Binocular and Accommodative Problems Associated With Computer Use

Binocular and Accommodative Problems Associated With Computer Use

Among the most frequent health-related problems reported by users of computer video display terminals (VDTs) are those related or attributed to vision. Working on the computer for long periods can lead to blurred vision, eye discomfort, fatigue, and headaches.1 When patients seek care for complaints related to computer use, it is important to accurately diagnose and treat all of their symptoms, not only the visual problems. Symptoms associated with VDT use can roughly be categorized into four primary areas—refractive, binocular vision, ocular and systemic health, and ergonomic. Symptoms resulting from each of these can be resolved with proper care and attention to environmental design.

Incidence of Computer Use

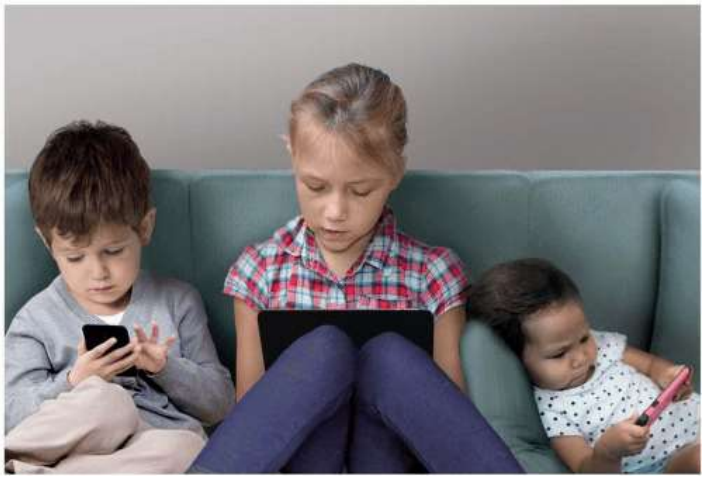
Nearly 15% of patients seeking general eye care schedule their visual examination as a result of computer-related visual complaints.2 This is not surprising as 70 million U.S. households (62%) contained one or more computers in 2003, a number which increased to 91.7 million households (76.7%) by 2010.3 Surveys indicate that, although more than 10% of patients present with symptoms primarily associated with computer use, more than 20% could not receive a definitive diagnosis and treatment plan.4

According to the U.S. Census Bureau, in 2010, 68% of Americans aged 15 and older used computers at home, 35% used computers at work, and 15% used computers at school.3 Utilization of digital devices, particularly mobile media, has increased substantially in recent years.5 In 2016, approximately two-thirds of American adults aged 30 to 49 years spent five or more hours on digital devices6 and in the UK, adults spent nearly 5 hours per day using digital media.7 In older age groups, use of technology also grew rapidly; between 2011 and 2017, the population classed as “recent Internet users” (within the last 3 months) more than doubled in the 75 years and over age group, and increased from 52.0% to 77.5% in those aged 65 to 74 years.8 Recent U.S. data indicate that 37% of adults aged 60 years and over spend five or more hours per day using digital devices. This age group prefers desktops and laptops for Internet browsing, whereas younger adults tend to use smartphones.6 Multitasking with digital devices is prominent among adults aged 20 to 29 years with 87% reporting simultaneous use of two or more digital devices.6

Digital device use is not limited to adults. Many children use computers for educational and recreational purposes; a multination European study found that by 3 years of age, 68% of children regularly use a computer and 54% undertake online activities.9 The way that children use the computer may make them even more susceptible to the development of computer-related vision symptoms. Children often continue performing an enjoyable task, such as playing video games, without breaks until they are near exhaustion. Such prolonged activity can increase eye-focusing problems and eye irritation. An additional issue is that computer workstations are typically arranged for adults. Therefore, a child using a computer on a typical office desk must often look up higher than an adult. This may cause problems with a child’s vision, as well as resulting in symptoms of arm, neck, and back discomfort. Further, a child who uses a tablet may place it his/her lap or lay down with it (Fig. 20.1), either of which can make an abnormally close distance which should not be sustained for a long period of time.

Computer Vision Syndrome versus Computer Use Complex

The problems associated with computer use are so frequent and there is so often a visually related symptom that the term computer vision syndrome (CVS) has been suggested as descriptive of the group of problems associated with computer use.10 CVS is characterized by a range of eye and vision-related symptoms and has been a recognized health problem for over 20 years.11 Reflecting the amount of time spent at the task and the variety of digital devices linked to potential problem, the terms visual fatigue (VF) and digital eye strain (DES) are also used.



▪ Figure 20.1 Children of all ages now use digital devices. These children often do not assume an “ideal” posture and many times have an inappropriate working distance that they sustain for long periods of time.

According to Stedman’s Medical Dictionary,12 a syndrome is a group of symptoms related to a specific disease. This calls into question the term computer vision syndrome, because it is likely that symptoms stemming from computer use are not a specific disease related solely to vision. This is especially significant when considering the physical symptoms that also accompany computer use; for example, neck, back, and wrist problems, such as carpal tunnel disease,1 and visual symptoms that are related to lid disease, lack of blinking, or dry eye rather than vision, per se.2

In medicine, a group of diseases or symptoms associated with similar etiologies is called a complex. Thus, the symptoms associated with computer use are more similar in this respect to a complex than a syndrome. For these reasons, we are using the term computer use complex (CUC) to include all of the visual and physical signs and symptoms associated with computer use. This chapter primarily discusses visually related signs and symptoms related to CUC—what is often referred to as CVS.13 However, and notwithstanding our use of CUC or the widespread use of CVS, it is probably equally, and maybe more, useful to use the terms VF or DES for communication with patients who often do not consider smartphones and/or tablets to be computers.13

Characteristics

SYMPTOMS AND THEIR PREVALENCE

The existence of symptoms associated with computer use has been widely documented in the scientific literature for over 20 years. However, determining the actual symptom prevalence is challenging because of continually increasing adoption of computers and other digital devices, the widely varying usage conditions, and the diverse instruments and procedures which have been used for detection. In most cases, symptoms occur when the visual demands of the task exceed the visual abilities of the patient to comfortably perform them. At greatest risk for development of symptoms are patients who spend two or more continuous hours of daily computer use.

According to the American Optometric Association,14 the most common symptoms are blurred vision, dry eyes, eyestrain, headaches, and pain in the neck and shoulders. Other common complaints include difficulty concentrating, diplopia, loss of comprehension over time, movement of the text on the screen, a pulling sensation, and sleepiness. Most symptoms are associated with computer use, although patients with computer-related symptoms also frequently complain of symptoms with reading or other close work.

The 2016 Digital Eye Strain report6 included survey responses from over 10,000 U.S. adults and identified an overall self-reported symptom prevalence of 65%; females were somewhat more commonly affected than males (69% vs. 60%, respectively). Symptoms were more frequently reported if individuals used two or more devices simultaneously (75%), compared with those using just one device (53%). Among 426 Spanish civil servants evaluated with a validated questionnaire, the overall prevalence of symptoms was 53%.15 Contact lens wearers were more likely to be affected (65%) than non-wearers (50%) after six or more hours of computer use.15

Sheedy et al16 described two distinct sets of symptoms: internal symptoms of ache, headache behind the eyes, and strain were linked to accommodative and/or binocular vision stress, whereas external symptoms of burning, dryness, irritation, and tearing were more closely linked to dry eye. Portello et al11 also identified a categorical split of computer-related symptoms: those associated with accommodation (blurred near vision, blurred distance vision after computer use, and difficulty refocusing after looking from one distance to another) and those linked to dry eye (dry eyes, eye discomfort, eyestrain, headache, irritated/burning eyes, tired eyes, and sensitivity to bright lights).

Portello et al11 documented the frequency (during the preceding week) that a particular symptom had been experienced at least “some of the time” during computer use by over 50% of respondents (Table 20.1). Emphasizing the frequent and persistent nature of symptoms, 17.3% to 39.8% of respondents reported at least one symptom over 50% of the time during computer use. A greater incidence of computer-related symptoms in females may be linked to gender differences in dry eye prevalence.17,18 Considering dry eye disease (DED) in computer users, a recent meta-analysis (16 studies, n = 11,365 subjects) estimated an overall prevalence of 49.5%, with a range of 9.5% to 87.5%.18 The problem of dry eye from digital device usage is not limited to adults. A South Korean study revealed that longer durations of visual display terminal (VDT)19 and smartphone19,20 use are risk factors for DED in children. Cessation of smartphone use for a 4-week period in children aged 7 to 12 years with DED resulted in significant improvements in noninvasive tear breakup time (BUT), punctate epithelial erosion, and Ocular Surface Disease Index scores, with affected children no longer being classified as having DED after the 4-week abstinence period.20

In summary, recent data representative of currently used devices indicate that many millions of adults are symptomatic after computer use. Although the prevalence has not been extensively evaluated, children also often have symptoms related to computer use. A meta-analysis of available data linked to asthenopia in children (5 studies, n = 2,465 subjects)21 reported a pooled prevalence of 19.7%. The scarcity of data in this area was highlighted, along with difficulties comparing studies because of the variation in methods.21 Given the possible impact of asthenopia on learning and school performance, and the increasing digital device use by children, further research is needed to appraise the consequences of children’s symptoms associated with computer use.

SIGNS

Visually related symptoms may be associated with any refractive error. Symptoms in presbyopic patients may be related to the binocular state or to the design of the prescription used for computer use. Thus, it is important for the clinician to evaluate the type of correction (bifocal or single vision) and the ways in which the prescription is used.

Table 20.1 PERCENTAGE OF RESPONDENTS (N = 520 NEW YORK CITY OFFICE WORKERS) REPORTING SYMPTOMS DURING COMPUTER USE AT LEAST HALF OF THE TIME OVER THE LAST WEEK

Symptom	Percentage of Respondents Reporting Symptom At Least Half of the Time
Dry eyes	31.5
Eye strain	30.6
Irritated or burning eyes	27.5
Blurred vision when looking into the distance	23.4
Difficulty or slowness in refocusing my eyes from one distance to another	21.6
Blurred vision while viewing the computer	17.3

Abstracted from Portello et al12

ANALYSIS OF BINOCULAR AND ACCOMMODATIVE DATA

Patients with visually related computer symptoms often have accommodation-based problems. Although a significant heterophoria at near may be an important finding in many cases, clinicians should use their judgment and generally rely on characteristics in addition to the magnitude of the heterophoria at distance and near in order to reach a diagnosis.

Direct tests of fusional vergence, including step, smooth, and jump vergences, are important in diagnosis. In addition, tests that indirectly assess fusional vergence should be considered. Tests performed binocularly with minus lenses evaluate the ability to stimulate accommodation and control binocular alignment using negative fusional vergence (NFV) (e.g., positive relative accommodation [PRA] and binocular accommodative facility [BAF] testing with minus lenses). A characteristic finding in patients with visually related computer use symptoms is a report of blur, rather than diplopia, as the endpoint on PRA and BAF testing.

Reduced PRA or BAF results may stem from the inability to stimulate accommodation or from reduced NFV. The differential diagnosis is based on the assessment of accommodation under monocular conditions. Simply cover one eye after the patient reports blur on the PRA test; if blur persists, the problem is usually accommodative (accommodative insufficiency or ill-sustained accommodation). If the vision clears, the problem is associated with binocular vision (NFV). Normal monocular accommodative ability on accommodative facility testing suggests reduced NFV.

Another important indirect test of NFV is monocular estimation method (MEM) retinoscopy.22 It is not unusual to find an abnormal result on this test on patients with visually related CUC symptoms. An MEM finding of greater plus than expected suggests that the patient is using as little accommodation as possible to decrease the use of accommodation or accommodative convergence.

Differential Diagnosis

It is typically not necessary to consider serious underlying etiology in cases of visually related CUC symptoms. As with other conditions, differential diagnosis depends on the nature of the patient's symptoms (Table 20.2). Visual conditions associated with serious underlying disease almost always have an acute onset, with associated medical problems or neurologic symptoms. Typically, patients with visually related CUC symptoms present with long-standing chronic complaints. The health history is negative, and although the patient may be taking medication known to affect accommodation (e.g., allergy-related medications such as loratadine [Claritin]), the symptoms usually are not easily related to use of the medication. The primary functional disorders that typically must be differentiated are basic heterophoria (esophoria, exophoria, and/or hyperphoria), convergence insufficiency, vergence infacility, and visual discomfort secondary to various accommodative anomalies (e.g., infacility, inaccuracy, or insufficiency).

Table 20.2 SYMPTOMS AND SIGNS OF VISUALLY RELATED COMPUTER USE PROBLEMS

Symptoms	
These symptoms are related to computer use, although there may also be symptoms with use of the eyes after reading or other near tasks:	
Eyestrain	Difficulty concentrating on reading material
Headaches	Loss of comprehension over time
Blurred vision	A pulling sensation around the eyes
Double vision	Movement of the print
Sleepiness	
Signs: Exophoria	**Signs: Esophoria**
Receded near point of convergence	Receded near point of convergence
Basic exophoria	Basic esophoria
Greater exophoria at near than at distance	Greater esophoria at near than at distance
Low AC/A ratio	High AC/A ratio
Direct measures of positive fusional vergence (PFV)	
Reduced smooth vergence	
Reduced step vergence	
Reduced fusional facility	
Indirect measures of PFV	
Low negative relative accommodation	
Low monocular estimation method retinoscopy finding	
Difficulty with plus lenses during binocular accommodative facility (BAF) testing	
If accommodative excess is also present	
Difficulty with plus lenses during monocular accommodative facility (MAF) testing	
If accommodative insufficiency is also present	
Difficulty with minus lenses during MAF and BAF testing	
Low positive relative accommodation	
Low amplitude of accommodation	
Possible improvement in near point of convergence testing with plus lenses	

AC/A, accommodative convergence to accommodation.

Most visually related CUC symptoms result from benign conditions, with no serious consequences other than visual symptoms (Table 20.2). It is relatively easy to differentiate the binocular vision disorder present. To do so requires a careful analysis of all accommodative and binocular vision data. Cases 2.1 to 2.4 in Chapter 2 provide examples of the analytical process to follow.

Ocular inflammation, such as blepharitis and meibomitis, can cause ocular symptoms of blurred vision after near work. This suggests that slit lamp evaluation is an important test in the differential diagnosis of apparent binocular symptoms related to CUC.

General Treatment Strategies for Visually Related Symptoms of Computer Use Complex

SEQUENTIAL MANAGEMENT CONSIDERATIONS

The concepts discussed previously for the sequential management considerations of binocular vision disorders also apply to problems related to computer use (Table 20.3). In the case of visually related symptoms of CUC, the important issues relate to the following:

- Correction of ametropia
- Added lenses
- Prism
- Vision therapy
- Ocular health
- Ergonomic issues

Table 20.3 SEQUENTIAL CONSIDERATIONS IN THE MANAGEMENT OF COMPUTER USE COMPLEX

Optical correction of ametropia	Vision therapy for sensory motor function
Added lens power	Horizontal prism
Vertical prism	Surgery
Occlusion for amblyopia	Ocular health management
Vision therapy for amblyopia	Ergonomic issues

CORRECTION OF AMETROPIA

Asthenopia and accommodative fatigue are frequent sequelae of uncorrected refractive errors such as hyperopia and astigmatism. For example, a patient with uncorrected hyperopia must accommodate for the computer working distance, as well as an additional amount to overcome the uncorrected hyperopia. Muscular fatigue resulting from prolonged (and occasionally excessive) accommodation may result in accommodative symptoms. Small amounts of uncorrected astigmatism and anisometropia also often result in visual symptoms. Some myopic patients experience discomfort when working on the computer while wearing eyeglasses. Each of these symptoms may be due to accommodative fatigue and accurate refractive correction must be considered in any management plan. The first management consideration, therefore, is correction of refractive error.

In some cases, patients who do not require correction for other daily activities may benefit from glasses prescribed specifically for computer use. In addition, persons already wearing corrective lenses may find that a prescription prescribed for general use may not be satisfactory for computer work; lenses may need to be prescribed to meet the unique visual demands of computer viewing. To properly correct the refractive error of any patient, including computer users, we recommend the prescribing criteria discussed in Chapter 3. It is also important to recognize that special lens designs, powers, and tints or coatings may help to maximize visual abilities and comfort.

LENS COATINGS—BLUE LIGHT PROTECTION

Suprathreshold[23,24] exposure to blue light (400 to 500 nm) can cause retinal damage.[25] Less intense, long duration exposure also may induce photochemical damage.[26] Even though long-term viewing at low levels of blue light probably does not represent a significant biohazard,[27] many current forms of low energy lighting emit significant amounts of blue light. As a result, harmful cumulative exposures may occur.[25,28]

Light exposure is a significant factor involved in regulating circadian rhythms. Short wavelength light exposure before bedtime (including digital devices) can disrupt sleep patterns;[29,30] use of short wavelength blocking spectacles in the evening improves sleep duration and quality[31,32] and reduces subjective late-night alertness.[33] Blue light from digital devices has also been shown to contribute to symptoms of dry eye syndrome. Isono et al[34] found reduced subjective complaints when young adults read from a sepia background (reduced blue light compared to the conventional white background of a modern digital tablet).

Notwithstanding the above, there is no strong consensus in studies of the effects of blue light. Indeed, a recent systematic literature review called for randomized controlled trials to address the health effects of blue blocking spectacle lenses.[35] Until such trials exist, and given the association between the blue light emitted from modern digital devices and ocular complaints, we suggest prescribing blue light-filtering spectacle lenses for patients using digital devices and computers. Addition of such filters, which reduce phototoxicity by up to 23.6% without degrading visual performance,[36] is relatively inexpensive and may provide useful protection against possible blue light hazard.

ADDED LENSES

Added plus lenses play a very important role in the treatment of visually related symptoms of CUC. Of course, patients with a high accommodative convergence to accommodation (AC/A) ratio in whom there is a significant esophoria at near (e.g., convergence excess) benefit from added plus lenses. In addition to the obvious near vision problems that result from the onset of presbyopia, various accommodative problems associated with pre-presbyopia, such as accommodative insufficiency and ill-sustained accommodation, cause CUC-related symptoms that can frequently be treated with added plus lenses. Accommodative problems in which the difficulty is with relaxation of (or frequent changes in) accommodation (accommodative excess and accommodative infacility) respond less well to added plus lenses and generally respond better to vision therapy treatments (Chapter 12).

When prescribing bifocals for computer users, it is important to recognize the difficulties that computer users often have with conventional bifocals, which are typically designed for distance and near viewing; the computer monitor distance is often at an intermediate (50 to 75 cm+) rather than a near (40 cm) distance so that the general-use bifocal is too strong for monitor viewing. Because conventional bifocals or progressive lenses are not designed for looking at a computer monitor, some people are forced to tilt their heads at odd angles or bend toward the screen to see the monitor clearly. These postures can result in muscle spasms or pain in the neck, shoulder, or back.

PRISM

Prism, which is important in cases of binocular vision disorders, is used for visually related CUC symptoms when there is an associated binocular problem. Thus, esophoric patients and patients with a vertical heterophoria should have prism considered as part of the sequential management for their CUC vision-related problem. See Chapters 11 and 15 for prism recommendations for patients with esophoria and vertical heterophoria, respectively.

VISION THERAPY

The final binocular vision-related treatment consideration is the use of vision therapy to restore normal binocular function. Vision therapy is generally an important step in the management of accommodative and vergence problems. In many cases, vision therapy is critical in treatment of the binocular difficulties that accompany CUC vision-related problems.

SURGERY

Surgery, which is a consideration for some binocular vision problems when there is a very large heterophoria, typically has no role relative to CUC-related vision problems.

OCULAR HEALTH

Eyelid health and tear film integrity are very important causes of symptoms in CUC. Because of the intensity of the viewing task, computer users tend to blink less frequently. Studies by Yaginuma et al[37] and Patel et al[38] demonstrate a diminished blinking frequency in computer users. Most people blink approximately 18 times per minute; Patel et al found that computer users blink as few as four times per minute.[38]

The reduced blinking rate of computer users may be part of an effort to gaze attentively at the computer monitor. In some patients, this decreased blink rate can compromise visual comfort after even a few minutes of computer work, especially in the presence of eyelid disease or dry eye.39 Further, some office buildings have excessively dry environments that cause increased dry eye symptoms in the presence of reduced blinking.

Given the reduced blink frequency and the incidence of dry eye associated with computer use, it is very important to objectively determine the severity of the patient's symptoms. A validated questionnaire40 for this purpose is the Standard Patient Evaluation of Eye Dryness Questionnaire (Table 20.4). There are eight questions which are answered on a 0 to 3 (for Frequency) or 0 to 4 (for Severity) scale. Frequency and Severity scores added together result in an overall score. There is a strong statistical correlation between lipid layer thickness and symptom score.41 A symptom score over 6 strongly suggests that treatment should be undertaken to bring the condition under better control.

Table 20.4 STANDARD PATIENT EVALUATION OF EYE DRYNESS (SPEED) QUESTIONNAIRE

1. Report the *FREQUENCY* of your symptoms using the rating list below:

Symptoms	**0**	**1**	**2**	**3**
Dryness, grittiness, or scratchiness				
Soreness or irritation				
Burning or watering				
Eye fatigue				

0, Never

1, Sometimes

2, Often

3, Constant

2. Report the *SEVERITY* of your symptoms using the rating list below:

Symptoms	**0**	**1**	**2**	**3**	**4**
Dryness, grittiness, or scratchiness					
Soreness or irritation					
Burning or watering					
Eye fatigue					

0, No Problems

1, Tolerable—not perfect, but not uncomfortable

2, Uncomfortable—irritating, but does not interfere with my day

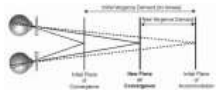
3, Bothersome—irritating and interferes with my day

4, Intolerable—unable to perform my daily tasks

Total SPEED score (Frequency + Severity) = ____/28; scores greater than 6 indicate a need for further evaluation.

You may also need

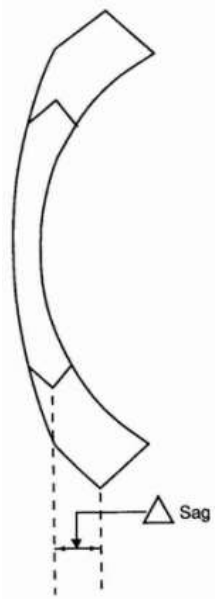
Primary Care of Binocular Vision, Accommodative, and Eye Movement Disorders



Introduction and General Concepts

Patient and Practice Management Issues in Vision Therapy

Low AC/A Conditions: Convergence Insufficiency and Divergence Insufficiency



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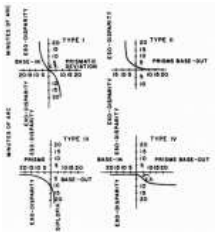
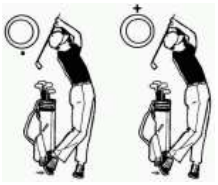
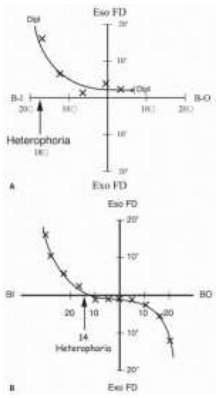


Interactions Between Accommodation and Vergence



High Accommodative Convergence to Accommodation Conditions: Convergence Excess and Divergence Excess

Binocular and Accommodative Problems Associated With Learning Problems



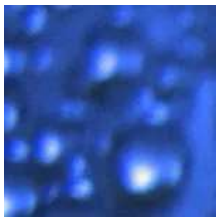
Fixation Disparity

General Treatment Modalities, Guidelines, and Prognosis

Case Analysis and Classification

Binocular and Accommodative Problems Associated With Acquired Brain Injury

Binocular Vision Problems Associated With Refractive Surgery



Normal AC/A Conditions: Fusional Vergence Dysfunction, Basic Esophoria, and Basic Exophoria

Diagnostic Testing

Cyclovertical Heterophoria

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