyperopia | 10,3% (11,8% / 9%) |
| | Both | 4,3% (4,2% / 4,3%) |

| Reference (Villa et al., 2009) | Test | Result (migraine/control) |
|---|---|---|
| | TMT A (time, s) | 23 ± 12,6 / 17,5 ± 4,5 |
| | TMT B (time, s) | 66,6 ± 36,6 / 41,7 ± 13,8 |
| | Letter cancellation test (time, s) | 148,4 ± 55,1 / 129,4 ± 32,5 |
| | Cancellation omission errors | 3,3 ± 3,7 / 2,9 ± 3,3 |
| | Reaction time task 1 VAT | 0,5 ± 0,1 / 0,6 ± 0,1 |
| | Reaction time task 2 VAT | 0,6 ± 0,1 / 0,6 ± 0,1 |
| | Reaction time task 3 VAT | 0,5 ± 0,1 / 0,5 ± 0,2 |
| | Omission errors task 1 VAT | 2,2 ± 2,8 / 1,0 ± 1,3 |
| | Omission errors task 2 VAT | 2,8 ± 2,7 / 1,9 ± 1,6 |
| | Omission errors task 3 VAT | 0,2 ± 0,4 / 0,1 ± 0,3 |
| | Action errors task 1 VAT | 2,4 ± 1,7 / 1,6 ± 1,3 |
| | Action errors task 2 VAT | 5,5 ± 3,5 / 3,4 ± 2,7 |
| | Action errors task 3 VAT | 2,4 ± 5,7 / 0,6 ± 1,6 |

## Risk of bias

Table 5 and 6 shows the answers to the CASP questions for the included articles. There are some unknown answers for the cross-sectional articles because was not easy to answer yes or no because of the wording of some of the questions.

Most of the articles have good results overall to the questions.

The two studies from (Sterner et al., 1999; Sterner et al., 2006)about accommodation got all yes which makes them strong studies. Of the cross-sectional studies (Hendricks et al., 2007; Toh et al., 2019)had the strongest results. They had only unknown on 1 question, but all studies got unknown on that. This because it was the question about the literature search process in systemic review.

These 4 studies are the studies that had the articles with the most information in them, which made me trust their results more.

Table 5: CASP – Cross-sectional studies

| Reference | 1. Did the review address a clearly focused question? | 2. Did the authors look for the right type of papers? | 3. Do you think all the important, relevant studies were included? | 4. Did the authors do enough to assess quality of the included studies? | 5. If the results of the review have been combined, was it reasonable to do so? | 6. What are the overall results of the review? | 7. How precise are the results? | 8. Can the results be applied to the local population? | 9. Were all important outcomes considered? | 10. Are the benefits worth the harms and costs? |
|---|---|---|---|---|---|---|---|---|---|---|
| (Akinci et al., 2008) | Y | U | U | U | Y | U | Y | y | Y | Y |
| (Dotan et al., 2014) | Y | U | U | Y | U | U | Y | Y | Y | Y |
| (Fares et al., 2017) | Y | U | U | Y | Y | Y | Y | Y | U | Y |
| (Hendricks et al., 2007) | Y | U | Y | Y | Y | Y | Y | Y | Y | Y |
| (Mehboob et al., 2019) | Y | U | Y | U | Y | Y | Y | Y | U | Y |
| (Mishra et al., 2013) | Y | U | N | U | U | N | N | Y | N | Y |
| (Toh et al., 2019) | Y | U | Y | Y | Y | Y | Y | Y | Y | Y |

Table 6 - Cohort-studier

| Reference | 1. Did the study address a clearly focused issue? | 2. Was the recruitment acceptable? | 3. Was the exposure accurately measured? | 4. Was the outcome accurately measured? | 5. Have they identified all important confounding factors? | 6. Have they take account of confounding factors in the design and/or analysis? | 7. Was the follow up of subjects complete enough? | 8. Was the follow up long enough? | 9. What are the results of this study? | 10. How precise are the results? | 11.Do you believe in the results? | 12. Can the results be applied into practice? | 13. Do the results of this study fit with other available evidence? | 14. What are the implications of this study for practice? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Roth et al., 2014) | Y | U | U | Y | U | U | Y | Y | Y | Y | U | U | N | U |
| (Sterner et al., 1999) | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| (Sterner et al., 2006) | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| (Villa et al., 2009) | Y | Y | N | Y | U | U | N | N | Y | Y | Y | Y | U | U |

## Discussion

This review gives a summary of studies that have examined the relationship between vision and musculoskeletal complaints and headaches. The methodological quality of the different studies was not as good. By summarizing the studies, the goal was to give advice on how to give better help to these patients and further research on the subject.

The studies that examined the relationship between headache and the visual system was the only articles that had measurements of refraction, visual acuity and accommodation. (Akinci et al., 2008; Dotan et al., 2014; Hendricks et al., 2007; Mehboob et al., 2019; Mishra et al., 2013; Roth et al., 2014; Sterner et al., 1999; Sterner et al., 2006) Most of the studies found a relationship between headache and the visual system, but not all. The one that did not find a relationship had included primary headaches and those are by diagnosis criteria not caused by the eyes which is a weakness of that study. (Mishra et al., 2013) Two studies examined the relationship between headache and accommodative disorders. One examined the relationship between different accommodation measurements and near symptoms. They found that accommodation amplitude and NRA measurements had a significant relationship. They found that accommodation amplitude lower than 8 D monocular and 11 D binocular could find 90 % of those with near symptoms. (Sterner et al., 2006) The other study evaluated the effect of accommodative facility training on accommodative dysfunction, the follow up was 2 years after completing the training. They found that all had no symptoms like headache and asthenopia at end of training or after 2 years. (Sterner et al., 1999) This shows that not enough just to do refraction to find out if headache is caused by the eyes, and that it is also important to take measurements on near. The best studies were those studies that had follow up to see the effect of the treatment, because they have showed that the treatment given

helped with the headache and complaints. (Dotan et al., 2014; Mehboob et al., 2019; Roth et al., 2014; Sterner et al., 1999; Sterner et al., 2006)

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formaterte: Norsk (bokmål)

The article about migraine found that visual attention was reduced in migraine patients. (Villa et al., 2009) This is rarely measured in optometric practice, but it is possible to do such measurement if you have test for it. This may help those with migraine to handle this period better since they are aware of the reduction in visual attention.

The articles about musculoskeletal complaints did not have visual measurements but showed that visual symptoms had a correlation with musculoskeletal complaints. And with visual symptoms it is a chance there are correlation with visual measurements also, therefore we need more research to investigate that possible relationship.

These studies show that it is important to do a thorough examination that includes binocular and near vision and a thorough patient history. For the patient history an questionnaire is option and idea, either giving the patients and parents it on forehand or fill it in in the examination.

## Clinical advice

Take the normal patient history you normally take but include these questions:

- Do you get headaches?
- Where is the headache?
- When do you get it?
- What kind of pain is it? Stabbing pain, pressure or the hole head heavy?
- Do you have any tricks to make it better?
- Do you have any discomfort or pain in your neck? When do you get it?

Repeat the questions for shoulders and back. You may have to point to the body parts on smaller children. You may have to adapt the questions to each child, so they understand what you are asking them.

- Do you like to read or play on the iPad?
- If no: Why do you not like it? What happens when you do that?
- How do you sit when you read or work on the Ipad?

The Wong-Baker face scale is a good aid to help the children with the grading of the pain or discomfort. The Wong-Baker Faces pain scale is a scale that rates pain from 0 to 10 and is suited for people older than 3 years old. To get access to the scale see their webpage: https://wongbakerfaces.org/.

When doing the optometric measurements, it is important not just to find out of the refractive error, but also assess the binocular vision. From getting referrals for second opinion evaluation I have experience that it is not all optometrist that evaluate binocular and near vision, even though it is outline in the clinical guides. (Optikerforbund) Since accommodation and convergence must work together it is important to check both to be sure the eyes is not causing the headaches or musculoskeletal complaints.

## Strengths and limitations

A strength of this review is the rigid structure of the search and screening process.

A limitation of this review was that there were only a small sample of studies included and that it was not possible to extract data from the studies since there was no homogeneous in the measurements and values. Since it was not possible to extract data it was not possible to do a qualitative analysis of the studies.

## Further research

There is a lack of uniformity in the studies so there are need for more studies that have a more uniform study design and articles that include more of the visual measurements in the text.

There are a create need for research especially on musculoskeletal complaints and that demands a coloration between the health professional that work with musculoskeletal problems and optometrist. And the articles and rapports need to specify visual measurements and symptoms better than earlier publications have.

## Conclusion and implications

It is not common jet to get so many with musculoskeletal complaints for an examination, so when we do it is important to do a thorough job so that we best can give the best help and advice to these children and adolescents

The 2 studies included about musculoskeletal complaints showed a relationship between these complaints and visual symptoms, but not to visual measurements.  To do a go job for these children and adolescents we need more research on the relationship between musculoskeletal complaints and visual measurements. The studies also showed a relationship between complaints and smartphone/tablet use.

It is both more common to get patients with headaches complaints for an examination and there is more, but not enough, research on that relationship. Even though not all can get help from us, it is important to find those we can help with a thorough examination.

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## Appendix 1

*The correlation between headache and refractive error. (Akinci et al., 2008)*

This study had 310 patients with headache and 843 controls. Visual acuity, autorefraction and slit-lamp examination was performed on all the children, in addition there were done a dilated fundus examination on the headache group. On children younger than 10 years autorefraction was done with cyclopentolate.

They defined myopia as at least -0,5 D spherical equivalent, and hyperopia at least +2,0 D and astigmatism at least 1,0 D, and anisometropia when the difference in spherical equivalent was greater than 2,0 D. They The also classified the ametropia as mild, moderate or severe. For myopia the subgroups criteria was mild (-0,5 to -3,0 D), moderate (-3,0 to -6,0 D) and severe (> -6,0 D), for hyperopia it was mild (+2,0 to +4,0 D), moderate ( +4,0 to +6,0 D) and severe (<+6,0 D). Astigmatism was classified both on grade and type. Mild astigmatism (1,0 to 3,0 D), moderate (3,0 to 6,0 D) and severe (> 6,0 D) and type of astigmatism, simple, compound or mixed. Miscorrection was defined as 0,5 difference in power, either spherical or cylindrical, between previous correction and current power.

This study found that compound and mixed astigmatism and anisometropia was more common in patients with headache than in controls. The total prevalence of refractive error was also greater. In addition, they found that miscorrection was more common in patients with headache than in controls.

They recruited from a hospital outpatient clinic so the population may not be representative for general population and is a limitation. Another limitation is that there was no follow up to see if correct correction had any effect one the headache.

Some strengths of the study are that only includes headaches of unknown origin and that the exclusion criteria are well defined.

*Uncorrected ametropia among children hospitalized for headache evaluation: a clinical descriptive study (Dotan et al., 2014)*

A retrospective study of patients aged 8 to 18 admitted to Tel Aviv Medical Center for headache between December 2008 to March 2013 with ametropia as the only abnormality found. The patients got 2 cycles of cyclopentolate 1% in each eye, 5 minutes apart, and cycloplegic refraction was performed by retinoscopy. 917 headache patients were evaluated and 16 had uncorrected ametropia as only abnormality. 12 of the 16 had either CT, MR or both, with normal findings. 4 children also had lumbar puncture; these findings also normal. 10 of 16 did not report any visual symptoms. 10 had anisometropia, 10 had myopia and 6 had hyperopia, and 3 had astigmatism also. They did not say what criteria they used but listed both cycloplegic refraction and glasses prescribed. With myopia they prescribed the cyclo refraction and with hyperopia they gave 1,5 less, or so the best eye had SE so close to 0 as possible. On follow up 1 month later 14 children no longer had headache complaints. An eye examination with refraction can identify a possible cause of the headache and calm the patient, and parents, and sometimes prevent the need for further investigation.

*Relationship between habitual refractive errors and headache complaints in schoolchildren (Hendricks et al., 2007)*

The objective of the study was to find out if there is a relationship between habitual refractive error and self-reported headache complaints. Children in aged 11 to 13 in primary schools in the Netherlands was asked to participate. 487 children participated. Those who participated got their refractive error measured by autorefraction and had to answer a questionnaire about headache. If the children used glasses or contacts, they were measured with them. They chose to also include small ametropias. Myopia < 0,5 D, emmetropia -0,5 D to +0,5 D, hyperopia > +0,5D and astigmatism > 0,25 D.

74 children had optical correction, more girls than boys. Habitual refractive error was found in 27 % of the children, 15 % myopia and 12 % hyperopia. The type of refractive error that where associated with headache differed among girls and boys. With girls they were associated with the spherical component and with boys the cylindric component. The difference between boys and girls is surprising, it has not been reported in literature before.

It is not possible to prove causal relations with cross-sectional design, but it is unlikely that the headache causes ametropia. The authors took age and gender into account; therefore, it is possible that the association found between ametropia and astigmatism and headache is of casual significance. If these findings could be generalized to different populations many could avoided headache complaints.

*Ametropia in children with headache (Mehboob et al., 2019)*

A cross sectional study performed at Combined Military Hospital Gujranwala from March 2018 to November 2018. 262 children aged 5 to 16 years that had 2 to 8 weeks of persistent headache. Exclusion criteria was history of squint, refractive error, head injury, trauma, intracranial space occupying lesions, sinusitis, migraine, prolonged drug use, epilepsy, fever, and other known neurological diseases. All children underwent an evaluation of visual acuity, cycloplegic refraction, visual acuity with cycloplegic refraction, Hirschberg and covert test for squints, stereopsis with Titmus and examination of anterior and posterior segment. Children with ametropia went back for an additional refraction, post mydriatic, and they were prescribed glasses. The effect of the prescribed glasses on headache complaints were evaluated after 4 to 8 weeks.

Ametropia was found in 56 of 262 children. After 4 weeks over half had alleviation of headache symptoms and after 8 weeks 75% had alleviation of symptoms. Why ametropia may give headache is still unexplained.

All types of headache were included, frontal, temporal, migraine like and cluster. In this study the prevalence of ametropia was 21,4%. Of these 20 had myopia, 24 had astigmatism and 12 had astigmatism.

Proper refraction and full optical correction can elevate headache symptoms for these children. Refractive error should always be considered as differential diagnosis in unexplained headaches.

*Recurrent headache in pediatric outpatients at a public hospital in Delhi (Mishra et al., 2013)*
In a 10-month period from April 2011 to January 2012 all children 3 to 18 years old attending the Pediatric Department with recurrent headache was included in the study. 3 headache episodes in the previous 12 months was defined as recurrent headache. The patients wrote a headache diary which was reviewed on follow up visit usually after 4 weeks. VAS scales were used for those older than 6 year and Face scale for those younger than 6 to grade headache pain.

The same ophthalmologist did the evaluation on all the children. The evaluation included refraction, orthoptic testing, intraocular pressure and retinal examination. Spectacle correction was given when needed. After 3 months the effect of the correction was evaluated.

43 children aged 3 to 17 years old was included. 26 children with different types of migraine, 11 had tension type headache and 6 others type of headaches. Only 2 had refractive errors, one already had myopic correction. On follow up after 3 months there was no change in headache characteristic or frequency for those 2.

The follow-up was good and a strength of the study. Since the recruitment only was at the pediatric department and not medicine or neurology department the study missed other primary headache disorders.

*Headache and refractive errors in children (Roth et al., 2014)*
A chart review of pediatric patients with a headache diagnosis in a private practice between January 2002 and January 2011, only patients younger than 13 years were included. They all underwent an examination with evaluation of visual acuity, pupils, external slit-lamp examination, motility, dilated fundus examination and cycloplegic retinoscopy.

158 patients were included, of those 43 had clinically significant refractive error or had previously prescribed glasses and 48 had other ophthalmologic disorders. 22 had headaches associated with visual task, while 15 had visual symptoms. Blurred vision and diplopia were most common. 33 patients need glasses or changing of refraction, whilst 4 could stop wearing their glasses. About 70% of the patients that received changing in refraction had an improvement of headache, but about 80% of those that had no refractive error also had improvement.

It was a small study, and that is a weakness. Another weakness is that some of the headache episodes were 10 years previously.

Children with headache warrants thorough medical examination, both common causes and more serious causes. But a full eye examination should be taken also, especially when there are indications of visual problems.

*Accommodative facility training with a long term follow up in a sample of school aged children showing accommodative dysfunction (Sterner et al., 1999)*

The children were referred from School Health Care for problems with near work and they complained about headache, blurred vision, asthenopia, concentration loss and avoidance of near work. 38 children, 9 to 13 years old, were included in the study. To be included the children had to have reduced negative and positive relative accommodation and/or reduced accommodative facility. Before the children started the training program, accommodation, cycloplegic refraction, visual acuity at distance, binocular vision, motility and stereopsis were measured. One was excluded because of exophoria and lack of stereopsis. The study had 3 control groups with volunteers, the first group of with 24 children in the same age group, the second control group was 4 adults over 30 and the last group was 4 preschool children under 6 years.

Accommodation facility was measured using the NRA and PRA value.

The children had to train 3 minutes every day with a flipper with + and – lenses. They started with a power they barely were able to focus through, and the power was gradually increased with 0,5 D steps. At the end of the treatment they had +/- 2,0 D in the flipper. To secure high compliance there was an optometric examination every 2 weeks. The training period continued until subjective symptoms we gone, how long the period was were different and were more related to compliance rather than accommodative ability. For all 38 the symptoms like headache and asthenopia gradually decreased until they were gone at the end of the training period.

None had spectacles, but 35 of 38 got hyperopic glasses at the end of the training period. At the start 27 had NRA lower than 1,75 D, that number was reduced to 6 at the end of the training period. For PRA the numbers were 20 before training and 5 after.

The follow up examination was 2 years after end of training, 20 of the 38 participated at the follow up. For the 20 that had the follow up examination the NRA and PRA values were the same as at the end of training and they had not regained any subjective symptoms again. A telephone interview was performed on those who did not have a follow up examination. They had neither regained any symptoms.

The study clearly indicates that there is a long-term benefit from flipper training on the accommodative facility.

*Accommodation and the relationship to subjective symptoms with near work for young school children (Sterner et al., 2006)*

The children were examined during school hours and the cohort was examined two times with 1,8 years in between them. 72 children aged 6 to 10 years were included after the first examination and 59 of them had the second examination also. The interview was strictly structured and standardized to avoid bias. The technical measurements had a standardized procedure and was repeated 3 times. The same questionnaire was used on both examinations, and in addition the child described the symptoms with their own words. The questionnaire had 4 yes- or no-questions, about headache, asthenopia, floating text and facility problems.

The examination included non-cycloplegic refraction, distance and near visual acuity, relative accommodation, accommodation amplitude with RAF-ruler. Accommodation amplitude was measured with extra – lenses if needed.

The prevalence of symptoms was higher on the second examination. There was a significant relationship between accommodation amplitude and NRA and symptoms. Refraction and PRA did not generally show discriminating potential. Accommodation amplitude lower than 8,0 D monocular and 11,0 D binocular found about 90% of the children with symptoms so accommodation amplitude lower than this implies a higher risk of symptoms. Headache was the most common symptom, followed by asthenopia, floating text and facility problems.

The authors believe that children with symptoms with near work should have an eye examination. From the age of 8 years it is reasonable to be aware of the near symptoms and the relationship between the symptoms and accommodation amplitude.

## Appendix 2

*Visual attention in children with migraine: a controlled comparative study. (Villa et al., 2009)*

30 migraine patients were recruited from an out-patients childhood headache service at a Federal University in San Paulo, 5 with aura and 25 without aura. 8 to 12 years of age that had not used migraine prophylaxis. The control group was selected from 2 public schools in San Paulo.

All children underwent medical and psychological evaluations. Exclusion criteria was systemic illness, neurological abnormalities, IQ below 80, psychiatric disturbances, learning disabilities and history of epilepsy, head trauma or medication use that effect the central nervous system.

All children took Trail Making test A and B, which explore visual attention, mental flexibility, visual scanning and psychomotor velocity. They also took the Letter-Cancelling test which asses selective and sustained attention. The third test was a test of Visual attention. The assessment was done when the children in the migraine group had been free for pain and symptoms for 2 days.

The only result that was the same for the two groups was reaction time on Visual Attention test. The migraine group performed significant worst on TMT and had more action errors in the Visual Attention test. The other variables were also worst, but not significant. The migraine group had problem with selective attention, mainly alternate attention. The high level of action errors indicates that the children in the migraine group is more impulsive.

## Appendix 3

*Musculoskeletal neck pain in children and adolescents: Risk factors and complications. (Fares et al., 2017)*

Patients that came to clinic in Beirut in 2015 with nonspecific neck pain. The interviewed individuals were under 18 years. Children were defined as between 8 to 11 years and adolescents 12 to 17 years.

The patients pointed out were they had the pain on a model. The children had a neurological assessment to test for sensory and motor deficits. They also had radiology to rule out pathology.

Questionnaire about daily habits, studying conditions, sitting and sleeping positions and technology use and they were asked to show neck positions when using technology.

Patients with pain because of injuries or congenital or systemic disease was excluded.

180 patients were included. Age range 8 to 17 years old, mean age 14.

All 180 had flawed flexion of their neck and back. They used smartphones and/or tablets and had a neck flexion greater than 45 degrees when they used it. Weight put on the neck increases as the flexion increases.

21 of the patients had eyestrain, 12 had dry eyes and 6 had myopia. 124 also had pain in shoulders and 109 had pain in lower back.

*Mobile touch screen device use and associations with musculoskeletal symptoms and visual health in a nationally representative sample of Singaporean adolescents. (Toh et al., 2019)*

2009 students recruited from Singapore schools, age 10 to 18 years. They completed an online questionnaire. A member from the research team was available to answer questions. There were questions about how long and how often they used technology an average weekday and weekend day. The questionnaire also had questions about use the last 12 months, ownership, bedroom usage, type of activities in the week and weekend, how much multitasking they did and length of use. A modified Nordic Musculoskeletal questionnaire were used to find out about musculoskeletal complaints for neck, shoulders, upper and lower back and hand/wrist. They graded prevalence, frequency, intensity and interference with activities. The questionnaire also had questions about visual health and visual symptoms during and after use of smartphones and tablets, glasses or contact lenses, trouble seeing far or near. The answers were also reported by gender and school levels.

1884 respondents were included in the analysis.

95,1% used smartphones and it was the device that was most used throughout the week. Total technology use increased from primary 5 to secondary 3 before it dropped in junior college1. Technology was used in school but not officially incorporated into the school curriculum.

Smartphone were used to all types of activities, and was the device mostly used to multitasking. The bout length of use was also highest for smartphones.

Neck/shoulder complaints were most common, and girls had significant higher prevalence of those complaints. The prevalence of symptoms for all body regions increased with age.

There were 9 visual symptoms, and tired eyes was the most common symptom reported.

How many hours of smartphone used a day was associated with higher last month prevalence of neck/shoulder, upper back, arms and wrist/hand symptoms, and more visual symptoms. In addition, the odds for myopia was decreased. With tablet use there was no significant associations with musculoskeletal or visual symptoms, wearing glasses or myopia.

The technology was used for school and leisure.

School related use and homework stood for a considerable amount of the mobile touch screen device use. This is before it has been integrated into schools, so the use would probably increase when technology is integrated.