Journal of Epidemiology and Public Health (2023), 08(02): 181-190
Masters Program in Public Health, Universitas Sebelas Maret

Meta-Analysis

Effect of Digital Device on Computer Vision Syndrome: Meta-Analysis

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ABSTRACT

Background: Computers are an integral part of today's modern human life, where long-term use can cause complaints of visual disturbances. Eye complaints related to computer use are called computer vision syndrome. This study aims to determine the magnitude of the influence of the use of digital screens or devices on the occurrence of computer vision syndrome with meta-analysis.
Subjects and Method: The meta-analysis was carried out using the PRISMA flowchart and the PICO Population: students model. Intervention: the duration of using the digital screen is long. Comparison: the duration of using the digital screen is short. Outcome: the incidence of computer vision syndrome. The databases used are PubMed, ScienceDirect, Web of Science, Cochrane library, Google Scholar and CINAHL with keywords (Computers OR Handheld OR Mobile Devices OR "Digital Device" OR Digital Screen) AND (Asthenopia OR "Computer Vision Syndrome" OR Eye Strain OR Digital Eye Strain) AND ("Students" OR School Children OR Secondary Children OR Postgraduate Students). The inclusion criteria in this study were full text articles with a cross-sectional design for 2018 to 2022 in English. The article was then critically reviewed using the Prisma flow chart diagram and analyzed with RevMan 5.3.
Results: Meta-analysis was conducted on 9 articles with a cross-sectional study design originating from Ghana, Saudi Arabia, Ethiopia, Spain, Thailand, Lebanon and China involving 28,888 students. The results of the meta-analysis show that the long duration of digital device use increases the risk of experiencing CVS by 2.31 times compared to the short duration of digital device use (aOR= 2.31; 95% CI= 1.60 to 3.32; p<0.001).
Conclusion: The duration of using digital devices has a higher risk of experiencing Computer Vision Syndrome.

Keywords: Student, Digital Device, Computer Vision Syndrome, Meta-Analysis

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Cite this as:
Azzahro AW, Murti B, Pamungkasari EP (2023). Effect of Digital Device on Computer Vision Syndrome: Meta-Analysis. J Epidemiol Public Health. 08(02): 181-190.
https://doi.org/10.26911/jepublichealth.2023.08.02.03.

BACKGROUND

Starting from the invention of the computer in 1822, computers have undergone many innovations and modifications to ease humans work. Currently, computers are equipped with digital screens whose job is to display data in the form of characters or graphics (Nadhiva and Mulyono, 2020). In Indonesia, based on data from the Indonesian Internet Service Providers Association, 2.2 million Indonesians are computer users (Sherti et al., 2021). The use of digital

screens for a long time can cause complaints of visual disturbances which are most likely caused by ultraviolet radiation and X-rays. These eye complaints related to computer use are called computer vision syndrome. (Seresirikachorn et al., 2022).

There are 60 million people in the world who experience computer vision syndrome, and this number continues to increase by 1 million per year. The risk of computer vision syndrome faced by computer users is estimated to be around 70%. Although it is not life threatening, computer vision syndrome can affect performance which results in decreased work productivity. In addition, Computer vision syndrome can also have an impact on decreasing fitness, to the quality of human life (Zenbaba et al., 2021).

Computer Vision Syndrome as a spectrum of symptoms related to the eyes and vision as a result of excessive computer use (Pratiwi et al., 2020). The exact cause of computer vision syndrome is not known, many factors contribute to the occurrence of computer vision syndrome, including individual, environmental and computer factors. Using a computer for more than 5 hours can increase the risk of developing computer vision syndrome. Not looking at the computer screen while operating it, staring at the computer screen for too long, and the higher position of the computer screen are some of the causes that contributed to the occurrence of computer vision syndrome (Rahman et al., 2011).

Based on the symptoms, computer vision syndrome is grouped into 4 main categories, including asthenopia symptoms (eyes strained, tired, sore), symptoms related to the surface of the eyeball (eyes dry, watery, irritated), visual symptoms (blurred vision, double vision, presbyopia, slow change of focus), and extraocular symptoms (neck pain, shoulder pain, back pain) (Bali et al., 2014). For some people, these symptoms may not be severe and quite disturbing. This can trigger public indifference to eye health, which in turn has an impact on the lack of a proper diagnosis and management process.

In this study, researchers are interested in compiling a systematic review and meta-analysis regarding "The Effect of Using Digital Devices on the Incident of Computer Vision Syndrome" to determine the magnitude of the influence of using digital screens or devices on the occurrence of computer vision syndrome.

SUBJECTS AND METHOD

1. Study Design

This study used a Systematic Review design and meta-analysis of data taken from PubMed, Science Direct, Web of Science, Cochrane library, Google Scholar and CINAHL databases. The keywords used are (Computers OR Handheld OR Mobile Devices OR “Digital Device” OR Digital Screen) AND (Asthenopia OR “Computer Vision Syndrome” OR Eye Strain OR Digital Eye Strain) AND (“Students” OR School Children OR Secondary Children OR Postgraduate Students).

2. Steps of Meta-Analysis

The meta-analysis was carried out through 5 steps as follows:

1) Formulate research questions using the PICO model (Population: students, Intervention: long duration of digital screen use, Comparison: short duration of digital screen use, Outcome: incidence of computer vision syndrome).
2) Search for primary study research articles from 6 online databases, viz PubMed, ScienceDirect, Web of Science, Cochrane library, Google Scholar and CINAHL.
3) Conduct screening and quality assessment of primary study articles.
4) Extract and analyze data into the RevMan 5.3 application.
5) Interpret the results and draw conclusions.

3. Inclusion Criteria

Full paper article using cross sectional design. The size of the relationship used is the adjusted odds ratio (aOR). The subjects were students aged 8-29 years old. Research intervention is exposure to digital screens. The study outcome is the incidence of computer vision syndrome.

4. Exclusion Criteria

Articles published before 2018, articles in languages other than English, and statistical results are reported in the form of bivariate analysis.

5. Operational Definition of Variables

Digital Screen Usage (Exposure Duration) is defined as all use of digital screens regardless of purpose, whether for communication, entertainment, work or education. Exposure duration is the length of time a digital device is used in a day expressed in hours per day.

Incidents of Computer Vision Syndrome is defined as a group of eye and vision related problems from prolonged use of computers, tablets, e-readers and mobile phones that cause increased stress especially to near vision.

6. Study Instruments

The quality assessment of the primary articles in this study used the Newcastle-Ottawa Scale (NOS) critical assessment list which has been adapted for cross-sectional studies.

7. Data Analysis

The articles in this study were collected using the PRISMA diagram and analyzed using the Review Manager 5.3 application (RevMan 5.3) by calculating the effect size and heterogeneity (I^2) to determine the combined research model and form the final results of the meta-analysis. The results of data analysis are presented in the form of forest plots and funnel plots.

RESULTS

The process of searching for primary articles related to the effect of using digital devices on the occurrence of computer vision syndrome in this meta-analysis study was carried out on 9 online databases which can be seen in Figure 1.

The total number of articles in the initial search process were 8,065 articles, with detailed articles from the database, after the process of deleting duplicate articles, 6,595 articles were found, of which 40 fulfilled the requirements for further full text review and 0 articles were obtained that were included in the systematic review and meta-analysis. Full text articles included in the exclusion criteria are due to the following reasons:

1. Outcomes and interventions from the study did not match the PICO criteria or formula in this study.
2. Does not include the value of the adjusted odds ratio (aOR) as a result of multivariate logistic regression analysis.
3. Study design other than cross-sectional.

Figure 2 showed the area of distribution of the primary articles used in this study which are spread across 3 continents, namely 1 article from the Continent of Europe (Spain), 2 articles from Africa (Ethiopia and Ghana) and 6 articles from Asia (Saudi Arabia, Thailand, Lebanon and China).

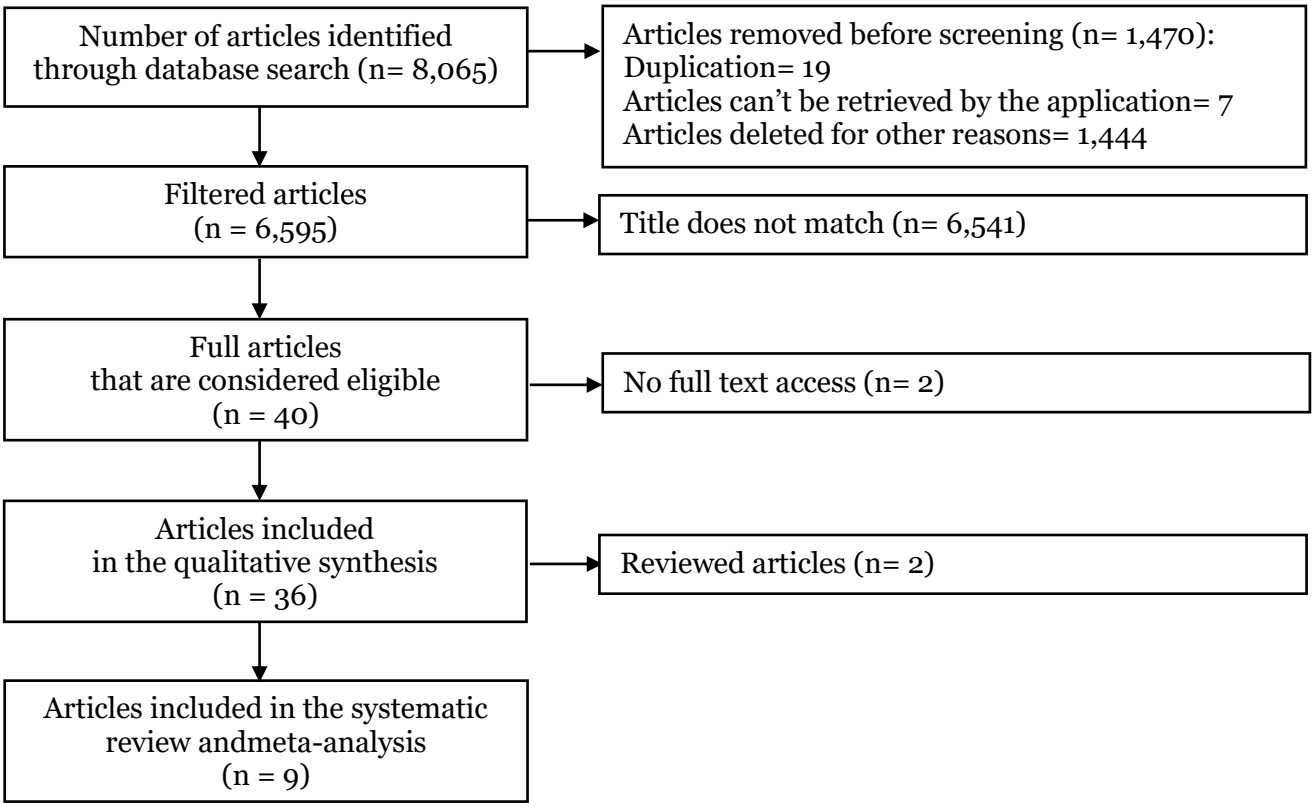

Figure 1. PRISMA Flowchart

Figure 2. Research areas on effect of digital device on computer vision syndrome

Table 1 showed the results of the primary study quality assessment used in this study. The primary study quality assessment in this study was carried out using the Newcastle-Ottawa Scale critical assessment which has been adapted for cross-sectional studies. Based on the results obtained from the study quality assessment, the total scores in the 9 selected primary studies ranged from 6 to 8, this indicated that the quality of all primary articles used in this study is feasible for meta-analysis.

Table 2 presented descriptions of 9 primary studies with cross-sectional study designs that were included in the meta-analysis of the effect of digital screen use on the incidence of computer vision syndrome. There were 9 articles with a total sample of 28,888 students aged 8 to 29 years old.

The forest plot in Figure 3 showed that there was an effect of using digital devices on the risk of CVS events, and this effect was statistically significant. Students who use digital devices for a long duration have a risk of experiencing CVS 2.31 times compared to short durations (aOR= 2.31; 95%CI= 1.60 to 3.32; p= 0.001). The forest plot also showed high heterogeneity of effects between studies (I^2 = 78%; p<0.001). Thus the calculation of the average effect estimate was carried out using the Random effect model.

The funnel plot in Figure 4 showed an asymmetric distribution of effects that are more located to the right than to the left of the estimated average vertical line, thus indicating publication bias. Because the estimate was located to the right of the mean vertical line in the funnel plot, which was the same as the location of the average effect estimate (diamond shape) which was also located to the right of the null hypothesis, this publication bias tend to overestimate the effect of the actual digital device (overestimated).

Table 1. Results of the quality assessment of the cohort study on the effect of vaccination on COVID-19 infection

Author (Year)	Question Criteria							
	1	2	3	4	5	6	7	Total
Akowuah et al. (2021)	1	1	1	1	1	2	1	8
Aldukhayel et al. (2022)	1	0	1	1	2	2	1	8
Belay et al. (2020)	1	0	1	1	2	2	1	8
Cantó-Sancho et al. (2020)	1	1	1	1	1	2	1	8
Lavin et al. (2018)	1	0	1	1	1	1	1	6
Seresirikachorn et al. (2022)	1	0	1	1	2	2	1	8
Touma et. al (2020)	1	1	0	1	2	2	1	8
Li et al. (2021)	1	1	1	1	1	2	1	8
Li et al. (2022)	1	1	1	1	1	1	1	7

Description of the question criteria:

1 = Does the article really represent the average of the target population?
2 = Is the article sample size justified and satisfactory?
3 = Can the characteristics of respondents and non-respondents be compared in the article, and is the response rate satisfactory?
4 = Does the article have exposure certainty (risk factors) such as a validated measuring tool?

5 = Are subjects in the different outcome groups comparable, based on study design or analysis and controlled for confounding factors?
6 = Does the outcome assessment follow independent blind assessment, record linking, self-report?
7 = Is the statistical test used to analyze the data clearly described?

Answer score description:

0 = No description
1 = Undecided
2 = Clear explanation

Table 2. Cross-sectional primary study characteristics included in the meta-analysis with each PICO (N= 28,888)

Author (Year)	Country	Total Sampel	P	I	C	O
Akowuah et al. (2021)	Ghana	362	Students aged ≥ 18 years old	Digital screen duration (>6 hours/day)	Digital screen duration (<6 hours/day)	CVS
Aldukhayel et al. (2022)	Saudi Arabia	547	Students aged 3-18 years old	Digital screen duration (>5 hours/day)	Digital screen duration (<5 hours/day)	DES
Belay et al. (2020)	Ethiopia	346	Students aged ≥ 18 years old	Digital screen duration (>4.6 hours/day)	Digital screen duration (<4.6 hours/day)	CVS
Cantó-Sancho et al. (2020)	Spain	244	Students aged 18-29 years old	Digital screen duration (>4 hours/day)	Digital screen duration (<4 hours/day)	CVS
Lavin et al. (2018)	Thailand	485	Students aged 13-18 years old	Digital screen duration (>6 hours/day)	Digital screen duration (<2 hours/day)	DES
Seresirikachorn et al. (2022)	Thailand	2,476	Students aged 13-18 years old	Digital screen duration (>6 hours/day)	Digital screen duration (<6 hours/day)	CVS
Touma et. al (2020)	Lebanon	457	Students aged ≥ 18 years old	Digital screen duration (<4 hours/day)	Digital screen duration (<4 hours/day)	CVS
Li et al. (2021)	China	21,966	Students aged 8–20 years old	Digital screen duration (<4 hours/day)	Digital screen duration (<4 hours/day)	CVS
Li et al. (2022)	China	2,005	Students aged 6-18 years old	Digital screen duration (>6 hours/day)	Digital screen duration (<6 hours/day)	CVS

Table 3. Adjusted Odds Ratio (aOR) of the effect of using digital devices on the incidence of computer vision syndrome (N= 28,888)

Studies	aOR	95%CI	
		Lower Limit	Upper Limit
Akowuah et al. (2021)	4.10	3.16	6.27
Aldukhayel et al. (2022)	2.24	1.49	3.35
Belay et al. (2020)	3.76	1.73	8.18
Cantó-Sancho et al. (2020)	3.43	1.03	11.42
Lavin et al. (2018)	7.62	3.25	17.82
Seresirikachorn et al. (2022)	1.91	1.13	3.23
Touma Sawaya et al. (2020)	0.70	0.32	1.51
Li et al. (2021)	1.62	1.01	2.28
Li et al. (2022)	1.53	1.12	2.07

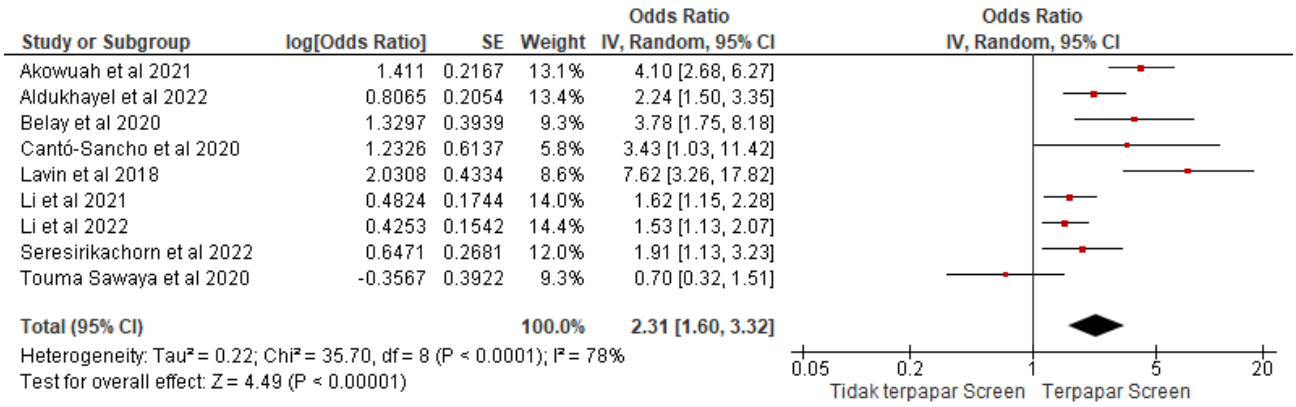

Figure 3. Forest plot of the effect of digital screen exposure on CVS incidents

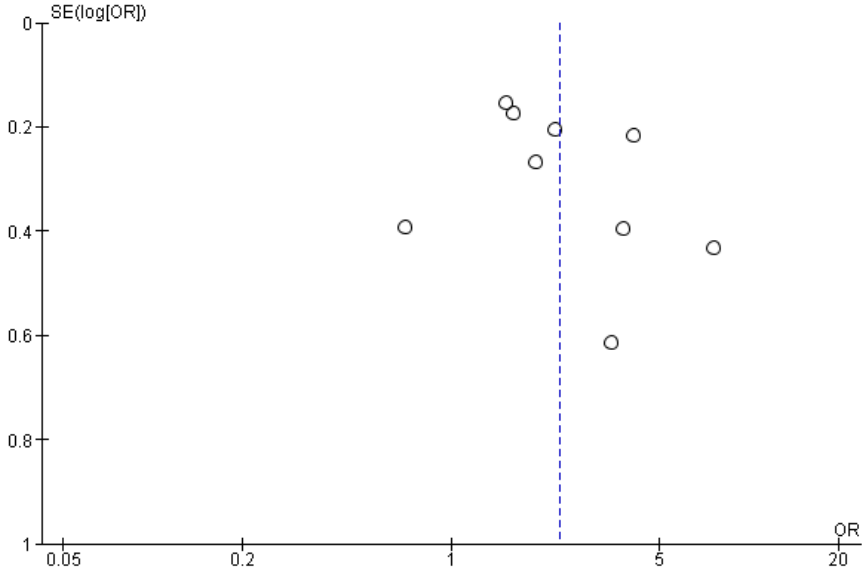

Figure 4. Funnel plot meta-analysis of the effect of digital screen exposure on CVS incidents

DISCUSSION

Computer Vision Syndrome is a visual impairment caused by exposure to the use of digital devices (Lumolos et al., 2016). Factors that influence the incidence of CVS consist of the duration of computer use, whether or not there are breaks when using the computer, the position of the eyes on the screen, and the distance between the eyes and the computer (AOA, 2020). The duration of using digital devices for children reached 4 hours per day, longer than before the COVID era which was 2 hours, of which 36.9% of them used digital devices for more than 5 hours per day and only 1.8% did it in the pre-COVID era (Ciputra and Dwipayani, 2022). Most research subjects had a continuous duration of exposure to computer screens (not accompanied by other activities) in a day for more than equal to 4 hours by 76 people (84.4%), while the duration of exposure that was less than 4 hours by 14 people (15.6%) (Aldy et al., 2021).

It is recommended that the duration of digital device use is no more than 4 hours a day. If it goes beyond that, the eyes are forced to focus on the digital screen for too long, so that the eye muscles become tense. This causes a decrease in the frequency of blinking and tear production which can

cause CVS symptoms (Lumolos et al., 2016). The duration of continuous computer screen exposure is significantly associated with CVS complaints. Research subjects who were continuously exposed to digital screens for more than or equal to 4 hours had a 7.3 times bigger risk of experiencing CVS compared to those exposed for less than 4 hours. The duration factor can be exacerbated by the presence of poor posture when using a digital screen which can be caused by several things. Firstly, due to the less ergonomic design of the workplace/study with the high duration and frequency of computer use. In addition, several ergonomic principles have not been applied (Aldy et al., 2021).

The diagnosis of CVS is obtained through anamnesis, physical examination and support. During anamnesis, it can be explored whether a person has eye complaints, such as feeling tired, irritated, heavy, watery, red, whether there are visual disturbances such as blurred or double vision. Extraocular symptoms should also be asked such as headache, shoulder pain or back pain. Other risk factors such as drug use, systemic disease, history of glasses use should also be asked. In addition, it is necessary to ask whether there is a history of digital screen exposure. If any, it is important to be tested regarding the number and type of devices used, viewing distance and viewing angle for each device, duration of exposure and other important parameters such as size, contrast and brightness of the digital screen (Ciputra and Dwipayani, 2022).

A comprehensive eye examination includes visual acuity, refraction, intraocular pressure, pupil examination, ocular adnexa and ocular motility examination, binocular examination, and slit-lamp examination which allows viewing of the anterior and posterior segments. The eyelids and the surface of the eye should also be thoroughly examined. Evaluation of the tear film and blink rate is also important for the diagnosis and can be considered in the treatment of CVS. Several questionnaires are also available for assessing CVS cases, including the Dry Eye Questionnaire (DEQ-5), Questionnaire by Hayes, Visual fatigue scale, Computer vision symptom scale (CVSS17), CVS Questionnaire (CVS-Q) (Ciputra and Dwipayani, 2022).

The CVS-Q questionnaire consists of 16 symptom parameters that will be assessed for their frequency and intensity. There are 3 ratings for frequency, namely never, sometimes and often or always, with each rating point 0, 1 and 2. The intensity aspect consists of 2 assessments, namely moderate and severe, with points 1 and 2 respectively. the frequency and intensity columns will be multiplied for each parameter. A score greater than or equal to 6 indicates the possibility of CVS (Ciputra and Dwipayani, 2022).

Considering that the factors that cause CVS incidents are multifactorial, a multifaceted approach is needed to relieve the symptoms of CVS. Meanwhile, patient education is the main management. Encouraging patients to take precautions is very important. Reducing the duration of exposure and the number of digital devices used should be reduced to reduce the risk of CVS (Ciputra and Dwipayani, 2022).

This study has several limitations, including language bias because this research only uses primary studies published in English. In this study, there were also limitations in the search for primary studies because researchers only searched through 5 online databases, namely PubMed, Science-Direct, Web of Science, Cochrane library, Google Scholar and CINAHL, thus ignoring other databases.

AUTHOR CONTRIBUTION

Asri Wahyu Azzahro as the main researcher who selected topics, conducted searches for

research data collection, and conducted research data analysis. Bhisma Murti and Eti Poncorini conducted a review of research documents.

ACKNOWLEDGEMENT

The researcher would like to thank to those who contributed to the preparation of this article, and to the database providers namely PubMed, ScienceDirect, Web of Science, Cochrane library, Google Scholar and CINAHL.

FUNDINGS AND SPONSORSHIP

The study was self-funded.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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