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Review Article

Digital eye strain in young screen users: A systematic review

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ABSTRACT

Digital eye strain (DES) or computer vision syndrome (CVS) is a phenomenon linked to ever increasing digital screen use globally, affecting a large number of individuals. Recognizing causative and alleviating factors of DES may help establish appropriate policies. We aimed to review factors that aggravate or alleviate DES symptoms in young, i.e. pre-presbyopic (< 40 years old), digital device users. We searched PubMed, Scopus, EMBASE, Cochrane, Trip Database, and grey literature up to 1st July 2021. Among a plethora of studies with heterogeneous diagnostic criteria for DES, we only included those using a validated questionnaire for the diagnosis and evaluating associated factors in young subjects. Relevant data were extracted, risk of bias assessment of the included studies and GRADE evaluation of each outcome were performed. Ten studies were included (five interventional, five observational) involving 2365 participants. Evidence coming from studies with moderate risk of bias suggested that blue-blocking filters do not appear to prevent DES (2 studies, 130 participants), while use of screens for > 4-5 h/day (2 studies, 461 participants) and poor ergonomic parameters during screen use (1 study, 200 participants) are associated with higher DES symptoms' score. GRADE evaluation for the outcomes of blue-blocking filters and duration of screen use showed low to moderate quality of evidence. It appears advisable to optimize ergonomic parameters and restrict screen use duration, for minimizing DES symptoms. Health professionals and policy makers may consider recommending such practices for digital screen users at work or leisure. There is no evidence for use of blue-blocking filters.

1. Introduction

Digital Eye Strain (DES) or Computer Vision Syndrome (CVS) are synonymous terms referring to eye symptoms related to the use of digital screens, a phenomenon which is on the rise worldwide and is increasingly being studied. The Covid-19 pandemic considerably increased the time spent on digital screens among people of all ages. Academic societies do give some guidelines regarding the use of screens by minors, however setting clear duration recommendations is challenging.(Hill et al., 2016; World Health, 2019; Gupta et al., 2022) Extensive screen use can cause a multitude of unwanted effects, including DES, so causative elements and alleviating interventions are currently sought for, to mitigate the phenomenon.

A couple of validated questionnaires have been developed for DES assessment, including the CVS-questionnaire (CVS-Q) by Segui et al. in 2015, which evaluates 16 symptoms and assesses their severity through a Likert scale 1 to 5, and the Rasch-based linear scale Computer-Vision Symptom Scale (CVSS17) by Gonzalez-Perez et al. in 2014, which

Abbreviations: DES, Digital eye strain; CVS, Computer vision syndrome; CVS-Q, CVS-questionnaire; CVSS17, Computer-vision symptom scale; RCTs, Randomized controlled trials.

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contains 17 items exploring 15 different symptoms.(Seguí Mdel et al., 2015; González-Pérez et al., 2014) Given that there is no consensus on a clinical definition of digital eye syndrome, a safe way for diagnosis is to only consider those subjects with a pathological score on one of these validated questionnaires. Despite the existence of these tools, a large number of studies use customized questionnaires which cannot be relied upon, as they have not been validated to either diagnose or accurately quantify DES symptoms and cannot be used to draw conclusions.

This systematic review aims to compile and evaluate current knowledge on factors that may aggravate or alleviate DES symptoms in pre-presbyopic subjects using digital screens. This evidence can be invaluable in formulating recommendations regarding the use of screens, and this review was commissioned to inform such guidelines by the World Society of Pediatric Ophthalmology and Strabismus.

2. Materials and methods

The study protocol has been published in OSF database: https://osf.io/ru4vc/. The study followed the reporting guidelines of "The PRISMA 2020 statement: an updated guideline for reporting systematic reviews" (Page et al., 2021). The PRISMA checklist is presented in Table S1.

2.1. Search strategy & information sources

Literature search strategies were developed using text words related to digital eye strain or computer vision syndrome (Table S2). PubMed, Scopus, EMBASE, Cochrane and Trip Database were searched up to 1st July 2021, without a starting point limitation. No restrictions were applied. The electronic databases' search was supplemented by searching in two clinical trials registries (ClinicalTrials.gov and Anzctr.org.au), as well as in the final programs of relevant Ophthalmology congresses of the years 2019–2021, finally through scanning the reference lists of the included studies.

2.2. Eligibility criteria

All the primary studies that report on symptoms of DES/CVS and associated factors (e.g. refractive error, duration of screen use, type of screen used etc.), either observational or with interventions to alleviate symptoms, were considered for inclusion. Interventional studies were chosen based on the PICO inclusion criteria and observational studies were chosen based on the PECO inclusion criteria (Table 1). Studies including presbyopic subjects, studies where diagnosis of DES was made without the use of a validated questionnaire, studies only on symptoms related to body posture and interventional studies without a control group were excluded. Also, case reports, editorials, commentaries, expert opinion reports and reviews were excluded.

Table 1
PICO inclusion criteria for interventional studies and *PECO* inclusion criteria for observational studies.

PICO inclusion criteria for interventional studies	
Participants	Children or young adults (pre-presbyopic i.e. age < 40 years) using digital screens
Intervention	An intervention aimed to alleviate DES symptoms
Comparator	The absence of an intervention aimed to alleviate DES symptoms
Outcome	DES symptoms, as diagnosed with a validated questionnaire
Study type	Interventional (RCTs or quasi-RCTs or non-randomized controlled trials)

***PECO* inclusion criteria for observational studies**	
Participants	Children or young adults (pre-presbyopic i.e. age < 40 years)
Exposure	Use of digital screens extensively e.g. > 2 h daily
With/without Comparator	Minimal or absent use of digital screens e.g. up to 2 h daily
Outcome	DES symptoms, as diagnosed with a validated questionnaire
Study type	Observational (cohort study, case-control study or cross-sectional study)

DES: digital eye strain, RCTs: randomized controlled trials.

2.3. Selection process and data collection process

Four independent reviewers (AM, AKS, SM, EP) performed all the steps of screening, data collection and risk of bias assessment in pairs. Titles and abstracts were screened against the pre-defined eligibility criteria and full texts were obtained for reports that appeared to meet the inclusion criteria, or where there was uncertainty. Full-text screening was again performed by two screeners independently, to judge eligibility. The reasons for full-text exclusion were justified in the Table S3. Whenever multiple reports of the same study were identified, the most recent/complete one was kept. Two reviewers also extracted data independently from each eligible study, using a data collection form in an Excel spreadsheet, designed specifically for this systematic review. In cases of disagreement, consensus was reached through discussion.

2.4. Data items

The primary outcome was factors preventing DES and secondary outcomes were presumed risk factors for DES. The data that was extracted from each included study were the following elements: study type, source of funding, population studied (number of participants, participant status, age, gender, ethnicity), intervention studied (type of intervention, comparator/control group), associated risk factors (refractive error of participants, duration of screen use, type of screen used, filter used on screen or on eyeglasses, distance of screen from eyes, ambient light during screen use, body stature during screen use), outcome (score on CVS-Q, CVSS17 questionnaires, specific signs/symptoms attributed to screen use, if applicable). For abstracts of a potentially eligible study, where a full text was not found to have been published, authors were contacted by email to ask for their data. Also, authors were contacted by email to ask for clarifications regarding their paper's full text, where appropriate.

2.5. Risk of bias (ROB) assessment

Two reviewers independently assessed the methodological quality of each included study. In cases of disagreement, consensus was reached through discussion. Randomized controlled trials (RCTs) were evaluated using the ROB 2.0 tool (Cochrane Collaboration tool for assessing the risk of bias).(Sterne et al., 2019) The overall risk of bias was classified as low if all domains were at low risk of bias, as high if at least one domain was at high risk of bias, or as "some concerns" if at least one domain was at unclear risk of bias and no domain was at high risk. The quality of the non-randomized clinical trials was evaluated using the ROBINS-I tool for non-randomized trials.(Sterne et al., 2016) The overall risk of bias was judged to be low if risk of bias was low across all domains, moderate if risk of bias was low or moderate for all domains, or serious if risk of bias was serious for at least one domain, but not critical for any domain. Finally, the quality of observational studies was assessed using the JBI tool for analytical observational studies.(Moola et al., 2020) To ensure consistency in using this tool, it was decided to attribute a) high ROB if one or more answers were "No"; or if > 4 answers were "Unclear", b) low ROB if all answers were "Yes", and c) moderate ROB in all other combinations. This tool asks if the exposure in the study is measured in a valid and reliable way (criterion 3). Ideally, one would need a validated questionnaire to measure the exposure, even if it would be self-reported. In its absence, studies were evaluated to present unclear risk of bias in terms of criterion 3. Whenever the data essential for judging the risk of bias for included studies was not available in the full text and the supplementary material of a publication, authors were contacted to obtain or confirm specific data.

2.6. Grading of recommendations, assessment, development and evaluations (GRADE) assessment

The quality of each outcome that was studied in more than one reports, was assessed according to the GRADE Working Group system. (Murad et al., 2017) Five domains were analyzed: methodological limitations of the studies or risk of bias, indirectness, imprecision, inconsistency and publication bias, and the overall quality of evidence was then evaluated based on these judgements.

3. Results

From an initial 931 entries found via databases and registries, as well as 339 additional reports identified from citation searching, 10 studies were eligible for inclusion (Fig. 1). These were five interventional (four RCTs and one non-randomized interventional study),(Alghamdi and Alrasheed, 2020; Dabrowiecki et al., 2020; Singh et al., 2021; Talens-Estarelles et al., 2021; Zheng et al., 2021) and five observational (cross-sectional) studies,(Boadi-Kusi et al., 2020; Cantó-Sancho et al., 2021; Gammoh, 2021; Mohan et al., 2021; Teo et al., 2019) involving 1171 children and 1194 adults. Characteristics of included studies are presented in Tables 2 and 3. All included studies used the CVS-Q questionnaire for DES diagnosis, evaluating the presence and severity of 16 items: burning, itching, feeling of a foreign body, tearing, excessive blinking, eye redness, eye pain, heavy eyelids, dryness, blurred vision, double vision, difficulty focusing for near vision, increased sensitivity to light, colored halos around objects, feeling that sight is worsening, and headache. (Seguí Mdel et al., 2015) Data collected from studies were too heterogeneous to synthesize, and so they are presented qualitatively.

Among interventional studies, only one concerned children, with a mean age of 13.5 years,(Zheng et al., 2021) while the others included young pre-presbyopic adults with a mean age ranging from 21 to 30 years.(Alghamdi and Alrasheed, 2020; Dabrowiecki et al., 2020; Singh et al., 2021; Talens-Estarelles et al., 2021) All five studies applied an intervention aiming to alleviate symptoms of DES: a) advice about DES including structured booklet and sticker on computer monitor reminding of 20/20/20 rule, b) blue-blocking filter glasses, c) artificial tears, or d) health education information promoting exercise and ocular relaxation and access to a digital behavior change intervention, with live streaming and peer sharing of promoted activities. In all but one study, (Singh et al., 2021) CVS-Q was used to quantify DES symptoms after the intervention.(Alghamdi and Alrasheed, 2020; Dabrowiecki et al., 2020; Talens-Estarelles et al., 2021; Zheng et al., 2021) All interventions were found to have no alleviating effect except the digital behavior change intervention, however this latter study presented high risk of bias. (Zheng et al., 2021) The remaining interventional studies were also evaluated to have a high risk of bias, except one which only had some concerns.(Dabrowiecki et al., 2020).

Alghamdi et al. (Alghamdi and Alrasheed, 2020) failed to show a positive effect of an advice booklet explaining the 20/20/20 rule and reminding sticker on computer monitor. Talens-Estarelles et al. (Talens-Estarelles et al., 2021) showed no effect of artificial tears on DES score after a 15-min reading task, possibly due to the short duration of visual task (15 min) and to the low DES scores recorded by the end of it. Glasses containing blue-blocking filters did not reduce DES scores in two studies carried out in different populations and with a different design.(Dabrowiecki et al., 2020; Singh et al., 2021) In both studies participants were masked. In the only included interventional study undertaken in children, it was suggested that delivery of health information promoting physical exercise and ocular relaxation was successful in reducing DES scores.(Zheng et al., 2021).

Among observational studies only one concerned children, with a mean age of 13.0 years,(Mohan et al., 2021) while the others included young pre-presbyopic adults with a mean age ranging from 20.7 to 31 years. (Boadi-Kusi et al., 2020; Cantó-Sancho et al., 2021; Gammoh, 2021; Teo et al., 2019) Evaluated risk factors for DES were a) ergonomic

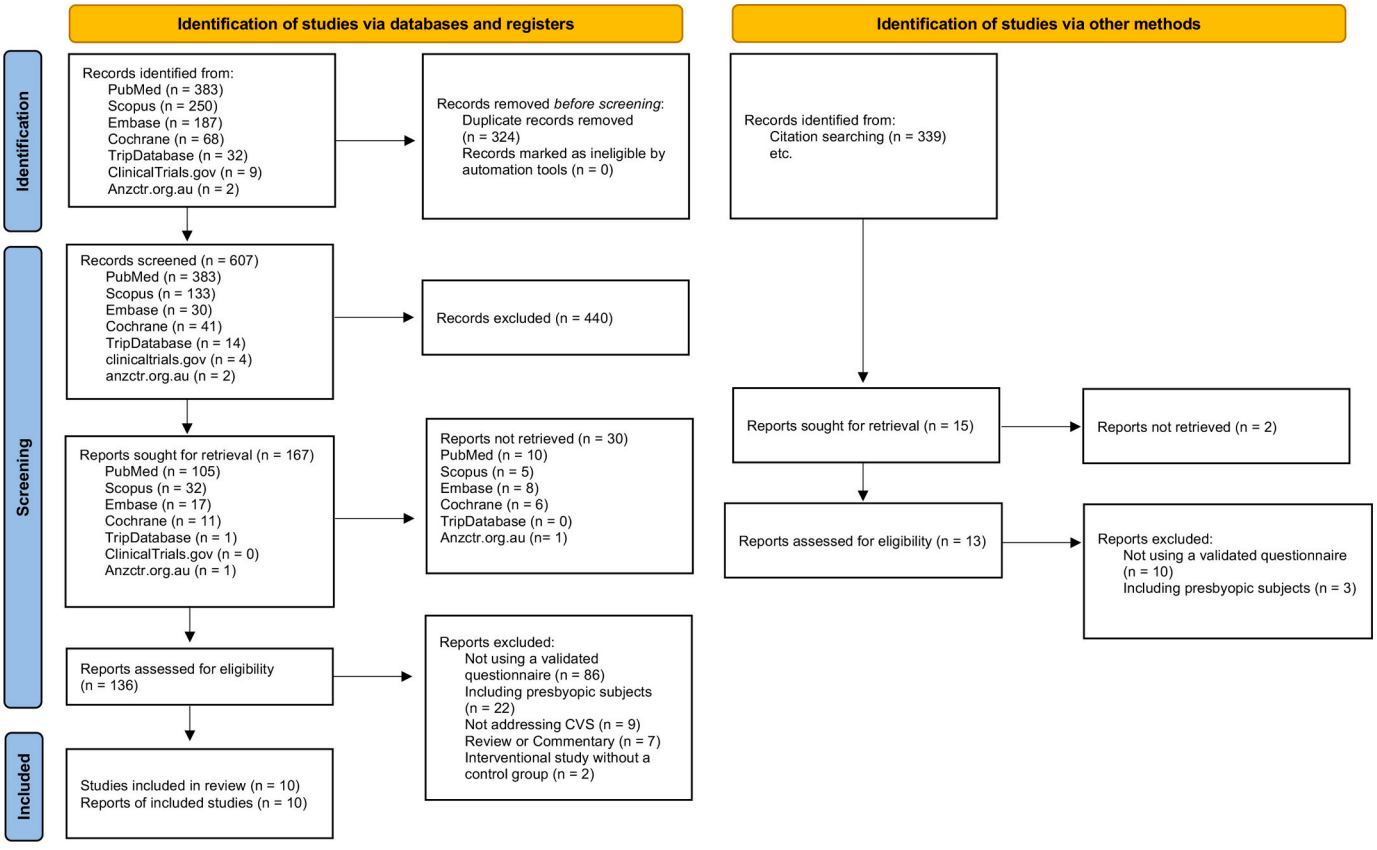

Fig. 1. PRISMA flow diagram summarizing the article selection process.

Table 2
Characteristics of interventional studies included in this systematic review.

Author, year	Study type	Funding	Participant demographics			Type of intervention	Comparator	Study outcomes	Findings	Overall risk of bias (tool used)
			Total number and status of subjects	Mean age in years (SD)	Male no. (%)					
Alghamdi and Alrasheed, 2020	Non-randomized interventional	None	40 patients at optometry clinic	28.3 (5.8)	40 (100)	Advice about CVS including structured booklet and sticker on computer monitor reminding of 20/20/20 rule	Advice to drink more water	CVS-Q 20 days after the intervention	No comparison made between groups, only within them (before-after comparison). No difference found in either group.	High (ROB 2)
Dabrowiecki et al., 2020	Crossover randomized controlled trial	None	10 radiology residents	29.4 (3.24)	4 (40)	Clear BFL glasses worn for a week during work (radiology residents)	Clear non-BLF glasses worn for a week during work	CVS-Q at the end of one week, and at the end of the consecutive week (crossover design)	No difference in the CVS-Q scores	Some concerns (ROB 2)
Singh et al., 2021	Randomized controlled trial	None	120 adults	Range 21–30	40 (33.3)	a) Blue-blocking spectacles, b) prerecorded video advocating for the intervention	a) Clear spectacles, b) prerecorded video advocating for the intervention	Eye strain symptom score after 2-h computer task, critical flicker-fusion frequency	No differences found for advocacy or spectacle lens types	High (ROB 2)
Talens-Estarelles et al., 2021	Non-randomized trial	Yes*	31 healthy volunteers	21.26 (1.73)	6 (19.4)	15-min reading task on four digital displays, using artificial tears	Same reading task without use of artificial tears	CVS-Q at the end of the 15-min reading task	No difference in the CVS-Q scores after use of artificial tears (for the same digital display)	Serious (ROBINS-I)
Zheng et al., 2021	Cluster randomized controlled trial	Yes**	954 school children	13.5 (0.5)	499 (52.3)	Health education information promoting exercise and ocular relaxation, and access to a digital behavior change intervention, with live streaming and peer sharing of promoted activities	Health education information only	CVS-Q two weeks after the intervention	Greater change in self-reported eye strain in the intervention versus comparator group	High (ROB 2)

SD: standard deviation, BFL: blue light filtering, CVS: computer vision syndrome, CVS-Q: computer vision syndrome questionnaire.

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parameters at the workstation, b) persistent neck pain, c) duration of exposure to digital screens, d) type of digital screen used, e) age and sex of the participants, and f) playing mobile games >1 h/day. Most associations of these risk factors with DES were found to be positive, and all studies had an overall moderate risk of bias, (Boadi-Kusi et al., 2020; Cantó-Sancho et al., 2021; Mohan et al., 2021; Teo et al., 2019) except one (Gammoh, 2021) which presented high risk of bias.

Observational studies universally identified the duration of digital screen use as a risk factor for developing DES, both in adults (Gammoh, 2021; Cantó-Sancho et al., 2021) and in children.(Mohan et al., 2021) Mohan et al.(Mohan et al., 2021) also found an increased risk in subjects preferring smartphone use over other digital devices, in male subjects and in those aged >14 years. One study identified poor ergonomic practices at the workstation as a risk factor (Boadi-Kusi et al., 2020) and another found that people with persistent neck pain are more likely to have DES.(Teo et al., 2019).

ROB assessment of included studies is presented in detail in Table 4. GRADE assessment of common outcomes among studies is detailed in Table 5, Table S4 and Table S5. Common outcomes were a) use of blue-blocking filters and b) duration of digital screen use. Evidence derived from two RCTs concerning the blue-blocking filters was of low certainty, whereas evidence derived from 3 cross-sectional studies regarding duration of screen use was of moderate certainty.

4. Discussion

To the best of our knowledge, this is the first systematic review on alleviating or aggravating factors associated with DES. It appears that there is a positive association of the presence of neck pain, poor ergonomic parameters and longer daily duration of digital device use with DES. Contrarily, the use of blue filter lenses did not seem to alleviate DES symptoms, nor did structured advice to keep with the 20/20/20 rule.

These findings resulted from a systematic approach, following a pre-published protocol, applying a focused question, a comprehensive

Table 3
Characteristics of observational studies included in this systematic review.

Author, year	Participant demographics			Factors assessed	Study outcomes	Findings	Overall risk of bias
	Total number	Mean age in years (SD)	Male no. (%)				
Teo et al., 2019	167 volunteers (74 subjects with neck pain and 93 subjects without)	23 (24) in subjects with persistent neck pain, 26.5 (24) in subjects without	48 (28.7)	Persistent neck pain	CVS-Q score	DES more prevalent among subjects with persistent neck pain than in those without	Moderate (JBI)
Boadi-Kusi et al., 2020	200 university administrative staff	31.0 (4.7)	112 (56.0)	Ergonomic parameters observed and measured at each workstation	CVS-Q score	Positive association with viewing angle from eye to top/center of computer screen, distance from horizontal to top/center/bottom of computer screen, viewing distance from eye to home row of keyboard, light intensity of room, light intensity between participant and computer	Moderate (JBI)
Cantó-Sancho et al., 2021	244 university students	20.7 (2.1)	105 (43)	Sociodemographic variables, optical correction and VDT exposure (duration)	CVS-Q score	The use of VDTs for >4 h a day to study was associated with an increased likelihood of DES compared with VDT use for <2 h a day. Being between 22 and 29 years of age was associated with a decreased likelihood of DES compared with the youngest group (18–19 years old).	Moderate (JBI)
Gammoh, 2021	382 university students	21.5 (1.8)	149 (39.1)	Time spent on digital devices (duration)	CVS-Q score	Positive association between hours spent on digital devices and DES symptoms	High (JBI)
Mohan et al., 2021	217 school children	13.0 (2.45)	101 (46.5)	Age > 14 years, male sex, Smart phone preference, digital device use ≥5 h/day, distance of screen from eyes <18 in., mobile games >1 h/day	CVS-Q score	Positive association with age > 14 years, male sex, smartphone preference over other digital devices, use of digital devices >5 h/day, and use of mobile games >1 h/day	Moderate (JBI)

SD: standard deviation, VDT: video display terminal, CVS-Q: computer vision syndrome questionnaire, DES: digital eye strain.
All studies are cross-sectional and no funding reported in any study.

search and using objective, reproducible criteria of study selection and prespecified tools for assessing validity of included reports. A limitation of our study was that although we searched grey literature, we did not screen optometry congresses, to identify potential unpublished relevant studies.

Despite a plethora of available studies identified in the literature, only few of these used a validated questionnaire for diagnosing the presence of DES and for quantifying its severity, leading to a small number of studies finally included in the review. Significant concerns were raised regarding the risk of bias in these studies, and additionally they were too heterogeneous to synthesize in a meta-analysis. GRADE evaluation revealed a low to moderate quality of evidence, therefore findings are to be interpreted with caution.

Interventional studies were generally found to have a high risk of bias, so results are questionable. Neither an advice booklet explaining the 20/20/20 rule and reminding sticker on computer monitor, nor artificial tears, or glasses containing blue-blocking filters showed any effect on reducing DES symptoms. The only intervention to show such an effect was the delivery of health information promoting physical exercise and ocular relaxation. However, the participants self-assessed their DES symptoms while knowing which arm of intervention they participated in, rendering the result unreliable.

Observational studies were mainly of moderate risk of bias. Duration of digital screen use, both in adults and in children, and poor ergonomic practices were identified as risk factors for developing DES symptoms. Although studies evaluating these factors are few and GRADE assessment was only possible for the duration of digital screen use, policy makers and healthcare providers may take these findings into consideration to formulate advice and take action for preventing DES in patients who use digital devices for long hours in education or work.

This systematic review revealed a few positive and negative associations of causative and alleviating factors that could be used for formulating digital screen use recommendations. Results are derived from a restricted number of studies that all share a valid method of diagnosing and evaluating DES. Based on these, awareness should be raised on the importance of improving ergonomic parameters at workstations and restricting the duration of digital screen use in both adults and children.

Future research needs to be appropriately designed to assess still unanswered questions, such as the preferable type of screen, the advisable number and duration of breaks, and other possible interventions to prevent or minimize frequency and intensity of symptoms. Most importantly, future studies should apply more rigorous methodology, i.e. not simply include subjects with ocular complaints after screen use, but, instead, include subjects with diagnosis of DES through a validated questionnaire.

In conclusion, despite a large number of existing studies on symptoms after digital screen use, only few of these have used a validated method for DES diagnosis. Poor ergonomic parameters and lengthy duration of digital screen use appear to be associated with DES symptoms, while blue-blocking filters showed no alleviating effect. This evidence may be used by health professionals and policy makers for making relevant recommendations.

Source of funding

No funding was secured for this study.

Table 4
Risk of bias assessment of each included study in this systematic review.

Author, year	Type of study	Risk of bias in each domain		Overall risk of bias
Alghamdi and Alrasheed, 2020	Randomized controlled trial	1. Randomization process	High	High risk [a]
		2. Deviations from the intended interventions	Some concerns	
		3. Missing outcome data	High risk	
		4. Measurement of the outcome	Some concerns	
		5. Selection of the reported result	Some concerns	
Dabrowiecki et al., 2020	Crossover randomized controlled trial	1a. Randomization process	Low risk	Some concerns [b]
		S. Period and carryover effects	Low risk	
		2. Deviations from the intended interventions	Low risk	
		3. Missing outcome data	Low risk	
		4. Measurement of the outcome	Low risk	
		5. Selection of the reported result	Some concerns	
Singh et al., 2021	Randomized controlled trial	1. Randomization process	Low risk	High risk [a]
		2. Deviations from the intended interventions	High risk	
		3. Missing outcome data	Low risk	
		4. Measurement of the outcome	Low risk	
		5. Selection of the reported result	Low risk	
Talens-Estarelles et al., 2021	Non-randomized trial	1. Due to confounding	Serious	Serious risk [c]
		2. In selection of participants into the study	Moderate	
		3. In classification of interventions	Low	
		4. Due to deviations from intended interventions	Low	
		5. Due to missing data	Low	
		6. In measurement of outcomes	Serious	
		7. In selection of the reported result	Low	
Zheng et al., 2021	Cluster randomized controlled trial	1a. Randomization process	Some concerns	High risk [d]
		1b. Timing of identification or recruitment of participants	Low risk	
		2. Deviations from the intended interventions	Low risk	
		3. Missing outcome data	Low risk	
		4. Measurement of the outcome	High risk	
		5. Selection of the reported result	Low risk	
Teo et al., 2019	Cross-sectional study	1. Criteria for inclusion in the sample	Yes	Moderate risk [e]
		2. Detailed description of study subjects and the setting	Yes	
		3. Valid and reliable measurement of exposure	Unclear	
		4. Use of objective, standard criteria for measurement of the condition	Yes	
		5. Identification of confounding factors	Unclear	
		6. Strategies to deal with confounding factors	Unclear	
		7. Valid and reliable measurement of outcomes	Yes	
		8. Appropriate statistical analysis	Yes	
Boadi-Kusi et al., 2020	Cross-sectional study	1. Criteria for inclusion in the sample	Yes	Moderate risk [e]
		2. Detailed description of study subjects and the setting	Yes	
		3. Valid and reliable measurement of exposure	Unclear	
		4. Use of objective, standard criteria for measurement of the condition	Yes	
		5. Identification of confounding factors	Yes	
		6. Strategies to deal with confounding factors	Unclear	
		7. Valid and reliable measurement of outcomes	Yes	
		8. Appropriate statistical analysis	Yes	
Cantó-Sancho et al., 2021	Cross-sectional study	1. Criteria for inclusion in the sample	Yes	Moderate risk [e]
		2. Detailed description of study subjects and the setting	Yes	
		3. Valid and reliable measurement of exposure	Unclear	
		4. Use of objective, standard criteria for measurement of the condition	Yes	
		5. Identification of confounding factors	Unclear	
		6. Strategies to deal with confounding factors	Yes	
		7. Valid and reliable	Yes	

(continued on next page)

Table 4 (*continued*)

Author, year	Type of study	Risk of bias in each domain		Overall risk of bias
		measurement of outcomes		
		8. Appropriate statistical analysis	Yes	
Gammoh, 2021	Cross-sectional study	1. Criteria for inclusion in the sample	Yes	High risk [e]
		2. Detailed description of study subjects and the setting	Yes	
		3. Valid and reliable measurement of exposure	Unclear	
		4. Use of objective, standard criteria for measurement of the condition	Yes	
		5. Identification of confounding factors	No	
		6. Strategies to deal with confounding factors	No	
		7. Valid and reliable measurement of outcomes	Yes	
		8. Appropriate statistical analysis	No	
Mohan et al., 2021	Cross-sectional study	1. Criteria for inclusion in the sample	Unclear	Moderate risk [e]
		2. Detailed description of study subjects and the setting	Unclear	
		3. Valid and reliable measurement of exposure	Unclear	
		4. Use of objective, standard criteria for measurement of the condition	Yes	
		5. Identification of confounding factors	Yes	
		6. Strategies to deal with confounding factors	Yes	
		7. Valid and reliable measurement of outcomes	Yes	
		8. Appropriate statistical analysis	Yes	

[a] Using the ROB 2 tool for randomized trials (Sterne et al., 2019).
[b] Using the ROB 2 tool for randomized crossover trials (Sterne et al., 2019).
[c] Using the ROBINS-I tool for non-randomized trials (Sterne et al., 2016).
[d] Using the ROB 2 tool for cluster-randomized trials (Sterne et al., 2019).
[e] Using the JBI tool for analytical observational studies (Moola et al., 2020).

Table 5
GRADE assessment of common outcomes in included studies.

Outcome	Effect	Number of participants (studies)	Certainty in the evidence*
Blue light filtering glasses' effect on DES symptoms	Studies showed no effect of blue filters on DES symptoms.	130 (2 RCTs)	Low certainty ⊕⊕OO (due to moderate to high risk of bias)
Effect of duration of screen use on DES symptoms	Studies showed that duration of screen use was associated with the severity of DES symptoms.	843 (3 cross-sectional studies)	Moderate certainty ⊕⊕⊕O

The outcome of interest is DES symptoms (for which a single pooled effect estimate was not available and only a narrative synthesis of the evidence was provided).
GRADE Working Group grades of evidence.
High certainty: We are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: We are moderately confident in the effect estimate; the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low certainty: Our confidence in the effect estimate is limited; the true effect may be substantially different from the estimate of the effect.
Very low certainty: We have very little confidence in the effect estimate; the true effect is likely to be substantially different from the estimate of effect.
* Commonly used symbols to describe certainty in evidence profiles: High certainty ⊕⊕⊕⊕, moderate certainty ⊕⊕⊕O, low certainty ⊕⊕OO and very low certainty ⊕OOO.

Authors' contribution

AM, AKS, SM, EP, KRD, AOA, ABH, KKN conceptualized and designed the study. AM, AKS, SM, EP contributed to the acquisition and analysis of data. AM, AKS, SM, EP, KRD, AOA, ABH, KKN interpreted the data. AM and AKS drafted the initial manuscript. AM, AKS, SM, EP, KRD, AOA, ABH, KKN critically reviewed and revised the manuscript. All authors approved the final version of the manuscript for publication and agree to be accountable for all aspects of the work.

Declaration of Competing Interest

Prof. Ken K. Nischal has the following financial disclosures Santen Inc., Graybug, Essilor and Ocumension none of which is relevant to this paper.

Data availability

No data was used for the research described in the article.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2023.107493.

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