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REVIEW

Digital Eye Strain: Updated Perspectives

Andrew D Pucker[1], Aaron M Kerr[2], Jennifer Sanderson[2], Chris Lievens[2]

[1]Clinical and Medical Sciences, Lexitas Pharma Services, Durham, NC, USA; [2]Southern College of Optometry, Memphis, TN, USA

Correspondence: Andrew D Pucker, Clinical and Medical Sciences, Lexitas Pharma Services, 5425 Page Road, Suite 410, Durham, NC, 27703, USA, Tel +1 (920)579-2900, Email andrewpucker@hotmail.com

Purpose: Digital eye strain (DES) is a growing worldwide concern because digital devices are prevalent in both our work and home lives. The purpose of this review was to summarize clinically relevant and evolving key topics related to DES.

Methods: A PubMed.gov search was conducted on or before June 8, 2024. No date restrictions were used during the primary search. The search was aimed at detecting all articles related to DES; thus, the search terms only included "digital eye strain" or "computer vision syndrome".

Results: The two most used, validated DES questionnaires are the Computer Vision Syndrome Questionnaire (CVS-Q) and Computer Vision Symptom Scale (CVSS17). The world-wide prevalence of DES ranges from 8.2% to 100% depending upon the subjects evaluated and the method used to evaluate them. The most common DES symptoms include headache, eye strain, eye redness, eye itching, tearing, photophobia, burning sensation, blurred vision, eye pain, neck and shoulder pain, and eye dryness. Ocular surface symptoms in DES are integrally tied to decreased blink frequency, which causes ocular surface desiccation, increased osmolarity, and dry eye-like symptoms. The most studied DES-specific treatments are improving subjects' environment, artificial tears, blinking exercises, and near work breaks.

Conclusion: DES is a highly prevalent condition that should be regularly screened for in clinic with a validated diagnosis instrument. While there are several treatment options, the community's treatment approach is evolving and primarily focused on treating the visual and dry eye-like symptoms associated with the condition.

Keywords: digital eye strain, computer vision syndrome, prevalence, digital device, symptoms

Introduction

Digital eye strain (DES) was defined in the 2023 Tear Film and Ocular Surface Society (TFOS) Lifestyles Report as "the development or exacerbation of recurrent ocular symptoms and/or signs related specifically to digital device screen viewing".[1] DES has historically been termed computer vision syndrome (CVS), yet the term CVS has lost favor in recent years given that patients use a plethora of digital devices in addition to computers such as smartphones, smartwatches, and tablets.[2] Authors have relatedly found that smartphones may be the most frequently used type of digital device.[3] DES is a growing worldwide concern because digital devices are now omnipresent in both our work and home lives,[1,4] and research suggests that screen time is increasing even more with device use being higher in work from home situations compared to people who even perform hybrid work.[5] Digital device use has likewise spiked in school-aged children in recent years because of the educational changes associated with the coronavirus disease (COVID)-19 pandemic.[6]

Although digital devices have dramatically increased our work efficacy, provided convenience, and introduced new lifesaving technologies, habitual use of digital devices may lead to DES, which negatively impacts the ocular system while also potentially causing musculoskeletal and neurological symptoms.[1,4] Many think that DES symptoms have become more prevalent since the start of the COVID-19 pandemic because many people around the world were forced to shelter in place and/or rely more heavily on digital devices to interact with the world.[7,8] While the COVID-19 pandemic has subsided and most people have been able to return to a new normal, the increased reliance of digital devices has continued.

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Since the beginning of the COVID-19 pandemic, there has been a worldwide explosion in the interest in DES. This is highlighted by a PubMed.gov search conducted on June 8, 2024 (search terms: digital eye strain or computer vision syndrome), which found 395 articles published between the years 1973 and 2019 and 544 articles published in the year 2020 and the roughly 3.5 years after this time point. With the increased interests in DES, increased use of digital devices, and the evolving thought patterns on this important topic, the authors deemed it prudent to review the recent hot topics around DES. Therefore, the purpose of this review was to summarize clinically relevant and evolving key topics related to DES since the beginning of the COVID-19 pandemic, so clinicians have a single, concise reference.

Methods

The authors completed a PubMed.gov search on or before June 8, 2024. No date restrictions were used during the primary search. The search was aimed at detecting all articles related to DES; thus, the search terms only included "digital eye strain" or "computer vision syndrome". While all articles were reviewed, this article focused on texts published after March of 2020 to give an updated perspective on DES.[8] Articles included before this time point were added when a historical perspective was needed. The reference lists of included texts were searched after the primary search to detect other relevant articles. The authors only considered articles written in English and articles aimed at answering clinical questions.

Results

DES-Specific Questionnaires

As the prevalence of DES continues to rise, there has been a demand for dependable and standardized instruments for identifying at-risk individuals, assessing their symptoms, and monitoring disease progression.[1] While there have been numerous investigator-developed instruments that lack psychometric backing (Table 1), there have been two DES-specific questionnaires developed to reliably measure the frequency and severity of DES symptoms and diagnose the condition while also affording the ability to track disease progression.

The most used instrument for making a DES diagnosis and to determine the prevalence of DES is the Computer Vision Syndrome Questionnaire (CVS-Q).[1,52] The CVS-Q is a tool specifically designed to evaluate symptoms associated with prolonged digital screen use. It was originally developed in 2015 in Spain to measure the visual symptoms of individuals who use video display terminals in the workplace. Rasch analysis was used to development the questionnaire, with the instrument proving to have good psychometric properties. The CVS-Q has a sensitivity and specificity over 70% while also achieving good test-retest repeatability.[52] The questionnaire measures the frequency and intensity of 16 symptoms associated with prolonged digital device use. The wide range of symptoms include burning, itching, foreign body sensation, 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 vision is worsening, and headache.[52] The frequency of each symptom is graded on a 0 to 3 point scale with never, occasionally (sporadic episodes up to once a week), often or always (2 to 3 times per week or almost every day), and very often or always (almost every day), corresponding to scores of 0, 1, or 2, respectively.[52] The intensity level of each symptom is graded on a 0 to 2 point scale with not applicable, moderate, and intense corresponding to scores of 0, 1, or 2, respectively.[52] The responses from each question are then multiplied (frequency × intensity score), and the sum of each of these products is the overall instrument score. An individual is diagnosed with DES if they have a score of ≥6.[52] CVS-Q scores can be further categorized as mild (6–12), moderate (13–18), and severe (19–23).[7]

The other DES-specific validated instrument is the Computer Vision Symptom Scale (CVSS17). The CVSS17 was developed in 2014 in Spain, and it was described by the developers as an instrument to quantify "vision-related symptoms" associated with digital device use.[53] The CVSS17 was developed based upon responses from 636 subjects in their pilot study. The CVSS17 used Rasch analysis to validate the 17-item questionnaire, which measures ocular and visual symptoms associated with prolonged digital screen use.[53] During the validation analysis, two subscales were identified: the Internal Symptom Factor (ISF), which includes symptoms such as blurred vision and double vision with possible correlations to accommodative issues, and the External Symptom Factor (ESF), which includes symptoms

Table 1 Studies Evaluating Symptomatology and Prevalence of Digital Eye Strain

Study	Country	Sample Size (n)	Subjects	Mean Age (Years)	Digital Eye Strain Frequency (%)
Computer Vision Syndrome Questionnaire (CVS-Q)					
Abuallut et al, 2022[9]	Saudi Arabia	407	School-Age Children	6 to 18	35.4
Alah et al, 2023[7]	Qatar	1546	Students: Children and Adolescents	11 ± 2	8.2
Aldukhayel et al, 2022[6]	Saudi Arabia	547	Children	3 to 18	69.8
AlHarkan et al, 2023[10]	Saudi Arabia	704[b]	Students: Children	12.9 ± 3.6	59.4
Almalki et al, 2022[11]	Saudi Arabia	2009	Digital Device Users >15 Years	20 (18;22)[c]	26[d]
Almudhaiyan et al, 2023[12]	Saudi Arabia	364	Undergraduate Students	18 to ≥55	76.1
AlQarni et al, 2023[13]	Saudi Arabia	750	Medical Students	21.6 ± 1.5	68.5
Alturaiki et al, 2023[14]	Libya	407	Adult Population	32.1 ± 12.8	38.6
Artime-Rios et al, 2021	Spain	622	Hospital Medical Staff	46.3 ± 11.0	56.8
Bahkir et al, 2020[15]	India	407	Adult Digital Device Users	27.4	95.8[a]
Cantó-Sancho et al, 2023[16]	Italy	238	Office Workers Using Digital Devices	45.6 ± 11.0	67.2
Chattinnakorn et al 2023[17]	Thailand	782	Children Using Digital Devices	12.4 ± 2.8	42.2[b]
Gammoh et al, 2021[18]	Jordan	382	University Students	21.5 ± 1.8	94.5
Ganne et al, 2021[19]	India	941	Adult Students and Non-Students	23.4 ± 8.2	Students = 50.6% General Public = 33.2%
Huyhua-Gutierrez et al, 2023[20]	Peru	796	Nursing Students	Not Reported	87.6
Issa et al, 2023[21]	Lebanon	749	Young Adults	24.5 ± 7.7	70.5
Mohan et al, 2021[22]	India	217	Students: Children	13.0 ± 2.5	50.2
Mrayyan et al, 2023[23]	Jordan	310	Nursing Students	95.8% of subjects <25 years old	77.8
Sengo et al, 2023[8]	Republic of Mozambique	325	University Students and Teachers	23.2 ± 5.9	76.6
Sharma et al, 2023[24]	India	345	University Students	21.0 ± 2.2	45.5

(*Continued*)

Table 1 (Continued).

Study	Country	Sample Size (n)	Subjects	Mean Age (Years)	Digital Eye Strain Frequency (%)
Uwimana et al, 2022[25]	China	452	University Students	27.3 ± 5.6	50.0
Vargas Rodríguez et al, 2023[26]	Colombia	300	Medical Students	Not Reported	78.0
Wang et al, 2023[27]	United States	2454	Undergraduate and Medical Students	Not Reported	Undergraduate Students: 77.1 Medical Students: 69.1
Wangsan et al, 2022[28]	Thailand	527	Students: Children	20.0 ± 2.2	81.0
Zayed et al, 2021[29]	Egypt	108	Information Technology Professionals	32.2 ± 6.0	82.4
Computer-Vision Symptom Scale (CVSS17)					
Gupta et al, 2021[30]	India	654	Students: Children	12.0 ± 3.9	92.8[a]
Khanwalkar and Dabir 2022[5]	India	66	Working Professionals	37 ± 5	Not Reported
Investigator-Developed Questionnaire					
Abusamak et al, 2022[2]	Jordan	1460	Adult General Population	5 to 99	Not Reported
Agarwal et al, 2022[3]	India	435	Adult Digital Device Users	18 to 79	81[a]
Alabdulkader 2021[31]	Saudi Arabia	1939	Adult General Population	18 to 81	78[a]
Alamri et al 2023[32]	Saudi Arabia	300	Undergraduate Medical Students	19.3 ± 3.7	Not Reported
Alamri et al 2022[33]	Saudi Arabia	400	Undergraduate	22.5 ± 11.5	91.0[a]
Basnet et al, 2022[34]	Nepal	318	Adult Hospital Participants Using Digital Devices	36	94.3
Chu et al, 2023[35]	Hong Kong	1298	Students: Children and Adolescents	10.9 ± 2.0	Not Reported
Das et al, 2022[36]	Nepal	319	IT Software Company Employees Who Use Digital Devices	33.4 ± 9.4	84.4[a]
Demirayak et al, 2022[37]	Turkey	692	Students: Children and Adolescents	9.7 ± 3.0	48.2[e]
Dossari et al, 2022[38]	Saudi Arabia	301	Teachers	38.6 ± 12.7	81.4
Gadain et al, 2023[39]	Sudan	149	Medical Students	NR, Medical Students	94[a]
Galindo-Romero et al, 2023[40]	Spain	198	Presbyopic Computer Workers	54.0 ± 8.0[c]	100[a]
Iqbal et al, 2021[41]	Egypt	733	Medical Students	21.8 ± 1.5	70.8[a]

(*Continued*)

Table 1 (Continued).

Study	Country	Sample Size (n)	Subjects	Mean Age (Years)	Digital Eye Strain Frequency (%)
Jain et al, 2022[42]	India	700	Medical and Non-Medical Professionals	20–40	Medical Professionals = 75.4 Non-Medical Professionals = 77.2
Lofty et al, 2022[43]	Egypt	412	University Students and Staff	18–50	88.8
Meyer et al, 2021[44]	United States	729	Contact Lens and Non-Contact Lens Wearers	26.0 ± 4.8	89[a]
Neena et al, 2023[45]	India	496	Students: Children and Young Adults	10.5 ± 3.8	50.8
Regmi et al, 2023[46]	India	1302	Working Adults and Students	24 (11)[c]	94.5
Shin et al, 2023[47]	South Korea	21,304	Working Adults	>20	Not Reported
Tsou 2022[48]	Taiwan	2813	Healthcare Workers	Doctor/Nurse: 49.9 ± 12.0 Non-Doctor/Nurse: 31.1 ± 10.9	Not Reported
Turkistani et al, 2021[49]	Saudi Arabia	691	General Population	33.8	77.1
Wadhwani et al, 2022[50]	India	185	Students: Children	14.2 ± 2.0	77.3[a,b]
Zenbaba et al, 2021[51]	Ethiopia	416	University Instructors	≥24	70.4

Notes: [a]Experienced at least one symptom, [b]Responses from caregivers, [c]Median, IQR, [d]Moderate to severe DES, [e]Experienced ≥3 symptoms.

associated with the ocular surface such as burning, stinging, and dry eyes.[54] The ISF and ESG subscales of the CVSS17 reflect the multifactorial nature of DES and its potential impact on overall well-being.[54] Scores ranges from 17 to 53, with a higher score indicating more symptoms.[53] Scoring of the instrument is performed by comparing the patient's responses to the response options for each question in the original manuscript.[53] The sum of these scores is then taken, multiplied by 17, and divided by the number of valid responses to determine the overall CVSS17 score.[53] The CVSS17 is also available in Spanish, English, and Italian and easily accessible at the following website: https://www.cvss17.com/.[55]

Symptomatology and Prevalence

While the literature contains reports evaluating the symptomatology and prevalence of DES prior to the COVID-19 pandemic,[56,57] there has been an explosion of studies related to this topic since the pandemic started (Table 1). This increased interest is in part because the community originally hypothesized that the prevalence and severity of DES would worsen with the increased screen time associated with the COVID-19 pandemic lockdown conditions. This hypothesis has generally rung true with numerous reports finding that digital device usage has increased since the beginning of the pandemic.[3,6,10,15,19,31,50] Work from Lotfy also suggests that the frequency of DES has increased since the start of the pandemic.[43] The authors specifically determined with their cross-sectional, online survey of college students and staff that the frequency of DES increased from 71.5% before the COVD-19 lockdown to 88.8% after the COVID-19 lockdown. Nevertheless, when Nunes et al used the Convergence Insufficiency Symptoms Survey (CISS) to evaluate visual discomfort, which is non-specific for evaluating DES, the authors found no additional increase in ocular symptoms when comparing subjects who were in pre- and post-pandemic situations.[58]

When evaluating the prevalence of DES in detail, the literature indicates that the prevalence of DES varies widely based upon the instrument being used and the subjects who are being evaluated (Table 1). When evaluating overall DES prevalence with validated symptoms questionnaires, the prevalence of DES ranges from 8.2% to 95.8% with studies using the CVS-Q, and a single study reported with the CVSS17 the prevalence of DES to be 92.8%. The literature furthermore suggests that when using the CVS-Q to evaluate adults and children, the prevalence of DES ranges from 38.6% to 95.8% and 8.2% to 81.0%, respectively. When using investigator-developed questionnaires, which typically determine a diagnosis of DES when any symptoms are present, the prevalence of DES ranges from 48.2% to 100% (Table 1). While the methodology of these investigator-developed questionnaires varies widely by study, they provide the most value with regards to identifying the most experienced DES symptoms. Also, while the aforementioned publications report a range of prevalences, which may seem confounding, even the lower range of the prevalences suggests that practitioners should be regularly screening all patients for DES.

Subjects commonly know that screen time can have a negative impact on their eyes and induce DES symptoms,[3,15,34] and authors have interestingly found that time spent using digital devices has made it more likely that subjects will develop DES.[9,18,35,49] While the frequency and symptoms of DES may vary by type of digital device, the authors were unable to find studies that clearly compared different types of digital devices to determine if one type of digital device is more likely to cause DES than another. The most common DES symptoms include headache, eye strain, eye redness, eye itching, tearing, photophobia, burning sensation, blurred vision, eye pain, and eye dryness.[3,7–10,13–18,22,27–31,33–37,39–41,43,45,48–51,57] Musculoskeletal-related symptoms such as neck and shoulder pain associated with poor ergonomics are also common.[4,59,60] The order of the most frequent symptoms within each study varied, likely because of the questions being asked and the subjects being evaluated. Risk factors for DES include female sex, age, using a digital device >4, 5, or 6 hours/day (study dependent time points), infrequent near work breaks, low digital screen brightness, decreased viewing distances (<20 cm), and dry eye disease.[6,8–12,14–16,19,20,22,24,25,28,29,31,38,40,46,47,51,61] Nevertheless, not all studies found sex to be a risk factor,[13,30,36] and one study has found male sex to be a risk factor.[37] Depression and anxiety have been furthermore directly correlated with DES,[21,48] which strongly suggest that DES can negatively impact quality of life. While originally hypothesized to be a risk factor for DES, contact lens use may not be associated with DES.[3] Specifically, Meyer et al determined with an investigator-developed survey that contact lens and non-contact lens wearers have similar symptomatology, though contact lens wearers may have less frequent eye strain or eye pain and more frequent dryness symptoms than non-contact lens wearers.[44]

DES's Impact on the Ocular Surface

DES encompasses a vast array of ocular and vision-related symptoms as described above. While all symptoms of DES are important to identify and manage, those related to the ocular surface may have a more serious impact and have the potential to lead to dry eye disease (DED) like effects. DED is a multifactorial condition characterized by symptoms of discomfort, visual disturbance, tear film instability, hyperosmolarity, and inflammation that can lead to ocular surface damage.[62] While DED and DES have distinctly different etiologies, their ocular sequelae overlap given that the primary effect that DES has on the ocular surface begins with increased tear evaporation leading to a hyperosmotic tear film.[15,63,64]

It is widely established that digital device usage causes a change in blink patterns.[1,59,60,65–67] These changes include decreased blink rates and more incomplete eyelid closure when blinking with the literature supporting more incomplete blinking to be more prevalent in DES and the causes of the majority of DED-related symptoms.[68–70] Decreased blink frequency is highlighted by Argilés et al who found that subjects who are in an unstimulated, distance viewing position have a blink frequency of about 16 blinks per minute while subjects who are viewing a tablet blink about 6 times per minute.[70] Reduced blinking is specifically a problem because the prolonged inter-blink-interval results in the tear film breaking up before the next blink occurs, which subsequently results in ocular surface desiccation.[71] Faster tear film break up times while using digital devices compared to unstimulated viewing have been corroborated by the literature.[72] During computer use, the gaze angle is also often increased causing a larger palpebral aperture (eg, eyes more open in up gaze) (Figure 1).[70] A larger area of exposed ocular surface increases tear evaporation and the chance that the device user will only partially blink.[4,15] Blinking serves as a vital mechanism for ocular surface stability and health.[73] Blinking

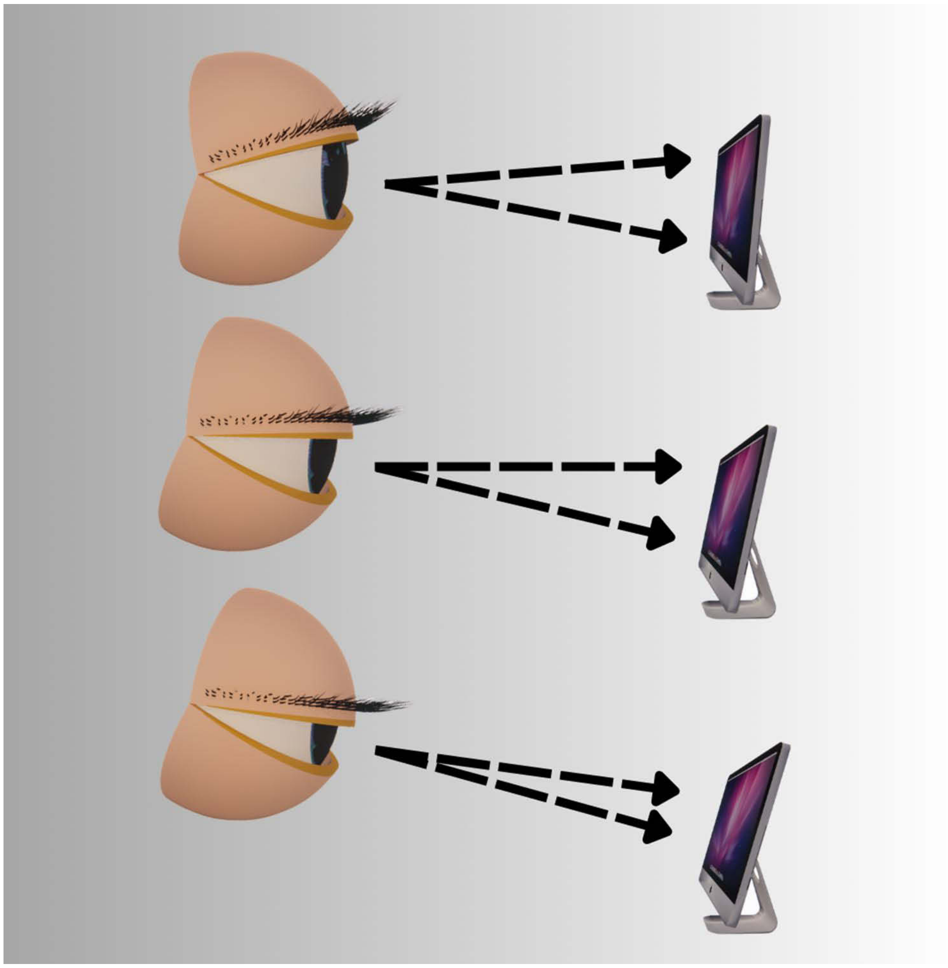

Figure 1 Ocular Surface Exposure Variations by Eye Gaze Position.

spreads the tear film across the surface of the eye, maintaining ocular hydration, protecting the ocular surface, and assisting in tear drainage.[66,74,75] Incomplete blinking leads to inadequate tear film distribution, increased tear film evaporation, ocular surface exposure, and decreased drainage, which disrupts the homeostasis of the tear film and causes poor tear film stability. One study reported that almost 97% of computer users had poor tear film stability.[1,76] A loss of homeostasis changes the composition of the tear film leading to hyperosmolarity, which is the core mechanism and hallmark of DED, which can induce dry eye-like sequela.[62]

The tear film's two layer composition consists of the innermost aqueous-mucin layer and the outermost lipid layer,[77] with the lipid layer being able to be further broken down into an external non-polar lipid layer and an inner polar lipid layer.[78] Goblet cells, present in the conjunctival epithelium secrete ocular mucins that lubricate the ocular surface and help to maintain a stabilized tear film.[79,80] Blinking aids in the distribution of mucins. The primary and most prevalent mucin in the tear film is MUC5AC, and it has been demonstrated that a reduced level of MUC5AC correlated with an increase in ocular discomfort.[67] Mucin deficiency has also been associated with a decreased tear break-up time, a known measure of tear film stability.[63] The lacrimal glands are responsible for secreting the majority of the aqueous layer of the tear film. The aqueous contains antimicrobial elements as well as soluble mucin and plays an active role in removing foreign substances, lubricating, and safeguarding the ocular surface.[79] There is evidence that long-term digital device use is associated with a reduction in the aqueous layer.[64,81] Complete blinking is necessary to renew the tear film by spreading tears from the lacrimal glands.[62] Meibomian glands, located within the tarsal plate of the eyelids, secrete the majority of the lipids that form the outermost tear film layer, which are vital to reducing tear film evaporation.[74,78] Blinking mechanically stimulates the meibomian glands to release lipids.[78] Less lipid secretion due to partial blinking leads to excessive tear evaporation.[82,83] Without a proper lipid layer, there is also a fall in the rate of tear film clearance and replenishment.[15] Reduced tear clearance can lead to an accumulation of inflammatory mediators in the tear prism.[62]

A hyperosmolar tear film due to excessive evaporation triggers a dangerous inflammatory cascade where additional inflammatory mediators may be released into the tear film.[71] This accelerates the cycle and exacerbates damage to the ocular surface.[71] Effects may include cellular dehydration, promoting the loss of goblet and epithelial cells. Epithelial cell loss leads to classic dry eye signs such as punctate erosions.[62] The decrease in mucin levels from goblet cell loss, and the decrease in lipid levels from the meibomian glands, which can result from chronic ocular surface inflammation, furthers the cycle of evaporation-induced hyperosmolarity, and ultimately DED-like signs and symptoms.[62,84] Understanding the relationship that DES and DED share and how the ocular surface can be impacted is essential for early recognition of ocular surface pathology associated with DES. Patient education and timely intervention allows for appropriate treatment and management aimed at safeguarding ocular health and alleviating symptoms that can impact a patient's quality of life.

Treatments

With DES and DED resulting in similar signs and symptoms given that they both can have an evaporative ocular surface component,[62,71] the two conditions have similar treatments. This section will focus on treatments that have been specifically evaluated in the DES space (Figure 2), yet if DED is present, patients should be treated for this disease. While a full description of DED treatments is beyond the scope of this report, a description of how to best treat DED can be found in the 2017 Dry Eye Workshop II Management and Therapy Report.[85] Thus, after appropriately conducting a history to establish habitual digital device use and exacerbation of symptoms with digital device use, a stepwise treatment approach should be taken.

First, consider prevention discussions with the patient (eg, decreasing digital device use if possible) or modifying their environment to make the workspace more ergonomic and less affected by wind.[46,86,87] Other preventive options can include situating the screen at an angle in alignment with primary gaze to limit inferior ocular surface exposure,[70] and antiglare computer screens and adjustment of brightness can significantly decrease DES symptoms.[29] The use of occupational glasses while using the computer has shown to be beneficial, as opposed to a standard progressive lens.[88] Also, presbyopic patients, while using handheld devices, have shown to be at greater risk for eye strain symptoms secondary to needing an increased add power over their younger counterparts;[89,90] thus, an updated spectacle prescription should be given to the patient to ensure optimal visual acuity at all distances. Although blue blocking filters are often requested by patients who have fallen prey to social media ads, recent studies indicate the filters do not aid in reducing DES.[91,92]

Artificial tears are a next logical treatment for patients with DES given that tear film disruption is a key factor in developing DES.[71] While artificial tears are indicated for DED,[93] artificial tears have been found effective in treating DES. Artificial tears are classified and categorized under the US FDA's *Ophthalmic Drug Products for Over the Counter Human Use* monograph as "topical drops which contain specific types of demulcents or emollients for the treatment of DED or ocular discomfort".[94] Older generation artificial tears were preserved with benzalkonium chloride and thiomersal.[95] More recent formulations have now been developed with gentler preservatives (eg, polyquaternium-1) that are more compatible with the ocular surface and are less likely to induce ocular surface irritation.[95] Additionally, preservative free artificial tears are an excellent alternative, especially for those advanced cases requiring ≥4 drop applications per day.[95] Now, unit-dose and multidose preservative free bottles ensure artificial tears remain contaminant free. Nevertheless, preserved and preservative free comfort drops have been shown to be able to effectively treat DES sufferers.[96] As demonstrated by Talens-Estarelles et al, artificial tear have been shown to improve ocular surface signs (bulbar redness; tear break up time) and symptoms (Ocular Surface Disease Index; Dry Eye Questionnaire −5) in DES subjects.[97] Work from Pucker et al has also indicated that artificial tear use in digital device users can significantly improve Impact of Dry Eye on Daily Life (IDEEL) Questionnaire Work, Daily Activities, and Feelings domain scores after only two weeks of use.[96] Duncan et al has since completed a similar study that supports Pucker et al's results.[96]

Blinking is inherently linked to DES given the reduction in blink rate with near tasks.[70] With reduced tear breakup times, tear evaporation is increased which leads to a hyperosmolar condition, further exacerbating the issues.[71] A recent study found prescribed blinking exercises may also be an effective treatment in reducing symptoms of DED.[73] In this

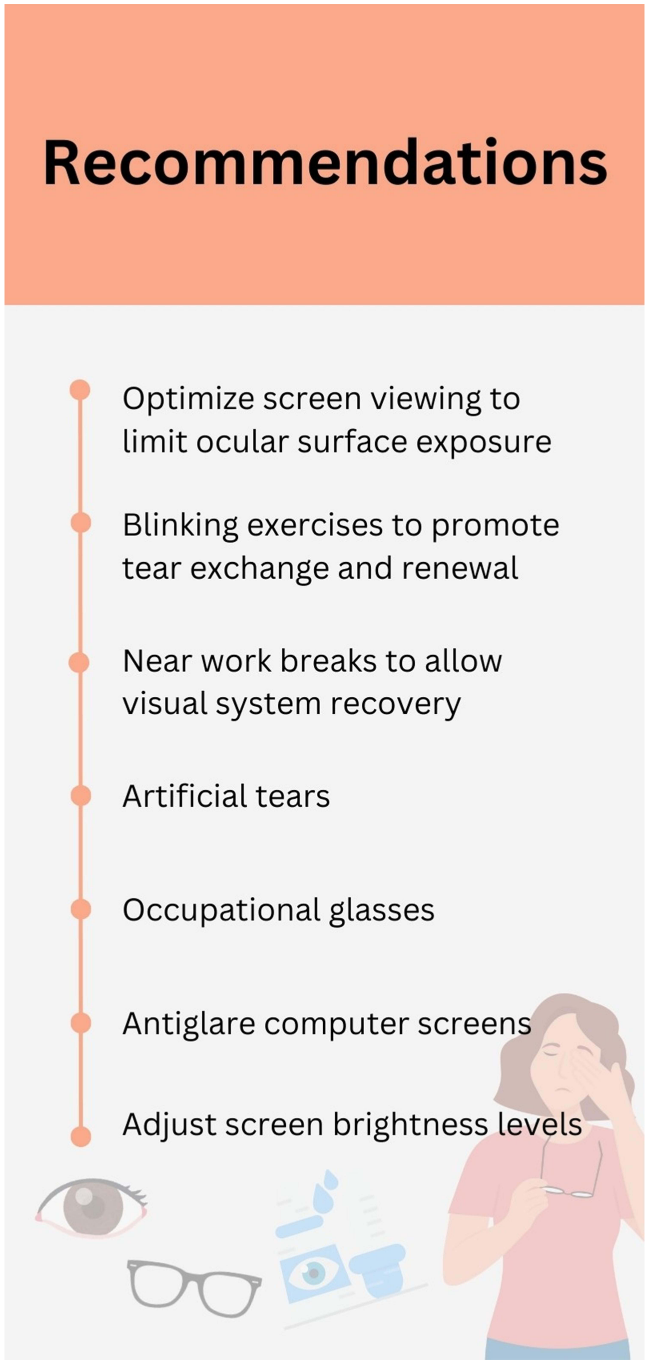

Figure 2 Digital Eye Strain Management Suggestions.

study, Kim et al evaluated DED subjects who were asked to complete a blinking exercises.[73] The authors specifically had the subjects close their eyes for 2 seconds and then open their eyes. They next had the subjects close their eyes for 2 seconds and then open their eyes again. The subjects then squeezed their eyelids together for 2 seconds and then relaxed their eyes. Subjects repeated this exercise plan every 20 minutes for 4 weeks while awake. The authors ultimately found that the first session of blinking while still in the office significantly increased the subject's mean tear break up times. Tear break up times further improved by the completion of the study while the subjects also had significant improvement in ocular comfort as measured by the Ocular Surface Disease Index questionnaire.[73] Blink training lastly was found to improve incomplete blinks.[73]

Taking breaks is another common DES preventive measure, which has been associated with improved or less frequent symptoms.[20,34,40] The literature furthermore indicates that at least in some populations the 20/20/20 rule is commonly practiced.[11,12,15,31] Anshel proposed the 20/20/20 rule in the late 1990s.[98,99] The 20/20/20 rule encourages patients to take a break every 20 minutes while looking away from their screen at a distance target 20 feet or more away for about 20 seconds.[29] Anshel developed the 20/20/20 rule from his "3-B" strategy (blink, breathe, and take breaks from near tasks) for reducing eye strain.[99] While many clinicians teach the 20/20/20 rule literally, Anshel notes that the 20/20/20 rule was only intended as a catchy way to remember his 3-B approach and that there is no scientific backing for this specific guidance.[99] Furthermore, recent work has refuted the 20/20/20 rule in its literal sense.[100] When evaluating questionnaire-based studies, Huyhua-Gutierrez et al determined that subjects who practiced the 20/20/20 rule were less likely to have DES, though only 13.1% of the subjects evaluated had prior knowledge of this treatment.[20] Datta et al likewise evaluated the effectiveness of the 20/20/20 rule in a questionnaire-based study, and they determined that only 8.8% of the subjects included in their study used the 20/20/20 rule as a treatment.[101] This same study determined that if subjects practiced the 20/20/20 rule, it did not improve their overall symptoms, though when looking at specific symptoms, the authors found that the 20/20/20 rule may improve burning sensation and headaches.[101] Both Huyhua-Gutierrez et al's and Datta et al's studies were cross-sectional in nature and likely suffered from selection bias.[20,101] Johnson and Rosenfield have since prospectively evaluated how taking 20 second breaks from reading to look at a distant scene at 5-, 10-, 20-, or 40-minutes intervals affected DES symptoms while completing a demanding 40-minute reading task.[100] The authors overall found no difference in DES symptoms when comparing the different break intervals.[100] Talens et al lastly prospectively evaluated the 20/20/20 rule.[102] The authors accomplished their study by loading a 20/20/20 rule reminder program on to their subjects' computers.[102] The program was not enabled during the first 2 weeks of the study, and then the program was turned on for the second 2 weeks of the study.[102] The authors overall determined that dry eye symptoms (Ocular Surface Disease Index, Dry Eye Questionnaire-5, and Symptom Assessment Questionnaire iN Dry Eye) significantly improved while practicing the 20/20/20 rule.[102] Nevertheless, these improvements in symptoms may not have been clinically meaningfully, and this study failed to find any improvement in DED signs.[102–104] Talens et al likewise only tested 20 second break intervals as dictated by the original 20/20/20 rule; thus, the author's work should be repeated by having groups of subjects who use different break intervals to determine the optimal break period or to determine if an optical break period even exists.

Conclusions

The COVID-19 pandemic sparked a new public and scientific interest in DES.[7,8] DES likely affects most digital device users to at least some extent and given that the majority of the developed world habitually uses digital device for both work and play, most of the population is likely at least occasionally touched by this condition.[1,4] In fact, many patients know that DES is an issue,[3,15,34] though the population still habitually uses digital devices because they have substantial benefits. DES likely affects adults at a greater frequency, though children are also highly susceptible as highlighted in Table 1. DES's effect on the ocular system has extensive overlap with DED given both conditions typically result in degraded tear films,[71] though DES influences visual quality and even the whole body given that DES sufferers frequently complain of symptoms such as neck and backache.[4,59,60]

While DED treatments may be applicable to DES patients, especially if the condition is habitually bothersome, DES specific treatments that have shown promise include maximizing the patient's environment by fully correcting their vision and optimizing their screen viewing situation,[88–90] artificial tears for treating a dysfunctional tear film,[96,97] blinking exercises for promoting tear exchange and renewal,[73] and near work breaks to allow the visual system to recover.[20,34,40] While all these treatments have shown to significantly improve DES signs and/or symptoms, the specific practice of the 20/20/20 rule lacks scientific backing,[99,100] and it is likely not the optimal break frequency given that when different break intervals are compared, they do not result in markedly different treatment outcomes.[100] This suggests that more research is needed to refine how we educate our patients about taking breaks.

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