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How do vision problems corrected by optometric intervention, affect headache and quality of life?

A systematic literature review

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This thesis is worth 30 study points.

Abstract

Background: Headache disorders have arisen as a major concern in the global public health system. In daily practice, optometrists encounter patients who seek treatment for their headache symptoms through optometric intervention. It is therefore critical to comprehend in what level headache may affect patients' quality of life. The aim of this study was to investigate whether there is a correlation between vision problems that can be resolved through optometric intervention, headaches, and quality of life in adults (population over 18 years old).

Methods: This study is a systematic literature review using the Cochrane Collaboration's template. Starting in January 2023, systematic searches were conducted across five databases. Studies were chosen for inclusion, based on their ability to address visual problems that can only be resolved by optometric procedures and their association with headaches and/or quality of life in adults. The overall quality of the evidence in each manuscript, was evaluated using the international grading system of critical appraisal JBI.

Results: Systematic searches in all five datasets using terms chosen by the PICO method, generated 2655 articles. However, only eight of them fulfilled the inclusion criteria. Vision abnormalities that can be corrected through optometric intervention, did not reveal any immediate impact on adult quality of life, whereas research on headache disorders revealed contradictory results. Most of the studies included, showed a moderate risk of bias that indicated evidence of an inadequate quality level.

Conclusion: Several publications indicated uncorrected refractive error and binocular problems, as a possible risk factor for headaches and poor quality of life, in adults. However, by the time this systematic literature review was completed, there was a lack of high-quality research papers that might demonstrate a credible and convincing connection established between them, in the adult population. For a more accurate outcome, extensive research in this field would be necessary.

Keywords: Optometric intervention, Refractive error, Binocular vision problems, Headache, Quality of life, Adults, Systematic review

Abstrakt

Bakgrunn: Hodepinelidelser har oppstått som en stor bekymring i det globale offentlige helsesystemet. I daglig praksis møter optikere pasienter som søker behandling for sine hodepinesymptomer gjennom optometrisk intervensjon. Det er derfor avgjørende å forstå på hvilket nivå hodepine kan påvirke pasientens livskvalitet. Målet med denne studien var å undersøke om det er en sammenheng mellom synsproblemer som kan løses gjennom optometrisk intervensjon, hodepine og livskvalitet hos voksne (befolkning over 18 år).

Metoder: Denne studien er en systematisk litteraturgjennomgang ved bruk av Cochrane Collaborations retningslinjer. Fra januar 2023 ble det gjennomført systematiske søk i fem databaser. Studier ble valgt for inkludering, basert på deres evne til å undersøke visuelle problemer som bare kan løses ved optometriske prosedyrer og sammenheng med hodepine og/eller livskvalitet hos voksne. Den generelle kvaliteten på bevisene i hver studie, ble evaluert ved å bruke det internasjonale Critical Appraisal Toll JBI.

Resultater: Systematiske søk i alle fem databasene med søkeord valgt av PICO-metoden, frembrakte 2655 artikler. Imidlertid oppfylte bare åtte av dem inklusjons kriteria. Brytningsfeil som kan korrigeres gjennom optometrisk intervensjon, avslørte ingen umiddelbar innvirkning på livskvaliteten for voksne, mens forskning på hodepineforstyrrelser viste motstridende resultater. De fleste av studiene som ble inkludert, viste en moderat risiko for avvik, som indikerte bevis på et utilstrekkelig kvalitetsnivå.

Konklusjon: Flere publikasjoner indikerte ukorrigert brytningsfeil og binokulære anomalier, som en mulig risikofaktor for hodepine og dårlig livskvalitet, hos voksne. Men da denne systematiske litteraturgjennomgangen ble fullført, var det mangel på forskningsartikler av høy kvalitet som kan demonstrere en troverdig og overbevisende forbindelse etablert mellom dem, i den voksne befolkningen. For et mer nøyaktig resultat vil omfattende forskning på dette feltet være nødvendig.

Nøkkelord: Optometrisk intervensjon, Brytningsfeil, binokulære problemer, Hodepine, Livskvalitet, Voksne, Systematisk gjennomgang.

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1.Introduction

1.1 The burden of headache

All types of headaches can be classified into two categories: Primary and Secondary. Primary headaches are characterized by the absence of an identifiable underlying cause, and their diagnosis is based on a thorough examination of the patient's medical history and pattern recognition. Secondary headaches are characterized by the presence of an underlying cause that can be identified through examination or investigation, with the headache serving as a symptom of this cause (ICHD-3, 2018). Primary headaches account for around 90% of the headaches observed in clinical practice, while secondary headaches make up less than 10% of the cases (Chai et al., 2014).

The International Headache Society diagnostic criteria are utilized by specialists to facilitate the diagnosis of headache disorders for primary care. Globally, it is approximated that half of individuals experiencing headaches, resort to self-treatment without seeking the assistance of healthcare practitioners (Ravishankar K., 2016). Neurologists are responsible for treating a maximum of 10% of cases, with a lower proportion in Africa and South-East Asia. Physical therapy, acupuncture, and naturopathy are prominent choices among alternative and complementary therapies. Headaches disorders are a widely distributed and prevalent condition that can result in disability, though largely treatable. However, they are often not given proper recognition, diagnosis, or treatment. (WHO, 2011)

The second edition of the International Classification of Headache Disorders (ICHD-2) published in 2004 includes the category of "headache attributed to refractive error". It was lately revised to the third edition in 2018 that state "Headache caused by ocular refractive error(s), generally symptomatic after prolonged visual tasks". The criteria for the classification is as follows:

A. Any headache fulfilling criterion C
B. Uncorrected or miscorrected refractive error(s) in one or both eyes
C. Evidence of causation demonstrated by at least two of the following:

- headache has developed and/or significantly worsened in temporal relation to the onset or worsening of the refractive error(s)
- headache has significantly improved after correction of the refractive error(s)

- headache is aggravated by prolonged visual tasks at an angle or distance at which vision is impaired.
- headache significantly improves when the visual task is discontinued.

(ICHD-3, 2018).

Headaches that cause eye disorders are referred as secondary headaches, meaning that the cause is an underlying pathology (Aaseth et al., 2008) linked to various ocular conditions such as acute glaucoma, refractive error, heterophoria, heterotropia, iritis, uveitis, scleritis, and optic neuritis (Jain et al., 2018). The prevalence of persistent secondary headaches has been reported as 2.14% in a specific cohort of 30,000 individuals aged 30-44 years, as documented in the Aakerhus study conducted in Norway (Aaseth et al., 2008).

1.2 Headache and quality of life

Headache disorders are a challenge for public health, due to disability and financial consequences that they impose on society. The most critical years for headache disorders are the productive years (late teens to 50s), thus the financial cost comes mostly from missed working hours and poor outcome in productivity. Migraine alone accounts for the loss of approximately 25 million working days annually, in the United Kingdom (WHO 2011). The impact of headache disorders in the global public health, has been recognized by the World Health Organization. This intervention is beneficial for individuals experiencing headaches, as they often receive inadequate attention in the healthcare system (Andrée et al., 2014). Headache disorders have a high prevalence globally, yet their significance was not acknowledged until the year 2000. Occasional headaches among general population, has delayed the recognition of the significant impact that headache disorders may have, on the quality of life of every affected individual (Goadsby et al., 2021).

Headache appears prominently as a reason for seeking medical consultation. Approximately, one-third of all neurological consultations is being attributed to this condition, as reported by both general practitioners and neurologists. A large general study of neurologists in the United Kingdom indicated that headache was the primary reason for consultation, for up to one in six patients aged 16-65 years old (WHO 2011).

The years of life with disability attributed to headaches, have been increased globally since 1990, which is consistent with the escalating prevalence of this condition (Stovner et al., 2018). Stress, withdrawal behaviour, limited social interactions, and lifestyle compromise, have been documented in 16% of migraine and 20% of tension-type headache sufferers, which is associated with reduced productivity (Lampl et al. 2016).

Following a global analysis, the prevalence of headache disorders appears to be increasing, despite a general pattern of decreasing incidence of other diseases with socioeconomic development (WHO, 2011). Three billion people experienced either a migraine or tension-type headache in the year 2016. Among these, 1.89 billion individuals were affected by tension-type headache, while 1.04 billion individuals experienced migraine. In 2016, the prevalence of headaches was particularly high among women aged 15 to 49 years old (Stovner et al.,2018). Worldwide, there is a prevalence of active headache disorder at 52.0% of the population, with migraine accounting for 14.0%, Tension-Type Headache (TTH) for 26.0% and headaches over 15 days for 4.6%. On an average day, 15.8% of the global population, suffers from headaches (Stovner et al., 2022).

Individuals who experience headaches, record higher levels of persistent negative emotional states, while those who experience constant headaches tend to depression. Tension-Type Headache (TTH) and migraine impacts concentration, memory, mood, and mental performance, that reduces quality of life (Smith, 2016) and performance at work. At approximately 22% of migraine and 10% of tension-type headache sufferers, are several days away from work because of their headache (Suzuki et al.,2014). Combined studies in Europe, under the umbrella of the Eurolight project indicated that only 50% of individuals with headache will complete a regular working day (Andrée et al.,2014). The frequency of headache disorders is significantly impacted by modern lifestyle, resulting in an earlier onset of headaches, which were previously common among individuals of 15 to 49 years old (Goadsby et al., 2021).

The possibility of suffering from chronic headaches in adulthood increases, once experiencing frequent headaches in childhood and adolescence. Approximately 40% of school-aged children experience at least one headache on a weekly basis. Headaches have an important effect on children’s quality of life (Straube et al., 2013). Based on the study findings of Hakala et al., adolescents aged 12-16 years experienced challenges in their daily activities due to head, neck-shoulders, and eye pain. According to the data, 20% of the participants experienced headaches, while 13.8% reported pain around the eyes. Additionally, the data revealed that 29% of the individuals experienced a poor quality of life, due to headaches (Hakala et al.,2012).

1.3 Headache and refractive error

There has always been a large percentage of vision specialists that would indicate headache as a typical patient complaint that they experience in their daily practice. According to research done by Whittington in 1958, out of more than 1400 patients who attended refraction appointments, 45% reported having headaches. Throughout the 20th century, there was a significant discussion in medical literature regarding the association between headache and refractive error. Several researchers have investigated this correlation to provide solid proof that may support this hypothesis (Gordon et al., 2001). Refractive errors are a prevalent condition that impacts a significant portion of the global population, regardless of demographic factors such as age, gender, ethnicity and can be corrected through spectacles, contact lenses or other optometric intervention (such as vision training), to achieve optimal visual acuity (Friedman,2018).

Headaches related to refractive error are typically concentrated in the frontal area and the eyes. These headaches often become worse during extended periods of visual activity and are linked to hyperopia and astigmatism. (Nguyen et al., 2021). In Norway, hyperopia was shown to be the most common refractive error among adolescents, whereas myopia was found to be uncommon. Uncorrected vision problems may cause headaches and have an impact on individual's reading ability and academic performance (Hagen at al.,2018). Refractive errors, such as hypermetropia and astigmatism, may cause headaches due to the strain produced when focusing at near, such as reading. This relationship between refractive errors and headache symptoms has been observed; however, it is generally agreed that most headaches among the population with refractive errors, are random, and their role in headache pathogenesis remains uncertain (Jain et al., 2018). Data presented by Daum et al. suggest that emmetropic patients are presented less often with headache, compared to myopes and hypermetropes (cited by Gordon et al., 2001).

Asthenopia is a condition characterized by ocular discomfort that can result in headaches and pain in the eyes. Common symptoms include eyestrain, visual fatigue following reading, and a sensation of heaviness in the eyelids after reading. Uncorrected refractive errors are the underlying cause (Sheedy et al.,2003). Asthenopia arises due to extended periods of near work and because of strain on the accommodation convergence system. The correction of refractive error associated with asthenopia, can lead to the alleviation of headache (Jain et al., 2018). A questionnaire-based study from Vincent et al., concluded that 16% of subjects experience headaches to be triggered by close work (cited by Gordon et al., 2001). Studies have reported that the incidence of visual fatigue among university students globally ranges from 46% to 71% (Bhanderi et al. 2008) and there has been an increase the last years (Sheppard et al 2018).

Scheiman et al., (2013) have noted that visual fatigue may arise from the strain placed on initial visual processes, specifically the need to focus and converge the eyes on nearby objects. Accommodative and binocular dysfunctions have been identified as potential contributors to visual fatigue (Golebiowski et al., 2020) that includes mild frontal headache among other symptoms (Hoffman et al., 2008). Accommodative amplitude and accommodative facility are used to measure the accommodation function. Phoria, fusional range reserves, and vergence facility are used to measure the vergence function. Vergence facility and accommodative facility, are the key factors for binocular vision assessments (Scheiman et al., 2013). Convergence insufficiency is a visual disorder that affects both eyes, characterized by a reduced ability to converge on a near target. The average prevalence in children is estimated to range from 2% to 4%, with some studies reporting rates exceeding 10%. The symptoms associated may involve asthenopia, which refers to eye strain or fatigue, diplopia, and headaches that occur during near work tasks, particularly reading (Chang et al.,2021).

There was also an important correlation between headache and computer use (Hakala et al.,2012). The COVID-19 pandemic has resulted in new laws and policies aimed at reducing the spread of the disease. Consequently, our reliance on digital technology has escalated due to remote work, distance learning, and social interaction through digital devices (Nagata et al.,2020). Excessive screen time was identified as the most important factor causing headache, among IT employes in China (Li et al., 2020) while Wang et al. (2018) underlined that excessive use of smartphone is associated with headache, sleep, and fatigue, impacting the quality of life. The American Association of Optometrists has established the term "computer vision syndrome" to refer to a collection of eye and vision issues that arise from activities that place strain on near vision and are encountered during or in relation to computer usage (Heus et al., 2018). The condition encompasses asthenopia, eye pain, headache, and blurred vision resulting from refractive defects, accommodation, or convergence disorders. Refractive errors exacerbate the condition (Gowrisankaran et al., 2015), while the implementation of suitable optical correction could enhance the efficiency of computer users by 2.5%. There exists a correlation between screen time and the significance of asthenopia as well as the stress experienced by skeletal muscles. According to Heus et al. (2018), in severe cases, the condition can have an impact on both the patient's behavior and quality of life.

1.4 Research question and purpose

How do vision problems corrected by optometric intervention, affect headache and quality of life? The aim of this systematic literature review was to investigate the correlation between vision disorders, headache, and quality of life in the adult population.

2. Methods

The method chosen was a systematic literature review. The significance of literature reviews in education is crucial, as scientific research play an important part in the academic world. (Vom Brocke et al., 2009). As in any other academic field, knowledge analyses are becoming increasingly essential to stay aware of the rapidly expanding eHealth literature. These syntheses assist clinicians, scholars, and graduate students in locating, assessing, and integrating the information included within numerous empirical and conceptual papers (Pare et al., 2015).

2.1 Search strategy

The aim of this literature review was to answer the research question as presented above, inform the readers, and support the evidence-based practice. The author used a wide variation of the keywords: “optometric intervention”, “headache”, “quality of life” and “adults”, utilizing the Medical Subject Headings (MeSH) for assistance. The PICO model was applied as a search strategy tool for conducting the literature search (Table 1).

The process involves a comprehensive search for relevant studies in various databases, with the assistance of the librarians from the University of South-Eastern Norway. The databases that were included in electronic search was: MEDLINE, CINAHL, PSYCHINFO, COCHRANE and ORIA. (Table 2).

All the suitable publications were imported to EndNote, a valuable software application for conducting online literature searches and managing bibliographic references in an efficiently. Following that, the author removed the duplicates and conducted a manual search of all studies that met the inclusion and exclusion criteria, which were then categorized and evaluated.

Table 1: The PICO model used as a tool for designing the clinical research question.

Patient/problem	Adults	Adult* Young adult* Middle aged Aged
Intervention/exposure	Optometric intervention	Spectacles Eyeglasses Prescription glasses Contact lenses Vision therapy Vision training Visual therapy Visual training Orthoptic* Pleoptic* Orthoptic exercise* Eye exercise*
Comparison	Control group	
Outcome	Headache, Quality of life	Headache*, Tension-Type headache*, Tension Type headache*, Idiopathic headache*, Tension Headache*, Primary headache, secondary headache, Eyestrain, Asthenopia, Quality of life, Life Quality, Health-Related Quality of Life, Health Related quality of life, HRQOL.

Table 2: The research keywords used in all five databases and the results generated.

	KEYWORDS	RESULTS
1	Adult* OR Young adult* OR Middle aged OR Aged	MEDLINE:2051744 CINAHL: 443540 PSYCHINFO: 767630 COCHRANE:2938 ORIA: 11637242
2	Spectacles OR Eyeglasses OR Prescription glasses OR Contact lenses OR Vision therapy OR Vision training OR Visual therapy OR Visual training OR Orthoptic* OR Pleoptic* OR Orthoptic exercise* OR Eye exercise*	MEDLINE:14579 CINAHL: 3814 PSYCHINFO: 1670 COCHRANE:557 ORIA: 3137677
3	Headache* OR Tension-Type headache* OR Tension Type headache* OR Idiopathic headache* OR Tension Headache* OR Eyestrain OR Asthenopia OR primary headache OR secondary	MEDLINE: 98626 CINAHL: 2689 PSYCHINFO: 20575 COCHRANE: 3041 ORIA: 572117

	headache	
4	Quality of life OR Life Quality OR Health-Related Quality of Life OR Health related quality of life OR HRQOL	MEDLINE:359666 CINAHL: 65662 PSYCHINFO: 86495 COCHRANE: 3611 ORIA: 7884961
1 AND 2 AND 3		MEDLINE: 32 CINAHL: 3 PSYCHINFO: 9 COCHRANE: 25 ORIA: 108
1AND 2 AND 3 AND 4		MEDLINE: 5 CINAHL: 0 PSYCHINFO: 1 COCHRANE: 4 ORIA: 57
1 AND 2 AND 4		MEDLINE: 77 CINAHL: 30 PSYCHINFO: 17 COCHRANE:34 ORIA: 714
1 AND 3 AND 4		MEDLINE: 845 CINAHL: 48 PSYCHINFO: 246 COCHRANE: 98 ORIA: 288

2.2 Inclusion's and exclusion's criteria

This systematic literature review, was an effort to collect, evaluate, and integrate all relevant studies that satisfies specified inclusions criteria. The study sample was restricted to individuals who were classified as adults, defined as those aged 18 years or older. Studies including vision problems that can be corrected only through optometric intervention were included. Moreover, the aetiology of the headache was a significant factor for inclusion. Headaches that was a result of a particular disease or syndrome as well as all the headaches as side effects of medicines or medicine overuse, were excluded. Only peer-reviewed articles were included and literature reviews, study protocols, as well as case reports were excluded. English and Scandinavian language and humans as research subjects was selected as inclusive criteria, whereas only full-length articles were included. The data were limited to publications after the year 2000, as the review is referred to studies conducted during the 21st century.

2.3 PRISMA Flow diagram

The flowchart diagram illustrates the progression of data throughout the various stages of a systematic literature review. The chart outlines the number of the included and excluded records (figure 1).

PRISMA 2009 Flow Diagram

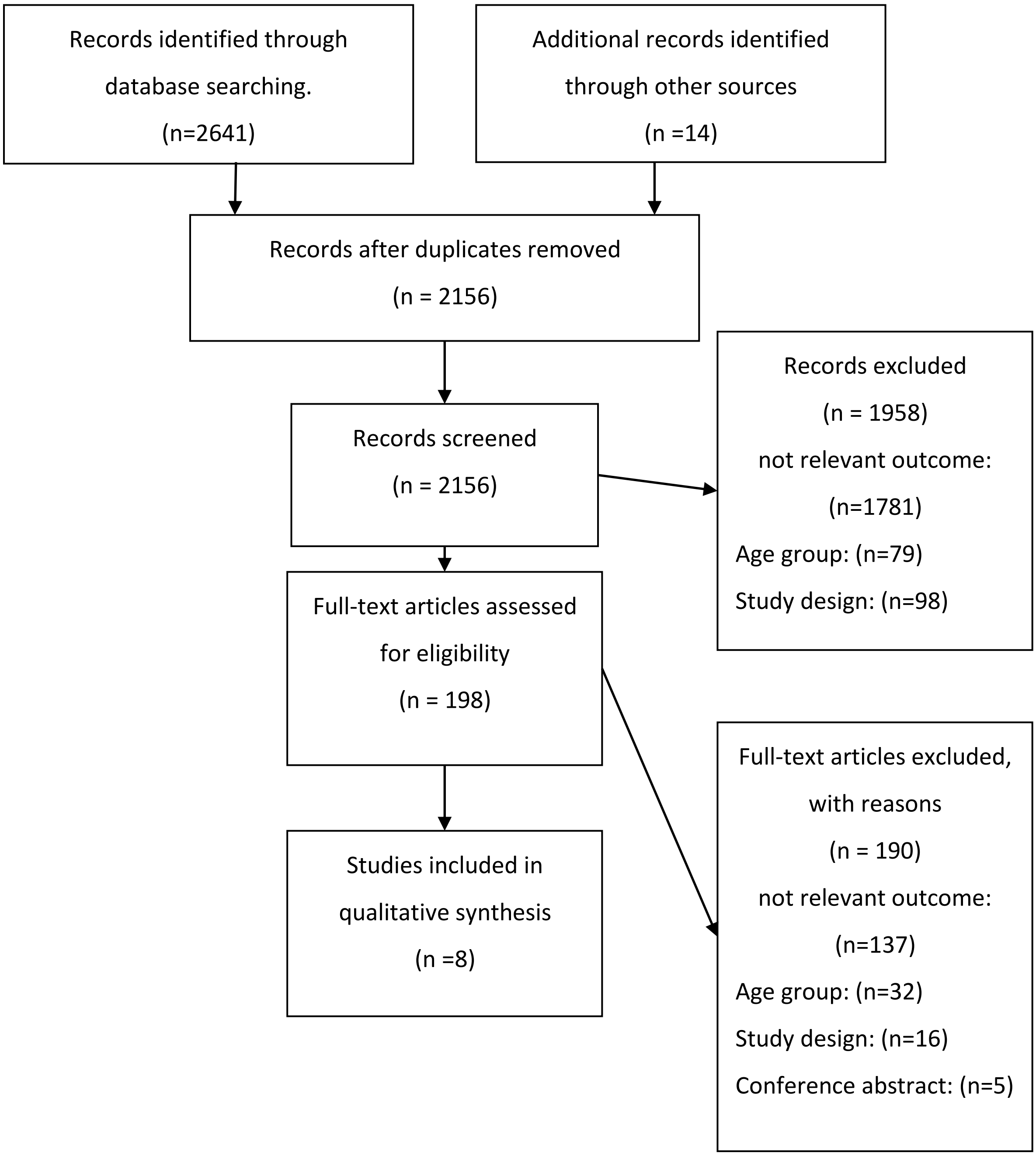

Fig. 1: PRISMA Flowchat that shows studies regarding to vision disorders, headache, and quality of life. Age group: adults (18+ years old).

2.4 Critical appraisal

Critical Appraisal was performed with JBI's critical appraisal tools, that allows the methodical evaluation of the reliability and outcomes of published academic works. The critical appraisal of all studies was conducted with respect to the following checklist, according to study designs, coming from JBI's site. The set of questions' checklists presented below, has been formulated by JBI to help reflecting on the studies, and work towards a methodical approach. The questions were recorded below, and the respective answers: "yes", "no" or "can't tell" in these questions, were listed in the table 4 and the assessment of the quality in table 5.

JBI's checklist for cross-sectional studies:

1. Were the criteria for inclusion in the sample clearly defined?
2. Were the study subjects and the setting described in detail?
3. Was the exposure measured in a valid and reliable way?
4. Were objective, standard criteria used for measurement of the condition?
5. Were confounding factors identified?
6. Were strategies to deal with confounding factors stated?
7. Were the outcomes measured in a valid and reliable way?
8. Was appropriate statistical analysis used?

JBI's checklist for case-control studies:

1. Were the groups comparable other than the presence of disease in cases or the absence of disease in controls?
2. Were cases and controls matched appropriately?
3. Were the same criteria used for identification of cases and controls?
4. Was exposure measured in a standard, valid and reliable way?
5. Was exposure measured in the same way for cases and controls?
6. Were confounding factors identified?
7. Were strategies to deal with confounding factors stated?
8. Were outcomes assessed in a standard, valid and reliable way for cases and controls?
9. Was the exposure period of interest long enough to be meaningful?
10. Was appropriate statistical analysis used?

JBI's checklist for cohort studies:

1.Were the two groups similar and recruited from the same population?

2. Were the exposures measured similarly to assign people to both exposed and unexposed groups?

3. Was the exposure measured in a valid and reliable way?

4. Were confounding factors identified?

5. Were strategies to deal with confounding factors stated?

6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?

7. Were the outcomes measured in a valid and reliable way?

8. Was the follow up time reported and sufficient to be long enough for outcomes to occur?

9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored?

10. Were strategies to address incomplete follow up utilized?

11. Was appropriate statistical analysis used?

Table 4: Critical appraisal of the included studies listed over, following the *JBI's* checklist above.

Authors	1	2	3	4	5	6	7	8	9	10	11
1.Zheng et al., 2021	Y	N	Y	N	Y	Y	y	N			
2.Lajmi et al., 2021	Y	Y	Y	N	Y	Y	Y	CT			
3.Hagen et al., 2020	Y	Y	Y	N	Y	Y	Y	Y			
4.Jain et al., 2018	Y	N	Y	N	Y	Y	Y	Y			
5. Marasini et al., 2012	Y	N	Y	Y	N	Y	Y	CT			
6.Hempala et al., 2014	Y	Y	Y	N	Y	N	Y	N	N	N	Y

7.Kommerell et al., 2015	Y	Y	Y	Y	CT	Y	Y	Y	N	Y	
8.Gil-Gouveia et al., 2002	Y	Y	Y	Y	Y	Y	N	CT	CT	Y	

**Y= yes, N=no, CT= can't tell*

Table 5: Study quality assessment based on the JBI's checklist above.

Authors	Score	Assessment
1.Zheng et al., 2021	5/8	moderate
2.Lajmi et al., 2021	6/8	moderate
3.Hagen et al., 2020	7/8	High
4.Jain et al., 2018	6/8	moderate
5. Marasini et al., 2012	5/8	moderate
6.Hempala et al., 2014	5/11	low
7. Kommerell et al., 2015	8/10	moderate
8.Gil-Gouveia et al., 2002	7/10	moderate

3.Results

After excluding the duplicate results, the total searches produced a total of 2156 articles. An electronic search conducted across five databases (MEDLINE, CINAHL, PSYCHINFO, COCHRANE, ORIA) and produced results for all except for 14 of the articles. Three of them was proposed by the supervisor teacher and 11 were obtained by manual search of the references of other review articles. These studies were analysed and categorised as included or excluded, based on the initial criteria. Eight of them were found qualified and included in this study. The study search and selection process is visually represented in a flowchart fig. 1.

The main reason for the exclusion of the articles was due to their failure to address headaches associated with refractive error. Instead, the articles focused on chronic migraines and primary headaches that were associated to a different underlying cause. Furthermore, articles that did not refer to adult individuals were excluded. The study design of the articles was also an important factor in the exclusion process.

A total of 1067 people participated in the eight studies included in this literature review. Five of the studies had a cross-sectional study design, two of them a case-control design and one was a cohort study. These studies included population from Norway, Sweden, Germany, Portugal, Nepal, Tunisia, India, and China. The mean age of the individuals varied from 19 to 39 years old. Five of the studies included, did not conduct any follow-up assessments of the participants. Conversely, the remaining three studies carried out a single follow-up assessment, with one of these studies reporting a follow-up rate of only 23% of the participants.

Six of the studies identified a correlation between refractive error and headache. Among these studies, two established a link between poor habitual amplitude of accommodation and headache, while two others reported a significant prevalence of asthenopia in computer users. Three of the conducted studies investigated the quality of life along with the other outcomes (table 6).

Authors	Research question	Population	Population source	Follow-up	Results
Gil-Gouveia et al. (2002)	Headaches Associated with Refractive Errors: Myth or Reality?	176 individuals agreed to participate. Mean age: group 1: 37,6/group 2: 34,8.	Cluster sample from two clinics (no more information).	1 follow-up for only 40 individuals (23%), after 10 months.	Correlation between hyperopia and headache.
Hagen et al. (2020)	Vision status and reading test results in adolescents in Norway.	436 adolescents, 16-19 years old.	Individuals from two upper secondary schools in South-East Norway.	No follow-up.	Correlation between headache and poor habitual amplitude of accommodation and moderate to high hyperopia. Correlation between vision anomalies and difficulties in reading/lower test score.
Hempala et al. (2014)	Optimal correction in spectacles: intervention effects on eyestrain and musculoskeletal discomfort among postal workers.	18 adults, 26-62 years old with the mean of 47.	Postal workers in Sweden, all participated in a previous study of the author.	No follow-up.	Correlation between eyestrain and eye fatigue and refraction/optimal correction. Correlation between musculoskeletal/neck discomfort and optimal correction.
Jain et al. (2018)	Determination of the proportion of refractive errors in patients with primary complaint of headache and the significance of refractive error correction in symptoms relief.	103 participants, 6-36 years old, mean age 19	Hospital based study, Puducherry, India.	1 follow-up, after 1 month headache group.	Correlation between hyperopia, astigmatism, and headache. Correlation between asthenopia and refractive error correction.
Kommerell et al. (2015)	Asthenopia, Associated Phoria, and Self-Selected Prism.	40 subjects, between 20-71 years old, mean age: Group 1: 39 Group 2: 24 years old.	Freiburg University based study, Germany, with paid participants (10 euro/hour).	No follow-up.	Found no correlation between latent deviation of vergence and discomfort/asthenopia.
Lajmi et al. (2021)	Headache associated with refractive errors: Characteristics and risk factors.	90 patients, Mean age Group 1: 25 +/- 11 Group 2: 25 +/- 10 years old.	No information	1 follow-up, from 1 to 4 months afterwards. Mean 2.44 months headache group.	Correlation between astigmatism, hyperopia and prolong screen working with headache associated with refractive errors (HARE). Found HARE as a risk factor for poor quality of life.

Marasini et al. (2012)	Ocular morbidity on headache ruled out of systemic causes—A prevalence study carried out at a community-based hospital in Nepal.	100 patients, Group 1<17 years old (20 people), Group 2<40 years old (60 people), Group 3>40 years old (20 people).	Patients referred from otorhinolaryngology or psychiatry department of Dhulikhel hospital, Nepal.	No follow-up.	Found high prevalence of refractive errors in headache patients (44%). Correlation between low degrees of refractive error and headache. Found high prevalence of astigmatism in headache patients, and 13% of prevalence for computer vision syndrome. Low prevalence (29%) of poor binocular vision among headache patients.
Zheng et al. (2021)	Investigation of the Relationship Between Subjective Symptoms of Visual Fatigue and Visual Functions.	104 individuals, 18-30 years old, mean age: 23,4	Students from Wenzhou medical university, China.	No follow-up.	Strong correlation between visual fatigue and binocular accommodative facility but not with vergence facility. Moderate correlation between accommodation/vergence and contrast sensitivity.

Table 6: Analyses of characteristics of studies included.

In six of the eight studies analysed, a questionnaire was employed as a method to register the symptoms and classification of headache. In contrast, only three of the studies enlisted a neurological examination, to confirm these findings. Each of them performed an ophthalmic evaluation. The criteria for refractive errors were described in only three of them (table 7).

The overall study's results demonstrated significant correlation between visual abnormalities such as refractive error, amplitude of accommodation, and vergence facility, and headaches. According to findings from three of the studies, headaches associated to refractive errors (HARE) can have an impact on the quality of life. There was, however, one study that failed to establish a correlation between latent deviation of vergence and asthenopia. Limitations of this study were that the headache classification was done through patients-reported information, no follow-up, and no placebo group. Additionally, the author stated that certain individuals with asthenopia may still get benefit from a prismatic correction.

Table 7: Classification of refractive error.

Authors	Refractive error
Hagen et al. (2020)	(SER = sphere + ½ cylinder) Myopia SER ≥ −0.75D Hyperopia SER ≥ +1.00D Emmetropia −0.75D < SER < +1.00D Astigmatism SER ≥ 1.00D Anisometropia SER ≥ 1.00D between the two eyes.
Lajmi et al. (2021)	Spherical equivalent (SE) Difference between eyes (DBE) myopia SE ≥ -0.50 D hyperopia SE ≥ +0.50 D. Astigmatism ≥ -0.5 D Anisometropia: DBE ≥ 3D in myopia ≥ 1D in hyperopia ≥ 1.5D in astigmatism
Marasini et al. (2012)	Spherical Equivalent Refractive Error (SERE) Emmetropia: −0.25 and +0.25 Dioptres (D) hyperopia SERE > +0.50 myopia SERE > −0.50 D Astigmatism > 0.50 D

The existing literature suggests a significant correlation between hyperopia and headaches associated with refractive errors, as evidenced by findings from four studies (Gil-Gouveia et al., 2002; Hagen et al., 2020; Jain et al., 2018; Lajmi et al., 2021). Two of the sources indicate that astigmatism holds a similar level of significance as hyperopia (Jain et al., 2018; Lajmi et al., 2021). However, in one of the sources, the prevalence of astigmatism surpassed that of hyperopia and myopia, with rates of 63.63% (hyperopia), 27.27% (myopia), and 9.09% (astigmatism), respectively (Marasini et al., 2012).

In one study, there is no statistically significant correlation observed between the frequency of headaches and refractive error in adults. (Gil-Gouveia et al.,2002). Hempala et al. (2014), underlined in his study that optimal correction decreased headache, eye fatigue and eyestrain. Specifically, 72.5% of the participants experienced a reduction in headache symptoms following appropriate correction. There was no observed correlation between the severity of refractive error and the incidence of headaches, though a placebo group had not been included. (Gil-Gouveia et al.,2002).

Hagen et al., (2020) found that headaches were associated with poor habitual amplitude of accommodation. This, in turn, can lead to reduced reading comprehension and a lower academic performance among adolescents. Visual fatigue was strongly associated with the accommodative facility (Zheng et al., 2021) and decreases in severity and in prevalence among participants after using optimal correction (Hempala et al., 2014). The presence of convergence insufficiency and esophoria has been identified from one study as a potential risk factor for headaches. Furthermore, it has been observed that optimal correction and orthoptic treatment can lead to a complete resolution of headache symptoms (Lajmi et al., 2021). However, in another study it is stated that eye fatigue is not correlated with vergence facility (Zheng et al., 2021).

The findings relating to the quality of life display a significant degree of inconsistency. According to Hagen et al. (2020), uncorrected vision anomalies can lead to negative outcomes such as headaches, reduced reading comprehension, and lower test scores, which may have a negative impact on the overall quality of life. According to Hempala et al. (2014), optimal correction has a beneficial impact on headaches and musculoskeletal discomfort, particularly pain in the neck, shoulders, and back, which can improve an individual's quality of life. According to Lajmi et al. (2021), a significant proportion of individuals (73%) experiencing headaches due to refractive disorders reported that the resulting impact on their quality of life was relatively insignificant (table 8).

Table 8: Methodologies and headache risk factors of the studies.

Authors	Methods	Risk factors
Gil-Gouveia et al. (2002)	Headache questionnaire Clinical evaluation Ophthalmologic evaluation Telephone interview after 10 months of proper prescription of the headache group. Follow-up 23% of participants	HARE: 6,6% of study group **Significant correlation between hyperopia and HARE (x2=4.4, P=0,03)** but not with other refractive errors. **After proper correction:** **72,5% improved headache** **0% worsen headache.** **37,5% ceased headache.**
Hagen et al. (2020)	Ophthalmologic evaluation Headache questionnaire Reading test	More **females** than males reported regular headache (females 12.6%, males 2.7%) headaches were associated with poor **habitual amplitude of accommodation** (p= 0.04) and **hyperopia** (p= 0.04), when adjusted for **sex**.
Hempala et al. (2014)	Ophthalmologic evaluation Questionnaire	After optimal correction: **Eye fatigue**: index decreased from 1.7 to 0.4 (p = 0.10) **Headaches**: index decreased from 0.6 to 0.4 (p = 0.71) **Neck discomfort:** index decreased from

		3,6 to 1,7 (p=0,18) **Eyestrain** decreased. **Eye fatigue** decreased in severity and in prevalence among participants with optimal correction.
Jain et al. (2018)	Ophthalmologic evaluation Follow-up after 1 month	**Hypermetropia** and **astigmatism** are the most common RE associated with headache (31%) and **asthenopia** (32%). **Relief of symptom of asthenopia:** 100% hyperopic astigmatism 100% myopic astigmatism 89% hypermetropia 80% mixed astigmatism Proportion of **asthenopia** in RE= 62% General relief of **asthenopia** after correction: 80% General relief of **headache** after correction: 69% **RE** found in 28% in the headache group.
Kommerell et al. (2015)	Ophthalmologic evaluation	No correlation between **discomfor**t and phoria. No correlation between associated phoria and **asthenopia.**
Lajmi et al. (2021)	Neurological evaluation Questionnaire Ophthalmological examination Questionnaire HIT-6 (headache impact test) Follow-up after 1-4 months	Multivariate analysis found out that the complex nature of **ametropia** (OR = 9.104; CI 2.534-32.715; P = 0.001), as well as the moderate nature of **hyperopia** (OR = 3.124; CI 1.192- 22.795; P = 0.01) and **astigmatism** (OR = 1.564; CI 1.025-14.622; P = 0.03) are risk factors for HARE. **Exposure to screen** is a risk factor for headache. **Convergence insufficiency** and **esophoria** were retained as a risk factor for headache.
Marasini et al. (2012)	Physical and neurological examination Ophthalmological examination Headache questionnaires	Prevalence of **refractive error** was 44% among headache patients. **Females** suffer more from headaches. **Uncorrected refractive error** was associated with frontal headache (44%). **Low degrees of refractive errors** are associated with headache because 88% of these patients had been presenting visual acuity of 6/6 and 6/9. The prevalence of **astigmatism** is higher than that of hyperopia and myopia (63.63%, 27.27% and 9.09%).
Zheng et al. (2021)	Questionnaire Ophthalmological assessment	**Visual fatigue** is strongly correlated with the results of binocular accommodative facility but not with vergence facility.

4.Discussion

Uncorrected refractive errors have been associated with **the prevalence of headaches** and eyestrain (Gil-Gouveia et al., 2002) and frontal headache (Marasini et al., 2012) or ocular headache due to visual effort (Gil-Gouveia et al., 2002). This theory has been a subject of debate, with studies conducted across diverse populations yielding inconclusive results (Dotan et al., 2014; Akinci et al., 2008). The International Headache Society (IHS) has classified "headache associated with refractive error" as a secondary headache. However, the IHS did not provide any empirical evidence to substantiate this classification (Olesen et al., 2018).

In the study conducted by Jain et al., the **distribution of refractive** error rate was analyzed among 103 cases of headache. The findings revealed that 28% of the cases were associated with refractive error (Jain et al., 2018). Comparable outcomes were observed in other studies when examining the correlation between refractive error and headache group, in contrast to normal population group (Gordon et al., 1966; Akinci et al., 2008). A study conducted in 436 adolescents (16-19 years old) in South-East Norway, revealed a higher prevalence of refractive error, at 44.0% of the individuals and a total of 61.9% with vision anomalies (Hagen et al., 2020). On the other hand, there are also a restricted number of studies that have documented statistically insignificant differences in the prevalence of refractive error between headache group and the general population (Fereshteh et al., 2018). According to Gil-Gouveia et al. (2002), the prevalence of headaches related to refractive error was found to be only 6.6%.

Hypermetropia is the most frequently diagnosed refractive error among the various types of refractive errors associated with headaches (Jain et al., 2018; Hagen et al., 2020). According to Gil-Gouveia et al. study, there is a stronger association between hypermetropia and individuals experiencing chronic headaches (Gil-Gouveia et al., 2002). Turville et al., made an early effort in 1934, presenting 123 cases that was estimated that 60% needed a hyperopic prescription, 50% of the prescribed refractive error was below 1D while 80% of all patients, reported some relief from headaches, after being prescribed spectacles. There was a significant 50% that reported a complete alleviation of headache. However, the methodology remains ambiguous (Gordon et al.,2001). Participants in the study group of Gil-Gouveia et al. (2002), reported higher rates of pain relief when closing their eyes, whereas 72,5% reported relief of headache after optimal refractive correction. Hypermetropia and **astigmatism** are risk factors for headaches related to refractive errors (Lajmi et al., 2021). The headache recovery rate in Jain et al., in patients with hypermetropia was 89% whereas there was 100% relief of symptoms after prescribing glasses for astigmatism. A correction of 0.25D in astigmatism may potentially alleviate a significant number of headache symptoms (Jain et al.,2018;), as evidenced by the fact that 88% of the individuals' experiencing headaches had normal visual acuity of 6/6 and 6/9 (Marasini et al., 2012). Gordon (1966), Lanche (1966), and Vaithilingham and Khare (1967), with their respective studies suggested that a low degree of prescribed astigmatism (less than 1DC) could potentially treat headaches in patients. The statement was not supported by any robust evidence in any of them. There is a conflict of opinion among authors regarding the efficacy of spectacles in correcting low degree refractive errors, as some authors consider it to be just a placebo effect (Gordon et al., 2001) and others argue that it is an effective method of minimizing symptoms of headaches (Hendricks et al., 2007). According to Akinci et al. study, there was an equal distribution of hypermetropia and myopia between the headache group and the normal population. However, astigmatism was found to be more prevalent only in the headache group (Akinci et al., 2008). Marasini et al. (2012), observed that the prevalence of astigmatism surpassed that of hyperopia and myopia, with percentages of 63.63%, 27.27%, and 9.09%, respectively. The etiology of headaches in cases of hypermetropia and astigmatisms remains unclear, although it is hypothesized that they may be attributed to visual blurring and ocular strain (Dotan et al., 2014).

Refractive errors have been also found to alleviate symptoms such as **asthenopia** and headache. Jain et al. study revealed a higher prevalence of asthenopia among patients diagnosed with hypermetropia and astigmatism. An important improvement of 80% was noted among patients suffering from asthenopia, after refractive error correction. (Jain et al., 2018). Another study investigating 18 postal workers in Sweden, stated that new spectacles and optimal correction resulted in a reduction of eyestrain, as well as reduction in intensity and prevalence of eye fatigue among the participants. The group requiring new glasses had a higher incidence of eyestrain, headaches, and eye fatigue, as well as musculoskeletal discomfort (Hemphala et al., 2014). Unfortunately, the type of the refractive error is not specified.

Marasini et al. reported that a total of 28.75% of the patients who presented with headache were observed with **poor binocularity**, within 16.25% of these individuals displaying a receded Near Point of Convergence. The prevalence of convergence insufficiency is comparatively lower than the findings reported by Gupta et al. in India (49%), Romania (60.4%), and Patwardhan and Sharma (71.4%) in India. This study observed a prevalence rate of 13% for computer vision syndrome, which is comparable to the rates reported in the United States (9-12%) (Marasini et al., 2012).

Several prior research studies have suggested a correlation between asthenopia and latent deviations of vergence (Evans JW, 2021; O'Leary et al., 2006; Karania et al., 2006). A significant correlation was observed between symptoms of asthenopia and associated phoria, particularly for near vision (karania et al., 2006). Due to this hypothesis, a considerable number of practitioners recommend the use of prisms as a potential treatment option (O'Leary et al., 2003). The frequency of asthenopia among computers users was calculated between 46.3% and 68.5% (Heus et al., 2018). Lajmi et al., conducted a study on a sample of 90 patients, and prolonged screen exposure had been identified as a potential risk factor for headaches. The univariate analysis identified convergence insufficiency and esophoria as a risk factor, however, the multivariate analysis did not retain this association (Lajmi et al., 2021). A similar improvement was measured by Wilmut et al. (1956), that found 91% of the subjects with migraine headache, to have excessive exophoria. After prescribing spectacles with base in prism, 70% experienced fewer or even no migraine attacks (Gordon et al.,2001).

On the contrary, findings presented by Kommerell et al. did not demonstrate any correlation between associated phoria and asthenopia, indicating that heterophoria may have been overestimated in asthenopia cases. The author did not necessarily rule out the possibility that certain individuals with asthenopia may benefit from a prismatic correction (Kommerell et al. 2015). Findings of Kommerell et al. are consistent with Waters et al. (1970) and Cameron et al., (1976) studies, that stated that there is not a strong relationship between vertical phoria and headache (Gordon et al.,2001). In addition, Zheng et al., studied 104 subjects and concluded that the outcome of the binocular accommodative facility is correlated with visual fatigue, that causes discomfort after near work and mild frontal headaches, but not with vergence facility. More specific, accommodative binocular dysfunction was found to interfere the ability of encoding fine details while reading, in adult population (Zheng et al., 2021). A study in 436 adolescences revealed a correlation between increased frequency of headaches and poor habitual amplitude of accommodation, as well as moderate-to-high hyperopia. Individuals with hyperopia exhibit a high incidence of poor accommodation, with a frequency of 65.5%. This is due to the uncorrected hyperopic refractive error surpassing the individual's capacity for accommodation. Frequent results of inadequate accommodation include reduced visual acuity when focusing on near objects and asthenopia (Hagen et al., 2020).

Individuals with vision anomalies demonstrated a higher incidence of poor reading comprehension (31,2%). Both speed and fluency of reading are important for understanding the written material. Nevertheless, they are mostly affected by poor accommodation. The challenges encountered during primary or secondary education, may have a significant impact on an individual's future academic achievements and quality of life (Hagen et al., 2020). Consistent with expectations, the group requiring new eyeglasses exhibited a greater incidence of ocular strain,headaches, eye fatigue, as well as musculoskeletal discomfort characterized by discomfort in the cervical, scapular, and lumbar regions attributable to inncorect posture that effected their daily life (Hempala et al., 2014). The presence of a headache significantly impacts an individual's quality of life. The impact of symptoms on mood and cognition is noteworthy, and it frequently results in significant psycho-social functioning challenges (WHO, 2007). The study of Lajmi et al., revealed that a considerable proportion of the participants (68%), experienced a moderate to significant negative effect on their quality of life, due to severe myopia. On the other hand, 73% of individuals experiencing headaches including all refractive disorders, have reported that the effect on their quality of life is insignificant (Lajmi et al., 2021).

Each of the eight studies analzed, exhibited certain limitations and variations in constraints (Table 9). The term "headache" encompasses a wide range of pain. The inclusion and exclusion criteria were variated across the studies, and six of them did not perform any physical or neurological assessment. Six of the studies employed questionnaires with unspecified content and design. Questionnaires without specifying the content, was used in six of them. It's possible that the findings of questionnaires and surveys referring to certain parts of people's life won't always provide reliable results. For instance, respondents might prefer not to reveal certain actions or beliefs due to shame, fear, or any other limiting perspective. In most cases, there is no method for confirming the information that has been provided. Two studies were conducted without a control group, and none of the studies incorporated a placebo group. Five studies lacked follow-up of the groups, while one study exhibited insufficient follow-up, with 23% of the participants included. The reviewed studies exhibited a discrepancy in their population selection, with only hospital-based samples being utilized in four of the studies, while four others included participants under the age of 18, despite the review's focus on the adult population. Two studies involved a limited number of participants, with only 18 and 40 individuals included. Additionally, compensation was provided to the subjects in two of the studies.

Table 9: Limitations and studies analysed

Limitations	Number of studies
Questionnaires	6/8
Included only hospital population	4/8
Included population under 18 years old	4/8
No/inadequate follow-up	6/8
Small sample (under 50)	2/8
Missing/no data for refractive error/binocular vision	3/8 missing data for refractive error 3/8 missing data for binocular vision
No control group	2/8
No placebo group	8/8
Paid glasses/examination/participation	2/8
Headache not diagnosed/categorised by experts	6/8
No optometrical evaluation	1/8

5. Conclusion

This systematic review investigated the influence of visual disorders on headaches and the quality of life in adult populations. The author collected data from a total of eight studies and subsequently performed an analysis. The formal establishment of the relationship between refractive errors, binocular anomalies and headache has not yet been achieved. Various academic publications have suggested that uncorrected refractive error and binocular problems may potentially be a risk factor for headaches. During the completion of this systematic literature review, it was found that there was a dearth of high-quality research papers that could establish a credible and convincing connection. All the potentially useful information was extracted from evidence of poor quality. Therefore, the reliability of the outcome cannot be guaranteed due to the limited number of studies and significant heterogeneity among them. In order to achieve a higher degree of precision in the results, extensive research in this field is necessary.

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