Specialist report: Dry eye disease and aging

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M.M.A. van Tilborg, H.S.M. Kort, P.J. Murphy. Specialist report: Dry eye disease and aging. Gerontechnology 2017;16(4):211-217; https://doi.org/10.4017/gt.2017.16.4.002.00 The common ocular pathologies relating to the aging eye, such as cataract, diabetic retinopathy, glaucoma, or macular degeneration, are all known to reduce visual functioning. Less well-known is the effect of common, age-related dry eye disease (DED). The impact of DED on daily activities can be intense, especially with reduced visual functioning, for example, an inability to watch television, or read from a tablet or smartphone screen. As a result of reduced visual functioning, DED is particularly problematic for ageing office-workers. Moreover, office work involving computer-use is known to adversely affect the tear film. Consequently, with the extension in retirement age in the working population, an increase in the incidence and extent of (dry) eye-related problems can be expected. This literature paper addresses the impact of age-related DED on visual functioning, the complexity of assessing visual functioning in daily activities at home or at work, the development of dry eye symptoms with increasing age, and the relationship of these issues with environmental factors. Special attention is made to the influence of light and light conditions that can positively and negatively influence visual functioning.

Keywords: aging eye, dry eye, visual functioning, light

Dry eye disease (DED) is not typically included in the more severe, sight-threatening, eye diseases, but, as an age-related disease, it can cause several vision-related symptoms. In particular, blurry vision and transient vision during the day can negatively affect visual functioning. However, DED is increasingly being seen as not just an age-related disease, since DED symptoms are frequently reported by those of working age, and especially office workers[1,2]. This literature survey arose from the interest of the authors in the role of primary healthcare in the management of work-related dry eye.

DED is primarily a disease that affects the quality and/or quantity of the pre-ocular tear film. The tear film performs several functions for the eye: it assists in producing a good optical quality at the retina by smoothing the irregular surface of the cornea; it lubricates the surface of the eye during blinking; it protects the exposed ocular surface from environmental risks; it provides nutrition and oxygen to the cornea; and it supplies immune system proteins as part of the ocular defenses against infection. The lubricating action of the tear film assists in maintaining ocular comfort during and after blinking, and helps to remove foreign bodies and infective agents from the pre-ocular tear film as part of the first line defence[3]. Any interference in the relationship between the tear film and the ocular surface, such as increased tear evaporation or a reduced blink-rate, has an impact on the performance of these roles, and will lead to ocular surface damage and symptoms, such as discomfort, visual disturbance or tearing of the eye[4]. These causes and consequences have been grouped together under a broad definition of 'dry eye disease'.

The recently published Dry Eye Workshop II report (DEWS II) has defined DED as: "Dry eye is a multifactorial disease of the ocular surface characterized by a loss of homeostasis of the tear film, and accompanied by ocular symptoms, in which tear film instability and hyper-osmolarity, ocular surface inflammation and damage, and neurosensory abnormalities play etiological roles"[5].

This definition focuses on tear film abnormalities but does include neuro-sensory abnormalities, which reflects that DED is often a symptoms-based disease, (referred to as ocular symptoms), but the impact of these symptoms on the quality of daily life is poorly recognized. Symptoms

of DED have been associated with an adverse impact on vision-related quality of life, the performance of daily activities, the ability to work, and emotional well-being[6].

Estimates for the world-wide prevalence of DED give a range from as low as 0.1% to as high as 33%, but, depending on the environment, population group, and the clinical signs assessed, it can be as high as 75%[7]. A particular problem when investigating the prevalence of dry eye arises from a lack of consensus about what criteria should be used to define the dry eye diagnosis, with the result that a prevalence range from 18% to over 50% has been reported in the population between 40-96 years of age[8]. Nevertheless, older age and female gender have been clearly identified as two of the main risk factors for DED[9,10].

Schaumberg et al. (2013) showed that older women with DED (with an average age of 70 years) had significantly greater problems with their vision than males[11]. The women were also diagnosed with DED earlier than men, and reported a significantly greater impact and worse quality of life from their disease. Problems with blurred vision, poor vision, and fluctuating/unstable vision were reported, which interfered with reading, driving at night, watching television, and working on a computer[1,2,5].

The WHO International Classification of Functioning and Disabilities (ICF) looks at the relationship between health and symptoms, and the influence of environmental factors on daily activities and the social participation of individuals[3,12]. Since, within the ICF, age belongs to the list of personal factors which might influence daily activities and participation, and since age is a risk factor for dry eye, an increasing incidence of dry eye symptoms can be expected as the retirement age of workers increases[4,7,12-14]. For the Netherlands, where the state retirement age will increase to 67 years in 2021, and will be linked to life expectancy from 2023, the potential impact of eye-related symptoms and DED on daily activities at work should be not under-estimated.

Environmental factors

One difficulty in assessing DED from symptoms is the lack of a direct relationship between subjective symptoms and type of DED[5,15]. In particular, the pain factor is not well understood. Symptoms often vary throughout the day, usually worsening in the evening[6,16,17]. Moreover, people are spending more time indoors and are working in modern, environmentally-controlled, office buildings. Since poor air quality has a strong relationship to dry eye symptoms, tiredness of the eyes and irritation[7,18], the quality of environmental control is becoming more important. Dry eye-related symptoms have also been reported, with a significantly higher frequency at work than at home ($p<0.00$) for office workers ($n=505$) working in a modern, visually-demanding office[2]. Office workers with moderate-severe dry eye symptoms have a greater dissatisfaction with their workspace environment in an environment with a compromised indoor air quality[2,11]. A high percentage of these office workers also experienced significant negative effects on their social activities after work. In a previous study reported by this author, optometrists in the Netherlands believed that the influences of the work environment and use of a computer were two of the main reasons for developing DED[2].

The discussion around a healthy environment in office buildings is not new. In 1984, the World Health Organization (WHO) reported that up to 30% of office workers world-wide, working in new and re-modelled buildings, complained about poor, indoor, air quality[12]. In popular culture, this led to the idea of the 'sick building'. However, strictly speaking, the term Sick Building Syndrome (SBS) is only used when the symptoms (divided into mucous membrane symptoms, such as eyes, nose, throat and dry skin, and general symptoms, like headaches and lethargy) are related to the building environment, and which disappear after leaving the building[19,20].

Humidity, temperature, light conditions and acoustics are identified as building-related environmental factors. In particular, low humidity, the presence of an air draft, and high ambient temperature are said to be factors with a greater influence on the signs and symptoms of dry eye. A low relative humidity ($RH<40\%$) and/or an air draft (>1.5m/s) can cause a higher evaporation rate from the tear film[21,22]. With ageing individual workers, who can also have other ocular pathologies, such as blepharitis (an eyelid margin disease), these environmental factors can contribute to a reduction in tear stability or production. In areas with air pollution, the incidence can increase further[23]. Alex et al. (2013) showed, in an experimental setting, that exposure to low humidity significantly increased corneal and conjunctival fluorescein staining (a clinical sign of ocular surface distress) in all participants, whether they had healthy eyes or dry eyes[24].

It is also known that working in extremely low relative humidity produces a higher percentage of employees with dehydration[25]. Walsh et al. (2012)[26] looked at whole-body hydration and dry eye and found that individuals with dry eye had sub-optimal hydration of the body, indicating that hydration should be taken into account in the management dry eye. Sub-optimal hydration is relatively common in the older adults and

is associated with several age-rated diseases[27]. It is known that older adults exhibit decreased thirst sensation and reduced fluid intake, and this should be taken into account when older adults are diagnosed with DED or experience dry eye symptoms[28].

Also, computer screen-use for more than 6 hours per day is linked to a reduced sleep quality (fewer hours and more broken nights)[29], and sleep deprivation is associated with dry eye symptoms[30]. A suggestion of a relationship between sleep disorders and DED in older people has been reported[31].

Visual functioning

In normal ageing, the eye experiences a gradual decline in visual acuity, degenerative eye pathologies. These diseases can further negatively influence visual acuity, visual field size, contrast sensitivity, and dark adaptation. Normal visual functioning is important in the lives of adults at all ages. However, large studies, such as the Beaver Dam and Blue Mountain Eye studies, have reported a decline in visual acuity in older age[32-34]. Moreover, visual acuity is not the single predictor in visual functioning – contrast sensitivity is also important, although this measurement is not a commonly-performed test in optometry or ophthalmology practice. More generally, visual functioning is related to the ability of an individual to perform vision-dependent tasks, such as reading, computer-work, driving, or watching television[35]. An association between visual function, general health and negative social impact for working-age individuals has been reported in the literature[32].

Daily activities, such as watching television or using a computer, could present difficulties for those with DED. Several investigators have found that reading from a computer screen causes a decreased blink-rate, an increased incomplete blink rate, tear film instability, and/or significantly increased symptoms of blurred vision, compared to reading from hard copy[36,37]. A commonly-used term for eye-related problems that occur while using a computer is Computer Vision Syndrome (CVS), which may include eyestrain, headache, ocular discomfort, dry eye, diplopia, and blurred vision[38]. Significant complaints can occur even after two hours of computer work, and include eye-related pain and tiredness, blurred vision, itchiness, gritty eyes, photophobia, dry eyes, and tearing eyes16. With more office-work being done in a digital environment, it is logical to think of an increase in eye-related symptoms among workers when performing highly visually-demanding reading tasks, with the use of a computer, laptop, tablet or smartphone. In a previous investigation, we found that more than two-thirds of office workers (n=505) reported experiencing a negative impact on functioning due to eye-related problems[2].

Visual functioning with DED can be influenced by the increased incidence and severity of symptoms of blurry vision or transient vision loss since the pathologic tear film irregularities can significantly affect the light pathway[39]. A diurnal difference may be a factor to consider since visual functioning has been shown to be reduced in the evening and in workers with mild/moderate dry eye, perhaps as a result of a compromised tear film and increased the damage of the corneal epithelial layer observed in the evening[40].

Koh et al. (2017)[41] found that an unstable tear film caused higher straylight levels and lower contrast sensitivity. Since age-related cataract already produces difficulties with straylight, the combination of DED and cataract may make older people especially vulnerable to visual difficulties in driving at night, reading, or walking.

However, visual acuity measurement alone is not specific enough to detect visual problems in DED. Contrast sensitivity, higher-order aberrations and straylight measurements are better methods to investigate the visual disturbance that dry eye patients experience. However, these measurements are not standard procedures in optometric practice. Best-corrected visual acuity is considered as the standard for assessing visual function. However, using visual acuity as a measure of visual performance is not correct, due to the fact that, most of the time, its measurement is performed in a controlled situation, under controlled lighting, with high contrast letters to read at a specific distance. In any case, visual acuity is not a single measure of visual functioning[42].

Light sensitivity

Light sensitivity, or photosensitivity, is a known causal factor for headaches and migraine, but it is also reported in several eye diseases and is strongly related to dry eye[43,44]. Dry eye patients report a difficulty in watching television or to a computer screen, but also fluorescent lights are reported to evoke photosensitivity[45]. Light sensitivity is thought to occur due to a pain sensation in the cornea arising from corneal epithelial inflammation acting on the corneal sensory nerves, with osmotic stress as the primary cause of corneal epithelial inflammation in DED. Corneal epithelial inflammation, and the inflammatory mediators released from the damaged corneal epithelial cell, initiates a reaction that ends in hyperalgesia of the cornea. It has been noted that tear evaporation can give a hypersensitivity reaction, producing corneal evaporative hyperalgesia. The term hyperalgesia is used when the reaction to a stimulus, which is normally painful,

becomes extreme. Either way, the dry eye sensation becomes a pain sensation[46].

Rosenthal et al. (2012) stated that all of the different pain mediators are assumed to be involved in dry eye. They also felt that long-standing neuropathic pain may be associated with impairment of cognitive functions, depression, and anxiety. In other research, there are ideas that pre-existing depression and anxiety can enhance the transition of nociceptive pain to a chronic disease. However, pain is not measurable with the standard diagnosing tests for dry eye[46,47].

A reduction in visual function, commonly manifested as blurred vision and glare, is difficult to measure objectively. In the literature, glare produced by an external light source can cause disability glare. Disability glare is defined as glare which causes a decrease in visual acuity or contrast sensitivity[45]. In several investigations, contrast sensitivity, with and without the presence of glare, was found to be significantly decreased in dry eye patients compared with non-dry eye subjects[45,48]. Knowledge of both disability and discomfort glare (glare that causes symptoms of discomfort, but not a reduction in visual acuity), and the possible adjustments in the home situation or at the workplace is needed to combat these glare sources.

Dry eye and certain light conditions could evoke a kind of disability glare, and that can develop into the more severe, but rare, condition of photo-allodynia, which is caused by a chronic neurotrophic pain. Allodynia means that there is a trigger from a stimulus that normally does not evoke pain, leading to a pain response. In the literature it is recommended that the underlying dry eye is treated aggressively with whatever treatments are available: artificial tears, gels, steroid drops or other therapeutic intervention, scleral lenses, tinted contact lenses, special filter glasses, and adjustment of the environment, to diminish the response in the eye[44].

Light conditions

Visual functioning depends highly on the lighting conditions, and the light specifically needed could be task-dependent. The parameters for standard lighting are, in general, not developed for the aging eye or for people who are visually impaired. Knowledge of the aging population at work and their lighting needs is necessary to enable older workers to work in comfort. As the mean workforce age is increasing alongside better life expectancy, individual needs should be addressed more.

A similar problem occurs with the general lighting conditions for older adults in nursing homes[49]. In general, the common recommendation is to provide equal daylight, avoid direct light to diminish glare, and provide high light-levels at the workspace.

At home and at work, accessibility to sun-screens, avoiding direct light reflections on the computer screen/tablet, or an adjustable light at the desk or table, could help older adults. In the worst-case scenario, discomfort glare becomes disability glare which causes a reduction in the contrast of the retinal image, leading to a reduced ability to read text from a computer or tablet screen, or even from hard copy.

Considerations

For the aging population, knowledge of the individual needs for (day) light is necessary. The challenge for the healthcare professional is to recognize the (eye) symptoms and visual functioning needs of the individual, and to address these needs by providing symptom relief, and by promoting the best possible ways to function in the work environment through adjustment of illuminance levels needed during the working day. Marmot et al (2006) showed that the impact of light, and the ability to adjust for it to match the needs of the individual worker, led to a reduction in the reporting of SBS symptoms[50]. Since dry eye symptoms may be associated with psychological and psycho-social factors (stress, depression, anxiety)[47,51], and that (occupational) stress lowers the threshold for eye irritation[52], there may be a negative impact on work productivity[53], and on perceived happiness in daily activities, as a result of increased dry eye symptoms[54].

Since DED is principally a symptoms-based condition, it is most often diagnosed by a direct patient assessment, but this requires a patient/clinician encounter. Without this, it is likely that some sufferers remain undiagnosed[55]. Even a mild/moderate dry eye can have an impact on the well-being, daily activities, visual functioning or work productivity of a patient[56].

The impact of age-related changes of the eye, like cataract and DED, on daily activities at work should be known by care-givers, relatives, eye-care professionals, employers, and the occupational health-care physician. An awareness of eye pathology and the individual needs of aging adults are needed for care-givers. Technology could be of help to test and recognize the needs of aging adults regarding their specific needs, for example with light sources in the living room or adjustable lights for specific tasks. The prevention of work-related dry eye should be a coordinated response by employee, employer, occupational health and safety service, occupational

health-care physician, optometrist and general medical practitioner. Facilitating eye screening at nursing homes, life-cycle-resistant homes, and preventative measures during the working years would be beneficial.

For the ageing population and DED, the development of effective multi-disciplinary healthcare, between optometrists, GPs, health and safety consultants, occupational healthcare physicians, and ergonomists, is important to provide a healthy (work) environment that promotes visual comfort and productivity[57]. The use of electronic devices, such as tablets and smartphones, as work-related reading devices is becoming more common, and there is a need to promote better visual comfort using these devices.

For visual functioning, the knowledge of visual discomfort caused by reflections seen at the screens is not a "standard" ergonomic instruction, and the tuning of the screen for contrast and intensity has to be personalised. This instruction should be as common as adjusting the chair and desk to the ergonomically-advised standards.

For developing work-spaces, life-cycle-resistant homes, nursing homes or other public spaces, visual functioning, in general, more attention should be made towards natural lighting and the avoidance of direct light-inducing glare. The environment should facilitate (work) activities during the day, and the environment, working space or living room should have light levels that will help address the normal loss of visual acuity that occurs through the ageing process, and to the individual needs produced by eye pathology.

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