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Research Article

Comparison of Blink Rate and Blink Pattern between Hard Copy Soft Copy Readers

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Abstract

Aim: The aim of this study is to assess complete and incomplete blinks while reading Hard copy (i.e. paper), Laptop, and I-Pad at arm's length in fix illumination and same font size in sitting position.

Method: A cross sectional hospital based study was performed which include total of 120 subjects (age range 15-30 years) in which 87 were female and 33 were male. All participants had good ocular health and reported no symptoms of dry eye (OSDI score <15). After doing Schirmer test and refractive correction, subjects were asked to read in three different material i.e. Hard copy, Laptop and I-Pad each for 2 minutes. It was performed under the same ambient lighting and environmental conditions and at reading distance of 40 to 60 cm and it was video recorded. The blink rate wasmanually assessed from the video.

Result: From the three reading material, there is reduction of blink rate while using electronic device as compared to Hard copy ($p < 0.001$). There is increase in number of incomplete blinks when reading was conducted on an electronic platform, in contrastto hard-copy text ($p < 0.001$). In Laptop there is decrease in complete blink and increasein incomplete blink compared to I-Pad ($p < 0.001$). Female blinks more in comparison to male ($p < 0.005$).

Conclusion: The study can be concluded by saying that the blinks are reduced while using reading material in electronic devices and further it can be said that incomplete blinks exists more in case of electronic devices. In case of Laptop, blinks were reduced as comparedto I-Pad. Female blinks are more as compared to male ones.

Keywords: Blink rate; Incomplete blink; Complete blink; Hard copy; Laptop; I-Pad

Introduction

Blinking is a protective mechanism for the cornea and conjunctiva, serving to maintain a tear layer over the ocular surface that is necessary for epithelial health and optical performance [1]. Normal blinking is essential to ensure the normal distribution of the tear film and to protect the ocular surface. Blinking abnormalities may result in poor tear distribution and hence cause damage to the ocular surface. Several studies have investigated the blink rate and the interval between blinks. It has been reported that the normal spontaneous blink rate is 12 to 15 per minute [3]. Blink speed can be affected by elements such as fatigue, eye injury, medication and disease.

There are three types of blink

Spontaneous blink

It occurs without any obvious external stimuli or voluntary willed efforts [15].

Reflex blink

It refers to the coordinated closing and opening movements of eyelid which occur reflexly in a response to some direct stimulus [15].

Voluntary blink

It refers to coordinated closure and opening movement of the eyelids, when carried out as a willed act in both eyes [15].

The usage of digital devices is increasing day by day in every area. Today's visual requirements may include viewing Laptop , tablets or I-Pad , electronic book readers, smartphones and other electronic devices both in workplace, at home or in the case of portable equipment, in any location [16].

In this study the subjects were ask to read in Hard copy, Laptop and I-Pad at 40 and 60 cm and they were video recorded to assess the blink rate while using different materials.

Ocular discomfort and visual fatigue are commonly reported during performance of close tasks such as reading, particularly when electronic devices are employed.

Many studies have explored the relationship between eye fatigue and use of VDTs [11]. One previous study found that the symptom most frequently reported among office workers was tired eye 40%; 30% reported symptoms of dry eye and eye discomfort [3].

Computers, tablets, and smartphones have become part of daily life and may increase risk of developing many ocular symptoms. In addition to a reduction in the number of blinks, an increase in the number of incomplete blinks during computer use has also been reported. Changes in the blink rate and pattern during computer use may cause ocular discomfort symptoms triggered, in turn, by lack of adequate tear distribution [3].

Aim

The aim of this study is to assess complete and incomplete blinks while reading Hard copy (i.e.: paper), Laptop, and I-Pad at arm length in fix illumination and same font size in sitting position.

Materials and Methodology

Study design: Cross sectional study.

Materials

- Schirmer strip
- Lux meter
- Mobile stand
- Laptop
- I-Pad
- Hard-copy

Inclusion criteria

- Good ocular health
- Age group 15 years to 30 years

Exclusion criteria

- Subjects having:
- Dry eye
- Any ocular pathology
- Systemic disease
- Contact lens users
- Subjects with Binocular vision imbalance
- Mentally retarded patients

Methods

120 participants with age ranging from 15 to 30 years were recruited for this study. Assessment of ocular health by torch light of all participants were done [2]. All participants were in good general and ocular health. No subject had any history of ocular or systemic disease, binocular vision abnormality, or any signs or symptoms of dry eye (according to Ocular Surface Disease Index [OSDI] score <15) [3]. First dry eye was assessed with the help of Schirmer strip and then all participants had binocular corrected distance and near visual acuity. Near point of convergence is measured with the help of pen and scale. Three reading materials were in same font and with same line spacing and typeface. All reading tasks were performed under the same ambient lighting and environmental conditions and at reading distance of 40 to 60 cm.

The study was carried out in three different modes of material.

- Hard copy with font size of 12 at 40 cm
- Laptop with font size of 12 at 60 cm
- I-Pad with font size of 12 at 40 cm.

Each of the study in the above three modes was carried out for a duration of two minutes.

Texts were presented in electronic devices (tablet and Laptop at 100% zoom levels) and Hard copy. To measure the blink rate, all participants were video recorded while six minutes of control reading in three different materials. The number of blinks was manually counted. Subjects were not informed that blinking would be monitored until after completion of the reading sessions to avoid possible contamination of the results [1].

Baseline and reading conditions

Three different experimental were tested (Hard copy, Laptop and I-Pad). A collection of different material for reading is done as for Hard copy it is "how to keep healthy eyes", for Laptop "why do we have asthenopia", and for I-Pad "most common eye diseases" [10]. All texts were presented in the same type face (times new roman), font size (12), line spacing (1.15), and approximate number of words per page. Electronic reading took place on a panoramic 15.6-inch, 16:9 LCD set to a resolution of 1366 x 768 pixels, and on a 9.7-inch, 4:3 display tablet at a resolution of 2048 x 1536 pixels. The same display was employed to present the text at 100% magnification. The Hard copy was of A4 size [2]. The level of luminance emitted by each display (computer and tablet) and room illumination was measured with a lux meter. Small differences in luminance were allowed to guarantee correct visualization of the text. Room temperature and humidity were maintained at 35 degree Celsius (+/-5 degree) and 90% (+/- 10%) respectively [2]. Background illumination was between 500 and 550 lux, and provided by diffuse lighting to avoid unwanted screen reflections.

Procedure

Following a complete visual and ocular examination according to the inclusion and exclusion criteria, each participant completed the sequence of experimental conditions in an order to account for the potential effect of fatigue on the results. All measurements including refractive correction were completed in approximately 20-25 minutes. Subjects were instructed to scroll down using the finger by lightly tapping the edge of the screen (I-Pad) or physically turning page (Hard copy text) and in Laptop by scrolling down by down switch or by cursor. All participants were instructed to use their spectacles [2].

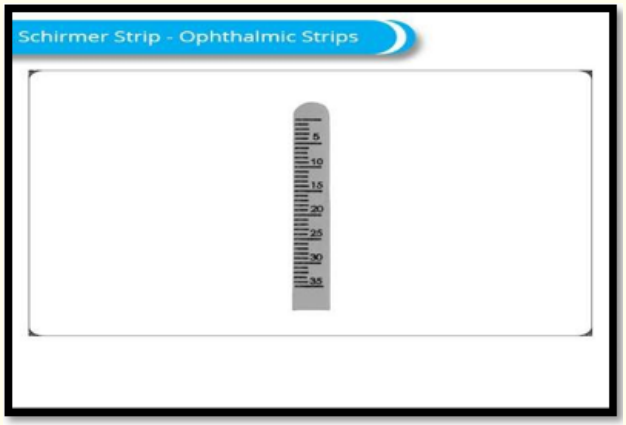


Figure 1: Schirmer strip.

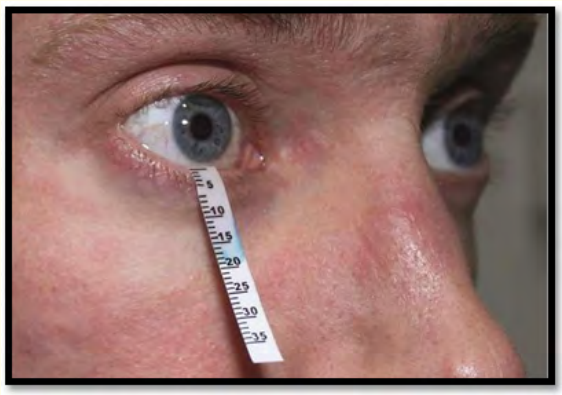


Figure 2: Schirmer strip.

Figure 3: I-PAD.

Figure 4: Lux meter.

Figure 5: Mobile stand.

Figure 6: Laptop.

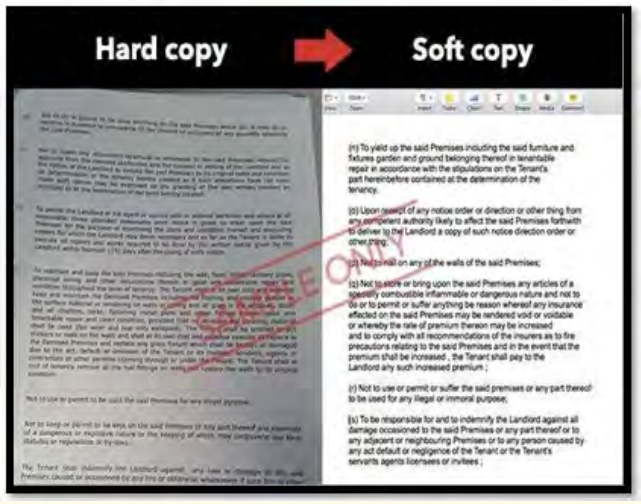


Figure 7: Hard-copy.

Figure 8: Incomplete blink.

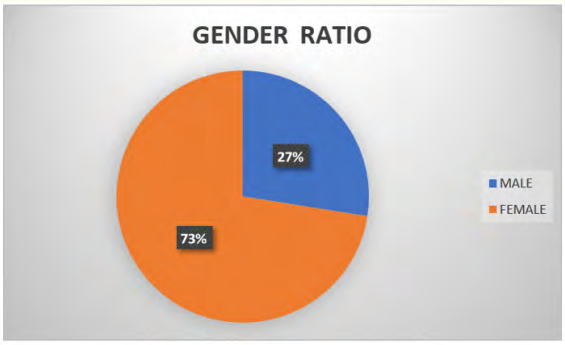
Figure 9: Complete blink.

Video recording and analysis

During reading sessions, video captures of the eyes of the participants were obtained with iPhone 7 which is attached to a mobile stand at a resolution of 750 x 1334 pixels. All video captures were saved for subsequent analysis. Complete masking was not possible as line of gaze and convergence were markers of observation distance. Complete blinks were counted when none of the cornea was visible on blink completion Otherwise, blinks were counted as incomplete. Minor twitches or lidtremors were ignored [2].

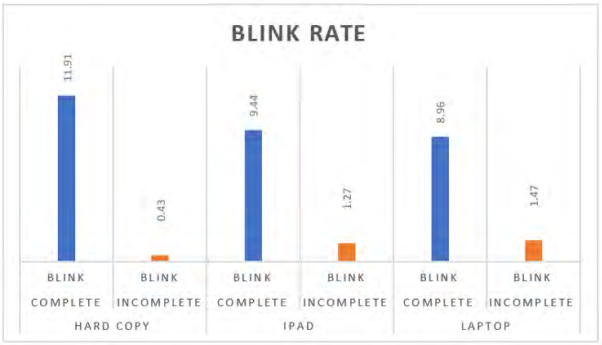
Results

Total of 120 subjects were included in this study, from which 87 were females and 33 were males with the age in range between 15 to 30 years. Number of complete and incomplete blink were assessed.



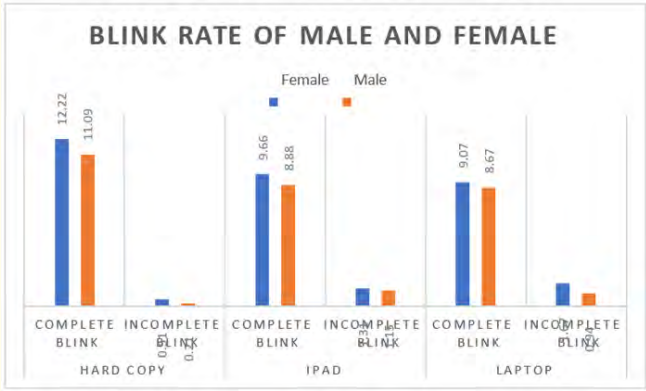
Graph 1: Distribution of gender ratio.

Graph 1 shows the ratio of female and male of which 27% are and 73% are female.



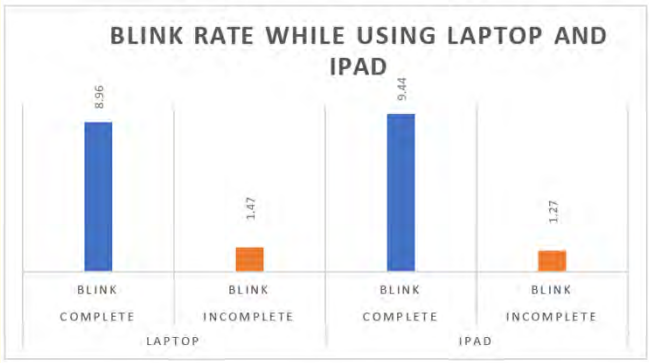
Graph 2: Complete and Incomplete blink rate while reading in 3 different materials.

Graph 2 represents comparison of complete and incomplete blink rate per 1 min between Hard copy, Laptop, and I-Pad. In HC the mean value of complete and incomplete blink is 11.91 ± 2.80 of SD and 0.43 ± 0.75 of SD respectively, in Laptop mean value of 8.96 ± 2.56 of SD for complete blink and mean value of 1.47 ± 1.32 of SD for incomplete blink. In I-Pad mean value of complete and incomplete blink is 9.44 ± of 2.66 SD and 1.27 ± 0.69 of SD. There is statistically significant difference between Hard-copy text and electronic text, with electronic reading leading to increase in incomplete blink compared to Hard copy ($p < 0.001$).



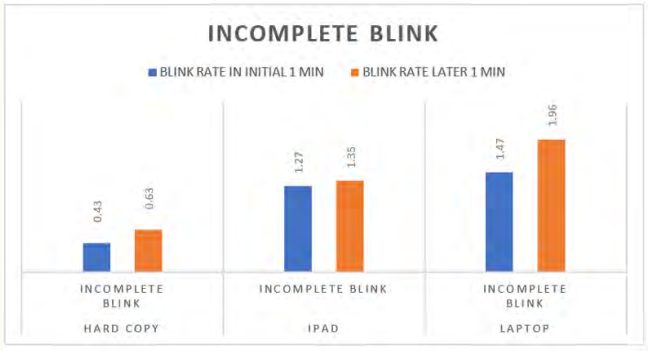
Graph 3: Comparison of complete and incomplete blink between male and female.

Graph 3 represents the comparison of blink rate between male and female. This graph shows that blink rate is more in female than male. The mean value for complete blink for female and male while reading in Hard copy is 12.22 ± 2.86 of SD and 11.09 ± 2.47 of SD respectively. The mean value for incomplete blink for female and male while reading in Hard copy is 0.51 ± 0.82 of SD and 0.21 ± 0.48 of SD respectively. In I-Pad for female and male mean value of 9.66 ± 2.76 of SD and 8.88 ± 2.33 of SD for complete blink and mean value of 1.31 ± 0.77 of SD and 1.15 ± 0.44 of SD for incomplete blink respectively. The mean value for complete blink for female and male while reading in Laptop is 9.07 ± 2.59 of SD and 8.67 ± 2.48 of SD. The mean value for incomplete blink for female and male while reading in Laptop is 1.67 ± 1.42 of SD and 0.94 ± 0.83 of SD respectively. For female and male complete and incomplete blink has statistically significant value ($p < 0.001$) and ($p < 0.005$).



Graph 4: Comparison of Blink rate between Laptop and I-Pad reading.

Graph 4 represents comparison of complete and incomplete blink between Laptop, and I-Pad. From the graph complete blink rate is more while using I-Pad compared to Laptop and incomplete blink is more while using Laptop compared to I-Pad. The mean value for complete and incomplete blink for Laptop is 8.96 ± 2.56 of SD and 1.47 ± 1.32 of SD respectively. For I-Pad mean value for complete and incomplete blink is 9.44 ± 2.66 of SD and 1.27 ± 0.69 of SD. There is statistically significant difference between Laptop and I-Pad reading ($p < 0.001$).



Graph 5: Number of Incomplete blink for initial 1 minute and later 1 minute.

Graph 5 represents the incomplete blink rate of initial 1 minute and later 1 minute. In Hard copy mean value for incomplete blink of initial 1 min and later 1 min is 0.43 ± 0.75 of SD and 0.63 ± 0.82 of SD respectively. For I-Pad mean value for initial 1 minute and later 1 minute for incomplete blink is 1.27 ± 0.69 of SD and 1.35 ± 1.07 of SD respectively. In Laptop mean value for incomplete blink for initial 1min and later 1 minute is 1.47 ± 1.32 of SD and 1.96 ± 1.36 of SD. It shows that as time increases there is increase in number of incomplete blink ($P < 0.001$).

Discussion

Total 120 subjects were enrolled in this with age group between 15-30 years out of which 87 were female and 33 were male.

The aim of the present study was to assess several blink related parameters while participants read texts in hard-copy and electronic format under controlled conditions. Normal blink rate is 15 blinks per minute [1].

Marc Argiles; Genis Cardona; Elisabet perezcabre; Margarita Rodriguez in their study concluded that the statistically significant differences were found between hard- copy and electronic reading in the percentage of incomplete blinks. Female blinks more than male in their study.

In this study there is reduction of blink rate while using electronic devices compared to Hard copy and also there is increase in number of incomplete blink while reading in electronic devices. It shows statistically significant differences between Hard copy and electronic devices for number of incomplete blinks ($p < 0.001$) so it is also clinically significant. In present study comparing the gender, female blink rate is more compared to male in both electronic device and Hard copy. The statistically significant difference is seen ($p < 0.005$).

Abusharha Ali A. in their study confirmed that both the blink rate and ocular comfort were strongly affected by close visual tasks. Both reading conditions influenced blinking; this may interfere in tear film dynamics .Result shows that there is significant fall in the blink rate was found after 15 min of reading either book or text on the electronic device. No significant difference was seen in the blink rate among the three 5 min intervals (5, 10, and 15 min) when text was presented in either Hard copy or on electronic device.

In this study there is increase of incomplete blink later 1 minute of blink as compared to initial 1 min and also there is reduction in number of blinks in Hard copy as well as electronic devices for later 1 minute. It shows statistically significant differences ($p < 0.001$).

Portello JK., *et al*. in their study concluded that CVS symptoms are associated with a reduce blink rate, the completeness of the blink may be equally significant.

In this study there is reduction of blink rate while using electronic devices as compared to Hard copy. While using Hard copy the mean value for complete blink is 11.91and for incomplete blink is 0.43 and for Laptop and I-Pad mean value for shows 8.96 and 9.44 of complete blink and 1.47 and 1.27 of incomplete blink respectively, which shows statistically significant value so it is also clinically significant ($p < 0.001$).

Freudenthaler N., *et al*. in their study concluded that VDT use is associated profound decrease of the SEBR in healthy subjects.

In this study there is decrease of SEBR while reading in electronic device i.e. is complete blink in healthy subjects which is statistically significant value ($p < 0.001$).

Measurements were restricted to 2 minutes, instead of the recommended 5 minutes, as it was observed that some of the participants failed to remain interested in the fixation target after 3 minutes [3]. In agreement with other studies, all reading conditions, both in hard-copy and electronic device, led to a similar reduction in SEBR [3]. Laptop and I-Pad at 100 % zoom level resulted in a SEBR, with median values of 8.96 and 9.44 blinks per minute, respectively. Previous researchers have reported that the ocular discomfort experienced by computer users may be associated with an increase in percentage of incomplete blinks [11]. In addition, this difference was particularly significant when comparing the 100% display (1.47 of incomplete blinks) and the I-Pad (1.27 of incomplete blinks) with Hard copy (0.43 of incomplete blinks). In effect, in contrast with Hard copy reading, reading in electronic format led to an increase in the percentage of incomplete blink and reduction of blink rate compared to Hard copy. Females were found to blink more frequently than men.

It may be argued that reading text presented in Hard copy or electronic formats is one of the most common cognitive demanding near-vision tasks [3]. Dry eye is a frequently reported symptom amongst VDT users, reading in paper format has not been traditionally associated with complaints of dry eye [1]. It may be noted that ergonomic recommendations for these devices suggest that the center of the display should be placed slightly lower than the horizontal line of sight. In contrast, Laptop users have been observed to place their devices in a variety of positions, usually opting for a lower position, compared with desktop computer users. As for tablets, e-books, and other handheld devices such as smartphones, they are usually viewed in inferior gaze, similar to traditional printed reading material, and at a shorter distance, although user preferences may vary [3]. Also, 20-20-20 rule should be explained to overcome from eye fatigue and eye strain. Look away from the screen every 20 minutes at 20 feet away for about 20 seconds and blink normally.

It must be noted that there is reduction of blink rate while using electronic device as compared to Hard copy and there is increase in incomplete blink while using Laptop as compared to I-Pad and Hard copy. According to gender, female blinks are more than male either in Hard copy, Laptop or I-Pad.

The previous studies show that the reduction in blink rate causes increase in the rate of tear-film breakup, along with a decrease in tear and mucin production and Meibomian secretions in both normal and dry eye patients with the disruption of tear-film components. As such, dry-eye patients are at a particular disadvantage during reduced-blink rate activities, such as working on the computer, reading, driving, etc. Exacerbation of dry-eye signs and symptoms from a reduced blink rate can lead to visual function disturbances [17]. Furthermore, a reduced tear-film breakup time and the prolonged exposure of surface produce a disrupted air-fluid interface, which in turn disrupts light transmission to retina. Hence, visual function is impacted [18].

Computer vision syndrome happens because your eyes follow the same path over and over and it gets worse the longer you continue the movement. When you work at a computer or Laptop, your eyes have to focus and refocus all the time. Your eyes react to images constantly moving and changing, shifting focus. All these jobs require a lot of effort from your eye muscles, the screen adds contrast, flicker, and glare. It is proven that we blink less frequently when using computer or electronic device, which causes the eyes to dry out and blur your vision periodically while working. Symptoms may include blurred vision, double vision, dry and red eyes, eye irritation, eye fatigue, headaches and neck or back pain [19].

Conclusion

The study can be concluded by saying that the blinks are reduced while using reading material in electronic devices and further it can be said that incomplete blinks exists more in case of electronic devices.

In case of Laptop, there is reduction in blink rate as compared to I-Pad.

There is increase in incomplete blink as time increases. Female blinks more as compared to male.

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