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COMPARISON OF INTRAOCULAR PRESSURE CHANGES AFTER VIEWING LAPTOP COMPUTER AND TABLET COMPUTER: A PILOT STUDY

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ABSTRACT: Prolonged computer use has been reported to be associated with elevated intraocular pressure (IOP) and an increased risk of Computer Vision Syndrome (CVS). However, this issue has been one of controversy. This study aimed to preliminarily investigate the effect of using a laptop computer and tablet computer in terms of changes to IOP in healthy adult participants. Ten healthy participants (aged 27.6 (6.4) years, ranging 21-39 years; male: female = 2:8) participated and were randomly assigned to either the laptop computer user or the tablet computer user group. Each subject was requested to work on either a laptop or tablet for 60 minutes. The IOP was subsequently measured via a non-contact tonometer in both eyes at 15, 30, 45, and 60-minute intervals. Pre-intervention IOP and IOP changes were compared within and between groups. The results showed that mean IOP at each interval was not significantly different when compared among pre-intervention at different time points in both eyes. Mean IOP in the laptop computer group was slightly higher than that of the tablet computer group, yet there was no significant difference. The results of this study demonstrate that laptop and tablet usage for 60 minutes may not affect IOP levels in healthy volunteers. Hence, further research involving a larger sample size and longer exposure time to computer screens is needed.

Keywords: Intraocular pressure, Laptop computer, Tablet computer, Computer vision syndrome

1. INTRODUCTION

Nowadays, computers have a great deal of impact on almost every aspect of our daily lives. Moreover, they have been developed to be easily carried in the form of portable computers, including laptop computers, tablet computers, and smartphones [1]. These devices are employed worldwide due to their convenience and efficiency with regards to accessing information, writing articles, communicating with others, and watching videos [2].Consequently, many individuals spend a significant amount of time utilizing digital devices. With the rapid growth of digital device usage, there has been an increase in the development of numerous computer-related visual symptoms. Symptoms reported include headaches, eye strain, blurred vision, and eye irritation with symptom severity rising with the number of hours spent on devices [3-5]. Collectively, these disorders are known as computer vision syndrome (CVS) [6]. A plethora of recent studies have suggested that prolonged exposure to computer screens can cause elevated intraocular pressure (IOP) [7-8].

Elevated IOP is one significant risk factor concerning degenerative eye disease and glaucoma: one of the leading causes of preventable blindness worldwide [9-12]. This ocular disease, if untreated, may lead to optic nerve degeneration and possibly result in visual impairment and blindness [13]. IOP is considered as typical between the ranges of 9 to 21 mmHg [14-15]. Moreover, the risk of developing glaucoma may increase if IOP rises above 21 mmHg [15].

There is a significant increase in the risk of developing visual field loss (even with only a small increase in IOP), especially once IOP rises above 26 mmHg to 30 mmHg [16-17]. As a consequence, almost all current treatment options for glaucoma aim to lower or prevent a rise in IOP [18]. Body posture is believed to be one factor that influences IOP fluctuation [19]. A previous study found that there was a significant increase in IOP during neck flexion when measured in the sitting position among healthy participants [21].

Furthermore, due to the portability of, and ability to carry computer devices, many individuals tend to spend several hours a day using a laptop or tablet computer accompanied with a weak and damaging posture. A prolonged poor-posture coupled with staring at a computer screen for extended periods may cause more severe elevation of IOP, and subsequently appear to put users at an increased risk of developing glaucoma. One study demonstrated that the implementation of smartphones rendered a more pronounced head flexion when compared to utilizing desktop computers [20].

As noted previously, some studies have reported that the range of head flexion among users is related to different types of computer tasks and computer devices [20], [22]. Another study highlighted that tablet computer screen viewing is significant in inducing visual fatigue and discomfort [23]. A further recent research focused on employing smartphones in daylight and low-light conditions in terms of alterations to IOP.

To date, no definite conclusion has been mentioned in terms of the effects of prolonged usage of portable computers incorporating different degrees of head flexion on IOP in healthy participants. Hence, this study aimed to preliminarily explore the impact of two different head positions while viewing a computer screen. The study also compared IOP values between laptop and computer users, and tablet computer users at different time points.

2. METHODS

2.1 Participants

All study participants were either students or employees of Khon Kaen University, Thailand, aged between 20 and 40 years. The study was approved by the Khon Kaen University Ethics Committee for Human Research. Participants were given details of experimental procedures prior to the study, and consented to participate.

They were then requested to complete a questionnaire on computer usage amid their daily lives. Participants who spent more than 4 hours a day viewing a computer or tablet were selected for participation.

Moreover, participants were included if they presented no signs or symptoms of glaucoma, crossed eyes, narrow angles, corneal infection or ulcer, corneal scarring, uveitis, retinal tear, or detachment. Each recruited volunteer's IOP was less than or equal to 22 mmHg in the sitting position with a refractive error of between -4.00 and +2.00 diopters.

Subjects were excluded as follows: (1) history of β–blockers or steroids before IOP measurement taking, and (2) unable to maintain the head in the neck flexion or neck extension position throughout the course of at least 15 minutes.

The researcher requested participants not to drink caffeinated products or alcohol 12 hours prior, and to sleep for at least 6-8 hours the night preceding IOP determination.

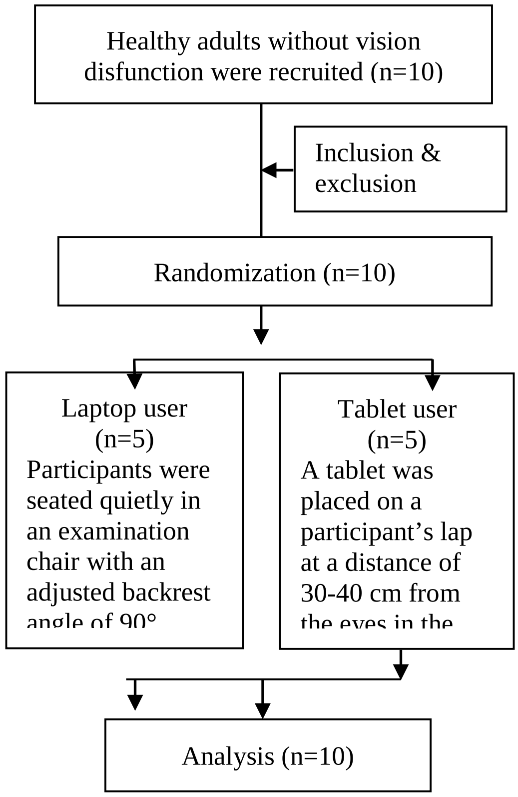

Fig.1 Study procedure flow chart

2.2 Materials and Procedures

In this preliminary study, participants were randomly assigned to either the laptop computer user group or tablet computer user group as follows:

Group 1 (the laptop computer users group): firstly, participants were seated quietly in an examination chair with an adjusted backrest angle of 90° for 5 minutes. After resting, participants were assessed for IOP as a pre-intervention value by the researcher. Then, they were asked to watch a laptop computer screen (LENOVO™ Ideapad 310, Lenovo Group Ltd., China, 14-inch screen, 141 PPI) with brightness set at 188 cd/m^2. Viewing distance was at approximately 50 cm. IOPs were subsequently measured at 15, 30, 45, and 60 minutes following exposure to the laptop screen.

Group 2 (the tablet computer user group): in this group, tablet computer (iPad® Pro 3rd Generation, Apple Inc., California, USA, 12.9-inch screen, 264 PPI) with brightness set at 600 cd/m^2 was employed. After a resting period of 5 minutes, a tablet was placed on a participant's lap at a distance of 30-40 cm from the eyes. IOPs were measured before viewing and at 15, 30, 45, 60 minutes post-viewing. Each participant was requested to maintain a head posture with the neck at a 40° to 60° flexion while viewing the tablet for 15 minutes. IOP was evaluated in the upright position.

All IOP measurements were taken within 30 seconds in a 90° upright sitting position with the right eye always measured first. IOP readings were obtained via the same non-contact tonometer (NCT; Nidek Co., Ltd., Aichi, Japan) over three consecutive occasions, with text means recorded for further statistical analysis. During laptop computer and tablet computer implementation, participants were requested to continuously maintain the same head posture and distance from the screen.

Data collection was obtained at a research laboratory located at the Faculty of Associated Medical Sciences, Khon Kaen University, Thailand. The study procedure was performed in an experimental room incorporating an illumination level of 300 lux with a room temperature of 25°C. All measurements were scheduled between 08:00-10:00 in the morning, to avoid possible diurnal IOP variation.

2.3 Statistical Analysis

Statistical analysis was performed using SPSS software version 23.0 for Windows (SPSS Inc, Chicago, IL). All variables were presented as mean (standard deviation, SD) or median (interquartile range, IQR) or frequency (percentage, %).

A comparison of mean values between pre-intervention and different time points within each group was analyzed by applying a paired sample t-test. Meanwhile, the independent-sample t-test was applied to compare between groups. For all tests, P-values of less than 0.05 were considered statistically significant.

Table 1 Demographics

Variables	Study group (n=5)	Control group (n=5)	p-value
Gender, n (%)			1.00
Male	1 (20)	1 (20)	
Female	4 (80)	4 (80)	
Age (year), mean (SD)	29.8 (7.9)	25.4 (4.1)	0.30
Weight (kg), mean (SD)	58.2 (9.2)	61.4 (14.5)	0.68
Height (cm), mean (SD)	163.2 (7.7)	162.4 (6.80	0.86
BMI (kg/m^2), mean (SD)	21.8 (2.7)	23.3 (6.8)	0.59
VA: LogMAR, Median (IQR)			
Right eye	0 (0, 0)	0 (0, 0)	1.00
Left eye	0.2 (0, 0.5)	0.2 (0, 0.5)	1.00

Data were expressed as mean (standard deviation, SD), median (interquartile range, IQR), or frequency (percentage, %); body mass index, BMI; visual acuity (VA); data were calculated via chi-square test, and t-test or Mann Whitney U-test which calculated continuous data.

3. RESULTS

A total of 10 healthy adults were included (8 females and 2 males) in this preliminary study with an age range of 27.6 (6.4) years (ranged 21-39). Half of the participants were assigned to watch a laptop computer screen, while the remaining participants were assigned to watch a tablet computer screen. Participants' demographic data are summarized in Table 1.

Table 2 Changes in intraocular pressure (IOP, mmHg) within groups

Group	Side	Pre-intervention	15 min	30 min	45 min	60 min
Laptop computer user	Right eye	14.5 (1.9)	15.1 (2.0)	14.9 (4.3)	15.1 (2.5)	15.3 (2.1)
	p-value		0.32	0.78	0.17	0.20
	Left eye	14.0 (2.4)	14.7 (2.0)	14.3 (2.8)	14.1 (2.3)	13.2 (1.6)
	p-value		0.19	0.71	0.82	0.46
Tablet computer user	Right eye	13.1 (1.6)	13.5 (1.9)	12.3 (1.9)	12.8 (2.3)	12.9 (1.7)
	p-value		0.69	0.47	0.75	0.80
	Left eye	12.4 (1.8)	12.7 (1.8)	12.2 (2.1)	12.4 (2.3)	12.2 (1.9)
	p-value		0.83	0.71	1.00	0.61

Data were expressed as mean (standard deviation, SD) and calculated via pair sample t-test.

Table 2 shows the IOP measurements obtained on both sides (the right and left eyes) of both groups (both laptop computer user group and tablet computer user group). IOP values at four intervals were checked (15, 30, 45, and 60 minutes) and compared to pre-intervention IOP values. Accordingly, it was discovered that there was no significant difference in IOP at each time point. Mean IOP value at pre-intervention in the right eye among laptop users was slightly lower than IOP at 60 minutes, yet this difference was not statistically significant. Table 3 shows mean IOP between both groups (laptop computer user and tablet computer user groups). When comparing IOP values between groups, the mean value of eyes in the laptop group was greater than in the tablet user group at all time check-points. Nevertheless, no significant differences in IOP values were observed between groups in both eyes in regards IOP measurements. Despite no significant changes to IOP in both eyes within and between groups, other signs of eye related issues (e.g. eye pain, visual acuity, and tissue hardness) which may relate to, or lead to blindness, were unclear.

4. DISCUSSION

Prolonged viewing of a computer screen can cause IOP elevation; a significant risk concerning the potential development of glaucoma [8], [25]. In addition, the underlying mechanism of ocular dynamics in regards to these IOP changes during prolonged work in front of a computer screen is not yet fully understood. Available evidence has suggested that alterations in IOP involve the occurrence of the accommodation and convergence of eye problems amid prolonged computer screen viewing.

Moreover, the researchers assume that further studies are needed to confirm that dry eyes and neck flexion posture due to extended periods of electronic display usage can cause IOP elevation. What’s more, psychophysiological stress is reportedly associated with fluctuations in IOP [8].

In this study, we examined changes to IOP at different junctures by implementing two types of computer screens in different head flexion angles. The results of this study demonstrate that there were no significant increases in IOP; on the other hand, the causes of glaucoma may affect not only an increase in IOP, but there are multiple factors covariate to blindness (e.g. comorbidities, computer screen brightness, and head position during prolonged exposure to a computer screen).

Evidence supports that numerous factors affect IOP in healthy participants. IOP measurements were taken while seated with the neck in a neutral position. Whereas, all other head positions, including flexion, extension, and supine body positions, result in IOP elevation [21]. Therefore, this may possibly explain why there were no alterations in IOP amid our study, i.e. the head was positioned in a neutral position.

Additionally, one study revealed that participants maintained a head flexion angle of 33°-45° from vertical when using a smartphone [20]. Similarly, another study showed that head and neck flexion angles during tablet use were higher than when utilizing desktop and notebook computers [22]. According to the details above, it may be assumed that head positioning can contribute to blindness in individuals. Besides, Ha [8] reported that IOP significantly increased immediately after 5 minutes and continued to elevate throughout 25 minutes post smartphone implementation under lowlight conditions. Another research showed that 4 hours of computer work resulted in significant IOP elevation among healthy young participants [7].

Based on the information mentioned prior, it would be reasonable to suggest that a forward head and neck flexion posture when utilising a mobile computer may cause IOP fluctuation, and eventual blindness.

Table 3 Between-group comparison of IOP value (mmHg) changes at different checkout points among laptop computer and tablet computer user groups.

Group	Pre-intervention		During intervention						Post-intervention	
	0 minute (baseline)		15 minutes		30 minutes		45 minutes		60 minutes (immediately after)	
	Right	Left	Right	Left	Right	Side	Right	Left	Right	Left
Laptop computer users	14.5 (1.9)	14.0 (2.4)	15.1 (2.0)	14.7 (2.0)	14.9 (4.3)	14.3 (2.8)	15.1 (2.5)	14.1 (2.3)	15.3 (2.1)	13.2 (1.6)
Tablet computer users	13.1 (1.6)	12.4 (1.8)	13.5 (1.9)	12.7 (1.8)	12.3 (1.9)	12.2 (2.1)	12.8 (2.3)	12.4 (2.3)	12.9 (1.7)	12.2 (1.9)
p-value	0.26	0.29	0.23	0.14	0.27	0.23	0.17	0.29	0.09	0.43

Data were expressed as mean (standard deviation, SD) and calculated via student t-test.

The researchers assume further studies are required to confirm that dry eyes and neck flexion posture due to extended periods of electronic display usage can cause IOP elevation. Besides that, psychophysiological stress is reportedly associated with fluctuations in IOP [8]. In this study, we examined alterations to IOP at different junctures using two types of computer screen in varied head flexion angles. Another research revealed that 4 hours of computer work resulted in significant IOP elevation among healthy young participants [7].

Our study is the first study to investigate IOP variations induced by viewing both laptop and tablet screens. Nonetheless, our outcomes did not support any of the earlier findings due to the fact that the results did not show any significant changes to IOP amid pre-intervention compared with different time-check points in both groups. Also, IOP among participants who used a laptop computer for a prolonged duration did not demonstrate statistical significance when compared with participants who utilised a tablet computer at any time point.

This preliminary study has several limitations that require consideration. First, the present study was limited in terms of the number of participants. Thus, further studies are called for among larger populations. Another limitation is that IOP values were collected for only a short time. Hence, a study employing a longer duration of computer usage will be considered. Lastly, IOP measurement recording utilizing a reliable method is necessary. Goldmann applanation tonometry (GAT) is regarded as the gold standard, and as a consequence ought to be applied amid further studies.

5. CONCLUSION

Study results suggest that laptop and tablet usage for 60 minutes in a neutral position may not affect IOP in healthy volunteers. Notwithstanding, further studies are necessary to clarify whether or not postural changes associated with prolonged computer or tablet usage cause IOP fluctuation.

6. ACKNOWLEDGMENTS

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