MUSCULOS CILIARES , , PUPILA, FFC, PARPADEOS, (OBJETIVOS Y SUBJETIVOS) QUESTIONARIES

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* 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
* 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

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* Dry eye has previously been cited as a major contributor to CVS. For example, Uchino et al.65 observed symptoms of dry eye in 10.1% of male and 21.5% of female Japanese office workers using VDTs. Furthermore, longer periods of computer work were also associated with a higher prevalence of dry eye.3
* In an extensive review, Blehm et al.66 noted that computer users often report eye dryness, burning and grittiness after an extended period of work. They suggested that these ocular surface related symptoms may result from one or more of the following factors: (1) Environmental factors producing corneal drying. These could include low ambient humidity, high forced-air heating or air conditioning settings or the use of ventilation fans, excess static electricity or airborne contaminants.
* . (2) Reduced blink rate. Several investigations have shown that blink rate is reduced during computer operation. For example, Tsubota and Nakamori67 compared the rate of blinking in 104 office workers either when they were relaxed, reading a book or viewing text on a VDT. Mean blink rates were 22 per min while relaxed, but only 10 and 7
* (3) Incomplete blinking. While blink rate has been shown to decrease significantly with computer use,68,69,74 an additional factor to consider is the completeness of the blink, i.e. does the upper lid cover the exposed cornea completely during the blink process. Himebaugh et al.71 analy

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* Jaschinski-Kruza (1988) stated that one reason for reports of visual fatigue from VDT workers is that the viewing distance is usually less than their dark-focus point. During performance of a VDT task, which is typically near work, a person’s ciliary accommodation muscle changes the optical power of the lens to form a sharp image on the retina, and the horizontal extraocular muscles converge the
* axes of the eyes to fuse the two retinal images. These oculomotor mechanisms of accommodation and convergence are increasingly strained as the viewing distance shortens. JaschinskiKruza (1988) showed that visual strain was greater at a viewing distance of 50 cm than at 100 cm, irrespective of the individual’s darkfocus point.
* Saito, Taptagaporn, and Salvendy (1993) and Iwasaki and Kurimoto (1987) measured the degree of eyestrain caused by visual work by measuring the temporary change in accommodation power following VDT work.
* Weissenbock (1982) measured visual acuity before and after the working period in order to indicate functional changes in the accommodation mechanism, and they reported that the decrease of visual acuity during work correlated well with different lengths of working periods.
* An increase in pupil size adversely affects the depth of focus and the precision required of the accommodative responses; thus pupil size has been used as an indicator of visual discomfort. For example, Saito et al. (1993) considered positive CRT displays to be better than negative ones because the pupil diameter was 10% smaller when viewing a positivetype CRT. Taptagaporn and Saito (1990) concluded that for all lighting conditions, a positive display caused less adaptive strain on the eye than a negative display because there were smaller pupil diameter differences among viewing a positive CRT display, a manuscript, and a keyboard. However, the relationship between pupil diameter and feelings of visual comfort has not been confirmed (Taptagaporn & Saito, 1990)
* For example, VDT workers are paced by the processing speed of the VDT; they have to input commands and continuously react to the information consequently displayed on the screen, forcing them to engage in very intense and stressful work as the processing speed of the VDT increases.
* When luminance was adequately controlled, however, task-evoked pupillary responses were shown to reflect information processing demands within capacity limits (Backs & Walrath, 1992; Beatty, 1982). Therefore, besides lighting and screen parameters, both information processing load and eye movement velocity can create an increase in the pupil diameter that adversely affects the depth of focus. From the measurement of eye movements, Saito et al. (1993) discovered that both the amplitude and frequency of eye movements during VDT work were relatively high. VDT operators had to move their eyes 2.5 times faster than traditional clerical workers who did not use VDTs. Hallett (1986) indicated that the extraocular muscle forces are a function of fixation position and angle of eye movement (saccadic amplitude). Extreme torsion will stress the optic nerve or lead to conjunctivitis and will therefore lead to damage and pain. Thus visual fatigue could be partially induced by the action of the eyeball and eye muscles, in particular when the operation of internal and external muscles of the eye is in excess of that required for normal levels of eye movement.
* Osaka’s (1985) research, found that green and yellow critical fusion frequency (CFF) deteriorated significantly 30 min after loading; however, the red CFF decreased significantly after performing the visual task for only 15 min. This decrease of CFF, which might indicate deterioration of the retinal function, was confirmed in Iwasaki and Akiya (1991). They presented a simple mathematical addition task to one eye (the loaded eye) while the other eye acted as the control
* Subjective rating scales are easy to administer and can at times be more sensitive than objective measurements (Hwang, Wang, & Her,
* 1988; Saito, Sotoyama, Saito, & Taptagaporn, 1994). However, subjective measures are not very diagnostic; they are only global indicators of workload. Hence, subjective rating scales have often been used to cross-validate more objective measurements of visual fatigue
* Accommodation power, visual acuity, pupil diameter, eye movement velocity, CFF, subjective rating scales, and task performance are all potentially useful measures of visual fatigue.

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* T he relationship between the degree of eye fatigue resulting from visual w ork and type of light source used to illum inate the field of w ork was assessed. The tests were perform ed using artificial light sources: fluorescent lamps, incadescent lamps, high pressure m ercury (vapour) and high pressure sodium (vapour) lamps. The assessm ent was perform ed on two groups of 10 wom en each, of which one included wom en w ithout, and the other with, refraction errors. O n the basis of changes o f nearer vision point and dispersing lens tolerance, it was found th at sodium light produced the highest visual fatigue in the test wom en, especially in those with refraction errors.
* Visual work leads to fatigue of the organ of vision.
* The m agnitude of the fatigue can depend on external factors, the m ajor being light and w ork difficulty, and on internal factors, the m ajor including errors of refraction and accom m odation and convergence disturbances (3, 13).
* The relationship between eye fatigue and the level of illum ination lum inance distribution in the w ork field and the degree of contrast between the workpiece and the background have been already studied in some detail. It was found that the type of artificial light source can affect: the m agnitude of the subjective sym ptom s of visual fatigue (2, 5, 8, 11) the degree of glare at equal lum inance (5), the efficiency and precision of visual w ork (6, 9, 10, 11) the level of general fatigue and the degree of variation of some physiological fatigue sym ptom s during work (9, 10).
* The question w hether the m agnitude of eye fatigue resulting from visual work depends on the type of artificial light source used to illum inate the surface of the visual work, when th e rem aining param eters of the light field are the same, has not yet been unequivocally solved.
* The light em itted by those sources differs widely in its spectral content an d pulsation, the latter being small for the lum inous flux of the incadescent lam ps and high for that of the discharge-type lamps.
* The condition of the fatigue can be evaluated by measuring the deterioration of contraction and relaxation of the muscles participating in the perform ed work.
* D uring visual w ork at near distance requiring accom m odation, the ciliary muscle is m ost active and the m easurem ent of its contraction and relaxation ability is often used to evaluate eye fatigue resulting from visual work (1, 3, 4, 7, 12).
* The fatigue depends on w orkload, and the w orkload is a resultant of work requirem ents and of individual's capacities. Refraction errors constitute one of the factors which reduce the individual's capacities and increase the workload. Therefore, the fatigue resulting from visual work, perform ed under conditions of light from various types of lam ps was evaluated in groups of persons w ithout errors of refraction, and with astigmatism.
* Fatigue of the ciliary muscle, just like fatigue of any other muscle, results in deterioration of its contracting ability and is manifested by increasing the distance of the nearer vision point (NVP). W ith greater fatigue, also the relaxation of the muscle may become incomplete, which is manifested by im paired dispersing lens tolerance (DLT). I

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* Additionally, computer usage for >2 hours [1] presents a 50%-90% risk of developing eye fatigue [9], i.e., mainly caused by contracted eye muscles. The eyes shrink while staring at a computer screen for an extended time [5]. Computer use has also decreased the blink rate, increasing the evaporation rate of tears, i.e., the cause of eye dryness. This effect is a symptom of eye fatigue, which leads to declined visual efficiency [10].
* Eye fatigue can be assessed by various methods, such as an asthenopia questionnaire, a dry eye questionnaire [11, 12], and a critical flicker frequency meter. Furthermore, the relationship between various factors that affect eye fatigue is also impactful in testing visual acuity [5, 13].

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* DES may be identified and measured using one of several available questionnaires, or objective evaluations of parameters such as critical flicker–fusion frequency, blink rate and completeness, accommodative function and pupil characteristics may be used to provide indices of visual fatigue.
* Correlations between objective and subjective measures are not always apparent.
* Considering dry eye disease (DED) specifically in computer users, a recent meta-analysis including data from 11365 individuals estimated an overall prevalence of 49.5%, ranging from 9.5% to 87. 5%.14 While these values appear higher than the 5%–33%DED prevalence observed in the general population,16 the heterogeneity of diagnostic criteria for DED used in studies to date mean that the overall figure has limited value. Standardised criteria for DED diagnosis and universal implementation would enable more robust estimates of the prevalence of the condition among computer users. The recent Tear Film and Ocular Surface Society Dry Eye Workshop II report included detailed recommendations for diagnostic methodology.17 Key proposals were symptom screening with either the Ocular Surface Disease Index (OSDI) or Dry Eye Questionnaire (DEQ-5) instruments, followed by objective clinical tests in DED suspects, including breakup time (preferably non-invasive), osmolarity and ocular surface staining with fluorescein and lissamine green.17
* The problem of dry eye linked to digital device usage is not limited to adults. Recent studies based in South Korea have indicated that longer daily durations of both visual display terminal (VDT)18 and smartphone18 19 use are risk factors for DED in children. Cessation of smartphone use for a 4-week period in children with DED aged 7–12 years resulted in significant improvements in non-invasive tear breakup time, punctate epithelial erosion and OSDI scores, with all affected children no longer being classified as DED sufferers at the end of the abstinence period.19 The prevalence of DES in paediatric populations has received little attention in the literature to date, although a recent meta-analysis of available data linked to asthenopia in children20 reported a pooled prevalence of 19.7%.
* ubjective methods A variety of instruments have been used to identify DES sufferers and grade the severity of complaints. A 10-item questionnaire created by Hayes et al21 has been deployed in several subsequent studies12 22 and relates to the level of ocular discomfort experienced from the symptoms listed in table 1, enabling calculation of a total symptom score. The six-item Visual Fatigue Scale requires users to respond using a Likert scale to difficulties in seeing, strange feeling around the eyes, eyes feeling tired, feeling numb, having a headache and feeling dizzy looking at the screen. It has been applied to study symptoms following the use of e-readers, indicating that reading from liquid crystal display (LCD) screens (eg, tablet devices) triggers more subjectively reported VF than reading from paper copies or e-ink displays.23 The Rasch-based Computer-Vision Symptom Scale (CVSS17)24 was developed in Spanish to measure visual and ocular symptoms in computer users. An English version of the questionnaire may be obtained, although currently, normal CVSS values dependent on race and other factors are unknown. Seguí and colleagues25 developed the first validated questionnaire in English to evaluate DES in the workplace. The self-administered Computer Vision Syndrome Questionnaire (CVS-Q) requires users to indicate the frequency and intensity of 16 symptoms experienced during computer use, allowing a single symptom severity score (CVS score) to be deduced, where six points or more is considered diagnostic of the condition. The CVS-Q was used to analyse CVS in contact lens wearers.15 Questionnaires with verified validity and reliability are useful tools to incorporate into regular patient care and clinical trials linked to ocular and visual health of workers engaged in computer use. Subjective questionnaires have also been used to provide additional validation for objective measures of VF,26 which are considered in the following section.
* objective evaluation Although DES affects a huge number of individuals, its precise physiological basis remains unclear. An array of measures of visual function have been used to provide indices of VF: accommodation parameters have received a significant amount of research attention given the accommodative nature of several DES symptoms, while critical flicker–fusion frequency (CFF) and blinking characteristics have been used regularly in recent DES research.
* Critical flicker–fusion frequency CFF is a recognised metric indicative of fatigue and mental workload27 and is the frequency at which a flickering light is indistinguishable from a steady, non-flickering light. A decline in this parameter has been attributed to reduced activity of the retina and/oroptic nerve.28 Negative changes in CFF following a prolonged computer task were observed to correspond with certain subjective ocular complaints (pain in/around the eyes, eyes feeling heavy and itchy eyes) in a recent study on the effects of short wavelength-blocking spectacles,29 although not all studies using the measure have established a correlation between worsening of CFF and increased symptoms.30 31 CFF may be influenced by task time, with Chi and Lin26 reporting a significant increase in the sensitivity of this parameter to load differences when task duration was extended. For a 0.4Hz tracking task, mean post-task CFF reductions were 1.2±1.5Hz and 2.2±0.7Hz for 20 min and 60min durations, respectively.26
* linking and squinting Blinking aids maintenance of a normal ocular surface, with most blinks instigating a cycle of secretion, dispersal, evaporation and drainage of tears.32 Reduced blink rate with computer use has been observed in numerous studies33–35 and may be relevant to dry eye symptoms that frequently occur with DES. Reductions in blink rate may be substantial, for example, Patel et al33 reported a mean rate of 18.4 blinks/min before computer use, decreasing to 3.6 blinks/min during operation, while Tsubota and Nakamori35 observed a mean rate of 22 blinks/min among office workers under relaxed conditions, reducing to seven blinks/minwhen viewing an electronic display. Sheedy et al36 hypothesised that reduced blink rate may be a consequence of involuntary squinting under symptom-producing conditions, with squinting contributing to asthenopia. Two potential benefits arise from squinting: improvement in visual acuity with refractive error and decreasing retinal illumination in the presence of a glare source in the superior visual field.37 The voluntary squint response, measured using electromyography (EMG) of the orbicularis oculi, influences blink rate significantly, with greater squint levels causing more substantial reduction of blink rate.36 A later study,38 exposing participants to various asthenopic conditions during computer use including small font size, low contrast, induced refractive error and glare revealed that conditions that may be improved by squinting (refractive error and glare) showed an increased EMG response from the orbicularis oculi along with an increase in blink rate, while those that would not benefit from squinting (small font size and low contrast) showed no significant EMG response but a reduction in blink rate. Blink inhibition may arise from high cognitive demand or low-legibility conditions necessitating a lengthening of fixation duration and allowing increased time to acquire visual information. Increased cognitive demand (eg, reading more challenging material) exacerbates the effect of visual stressors such as low contrast or refractive error.39 Rosenfield et al40 exposed 16 teenage subjects to texts of two distinct levels of cognitive demand, both on a modern tablet computer and hard copy printed versions. Changing the cognitive demand had a greater impact on blink rate than presentation format. Mean blink rates for the low demand task were 8.34 and 9.06 blinks/min for the tablet and paper presentations, respectively, reducing significantly to 7.43 and 6.67 blinks/min, respectively, for the high demand task. It is possible that technological improvements in digital displays mean that they are more similar to printed materials, so the substantial reductions in blink rate with computer use reported in older studies may not be indicative of modern effects. Although reduced blink rate may be a less pertinent issue now, many individuals continue to experience signs and symptoms of dry eye associated with digital device usage. Incomplete blinking, where the upper eyelid does not cover the entire corneal surface, may be more relevant to dry eye than blink rate as tear film stability can be maintained with a reduced blink rate, providing that most blinks are complete.41 Incomplete blinking can result in increased evaporation and tear film break up due to reduced tear film thickness in the inferior corneal region.42 Argilés et al43 observed a reduction in blink rate during reading tasks on tablet and computer displays (table 2), as well as hard copy text. However, reading from a hard copy was associated with a significantly lower proportion of incomplete blinks (0%–5%) compared with reading from a tablet (14.5%), expanded computer display (13.5%) or electronic reading (9%; see table 2). The specific influence of digital devices on incomplete blinks is unclear, and further research is needed to address this issue, along with the possible benefits of blink training.
* Accommodative effects To perform near tasks comfortably, pre-presbyopes must be able to accommodate rapidly and smoothly and maintain an accurate response.44 The lag of accommodation when viewing computer displays has been studied by several authors. Wick and Morse45 reported from a small sample of young adults that lag (measured with an openview autorefractor) was approximately 0.33 D higher in 4 of 5 participants when reading from a VDT compared with printed material, although Penisten et al46 found similar lags (by dynamic retinoscopy) in printed and VDT conditions. More recently, Collier and Rosenfield47 reported a stable mean lag of approximately 0.93 D among 20 adults during a 30min laptop-based task. Notably, no differences in static accommodation responses were identified between the most symptomatic and least symptomatic Table 2 Blink rate and proportion of incomplete blinks for various hard copy text and electronic reading conditions, as reported by Argilés et al43 Experimental condition Spontaneous blink rate, blinks/ min Median (IQR) % Incomplete blinks Median (IQR) Baseline:  viewing picture at 2m 15.5 (16) 14.5 (29.5) Tablet:  reading at 45° angle at 40cm 6 (11) 14.5 (28.5) PC: reading at 100% magnification at 60cm 6.5 (11) 9 (20) PC: reading at 300% magnification at 60cm 11.5 (11) 13.5 (25.8) Text: pasted on switched off display at 60cm 7 (12) 0 (16.3) Text: on book rest at 45° angle at 40cm 5 (10) 5 (22.8) Text: read aloud at 45° angle at 40cm 4 (9) 0 (14.5) BMJ Open Ophthalmology: first published as 10.1136/bmjophth-2018-000146 on 16 April 2018. Downloaded from https://bmjophth.bmj.com on 25 November 2024 by guest. Protected by copyright. Sheppard AL, Wolffsohn JS. BMJ Open Ophth 2018;3:e000146. doi:10.1136/bmjophth-2018-000146 5 Open Access groups, although the task duration may not characterise heavy usage patterns of digital devices. The accommodative response to a stationary near target exhibits microfluctuations—small temporal variations in power of up to 0.25 D,48 49 comprising a low frequency component (LFC) of
* upillary light reflex and size Along with accommodation and convergence, the pupil response is the third component of the near triad. Changes in pupillary characteristics and response have been explored as potential indicators of VF. Monitoring pupil diameter within-task has led to the hypothesis that an increase in pupil size indicates VF, due to detrimental effects on depth of focus.26 Task type has been shown to influence changes in pupil diameter, with more demanding tasks, such as faster on-screen presentation of figures55 and tracking (rather than reading or monitoring), causing greater increases in pupil diameter, although only a weak correlation with subjective complaints has been established.26Gray et al51 reported a significant overall increase in pupil size during 20min tasks on various displays, with the effect observed in 3 of 5 visually normal subjects. After effects have been reported in up to 33% of individuals following intense near work,56 where the pupil may retain a somewhat constricted state after task completion. Saito et al57 noted reduced pupil diameter and increased amplitude of pupillary reflexes following a prolonged VDT task, postulating that spasms of the sphincter pupillae and ciliary muscle may be responsible. Dynamic recording of pupil size and refractive error using an open-view autorefractor as described by Gray et al51 could facilitate analysis of post-task pupil recovery when after effects are present while also enabling study of within task accommodative response (accuracy) and pupil size.
* anagement of dry eye Dry eye is considered a significant aetiology of DES, with factors such as altered blinking characteristics, environmental influences and gaze angle considered relevant to dryness with digital device use. Office environments commonly feature low humidity, ventilation fans, air conditioning and airborne dust/toner particles, which may promote corneal drying.59 Desktop computer screens are frequently viewed in horizontal gaze, thus the palpebral aperture is wider than for conventional reading tasks (or laptop/tabletuse), which are usually performed in downgaze. Consequently, a larger ocular surface area is exposed to the effects of tear film evaporation.58 59 Use of lubricating eye drops has been shown to reduce symptoms such as tiredness, dryness and difficulty focusing during sustained computer use,60 although complete resolution of symptoms may not occur.61 A randomised controlled study of 478 symptomatic computer users (>3hours per day) demonstrated a beneficial effect of dietary supplementation with omega-3 fatty acids on dry eye signs and symptoms, with 70% in the treatment group being symptom free after 3 months.62 Given the impact of digital device usage on blinking characteristics, blink training may be helpful in the management of DES symptoms linked to dry eye. Increasing blink rate through use of an audible prompt signal every 4s during a computer task was not found to alter symptom scores,63 although blink efficiency exercises to reduce the number of incomplete blinks may be more appropriate given the link between screen use and incomplete blinking

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* Excessive use of ED is the leading risk of exposure to DED.4 The blinking rates are 22 blinks/min while relaxing, 10 blinks/min while reading on a paper, and 7 blinks/min while viewing on a digital screen.5 This causes poor dispersion of tear film, which leads to inadequate lipid layer, unstimulated meibomian glands, and ocular surface evaporation; thus, eyestrain symptoms such as eye dryness, burning, itching, and grittiness.6
* DED is among the most common reasons for ophthalmology visits.4 As reported by the Tear Film Ocular Surface Society (TFOS) Dry Eye Workshop (DEWS) II, DED is the frequently complex disorder of tear film and ocular surface (cornea and conjunctiva) defined by alteration of lacrimal dynamics and hyperosmolarity.7 DED significantly affects the quality of life (QoL) of affected people and reduces their productivity.8 In the United States, the total loss of productivity due to DED was estimated to be $55,4 billion per year.9
* DES and DED symptoms are both associated with screen exposure time and may co-occur; thus, some DED symptoms can be attributed to DES and vice versa.10 For instance, in the CVS-Q, there are also questions about dry eye symptoms, such as burning, itching, feeling of a foreign body, tearing, excessive blinking, eye redness, eye pain, heavy eyelids, and dryness.
* Most previous studies have separately investigated DES and DED symptoms; however, the concurrence of these two conditions has not yet been given an important evaluation. Therefore, based on the definite paucity of literature about the correlation between DES and DED, the present study aimed to evaluate this correlation and determine the prevalence of DED symptoms according to the severity of DES. In addition, this study provides recommendations from our experts regarding safer practices while extensively using ED.

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* A strong association between dry eye and computer related symptoms has also been noted (Rosenfield, 2011). Longer periods of computer work are associated with a higher prevalence of dry eye (Uchino et al., 2008). One explanation for the higher prevalence of dry eye symptoms when viewing screens may be due to changes in blink patterns.
* Several investigations have reported that the blink rate is reduced during computer operation.
* For example, Tsubota and Nakamori (1993) compared the rate of blinking in 104 office workers either when they were relaxed, reading a book or viewing text on an electronic screen. Mean blink rates were 22/min while relaxed, but only 10/min and 7/min when viewing the book or screen, respectively. However, these 3 testing conditions varied not only in the method of presentation, but also in task format
* It has been noted that blink rate decreases as font size and contrast are reduced (Gowrisankaran, Sheedy, & Hayes, 2007), or the cognitive demand of the task increases.
* Many subjects experience ocular and visual symptoms when viewing digital electronic screens.
* Previous studies have reported a reduced blink rate during computer operation and suggested that this may account for some of the symptoms experienced during such tasks. However, it is unclear whether these changes in blink rate are related to the screen display or to differences in the mental requirements of the task. Accordingly, the present study compared blink rates when reading material having low or high cognitive demand from a tablet computer or hard copy printed text.

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* Digital device use has been implicated as a contributing factor to dry eye disease.[43] Substantial research points to an increased prevalence of dry eye signs and symptoms amongst digital display users.
* Ocular surface and tear film abnormalities, including reduced tear stability, alterations in tear volume and tear composition, increased oxidative stress, ocular surface inflammation and even meibomian gland dysfunction have been found in computer users and tend to exacerbate with longer durations of device use.
* Alterations in the pattern of blinking, mainly a reduction in the blink rate and blink amplitude (i.e., increase in incomplete blinking), have been identified as one of the main mechanisms behind the harmful effects of digital screens on the ocular surface.

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* ] In today’s dynamic world, need for near and intermediate visual tasks has been dramatically increased, requiring prolonged computer and gazette‑related works and reading books. It demands excessive working of the extraocular muscles (EOMs) (vergence) and ciliary muscles (accommodation) which may cause eye fatigue which in turn may lead to other associated asthenopic symptoms.[3]

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