

Changes in Accommodative Parameters After E-reading

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Abstract

Background and Objectives: The purpose of the study was to determine changes in accommodative parameters after constant reading from digital print (Kindle and MacBook) and hard print (Novel).

Methods: A total of 30 subjects were enrolled in the study with the age group between 18 to 30 years (21.4 ± 1.5) years. A complete eye examination was performed on all subjects including the assessment of accommodative parameters. Subjects were made to read a novel for 30 minutes after which an assessment of accommodate parameters was done again, A break of 2 hours subjects were made to read from kindle for 30 minutes followed by an assessment of accommodative parameters. Again, a break of 2 hours was given, followed by reading on MacBook and, an assessment of accommodative parameters was done post-reading.

Results: There was a significant decrease in the Negative Relative Accommodation (NRA) and binocular Accommodative Facility (AF) while using the MacBook in comparison with the other devices mentioned. There were no significant changes in the other Accommodation parameters i.e., Near Point of Accommodation (NPA), Positive Relative Accommodation (PRA), Monocular Estimation Method (MEM), and uniocular Accommodative facility.

Conclusion: Reading from MacBook induce slight increase in accommodative parameters, while Kindle can be used for reading with minimal effects on accommodative parameters as compared to traditional books.

Keywords: Accommodation; Kindle; MacBook; VDU; Reading; Hard Print; Softcopy

Introduction

Digital devices (computers, tables, TV and mobile phones) have been increasing in the past few years. People of all ages are using digital devices for either work, academic, or entertainment purposes. After the COVID-19 outbreak, most countries applied lockdown as a preventive measure to stop or slow down the spread of the COVID-19 virus, during this period the usage of digital devices has been increased, as outdoor activities had been very

limited [1]. A shift of professional, education and social activities being undertaken on web applications and/or mobile applications post-onset of the novel coronavirus resulted in increased usage of digital devices. These activities include work from home, online execution of class, E-assignments, personal and social video calls, webinars, shopping, leisure, entertainment etc. It has been proven that approximately 75% of companies have incorporated desktop computers into the workplace [2]. Reading from digital devices is

no longer limited to a desktop computer located in the workplace. Advancements in digital devices, the use of laptops, tablets, and electronic book readers like Kindle and smartphones. This is ensuing the replacement of hard print materials, as digital devices have become an elemental part of individuals' daily lives [3].

The term computer vision syndrome (CVS) is applied collectively to a set of disparate symptoms in computer users who either are habitually or are obliged to use computers for a prolonged time during day and night [4]. These include asthenopia, irritation, redness, blurred vision, and double vision, in sum are referred to as computer vision syndrome. A handheld electronic device screen was shown to significantly influence subjective asthenopia symptoms in conjunction with objective tear film breakup time (TBUT). Markedly, asthenopia resulted even when using state-of-the-art, high pixel quantity technology (improved retina display) [5,6].

The accommodative parameters are fundamental parts of eye examination to determine optimal refractive correction and to eliminate vision-related problems while employing VDU as a target. Likewise, it is a proven association of accommodation with vision fatigue and asthenopia symptoms while performing near work. Abnormality of accommodation (i.e., insufficiency, in-facility, and lag) was recorded in VDU users [7].

Accommodative problems can induce asthenopia [8,9] and a meagre difference was shown between viewing digital devices and hard copy [10].

As the technologies improve with time, many institutions have induced a digital way of teaching and the traditional paper reading is almost minimized for students as well as for teachers. Laptops, Kindles, tablets and phones are widely used by students for reading purposes. So this study aims to compare changes in the accommodative parameters on reading from Digital print (Kindle, MacBook) and Hard print (Novel). Previous Studies, showed subjective changes against the digital devices, which involved questionnaires and proved to cause more eye strain and asthenopia. Whereas our study aims to compare the changes on basis of tests performed without using questionnaires.

Materials and Methods

A prospective analytical study was conducted at Nethradhama School of Optometry, in association with Nethradhama Super

speciality Eye Hospital from March 2021 to November 2021. A total of 30 subjects were enrolled in the study with the age group between 18 to 30 years (21.4 ± 1.5) years. Subjects were enrolled in this study based on the inclusion and exclusion criteria. Inclusion criteria: Subjects between the age group of 18-30 years, emmetropes (with the spherical equivalent of ± 0.25 D to ± 0.50 D), subjects with normal contrast sensitivity and colour Vision, subjects with normal binocular vision, and subjects with Intermediate English proficiency. Exclusion criteria: Subjects with refractive error; subjects with binocular vision disorders, subjects with abnormal retinal correspondence, undergone any ocular surgeries, Poor contrast sensitivity, subjects with previous ocular or systemic history and subjects with any ocular abnormalities. A detailed history of every subject was recorded. Both males and females were included in the study. The subjects underwent comprehensive optometric examinations. Subjects with BCVA underwent a detailed binocular visual assessment (sensory, motor, and accommodative evaluation). Each subject was informed about the procedure and written consent was obtained from each subject. After obtaining the informed consent form, the subjects were enrolled in the study. The study was usually performed from 9 am and the subject's preliminary data was recorded and were made to read the novel for 30 mins after which data was recorded again. A break of a minimum two of hours was given, followed by reading from Kindle and MacBook. The subjects were presented with a novel (The Alchemist), the same reading material was given in three parts – kindle, MacBook, and novel. The subject had to read on each device for 30 minutes in full room illumination (500lux), after which accommodative parameters were measured and acquired values were noted down. A break of at least 2 hours was given in between each reading to relax the stimulated accommodation induced in the previous 30 minutes of reading. Subjects were requested not to use their cell phones or other digital devices and indulge in near-focus demanding tasks during the break periods.

Statistical analysis

All the statistical analyses were carried out with SPSS PC software version 25.0. Test for normality for our sample was performed using the Kolmogorov-Smirnov test as our sample size was less than 50. For comparison related samples between groups, we have used repeated measured parametric for data which was normally distributed and Friedman test for samples that were not normally distributed. Post HOC analysis was done using Bonferroni

adjustment. A pValue less than 0.05 was taken as statistically significant.

Results and Discussion

A total of 30 subjects were enrolled for the study (17 males and 13 females) in the age group of 18 to 30 years with a mean age of 21.4 (1.5) years. NPA data showed no significant change after reading from Kindle, MacBook, and Novel. The median NPA value for the right eye, left eye, and binocularly is mentioned below in table 1. No statistically significant differences were found in NPA monocularly and binocularly after reading from Kindle, MacBook, and Novel.

| Eye | Preliminary (cm) | Kindle (cm) | Macbook (cm) | Novel (cm) | p-value |
|-----|------------------|-------------|--------------|------------|---------|
| OD | 6.0 (1.0) | 6.0 (2.0) | 6.0 (1.0) | 6.0 (2.0) | 0.116 |
| OS | 6.0 (1.0) | 6.0 (2.0) | 6.0 (1.0) | 6.0 (2.0) | 0.131 |
| OU | 6.0 (1.0) | 6.0 (1.0) | 6.0 (2.0) | 6.0 (1.0) | 0.396 |

Table 1: Median (IQR) of Near point of accommodation.

The means PRA and standard deviations with p-value are reported in table 2, which is denoted in Diopters (D). PRA data showed no statistically significant difference between reading from Kindle, MacBook, and Novel.

| Preliminary (D) | Kindle (D) | Macbook (D) | Novel (D) | p-value |
|-----------------|------------|-------------|------------|---------|
| -5.9 (1.1) | -5.8 (1.1) | -5.9 (1.1) | -6.0 (1.1) | 0.605 |

Table 2: Mean (SD) of Positive relative accommodation.

The means NRA and standard deviations with p-value are reported in table 3, which is denoted in Diopters (D). A statistically significant difference in NRA values was reported and pairwise comparison, which indicated a statistically significant decrease in NRA value after reading from MacBook compare to kindle and novel (p-value < 0.05).

| Preliminary (D) | Kindle (D) | Macbook (D) | Novel (D) | p-value |
|-----------------|------------|-------------|-----------|---------|
| 3.6 (0.8) | 3.4 (0.8) | 3.1 (0.7) | 3.4 (0.8) | 0.005 |

Table 3: Mean (SD) of Negative relative accommodation.

MEM median values are reported in table 4. No statistically significant difference was found in MEM after reading from kindle, MacBook, and novel.

| Preliminary (D) | Kindle (D) | Macbook (D) | Novel (D) | p-value |
|-----------------|--------------|--------------|--------------|---------|
| 0.000 (0.50) | 0.000 (0.31) | 0.000 (0.50) | 0.000 (0.25) | 0.153 |

Table 4: Median (IQR) of Monocular estimation method.

Accommodative facility MEAN values are reported in table 5. There was a significant change in the binocular accommodative facility. Pairwise comparison showed accommodative facility statistically significant decrease after post-reading from MacBook in comparison to kindle and novel reading (p-value < 0.05).

| Eye | Preliminary (Cpm) | Kindle (Cpm) | Macbook (Cpm) | Novel (Cpm) | p-value |
|-----|-------------------|--------------|---------------|-------------|---------|
| OD | 13.0 (3.0) | 13.5 (2.5) | 12.4 (2.7) | 13.5 (2.1) | 0.051 |
| OS | 13.1 (3.0) | 13.2 (2.6) | 13.3 (2.4) | 13.3 (2.8) | 0.156 |
| OU | 12.5 (3.3) | 12.6 (2.6) | 10.8 (2.3) | 13.2 (2.9) | 0.000 |

Table 5: Mean (SD) of Accommodation facility.

There were no changes seen in the near point of accommodation (NPA), positive relative accommodation (PRA), and monocular estimation method(MEM) whereas there was a slight decrease in the binocular accommodative facility and negative relative accommodation(NRA) while reading from MacBook as compared to the other readings that were recorded (preliminary, kindle and novel). A similar study done by Marco Pedrotti., et al. titled "E-Readers and Visual Fatigue" showed that both objective (Blinks per second) and subjective (Visual Fatigue Scale) measures suggested that reading on the LCD (Kindle Fire HD) triggers higher visual fatigue concerning both the E-ink (Kindle Paperwhite) and the paper book [12]. The absence of differences between E-ink and paper suggests that, concerning visual fatigue, the E-ink is indeed very similar to the paper. Our study showed no accommodative changes when reading from a novel and a kindle and kindle appear as a close to a book reading experience whereas MacBook or LCD

screens have a slight impact on the accommodative parameters while compared to kindle and novel. Hence this study signifies that the kindle can be used for reading with minimal effects on accommodative parameters as compared to traditional books. Also adding additional convenience to students as they don't have to carry multiple bulky textbooks as one kindle device can display all the downloaded textbooks. A decrease in NRA and binocular accommodative in the MacBook facility implies there may be associated vergence related factors, which should be assessed in future studies.

Conclusion

Kindle can be considered close to a book reading experience and reading from kindle compared to reading in novel whereas reading from MacBook induces a slight increase in the accommodative parameters i.e., Negative Relative Accommodation and binocular accommodative facility as compared to a novel and kindle. The study might pose suggestions for changes in vergence parameters, which were not included in this study.

Conflict of Interest

The authors declare that they don't have any conflict of interests.

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