® Postepy Hig Med Dosw (online), 2020; 74: 151-154
e-ISSN 1732-2693

www.phmd.pl
Review

Received: 22.08.2019
Accepted: 15.04.2020
Published: 22.05.2020

Smartphones and vision

Smartfony a wzrok

Lidia Puchalska-Niedbał[1], Janusz Czajkowski[2], Robert Grabowski[3]

[1] 2nd Chair and Department of Ophthalmology, PMU, Szczecin
[2] Centrum Okulistyczne „Contact-Med" in Łódź
[3] Vision Express, Warszawa

Summary

Many people spend too much time using their smartphones. Contrast, small screen size, resolution, image repetition frequency and screen reflection will cause characteristic ocular symptoms.

The objective of this study is to describe the ophthalmological symptoms in persons who spend a large number of hours using electronic devices. For this purpose, a search was conducted in the Pubmed and MED line database to find the appropriate articles.

The most frequent ocular manifestation after prolonged use of smartphones without care for eye hygiene were ocular complaints, such as tiredness, eye irritation, blurred vision and transient, but marked elevated intraocular pressure.

Early and adequate recognition of ophthalmic symptoms that may be associated with the using smartphones for many hours and the implementation of appropriate management can protect against the occurrence of late complications in the form of permanent eye damage.

Keywords: **Smartphone • Intraocular pressure • Transient blindness**

GICID 01.3001.0014.1531
DOI: 10.5604/01.3001.0014.1531
Word count: 2431
Tables: –
Figures: –
References: 19

Author's address: Dr hab.n.med. Lidia Puchalska-Niedbał, 2nd Chair and Department of Ophthalmology, PMU, Al. Powstańców Wielkopolskich72, 71-113 Szczecin; e-mail: lidianiedbal@tlen.pl

INTRODUCTION

Personal mobile equipment (i.e. smartphones) has become a part of daily life. The most modern devices are so advanced that they work as personal computers. Many people spend much time using their smartphones not only for the purpose of phone calls. Unlike conventional computers, unique smartphone aspects, such as small screen size, resolution, contrast, image repetition frequency and screen reflection, will cause characteristic ocular symptoms. Due to the mobility of smartphones, many people use them with poor illumination. The small size of smartphones requires reduced font size; this leads to looking at smartphones from closer distances, which increases the demand for both accommodation and convergence. Furthermore, since an

object viewed on a smartphone frequently changes, the eyes must constantly focus to maintain a sharp image on the retina. Frequent movement of the eyes, accompanied by contraction of the medial rectus muscle (EOM), is required during smartphone use, in particular when scrolling or reading texts. As a result, a new phenomenon emerged—so-called digital eye-strain. It results from intensive screen viewing, focusing oneself and one's eyes on reading the contents for more than two hours on a single occasion.

The high number of hours spent on using electronic devices may in some users cause Computer Vision Syndrome (CVS), a commonly known phenomenon [12]; it is characterized by ocular complaints, such as tiredness, eye irritation, blurred vision and neck and back myalgia.

SMARTPHONE AND INTRAOCULAR PRESSURE

A smartphone as a hand-held device can be positioned at almost any direction, which often requires continuous eye convergence in a vertical and/or horizontal direction. Such eye movements and related contraction of the medial rectus muscle of both eyes may result in increased intraocular pressure (IOP) while using a smartphone.

Focusing the eyes on smartphone images from a close distance from the eye for a long time causes permanent accommodation and convergence exertion, which may cause transient, but marked IOP fluctuations [15]. Yan et al. found that accommodation may cause transient IOP elevation in subjects with progressive myopia [19], and Qudsiya et al. demonstrated that four hours of using a computer causes marked IOP elevation in young healthy subjects [13].

Authors found in their studies a marked difference in fluctuations of intraocular pressure depending on illumination conditions while using smartphones [8].

Under normal conditions of daily illumination, average IOP increased after only 5 minutes of using a smartphone. After putting the smartphone away, IOP values returned to values from before starting using the smartphone. The authors demonstrated that using a smartphone may transiently increase IOP both under daily illumination and with poor illumination, but with poor illumination IOP increased more rapidly than under daily illumination. Basic eye dynamics for this IOP changes during and after use of a smartphone is unclear [5].

The following mechanisms are assumed to be involved: accommodation, convergence, contraction of the medial rectus muscle, psychophysiological stress, dry eye and neck-flexion posture while viewing images on a smartphone.

Using smartphones is associated with psychophysiological stress; it stimulates the sympathetic nervous system, and IOP is strongly dependent on increased norepinephrine levels that occur as part of the sympathetic response [3].

DRY EYE

Prolonged periods of using electronic displays are associated with a higher prevalence of dry eye [16]. Persons who spend much time using smartphones or tablets, which is more and more common among young children, are more prone to dry eye disease. This is a condition in which eyes do not produce adequate amounts of tears to provide a protective eye film; this means that the eye surface becomes more prone to irritation. Meibomian gland dysfunction (MGD) is a principal cause of dry eye diseases and this dysfunction may result from less common blinking while using digital devices [4]. A markedly higher rate of incomplete blinking occurs while using electronic displays. Consequent "dry eye" not only causes eye discomfort, but also may contribute to increased IOP by stimulating free nerve endings in the cornea, resulting in outgoing nerve impulses through the trigeminal nerve. Although a definite relation between dry eye and IOP has not been clarified under clinical conditions, it is possible that irritation of corneal nerve endings due to dry eye may affect IOP fluctuations. Studies have also indicated that, after putting the smartphones away, dry eye symptoms drastically resolve.

Anatomical characteristics of the eye, such as increased pupil diameter and iris thickening in the dark, have been well documented [10]. Structural changes of the eye as well as high contrast between the smartphone screen and the surrounding in the dimmed light may contribute to further increase of IOP versus daily illumination. Poor illumination of the surroundings causes more vision fatigue and reduces visual efficacy while using a smartphone screen [10].

It was not determined whether IOP changes from using a smartphone increase the risk of glaucoma in healthy subjects. However, a brief increase of fluctuations of intraocular pressure plays an important role in the disease progression in glaucoma patients.

SMARTPHONES AND POSTURE

In most cases smartphones are held below the eye level, which favors neck flexure. Straker et al. concluded that a smaller screen requires the user to bend his neck more that with a larger monitor [17]. The average neck flexure of 33–45° from the vertical plane was found, which persisted while the subjects used a smartphone [11]. Obviously, the body and head position affect IOP that was much higher in subjects viewing the smartphone with flexed neck versus subjects who maintained their neck in the same position as their trunk or in neutral position [9, 18]. Thus, prolonged neck flexion posture while reading or writing on a smartphone may contribute to increased IOP.

Screen brightness also affects digital eye fatigue. It is less clear if "blue light" often emitted by the screens of such devices as smartphones or laptops causes any other problems than ocular. Blue light inhibits melatonin release that naturally regulates sleep, because it creates an impression that the day continues.

Teenagers and even small children spend more and more time with their smartphones and computers and the same group often experiences sleep problems. Sleep is a key element in a child's development and its lack may cause many disorders. Immediate symptoms include fatigue and impaired concentration. Long-term sleep deficit may increase the risk of such diseases as obesity, diabetes mellitus and heart disease. Children below two years of age should not look at the screens of electronic devices at all, while those under five years of age should spend no more than an hour daily with them – as recommended by the World Health Organization (WHO). Children below five years of age should be physically active and have good sleep; this will help them develop good habits and prevent obesity and other diseases later in life.

Blue light is especially dangerous for our eyes, since, contrary to other types of light, neither the cornea nor the eye lens are able to block or reflect it; thus, this light directly reaches eye photoreceptors – retinal cells sensitive to light that do not undergo regeneration.

LED diodes used in television sets, computers, smartphones and tablets, emit light that seems white, but exhibits peak emission in the blue light range (400–490 nm). Experimental studies indicate that exposure to blue light may affect multiple physiological functions [18] and may also damage the photoreceptors [7]. These data confirm that exposure to blue light in the 400-470 nm range may damage photoreceptors and the cells of the retinal pigment epithelium [1].

TRANSIENT SMARTPHONE BLINDNESS

Currently, smartphones have become a necessity; unfortunately, a new phenomenon has emerged, so-called transient smartphone blindness (TSB) [1].

This applies to transient loss of vision in one eye, associated with smartphone use while lying down in the dark [14]. Symptoms reported by patients are usually contralateral to the side on which the person was lying. Blocking access to light in one eye, connected to lying down on one's side, contributed to one eye adapting to darkness, while the other (viewing) eye adapted to light. This resulted in transient contrary light adaptation between two retinas. When the light blockade was removed, the eye adapted to light lost monocular vision for a few to as many as up to 15 minutes [4]. This is a relatively unknown phenomenon, associated with a risk of misdiagnosis as multiple sclerosis or vascular ischemic disease [17].

Transient smartphone blindness (TSB) is regarded as relatively benign short-term pathology; long-term consequences of this disease have not been clarified.

Currently, the risk of TSB is increased by the universal use of smartphones, lack of knowledge of the effects smartphones have on their users, and the intensive blue light emitted by the newest smartphones. Disturbances of the sleep cycle caused by exposure to blue light may be exacerbated by using a smartphone in bed and thus promoting TSB. There is a danger that incorrect therapy may be initiated as a result of erroneous diagnosis in patients with unclear test results [1]. Thus, it is important that ophthalmologists and neurologist consider the history of smartphone use by the patient in their routine practice before establishing a diagnosis. To prevent TSB, smartphone users should use them in a well-illuminated room and maintain posture in which the light does not enter only one eye. People should also stop using smartphones before going to sleep to avoid disturbances of the sleep cycle as a result of blue light. Another factor that may help avoid changes of the sleep cycle by blue light is using technology that automatically reduces blue light for some time. Cell phone manufacturers may distribute information through public communications, warning their clients about the possible side effects of using telephones in bed and in poorly illuminated rooms. Ophthalmologists should know about TSB in order to advise their patients, in particular teenagers, on how to use smartphones. In the meantime, researchers advocate precautions, such as wearing sunglasses that filter UV and blue light and advise not reading on mobile devices in the dark, which puts additional stress on delicate photoreceptors.

How can we protect ourselves from blue light in our telephones and laptops, knowing that it is a part of natural sunlight?

Multiple solutions are recommended, including shortening the time of smartphone (computer) use or putting the device away completely. This is particularly important at night, because energy from the transmitted blue light may be more focused and intensified, and can cause more destruction to our retinas. Simply close your eyes or turn your eyes away from the screen for a short period of time to let your eyes rest.

Adults, adolescents and even small children spend more and more time in front of a smartphone and computer. Extended periods of using smartphones at short distances with no eye rest and limited outdoor activity contributes to "accommodation fatigue" manifested as a delay in the accommodation movement and occurrence of functional accommodation spasm (so-called school short-sightedness), i.e. an apparent shift of ocular refraction towards myopia. In the initial period, accommodation spasm may occur periodically, but when adverse work conditions persist (too close distance to the images watched in smartphones with inappropriate lighting) accommodation spasms become prolonged and with time may contribute

to the development of true myopia. To prevent the development of true myopia, we have prepared short 10-min exercises of reading Snellen chart optotypes with ophthalmic lenses (+1.0 D, +1.5 D), with stepwise increases in the distance from the chart [2]. Continuing regular exercises and increased duration of outdoor activities improve visual comfort and help protect patients from the need to permanently use minus power lenses.

Early and adequate recognition of ophthalmic symptoms that may be associated with extended use of smartphones and the implementation of appropriate management can protect against the occurrence of late complications in the form of permanent eye damage.

REFERENCES

[1] Alim-Marvasti A., Bi W., Mahroo O.A., Barbur J.L., Plant G.T.: Transient smartphone "blindness". N. Engl. J. Med., 2016; 374: 2502–2504

[2] Baranowska-George T., Puchalska-Niedbał L., Modrzejewska M.: Metoda leczenia patologicznego skurczu akomodacji wywołanego stresem opracowana w Przychodni Przyklinicznej Katedry Okulistyki w Szczecinie: Opis przypadków. Okulistyka, 2013; 16: 28–30

[3] Blehm C., Vishnu S., Khattak A., Mitra S., Yee R.W.: Computer vision syndrome: A review. Surv. Ophthalmol., 2005; 50: 253–262

[4] Chu C.A., Rosenfield M., Portello J.K.: Blink patterns: Reading from a computer screen versus hard copy. Optom. Vis. Sci., 2014; 91: 297–302

[5] Ha A., Kim Y.K., Park Y.J., Jeoung J.W., Park K.H.: Intraocular pressure change during reading or writing on smartphone. PLoS One, 2018; 13: e0206061

[6] Hasan C.A., Hasan F., Mahmood Shah S.M.: Transient smartphone blindness: Precaution needed. Cureus., 2017; 9: e1796

[7] Kuse Y., Ogawa K., Tsuruma K., Shimazawa M., Hara H.: Damage of photoreceptor-derived cells in culture induced by light emitting diode-derived blue light. Sci. Rep., 2015; 4: 5223

[8] Lanigan L.P., Clark C.V., Hill D.W.: Intraocular pressure responses to systemic autonomic stimulation. Eye, 1989; 3: 477–483

[9] Lee S., Kang H., Shin G.: Head flexion angle while using a smartphone. Ergonomics, 2015; 58: 220–226

[10] Lin C.J., Feng W.Y., Chao C.J., Tseng F.Y.: Effects of VDT workstation lighting conditions on operator visual workload. Indl. Health, 2008; 46: 105–111

[11] Malihi M., Sit A.J.: Effect of head and body position on intraocular pressure. Ophthalmology, 2012; 119: 987–991

[12] Munshi S., Varghese A., Dhar-Munshi S.: Computer vision syndrome – A common cause of unexplained visual symptoms in the modern era. Int. J. Clin. Pract., 2017; 71: 10.1111/ijcp.12962

[13] Qudsiya S.M., Khatoon F., Khader A.A., Ali M.A., Hazari M.A., Sultana F., Farheen A.: Study of intraocular pressure among individuals working on computer screens for long hours. Ann. Med. Physiol., 2017; 1: 22–25

[14] Sathiamoorthi S., Wingerchuk D.M.: Transient smartphone blindness: Relevance to misdiagnosis in neurologic practice. Neurology, 2017; 88: 809–810

[15] Saunders R.A., Helveston E.M., Ellis F.D.: Differential intraocular pressure in strabismus diagnosis. Ophthalmology, 1981; 88: 59–70

[16] Schlote T., Kadner G., Freudenthaler N.: Marked reduction and distinct patterns of eye blinking in patients with moderately dry eyes during video display terminal use. Graefes Arch. Clin. Exp. Ophthalmol., 2004; 242: 306–312

[17] Straker L.M., Coleman J., Skoss R., Maslen B.A., Burgess-Limerick R., Pollock C.M.: A comparison of posture and muscle activity during tablet computer, desktop computer and paper use by young children. Ergonomics, 2008; 51: 540–555

[18] Tosini G., Ferguson I., Tsubota K.: Effects of blue light on the circadian system and eye physiology. Mol. Vis., 2016; 22: 61–72

[19] Yan L., Huibin L., Xuemin L.: Accommodation-induced intraocular pressure changes in progressing myopes and emmetropes. Eye, 2014; 28: 1334–1340

The authors have no potential conflicts of interest to declare.