M E T A - A N A L Y S I S

UDC: 617.7-02-07
DOI: https://doi.org/10.2298/VSP220301024D

Prevalence of computer vision syndrome in computer users: a systematic review and meta-analysis

Prevalencija sindroma „kompjuterskog vida“ kod korisnika računara: sistematski pregled i meta-analiza

Vanja Dimitrijević*, Ivana Todorović†, Biljana Viduka‡, Igor Lavrnić§, Dejan Viduka‖

***University of Novi Sad, Faculty of Sport and Physical Education, Novi Sad, Serbia; †University of Priština/Kosovska Mitrovica, Faculty of Medicine, Kosovska Mitrovica, Serbia; ‡Educons University Sremska Kamenica, Faculty of Project and Innovation Management, Belgrade, Serbia; §Faculty of Maritime Academic Studies Belgrade, Serbia; ‖University Business Academy, Faculty of Applied Management, Economics, and Finance, Belgrade, Serbia**

Abstract

Background/Aim. Vision and health problems associated with the use of computers and other digital devices are known as computer vision syndrome (CVS). Advances in technology have led to increased use of computers, so the prevalence of these symptoms is increasing. The aim of this study was to calculate the overall prevalence of CVS and CVS symptoms using meta-analysis. **Methods.** The study was developed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement. In July 2021, a systematic search of four electronic databases with article collections was performed: PubMed, Cochrane Library, Web of Science, and Google Scholar. The key search terms were: "computer vision syndrome", "computer users", "digital eyestrain", "headache", "dry eyes", "red eyes", "eyestrain", "neck pain", "back pain", and "shoulder pain". The articles included in the study had to be original articles written in English only, and the criterion that had to be met was that the research included computer users. As a result, the prevalence of CVS or the prevalence of any of the symptoms of CVS had to be measured. **Results.** A total of 43 articles were fully reviewed, of which 20 were included in the meta-analysis. The total calculated prevalence for all studies was 74.4%, while the prevalence for individual symptoms was: headache – 43%, dry eyes – 24.4%, eyestrain – 29%, red eyes – 20.7%, and neck, back, or shoulder pain – 46.3%. **Conclusion.** The results obtained are worrying and point to the necessity of a multidisciplinary approach to solving CVS-related problems.

Key words:
asthenopia; computers; databases, bibliographic; health; meta-analysis.

Apstrakt

Uvod/Cilj. Problemi sa vidom i zdravstveni problemi povezani sa upotrebom računara i drugih digitalnih uređaja poznati su kao sindrom „kompjuterskog vida“ (SKV). Napredak u tehnologiji doveo je do povećane upotrebe računara, tako da je rasprostranjenost tih simptoma sve veća. Cilj rada bio je da se izračuna ukupna rasprostranjenost SKV-a i simptoma SKV-a primenom meta-analize. **Metode.** Studija je razvijena u skladu sa Izjavom o preferiranim stavkama izveštavanja za sistematske preglede i meta-analize (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses* – PRISMA). U julu 2021. godine, izvršena je sistematska pretraga četiri elektronske baze podataka sa zbirkama članaka: *PubMed, Cochrane Library, Web of Science* i *Google Scholar*. Ključni termini za pretragu bili su: „sindrom kompjuterskog vida“, „korisnici računara“, „digitalno naprezanje očiju“, „glavobolja“, „suve oči“, „crvene oči“, „naprezanje očiju“, „bol u vratu“, „bol u leđima“ i „bol u ramenu“. Članci koji su bili uključeni u studiju morali su da budu originalni članci napisani samo na engleskom jeziku, a kriterijum je nalagao da se istraživanjem moraju obuhvatiti korisnici računara. Kao rezultat toga, morala je biti merena rasprostranjenost SKV-a ili rasprostranjenost bilo kojeg od simptoma SKV-a. **Rezultati.** U potpunosti su pregledana 43 članka, od kojih je 20 bilo uključeno u meta-analizu. Ukupna izračunata rasprostranjenost za sve studije iznosila je 74,4%, dok je

Correspondence to: Dejan Viduka, University of Business Academy, Faculty of Applied Management, Economics, and Finance, Jevrejska 24/1, 11 000 Belgrade, Serbia. E-mail: dejan@viduka.info

rasprostranjenost za pojedinačne simptome bila: glavobolja – 43%, suve oči – 24,4%, naprezanje očiju – 29%, crvene oči – 20,7% i bol u vratu, leđima ili ramenu – 46,3%. **Zaključak.** Dobijeni rezultati su zabrinjavajući i ukazuju na neophodnost multidisciplinarnog pristupa rešavanju problema vezanih za SKV.

Ključne reči:
astenopija; kompjuteri; baze podataka, bibliografske; zdravlje; meta-analiza.

Introduction

In the last few decades, advances in technology have become the focus of most countries (especially the underdeveloped ones) [1]. There is no doubt that the computer has freed us from many difficult tasks. However, its constant use leads to unforeseen vision and health problems, especially when its use is uncontrolled [2]. These vision and health problems associated with computer use are known as computer vision syndrome (CVS). Prolonged use of the screen can cause problems such as dryness of eyes, redness, eyestrain, irritation, tired eyes, blurred vision, hypersensitivity to light, headaches, and muscular problems, specifically back, shoulder, and neck pain that stem from using a computer [3, 4]. According to the American Optometric Association [5], all these symptoms of CVS are also called digital eyestrain, or in some studies, it is called asthenopia [6–10].

Research shows that as many as 90% of people who use computers for more than 2 hrs a day experience symptoms associated with vision problems [11]. A study from Japan by Iwakiri et al. [12] reported that the prevalence (PRv) of CVS among office workers was 72.1%. In Egypt, eyestrain (72.4%) and headache (64.4%) were the most commonly reported symptoms of CVS [13]. CVS is reported in 54.6% of call center operators in Sao Paulo, Brazil [14]. A study of 419 computer users in India [15] found that about 46.3% of users experienced two or more of the following symptoms during or after working on a computer: burning sensation, itchy eyes, pain, tenderness, redness, excess tears, dryness, discomfort when looking, blurred vision, and discoloration of objects. Studies among students show that the PRv of CVS among student engineers was 81.9%, while among medical students, it was 78.6% [16]. In the United States, about 54 million children use computers, 25–30% of whom have developed eye problems and have to rely on glasses for better vision [17]. CVS occurs because the eyes and brain have different reactions to characters seen on a computer screen than the characters printed on paper. Changes may occur constantly on the computer screen, but the printed characters remain stable and have clear contrast and edges [18]. When the eyes are fixed on the computer for a long time, and the distance between the eyes and the computer is small, fatigue of the ciliary muscles can occur, which can cause headaches [19]. One or more factors may be responsible for the development of CVS. These factors are infrequent blinking, prolonged viewing of digital screens, inappropriate lighting conditions, ametropia, glare, and incorrect distances between the eye and the computer [20]. Due to the consistent focus on the screen, our blinking rhythm is disturbed, which contributes to reduced tear production and reduces the natural moisture of the eyes, resulting in corneal stress and causing dry eyes, watery eyes, itching, and eye pain [21], additional cramps accommodation of the eye, the disorder of the accommodation mechanism (blurred vision, double vision, presbyopia, myopia, and slow change of focus) [4].

The computer releases electromagnetic radiation, so a great deal of energy-related stress is developed against the ciliary muscles. Poor lighting conditions, prolonged computer use, screen brightness, refractive errors, and improper workstation tuning are also risk factors for CVS [22, 23]. Improper height and angle of inclination of the visual display unit lead to pain in the back, neck, and shoulders. Twenty-two percent of computer workers report musculoskeletal disorders [24]. When the screen is at a higher level, the user turns backward, which causes muscle strain on the trapezius and neck muscles [25].

Daily use of personal computers and digital screens for 3 hrs or more leads to a high risk of developing CVS, occupational overuse syndrome, and psychosocial stress [26]. Even infrequent daily use of computers leads to various health problems [27]. Instruments used for diagnosis are usually unstructured questionnaires that focus on the frequency of symptoms occurrence [28–30], their intensity [31], or both [26, 32]. Using the previous questionnaires, Segui et al. [33] validated a questionnaire for respondents with CVS problems.

The aim of this study was to assess the overall PRv of CVS for all included studies using meta-analysis, as well as the PRv of certain symptoms that characterize CVS.

Methods

This study has been developed and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [34].

Data sources and searches

A search strategy was developed to identify all relevant studies dealing with the PRv of CVS. Our systematic search included PubMed, Cochrane Library, Web of Science, and Google Scholar databases. We used combinations of the subject titles “computer vision syndrome”, “digital eyestrain”, “asthenopia”, “computer users”, “dry eyes”, “headache”, “eyestrain”, “red eyes”, “neck pain”, “back pain”, and “shoulder pain”. The diagram of the process of study selection for the meta-analysis is shown in Figure 1. We also manually searched for reference citations of identified critiques and selected original research articles to download the full text.

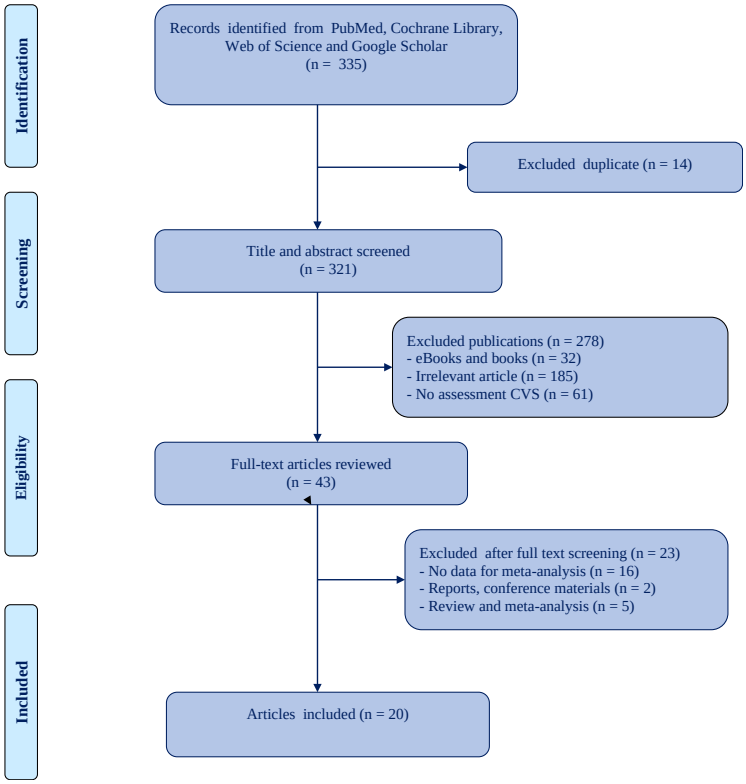

Fig. 1 – Flow diagram of the process of study selection for the meta-analysis. CVS – computer vision syndrome.

Study selection

In order to be included in our analysis, the original research article had to meet the following criteria: 1) the research had to include computer users; 2) as a result, the PRv of CVS or the PRv of any of the symptoms of CVS had to be measured. The inclusion of studies in our analysis was limited to English language only. The studies included in our analysis were not older than five years. In July 2021, a systematic search of four electronic databases was conducted. The inclusion/exclusion of studies was done by two investigators by consultation and consensus.

Data extraction and quality assessment

After selecting the studies based on the inclusion and exclusion criteria, the two investigators independently conducted data extraction. The following variables were abstracted into a pre-formatted table: authors, year of publication, number of participants, outcomes, percentage of CVS, occupation, and age of respondents. All studies included had data available.

Risk of bias was assessed for each study using Downs and Black [35] quality score for non-randomized studies and comprised of five sections: reporting (ten items) – to assess the overall quality of the study; external validity (three items) – to determine the ability to generalize the findings of the study; internal validity (seven items) – to assess bias in the intervention and outcome measures; selection bias (six items) – to determine bias from sampling or group assignment; power (one item) – to determine whether findings are due to chance. Two researchers independently assessed the quality of the studies involved and classified the studies as adequate or inadequate. As no intervention study was selected, the maximum score possible in the present review was 13 points. The minimum score of the studies included was 7 points, and below that number, the studies would not be included in the analysis.

Data synthesis and analysis

Meta-analysis and statistical analysis were performed using MetaAnalyst software version 3.2 (Brown University, 2012, USA) [36]. For six outcomes (total CVS, headache, red eyes, dry eyes, eyestrain, and neck, back, or shoulder pain), overall PRv was assessed. Freeman-Tukey Double Arcsine Proportion (PFT) Random model [DerSimonian-Laird (DL)] for dichotomous data was used in the meta-analysis to calculate the pooled PRv for all studies included. A subgroup analysis for CVS outcome was also performed, using Untransformed Proportion (PR) Random model DL for dichotomous data divided into respondents from the information technology (IT) sector and those who were not from that sector. When the *p*-value was < 0.05, the results were considered statistically significant. Since proportion estimates are usually heterogeneous [37, 38], we have not addressed the problem of increased heterogeneity. Heterogeneity between studies was assessed using the Higgins I^2 test and *p*-values. The number of degrees of freedom is presented in each analysis as *df*.

Results

Study selection and characteristics

Based on the search strategy, a total of 335 studies were selected from the initial database search. Of that number, 14 studies were excluded due to duplication, so 321 studies were selected for further analysis. Following the presentation of the abstract and title, 278 studies were excluded because they did not meet the inclusion criteria. The remaining 43 studies were fully reviewed. When the full-text articles were reviewed, 23 studies were excluded. The remaining 20 studies were included in this systematic review and meta-analysis. The flow chart of the study selection process is shown in Figure 1.

Table 1 [2–4, 19, 21, 27, 39–52] shows the main characteristics of the included studies. A total of 4,560 respondents participated in the 20 included studies; the sample size of the included studies ranged from 50 to 713. The age of the respondents ranged between 17 and 60 years. The studies included in the analysis were conducted in nine countries. Of those nine countries, only one was from Europe.

Table 1

Characteristics of the included studies

Study	Respondents n	Outcome	Country	CVS %	Computer users	Respondents age years
Agbonlahor [2]	215	CVS (eyestrain, headache, red eyes, dry eyes, neck, back, or shoulder pain)	Nigeria	65.6	working-class adults	18–35
Arjuna et al. [39]	125	CVS (headache, dry eyes, red eyes)	Indonesia	59.2	workers	no answer
Astuti et al. [40]	50	CVS	Indonesia	52	employees in Telekom	> 40 (6*) < 40 (44*)
Hadi et al. [3]	385	headache, dry eyes, neck, back, or shoulder pain	Pakistan	no answer	students	17–24
Hamdani et al. [19]	134	CVS (headache)	Indonesia	61.9	computer workers	> 40 (100*) < 40 (34*)
Iqbal et al. [41]	100	CVS (headache, dry eyes, red eyes)	Egypt	86	medical students	18–24
Kamal and Abd El-Mageed [42]	218	eyestrain, headache	Egypt	no answer	bank employees	23–59
Kausar et al. [21]	350	CVS (headache)	Pakistan	88	software engineering students	18–25
Kumar and Sharma [43]	100	CVS (eyestrain, dry eyes, headache)	India	69	computer users	20–60
Kumar [27]	60	CVS (eyestrain, headache, dry eyes, red eyes)	India	85	medical students	no answer
Noreen et al. [44]	326	CVS (eyestrain, red eyes)	Pakistan	16	medical students	17–25
Poudel and Khanal [45]	263	CVS (headache)	Nepal	82.5	IT workers	20–30 (218*) > 30 (45*)
Ranganatha and Jailkhani [46]	150	CVS (eyestrain, headache, dry eyes, red eyes, neck, back, or shoulder pain)	India	86.7	computer science students	19–22
Shahid et al. [47]	150	CVS (headache, neck, back or shoulder pain)	Pakistan	75.3	college students, employees of multinational companies	18–50
Sitaula et al. [48]	234	CVS	Nepal	76.5	computer science students	17–26
Al Tawil et al. [49]	713	dry eyes, headache, red eyes, dry eyes, neck, back, or shoulder pain	Saudi Arabia	no answer	medical and business students	no answer
Tesfa et al. [50]	217	CVS (eyestrain, headache, red eyes)	Ethiopia	75.6	secretary employees	21–48
Viduka et al. [4]	90	dry eyes, headache, red eyes, neck, back, or shoulder pain	Serbia	no answer	computer users	≤ 30 (38*) > 30 (52*)
Vikanaswari and Handayani [51]	600	CVS (headache, neck, back or shoulder pain)	Indonesia	58.8	medical students	≤ 20 (474*) > 20 (126*)
Zalat et al.[52]	80	CVS	Egypt	81.2	staff members in a medical college	47.1 ± 8.1**

CVS – computer vision syndrome; IT – information technology; n – number;
***number of respondents within the age group; **mean ± standard deviation.**

Risk of bias

Table 2 [2–4, 19, 21, 27, 39–52] presents the summary of the risk of bias for each included study. For the parameter of Reporting, eight studies had a score 6/6, eleven studies had a score 5/6, and only one study scored 4/6. For the item External validity, eleven studies had a score 2/2, six studies 1/2, and three studies 0/2. The Internal validity parameter was 2/2 in eleven studies, 1/2 in eight studies, and only one study had 0/2. For the item Selection bias, five studies had a score 2/2, eleven studies 1/2, and four studies 0/2. For item Power, 17 studies had a score 1/1, while three studies had a score 0/1. The lowest overall score was 7, while the highest was 13. The mean score in all 20 included studies was 10.1 ± 2.

Table 2

Risk of bias for each study

Study	Reporting	External validity	Internal validity	Selection bias	Power	Downs and Black [35] score
Agbonlahor [2]	adequate (6/6)	adequate (2/2)	adequate (2/2)	adequate (2/2)	adequate (1/1)	13
Arjuna et al. [39]	adequate (5/6)	inadequate (0/2)	inadequate (1/2)	inadequate (1/2)	inadequate (0/1)	7
Astuti et al. [40]	adequate (4/6)	inadequate (0/2)	adequate (2/2)	inadequate (1/2)	adequate (1/1)	8
Hadi et al. [3]	adequate (5/6)	adequate (2/2)	adequate (2/2)	inadequate (1/2)	adequate (1/1)	11
Hamdani et al. [19]	adequate (6/6)	inadequate (0/2)	adequate (2/2)	inadequate (1/2)	adequate (1/1)	10
Iqbal et al. [41]	adequate (5/6)	inadequate (1/2)	inadequate (0/2)	inadequate (1/2)	inadequate (0/1)	7
Kamal and Abd El-Mageed [42]	adequate (6/6)	inadequate (1/2)	inadequate (1/2)	inadequate (1/2)	adequate (1/1)	10
Kausar et al. [21]	adequate (6/6)	adequate (2/2)	inadequate (1/2)	adequate (2/2)	adequate (1/1)	12
Kumar and Sharma [43]	adequate (5/6)	inadequate (1/2)	inadequate (1/2)	inadequate (0/2)	adequate (1/1)	8
Kumar [27]	adequate (5/6)	inadequate (1/2)	inadequate (1/2)	inadequate (0/2)	inadequate (0/1)	7
Noreen et al. [44]	adequate (5/6)	adequate (2/2)	inadequate (1/2)	inadequate (0/2)	adequate (1/1)	9
Poudel and Khanal [45]	adequate (5/6)	adequate (2/2)	adequate (2/2)	inadequate (1/2)	adequate (1/1)	11
Ranganatha and Jailkhani [46]	adequate (6/6)	adequate (2/2)	adequate (2/2)	inadequate (1/2)	adequate (1/1)	12
Shahid et al. [47]	adequate (6/6)	adequate (2/2)	adequate (2/2)	inadequate (0/2)	adequate (1/1)	11
Sitaula et al. [48]	adequate (6/6)	adequate (2/2)	adequate (2/2)	inadequate (1/2)	adequate (1/1)	12
Al Tawil et al. [49]	adequate (6/6)	adequate (2/2)	adequate (2/2)	adequate (2/2)	adequate (1/1)	13
Tesfa et al. [50]	adequate (5/6)	adequate (2/2)	adequate (2/2)	inadequate (1/2)	adequate (1/1)	11
Viduka et al. [4]	adequate (5/6)	inadequate (1/2)	inadequate (1/2)	inadequate (1/2)	adequate (1/1)	9
Vikanaswari and Handayani [51]	adequate (5/6)	adequate (2/2)	adequate (2/2)	adequate (2/2)	adequate (1/1)	12
Zalat et al. [52]	adequate (5/6)	inadequate (1/2)	inadequate (1/2)	adequate (2/2)	adequate (1/1)	9
						10.1 ± 2*

*** mean score ± standard deviation.**

Meta-analysis for computer vision syndrome

First, an analysis was performed for the overall PRv of CVS. A total of 15 studies measured the PRv of CVS. The pooled PRv for these 15 studies was: PFT = 74.4% [95% confidence interval (CI) = 68%–80.4%, $p < 0.001$]; 2,059 subjects out of 2,828 reported some of the symptoms of CVS; heterogeneity I^2 = 92.66%, $p < 0.001$; df = 14 (Figure 2). Subsequently, subgroup analysis for CVS outcome was performed using PR. Employees in the IT sector and those who were IT students had a slightly higher PRv than those who were not in the IT sector. The PRv of the IT subgroup was: PR = 78.1%, 95% CI = 71.1%–85.1%, $p < 0.001$; 986 respondents out of 1,231 reported some of the symptoms of CVS; heterogeneity I^2 = 89.89%, $p = 0.001$. The PRv of the non-IT subgroup was: PR = 71.3%, 95% CI = 63.6%–79%, $p < 0.001$;

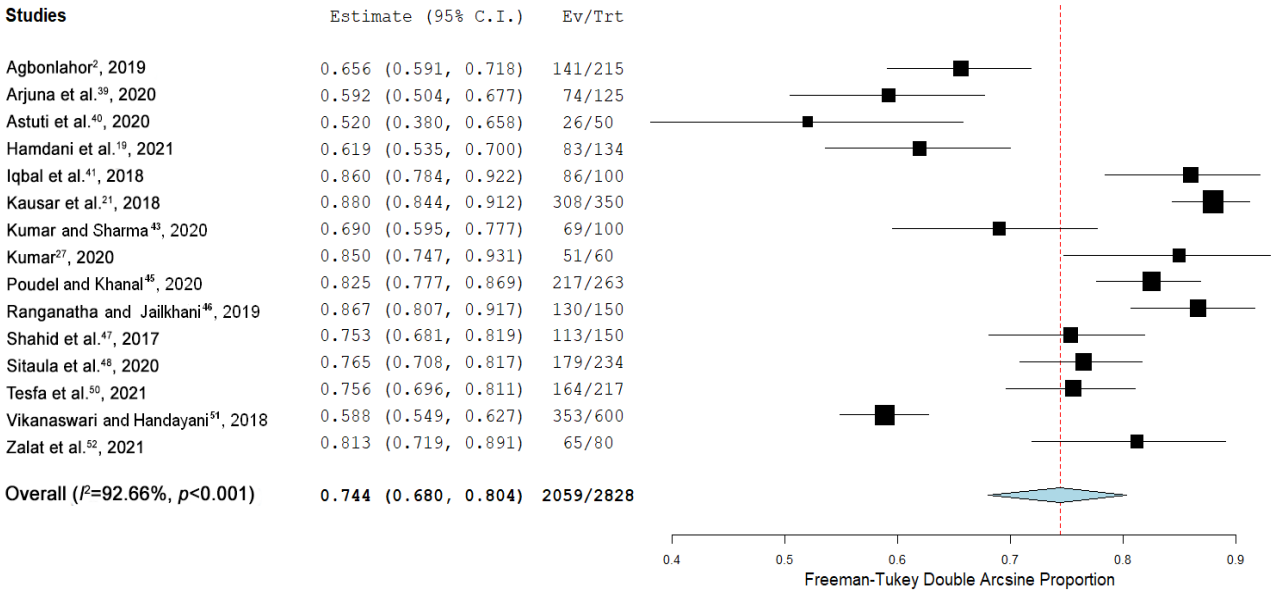

Fig. 2 – Forest plot, outcome: computer vision syndrome. C.I. – confidence interval; Ev/Trt represents the test group.

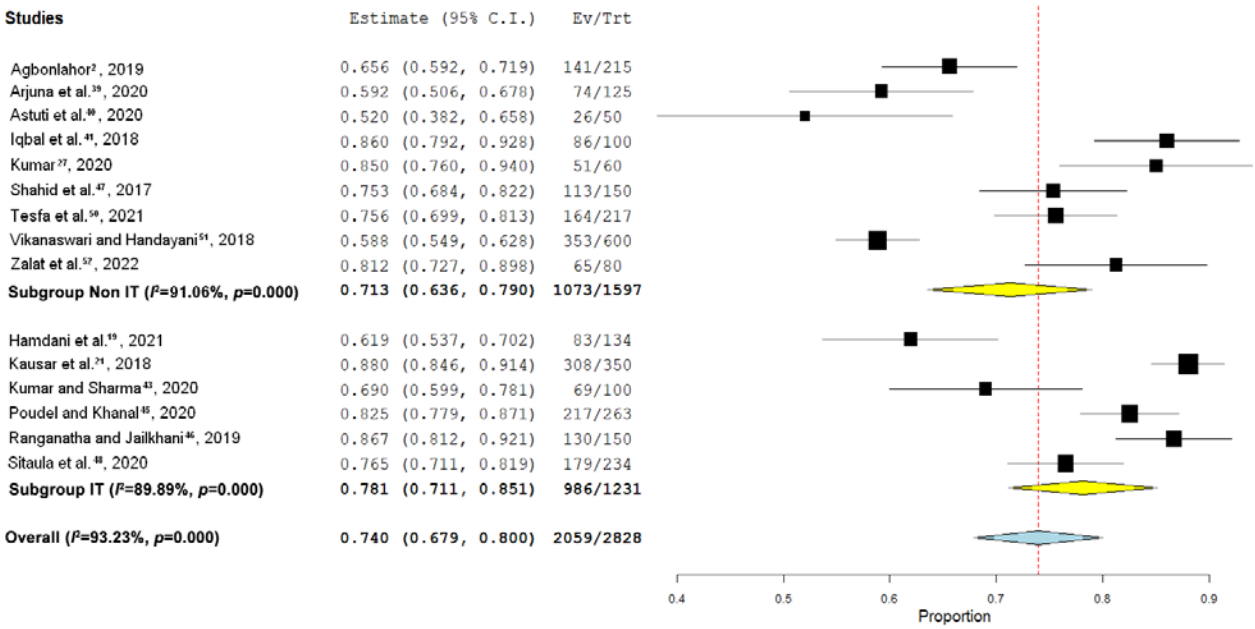

Fig. 3 – Forest plot, outcome: subgroups of computer vision syndrome – information technology (IT) and non-IT. For abbreviations, see Figure 2.

1,073 subjects out of 1,597 reported some of the symptoms of CVS; heterogeneity I^2 = 91.06%, p = 0.001 (Figure 3).

Meta-analysis for headache

Seventeen studies examined the PRv of headaches. The pooled PRv for the headache outcome was: PFT = 43%, 95% CI = 34.1%–52.1%, $p < 0.001$; 1,894 subjects out of 4,196 reported headache symptoms; heterogeneity I^2 = 97.1, $p < 0.001$; df = 16 (Figure 4).

Meta-analysis for dry eyes

Nine studies examined the PRv of dry eyes. The pooled PRv for the dry eyes outcome was: PFT = 24.4%, 95% CI = 14.4%–36.1%, $p < 0.001$; 632 subjects out of 1,938 reported

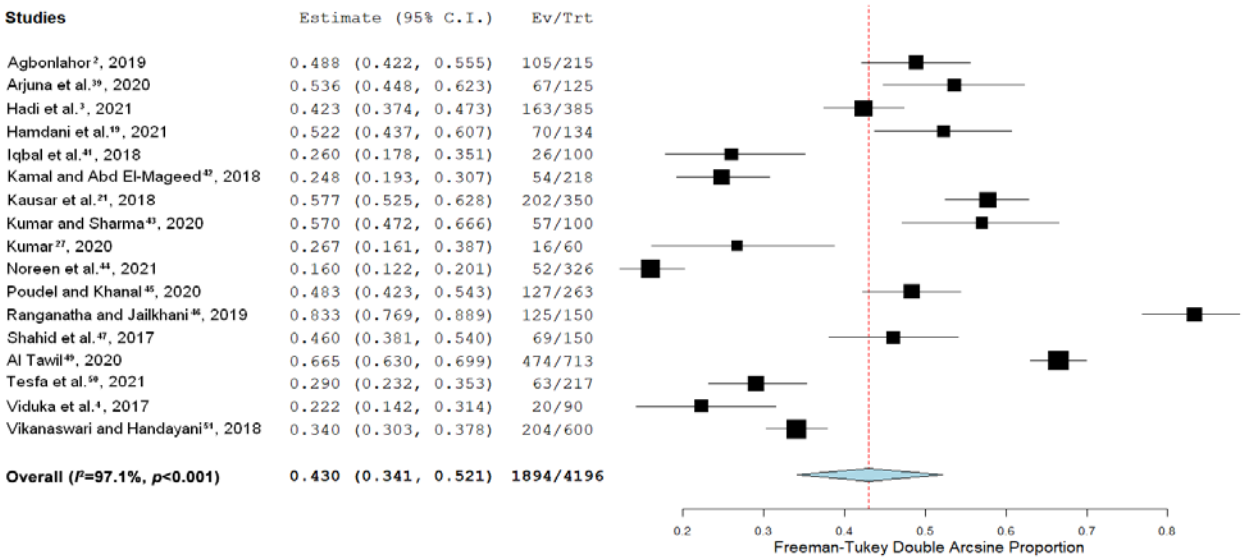

Fig. 4 – Forest plot, outcome: headache.
For abbreviations, see Figure 2.

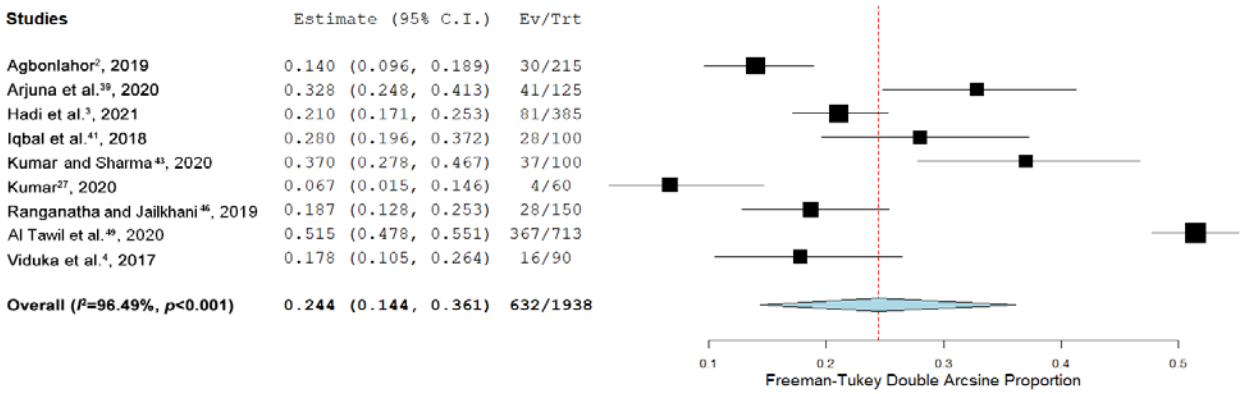

Fig. 5 – Forest plot, outcome: dry eyes.
For abbreviations, see Figure 2.

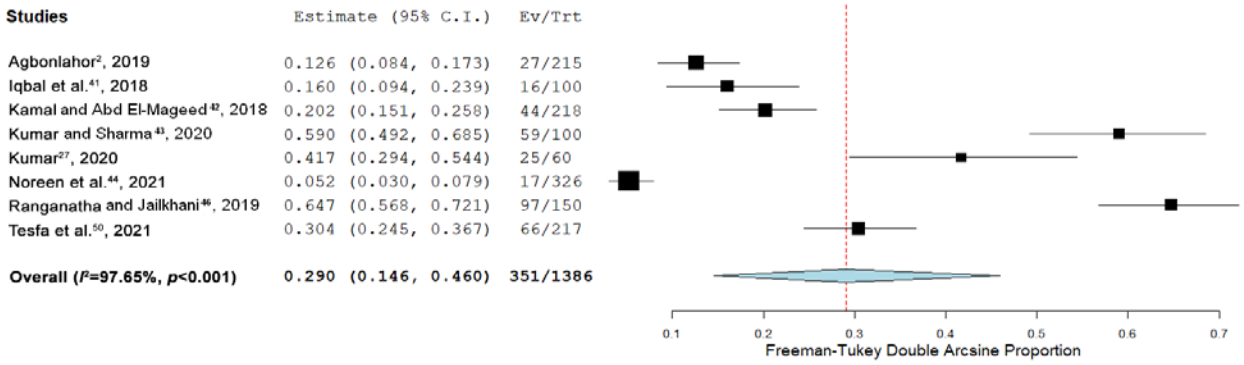

Fig. 6 – Forest plot, outcome: eyestrain.
For abbreviations, see Figure 2.

dry eye symptoms; heterogeneity I^2 = 96.49%, $p < 0.001$; df = 8 (Figure 5).

Meta-analysis for eyestrain

Eight studies examined the PRv of eyestrain. The pooled PRv for the eyestrain outcome was: PFT = 29%, 95% CI = 14.6%–46%, $p < 0.001$; 351 subjects out of 1,386 reported eyestrain symptoms; heterogeneity I^2 = 97.65%, $p < 0.001$; df = 7 (Figure 6).

Meta-analysis for red eyes

Nine studies examined the PRv of red eyes. The pooled PRv for the red eyes outcome was: PFT = 20.7%, 95% CI = 11.1%–32.2%, $p < 0.001$; 528 subjects out of 1,996 reported

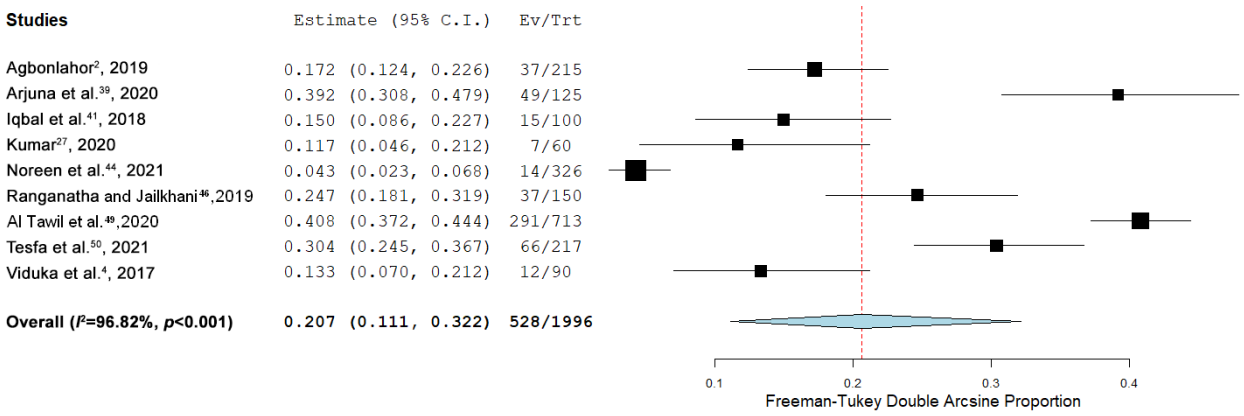

Fig. 7 – Forest plot, outcome: red eyes.
For abbreviations, see Figure 2.

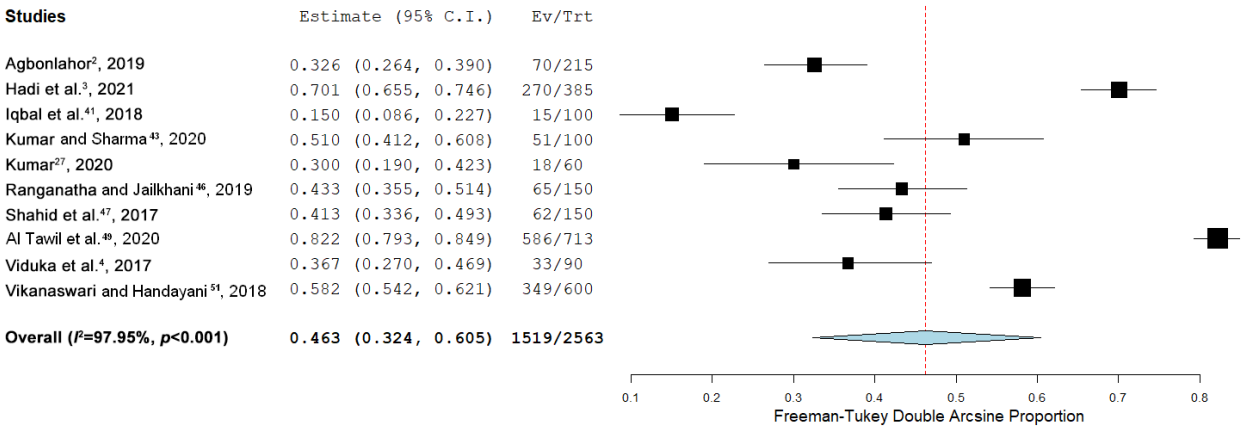

Fig. 8 – Forest plot, outcome: neck, back, or shoulder pain.
For abbreviations, see Figure 2.

red eyes symptoms; heterogeneity I^2 = 96.82%, $p < 0.001$; *df* = 8 (Figure 7).

Meta-analysis for neck, back, or shoulder pain

Ten studies examined the PRv of neck, back, or shoulder pain. The pooled PRv for the outcome of neck, back, or shoulder pain was: FTT = 46.3%, 95% CI = 32.4%–60.5, $p < 0.001$; 1,519 respondents out of 2,563 reported symptoms of neck, back, or shoulder pain; heterogeneity I^2 = 97.95%, $p < 0.001$; *df* = 9 (Figure 8).

Discussion

In this systematic review, we pooled the results of 20 studies to calculate the combined PRv of CVS and some of the symptoms of CVS. The total number of subjects in these 20 studies was 4,560. Progressive advances in technology have led to the increased use of computers and other digital devices, so the emergence of CVS is a modern problem. An increasing number of studies deal with the problems of CVS, so we also tried to make a cross-section in this paper, including in our analysis only studies that were not older than five years.

The total overall PRv in the 20 studies included in our analysis was 74.4%, which is in line with the previous statements. The subgroup analysis indicates that the PRv is slightly higher among respondents in the IT sector than among other respondents (78.1% vs. 71.3%). These results confirm that there is almost no difference in computer hrs between professional users and non-professional users. The digitalization of work has led to the fact that almost all respondents in the studies have become professional computer users. It is certain that smartphone misuse and other devices also influence these results. After this analysis, other analyses were performed to assess the overall PRv of individual CVS symptoms and those that were most evaluated by the included studies. The overall PRv for headache was 43%, for dry eyes 24.4%, for eyestrain 29%, for red eyes 20.7%, and for neck, back, or shoulder pain 46.3%. The last analysis for the symptom of the neck, back, or shoulder pain was the most difficult to do because some studies examined one of these symptoms separately, some two symptoms together, and some all three symptoms together. Due to the musculoskeletal problems caused by CVS and their importance for the normal life of computer users, we did this analysis as well. We did not deal with the amount of time users spent at the

computer because we believe a separate study should be conducted for that.

Our meta-analysis is the only one that has addressed the issues of CVS PRv and CVS symptom PRv. A meta-analysis by Vilela et al. [53] dealt with the problem of asthenopia in children aged 5–19 years. Five studies were included in the meta-analysis. Due to the large difference in the number of studies included and due to the different types of respondents, it is not possible to compare the results of our two studies. We found four reviews [18, 54–56] that addressed the problem of CVS. They detailed the problems related to CVS, but since no meta-analysis was done, we were unable to compare our results with them. Previous research [11, 12, 57–60] has shown a PRv of CVS between 64% and 90%. In our meta-analysis, this range is from 68% to 80.4%, which shows that the obtained results confirm previous research.

Certainly, these results indicate a reduced quality of work and productivity among employed computer users. CVS represents a significant health problem among computer users of different occupations: architects, accountants, flight controllers, scientists, engineers, and lecturers [23]. Ophthalmologists, doctors of various specialties, and kinesitherapists due to musculoskeletal deformities are involved in solving the problem of CVS. Some authors [61, 62] recommend different types of eye exercises or rinsing the eyes and using distilled water. Appropriate spectacle correction can resolve the visual symptoms of CVS, which include muscle asthenopia and accommodative fatigue [63]. While using the computer, the reading materials should be ideally positioned; the goal is to position the reading material in such a way that the head does not move between reading the document and reading from the computer screen [64]. It is important to position the monitor to avoid direct glare from light sources using low-voltage bulbs and fluorescent tubes [65]. Blinking is very important when working on a computer screen because it moisturizes the eyes to prevent dryness and irritation [66]. After 30 min of working on the computer, the eyes should be closed for 30 sec [67].

This study has several limitations. First, despite a comprehensive search, our study included only those written in English. Second, we did not find any study that included inclusive criteria that came from developed countries in Western Europe and America.

Conclusion

This study examined the PRv of CVS through meta-analysis. CVS is a disorder characterized by various symptoms, the most common being those we analyzed in our study: headache, dry eyes, eyestrain, red eyes, and neck, back, or shoulder pain. The results we have shown are certainly worrying and recommend better education of users for more proper use of computers and other digital devices, and require a multidisciplinary approach in eliminating the problems caused by CVS. CVS, as a modern global problem, requires the help of science and the involvement of experts from various fields in order to remedy its consequences. With our study, we have tried to make a contribution.

REFERENCES

1. *Ranasinghe P, Wathurapatha WS, Perera YS, Lamabadusuriya DA, Kulatunga S, Jayawardana N,* et al. Computer vision syndrome among computer office workers in a developing country: an evaluation of prevalence and risk factors. BMC Res Notes 2016; 9: 150.
2. *Agbonlahor O.* Prevalence and knowledge of computer vision syndrome (CVS) among the working class adults in FCT Nigeria. J Niger Optom Stud Assoc 2019; 21(1): 49–60.
3. *Hadi KN, Rehman MH, Toru HK, Orakzai AA, Khalid S, Iftikhar B.* Assessment of computer vision syndrome in University students in Peshawar; A descriptive cross-sectional study. The Stetho 2021; 2(6): 6–14.
4. *Viduka D, Dragičević M, Bašić A, Viduka B, Lavrnić I.* 21st Century engineering challenges observed through computer vision syndrome. Teh Vjesn 2017; 24(Suppl 1): 201–5.
5. *Loh KY, Redd SC.* Understanding and preventing computer vision syndrome. Malays Fam Physician 2008; 3(3): 128–30.
6. *Gowrisankaran S, Nahar NK, Hayes JR, Sheedy JE.* Asthenopia and blink rate under visual and cognitive loads. Optom Vis Sci 2012; 89(1): 97–104.
7. *Thorud HM, Helland M, Aarås A, Kvikstad TM, Lindberg LG, Horgen G.* Eye-related pain induced by visually demanding computer work. Optom Vis Sci 2012; 89(4): E452–64.
8. *Pointer JS, Gilmartin B.* Clinical characteristics of unilateral myopic anisometropia in a juvenile optometric practice population. Ophthalmic Physiol Opt 2004; 24(5): 458–63. Erratum in: Ophthalmic Physiol Opt 2004; 24(6): 607.
9. *Sheedy JE, Hayes JN, Engle J.* Is all asthenopia the same? Optom Vis Sci 2003; 80(11): 732–9.
10. *Ostrovsky A, Ribak J, Pereg A, Gaton D.* Effects of job-related stress and burnout on asthenopia among high-tech workers. Ergonomics 2012; 55(8): 854–62.
11. *Hayes JR, Sheedy JE, Stelmack JA, Heaney CA.* Computer use, symptoms, and quality of life. Optom Vis Sci 2007; 84(8): 738–44.
12. *Iwakiri K, Mori I, Sotoyama M, Horiguchi K, Ochiai T, Jonai H,* et al. Survey on visual and musculoskeletal symptoms in VDT workers. Sangyo Eiseigaku Zasshi 2004; 46(6): 201–12. (Japanese)
13. *Gabal MS, Elaziz KMA, Mostafa NS, Almadani TA.* Computer vision syndrome and musculoskeletal disorders among call center workers of a private company. Egypt J Community Med 2016; 34(4): 51–7.
14. *Sa EC, Ferreira Junior M, Rocha LE.* Risk factors for computer visual syndrome (CVS) among operators of two call centers in São Paulo, Brazil. Work 2012; 41(Suppl 1): 3568–74.
15. *Bhanderi DJ, Choudhary S, Doshi VG.* A community-based study of asthenopia in computer operators. Indian J Ophthalmol 2008; 56(1): 51–5.
16. *Logaraj M, Madhupriya V, Hegde S.* Computer vision syndrome and associated factors among medical and engineering students in Chennai. Ann Med Health Sci Res 2014; 4(2): 179–85.
17. *Bandela PK, Satgunam P, Garg P, Bharadwaj SR.* Corneal transplantation in disease affecting only one eye: does it

make a difference to habitual binocular viewing? PLoS One 2016; 11(3): e0150118.
18. *Akinbinu TR, Mashalla YJ.* Impact of computer technology on health: Computer Vision Syndrome (CVS). Med Pract Rev 2014; 5(3): 20–30.
19. *Hamdani D, Kurniawati N, Ernawati T.* Computer vision syndrome and tension type headache in computer workers. J Widya Medika Junior 2021; 3(2): 110–5.
20. *Hazarika AK, Singh PK.* Computer vision syndrome. SMU Med J 2014; 1(2): 132–8.
21. *Kausar S, Sughra U, Khan WA, Nabeel K.* Prevalence of computer vision syndrome (CVS) symptoms and its awareness among software engineering students of Twin cities. Al-Shifa J Ophthalmol 2018; 14(1): 28–33.
22. *Ihemedu CO, Omolase CO.* The level of awareness and utilization of computer shields among computer users in a Nigerian community. Asian J Med Sci 2010; 1(2): 49–52.
23. *Torrey J.* Understanding computer vision syndrome. Empl Rel Today 2003; 30(1): 45–51.
24. *Anshel J.* Diagnosing, treating CVS relies on good case history: basic eye care, ergonomics and optical correction are all part of an effective treatment plan for computer vision syndrome. Prim Care Optom News 2007; 12(9): 1081–6437.
25. *Wimalasundera S.* Computer vision syndrome. Galle Med J 2006; 11(1): 25–9.
26. *Sen A, Richardson S.* A study of computer-related upper limb discomfort and computer vision syndrome. J Hum Ergol (Tokyo) 2007; 36(2): 45–50.
27. *Kumar BS.* A study to evaluate the knowledge regarding computer vision syndrome among medical students. Biomed Pharmacol J 2020; 13(1): 469–73.
28. *Mocci F, Serra A, Corrias GA.* Psychological factors and visual fatigue in working with video display terminals. Occup Environ Med 2001; 58(4): 267–71.
29. *Woods V.* Musculoskeletal disorders and visual strain in intensive data processing workers. Occup Med (Lond) 2005; 55(2): 121–7.
30. *Rocha LE, Debert-Ribeiro M.* Working conditions, visual fatigue, and mental health among systems analysts in São Paulo, Brazil. Occup Environ Med 2004; 61(1): 24–32.
31. *Ye Z, Honda S, Abe Y, Kusano Y, Takamura N, Imamura Y,* et al. Influence of work duration or physical symptoms on mental health among Japanese visual display terminal users. Ind Health 2007; 45(2): 328–33.
32. *Carta A, Pasquini L, Lucchini R, Semeraro F, Apostoli P.* Relation of asthenopia and some ophthalmological, neuropsychological, and musculoskeletal parameters in workers assigned to video display terminals. Med Lav 2003; 94(5): 466–79. (Italian)
33. *Seguí MDM, Cabrero-García J, Crespo A, Verdú J, Ronda E.* A reliable and valid questionnaire was developed to measure computer vision syndrome at the workplace. J Clin Epidemiol 2015; 68(6): 662–73.
34. *Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group.* Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med 2009; 151(4): 264–9, W64.
35. *Downs SH, Black N.* The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. J Epidemiol Community Health 1998; 52(6): 377–84.
36. *Wallace BC, Dahabreh IJ, Trikalinos TA, Lau J, Trow P, Schmid CH.* Closing the gap between methodologists and end-users: R as a computational back-end. J Stat Softw 2012; 49(5): 1–15.
37. *Lin L, Xu C.* Arcsine-based transformations for meta-analysis of proportions: Pros, cons, and alternatives. Health Sci Rep 2020; 3(3): e178.
38. *Higgins JP, Thompson SG.* Quantifying heterogeneity in a meta-analysis. Stat Med 2002; 21(11): 1539–58.
39. *Arjuna SR, Ernawati T, Djaputra EM.* Association between computer vision syndrome and attention in workers. J Widya Medika Junior 2020; 2(2): 125–9.
40. *Astuti D, Makaba S, Tingginehe RM, Ruru Y.* The determinant factors affecting the event of computer vision syndrome (CVS) on helpdesk employees at PT. Telkom Access Papua in 2020. Int J Sci Basic Appl Res 2020; 53(1): 17–34.
41. *Iqbal M, El-Massry A, Elagouz M, Elzembely H.* Computer vision syndrome survey among the medical students in Sohag University Hospital, Egypt. Ophthalmol Res Int J 2018; 8(1): 1–8.
42. *Kamal NN, Abd El-Mageed AS.* Determinants of computer vision syndrome among bank employees in Minia City, Egypt. Egypt J Community Med 2018; 36(4): 70–6.
43. *Kumar N, Sharma N.* To determine the prevalence of computer vision syndrome among computer users: a descriptive study. Eur J Mol Clin Med 2020; 7(10): 3933–8.
44. *Noreen K, Ali K, Aftab K, Umar M.* Computer vision syndrome (CVS) and its associated risk factors among undergraduate medical students in midst of COVID-19. Pak J Ophthalmol 2021; 37(1): 102–8.
45. *Poudel S, Khanal SP.* Magnitude and determinants of computer vision syndrome (CVS) among IT workers in Kathmandu, Nepal. Nepal J Ophthalmol 2020; 12(24): 245–51.
46. *Ranganatha SC, Jailkhani S.* Prevalence and associated risk factors of computer vision syndrome among the computer science students of an engineering college of Bengaluru- a cross-sectional study. Galore Int J Health Sci Res 2019; 4(3): 10–5.
47. *Shahid E, Burhany T, Siddique WA, Fasih U, Shaikh A.* Frequency of computer vision syndrome in computer users. Pak J Ophtahlmol 2017; 33(2): 108–12.
48. *Sitaula K, Kafle N, Acharya A, Mishra VP.* Prevalence and associated factors of computer vision syndrome among the computer engineering students of Pokhara University affiliated colleges of Kathmandu valley. Int J Community Med Public Health 2020; 7(6): 2027–31.
49. *Al Tawil L, Aldokhayel S, Zeitouni L, Qadoumi T, Hussein S, Ahamed SS.* Prevalence of self-reported computer vision syndrome symptoms and its associated factors among university students. Eur J Ophthalmol 2020; 30(1): 189–95.
50. *Tesfa M, Ibrahim M, Markos Y, Adere A, Temam L.* Computer vision syndrome and its predictors among secretary employees working in Jimma University, Southwest Ethiopia. Int J Sens Sensor Netw 2021; 9(1): 11–8.
51. *Vikanaswari GI, Handayani AT.* The screening of computer vision syndrome in medical students of Udayana University. Bali J Ophthalmol 2018; 2(2): 28–34.
52. *Zalat MM, Amer SM, Wassif GA, El Tarhouny SA, Mansour TM.* Computer vision syndrome, visual ergonomics and amelioration among staff members in a Saudi medical college. Int J Occup Saf Ergon 2022; 28(2): 1033–41.
53. *Vilela MA, Pellanda LC, Fassa AG, Castagno VD.* Prevalence of asthenopia in children: a systematic review with meta-analysis. J Pediatr (Rio J) 2015; 91(4): 320–5.
54. *Blehm C, Vishnu S, Khattak A, Mitra S, Yee RW.* Computer vision syndrome: a review. Surv Ophthalmol 2005; 50(3): 253–62.
55. *Gowrisankaran S, Sheedy JE.* Computer vision syndrome: A review. Work 2015; 52(2): 303–14.

56. *Rosenfield M.* Computer vision syndrome: a review of ocular causes and potential treatments. Ophthalmic Physiol Opt 2011; 31(5): 502–15.
57. *Bergqvist U, Knave B, Voss M, Wibom R.* A longitudinal study of VDT work and health. Int J Hum Comput Interact 1992; 4(2): 197–219.
58. *Thomson WD.* Eye problems and visual display terminals—the facts and the fallacies. Ophthalmic Physiol Opt 1998; 18(2): 111–9.
59. *Yan Z, Hu L, Chen H, Lu F.* Computer Vision Syndrome: A widely spreading but largely unknown epidemic among computer users. Comput Hum Behav 2008; 24(5): 2026–42.
60. *Agarwal S, Goel D, Sharma A.* Evaluation of the factors which contribute to the ocular complaints in computer users. J Clin Diagn Res 2013; 7(2): 331–5.
61. *Bhutada RS.* The effect of eye exercise, triphala kwath eyewash, and instillation of distilled water on computer vision syndrome. J Datta Meghe Inst Med Sci Univ 2019; 14(6): 78–82.
62. *Dewi MA, Rahmi FL, Saubig AN, Julianti HP.* The effect of "Permata-Ku" exercises on the improvement of computer vision syndrome score. Diponegoro Med J 2021; 10(2): 128–31.
63. *Scheiman M, Wick B.* Clinical management of binocular vision: heterophoric, accommodative, and eye movement disorders. 4th ed. Philadelphia, USA: Wolters Kluwer Health/Lippincott Williams and Wilkins; 2014. 722p.
64. *American Optometric Association*. Computer vision syndrome [Internet]. 2020 [accessed on 2023 June 30]; Available from: https://www.aoa.org/healthy-eyes/eye-and-vision-conditions/computer-vision-syndrome?sso=y
65. *Chu C, Rosenfield M, Portello JK, Benzoni JA, Collier JD.* A comparison of symptoms after viewing text on a computer screen and hardcopy. Ophthalmic Physiol Opt 2011; 31(1): 29–32.
66. *Rossignol AM, Morse EP, Summers VM, Pagnotto LD.* Video display terminal use and reported health symptoms among Massachusetts clerical workers. J Occup Med 1987; 29(2): 112–8.
67. *Anshel JR.* Visual ergonomics in the workplace. AAOHN J 2007; 55(10): 414–20.

Received on March 1, 2022
Revised on April 17, 2023
Accepted April 25, 2023
Online First April 2023