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RESEARCH ARTICLE

Effect of Integrated Ocular Exercise Program on Selected Visual Impairments Among Chronic Smartphone Users

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Abstract
The aim of the study was to determine the effectiveness of an integrated ocular exercise program on the three selected visual impairments. The study was conducted among 100 individuals, 67 of them were females and 33 were males between the age group 18-35 years with visual impairments who fulfilled the inclusion criteria. Two groups were formed both following the conventional treatment of an ophthalmologist, with the experimental group added with an integrated ocular exercise program for four weeks. The Standard Patient Evaluation of Eye Dryness (SPEED) score for the dry eye level of group A was 14.6 $\pm$ 3.785, and the values for group B were 16.58 $\pm$ 3.351 (P <0.0001). The visual acuity post-intervention in the treatment group was 29.1$\pm$ 15.57 and the control group was 32.5 $\pm$ 15.625, which shows much difference (P=<0.001). According to Snallen’s chart, there was a much significant difference between the pre-post visual eye fatigue questionnaire (P=0.001). The results showed that at the end of the 4 weeks, the designed exercise program along with the conventional method proved beneficial for the patients with selected visual impairments. An unpaired t-test was used for comparing two separate groups. The chi-square test was used for calculating binary variables and effect size. According to the results of our study, the Integrated ocular exercise program was useful among chronic smartphone users for reducing their eye discomforts like eye fatigue, dry eyes, and visual acuity. In conclusion, the Experimental group shows more improvement in the post-intervention than the control group.

Keywords
Smartphones, Ocular Exercises, Visual Impairment, Eye Fatigue, Visual Acuity

INTRODUCTION

The usage of smartphones has increased over the past decade. The development of the multipurpose smartphone and its following global acceptance have impacted the communication and informational environment. It altered the interests, principles, and desires of many users, and raised concerns about addiction and usage all over the world (Panova et.al., 2018). A large portion of the population, especially young people, routinely uses their smartphones for a variety of objectives. They use their smartphones for a wide range of activities, including calling, texting, gaming, navigation, social networking, etc. (Salehan et. al., 2013).

During the period of lockdown, more people are using their smartphones for entertainment,

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while students are using them to study and take online classes from schools. (S. Shinde et.al., 2023) Extensive development and usage of smartphones in everyday life have an impact on communication and interaction between individuals. Among adolescents aged over 18 years, the health problems related to smartphone use are headaches and eye problems. Internet addiction has been a worldwide problem and is related to stress, sleep problems, and depressive symptoms which are also related to availability demands and being awakened at night for smartphone usage. (Machado et al., 2023). Smartphone users can perform repetitive tasks while slouching over their small screens for extended periods of time, which affects the eyes (S. Shinde et.al., 2022). Blue light is the foundation of smartphone technology. Using them for an extended amount of time increases the risk of vision damage because blue light has a shorter wavelength (Park et.al., 2017). Due to their numerous applications, smartphones have recently become widely used by the majority of people, particularly college-going students.(Torpil et. al., 2022). Smartphones are useful in many ways, but they also have disadvantages like reduced productivity, attention-grabbing social interactions, and psychological addiction. Currently, between 24.8% and 27.8% of students are smartphone addicts, and that percentage is growing (Jeonge et.al.,2015). The number of blind persons worldwide is estimated to be 36 million and the number of people with vision impairment is estimated to be 216.6 million. 90% of these people live in developing and middle-income countries (Flaxman et.al., 2017; Rono et. al., 2020).

Visual impairment is caused by a variety of diseases or degenerative processes and results in considerable limitation in vision (Vilmaz et. al., 2023). On a global scale, millions of people experience dry eye, a serious tear insufficiency disorder of the ocular surface. A recent survey found that there has been a substantial increase in the number of dry eye patients (Goto et. al., 2002). Dry eye is characterized by a number of symptoms including ocular fatigue, discomfort, red eyes, and a heavy feeling in the eyes (Lemp et.al.1998). Dry eye disease (DED) is a highly frequent, multifunctional condition that affects the tear film and the ocular surface. Millions of people all around the world experience ocular pain and discomfort due to dry eye. The primary symptoms of DED are ocular surface dryness, stinging, burning, pain, and feeling of a foreign body (Fjaervoll et.al., 2022). If visual fatigue continues in normal life, it can impact visual processing and can cause various problems such as eye discomfort, damaged corneal epithelial cells, conjunctival hyperemia, and reduced visual acuity (Park et. al., 2017).

Optometrists may recommend a variety of treatments for vision, to help with particular vision problems that cannot be treated by simply wearing glasses or contact lenses (Rouse et.al., 1987). In certain conditions eye physical therapy, where patients' performance and function are improved by correcting vision issues (Mohamed et.al., 2013). Sometimes visual disorders occur in patients who have neck pain. Neck muscles have an important role in normal mobility and stability of the cervical spine. The McKenzie method is one of the popular approaches to evaluating and treating patients with neck pain. (Avaghade et.al., 2023).

The vestibular-ocular reflex is a component of the vestibular system which helps to stabilize vision (Morimoto et.al.2011). When the ciliary muscle
fails to contract and relax fully to focus and refocus the vision becomes low and vision impairments come into the picture. (Gosewade et al., 2013). Fixation, saccadic movements, smooth pursuit, as well as optokinetic and vestibular motions are all elements of ocular-motor exercises. (Minoonejad et. al., 2019).

There is a scarcity of research examining the efficacy and impact of an integrated exercise program as a physiotherapy intervention for addressing visual impairments, including dry eye, eye fatigue, and visual acuity issues, especially among individuals who are chronic smartphone users. This study focuses on visual impairments like dry eye, eye fatigue, and visual acuity in chronic smartphone users with Physiotherapy exercises. This study addressing the outcome measures to find out the impact on visual impairments.

According to recent reports, the usage of a smartphone most adversely affects the eye. However, there is a lack of information in the medical literature about how smartphones affect the eyes (Maddii et al., 2018). The present study aims to identify the immediate beneficial effects of an integrated ocular exercise program developed and handed down by physiotherapists.

MATERIALS AND METHODS

Study design and population

Among all 100 subjects in this study, 50 subjects were enrolled in the treatment group and 50 in the control Group. 67 of them were females and 33 were males.

Table 1. Demographic characteristics of the participants

Age Group	Male	Female
18-22	24	44
23-30	5	9
31-35	4	14

This experimental study has been carried out in Krisha Vishwa Vidyapeeth, karad after receiving approval from the Institutional Ethical Committee. (Protocol no. 298/2022-2023). Participants' allowance to permit the experiment was taken through signing the consent form. A total of 110 individuals fulfilled the inclusion criteria, out of which 3 individuals did not agree to participate while the other 7 terminated the treatment. The remaining 100 individuals participated actively in the study. Then 100 participants were randomly allocated into two groups, namely Group A and Grop B by simple random sampling. The study duration was a period of 6 months at Krishna Hospital in the physiotherapy outpatient department, Karad. The intervention was done for a period of 4 weeks. Patients of all genders ranging in age from 18-35 years, individuals experiencing dry eyes, eye fatigue or low vision, and eye symptoms caused only due to smartphone use were included. Patients were excluded if they are visually disabled.

Measuring methods

Selected three impairments were assessed with the specific respective scales of each. Standard Patient Evaluation of Eye Dryness (SPEED) questionnaire for dry eyes (Gulati et.al., 2006). Visual Eye fatigue questionnaire for evaluating the level of eye fatigue and a Snellen's chart to score Visual acuity (Habibi et. al., 2011; Lovie Kitchin et.al., 1988).

The study was started by conducting a quick assessment of smartphone addiction through a 'Smartphone Addiction Scale'. The assessment was conducted through the online platform google forms which were circulated among individuals aged between 18 to 35. Individuals with high smartphone addiction were considered for the study. A summing 100 participants consisting of males and females underwent an examination for Dry Eyes, Eye Fatigue, and Visual Acuity, and the scores were recorded. Respective scales were used for evaluation. Through voluntary participation and allowance of the participants they were divided into two groups and further experiment was carried. Group 'A' was the control group following the conventional treatment by an ophthalmologist. The 'B' group was the treatment group and was given the conventional treatment by an ophthalmologist added with the integrated ocular exercise program. After completion of the intervention, both groups were examined through the same tests they underwent prior to the exercise intervention.

An integrated ocular exercise program designed particularly for targeted impairments was implemented. The program aimed not only at eye muscle maintenance but also relaxation of the neck and shoulder. Four weeks of intervention were exhibited and exercises were advanced after the first two weeks. The protocol was as follows.

Table 2. Description of the ocular exercises for 1-2 weeks protocol

Sr. No.	1-2 weeks	Repetitions
1.	Palming	10 breaths× 2 sets
2.	Blinking	3 times/ day
3.	sideways viewing	10-sec hold × 10 reps
4.	front and sideways viewing	10-sec hold × 10 reps
5.	rotational viewing	5-sec hold × 10 reps
6.	up and down viewing	5-sec hold × 10 reps

7	nose-tip gazing	10-sec hold × 10 reps
8	near and distant viewing	3 times/day

Sr. No.	**3-4 weeks**	**Repetitions**
1.	Saccadic eye movement	10-sec hold × 10 reps
2	The subject moving the target horizontally And tracking it with the eyes while keeping the head still	10-sec hold × 10 reps
3	The subject moving the head horizontally While keeping the stationary target in focus	10-sec hold × 10 reps
4	The subject moves the head and target in opposite directions horizontally while tracking the target with the eyes.	10 mins
5	Smooth Pursuit eye movements	10-sec hold × 10 reps
6	Candle gazing	10 mins
7	Candle reading	10 mins
8	Visual imagery	15 mins

To maintain eye hygiene and enhance relaxation these techniques were followed daily like cold fomentation with eyes closed, following the 20-20-20 rule. (Minoonejad et al., 2019; Kim et.al. 2016; Sheikh et. al. 2020; Swathi et.al. 2022).

Statistical analyses

Statistical analyzes of the study were performed using the "Statistical Package for Social Sciences" (SPSS) version 23.0 (Kirkpatrick et. al., 2015). Visual (histogram, probability graphs) and analytical methods (KolomogrovSmirnov/Shapiro-Wilk's test) were used to define whether the variables were normally distributed. Customarily distributed numerical variables will be shown as mean±standard deviation. An independent student t-test is used to find out the statistical difference between two arithmetic means. Chi-square was used for calculating binary variables, effect size between participant's age, and eye symptoms caused only due to smartphone use. The results were calculated through statistical analysis using the software SPSS version 23.0.

RESULTS

Table 3, represents the Standard Patient Evaluation of Eye Dryness (SPEED) score before (Pre) and afther the intervention for Group A and Group B. For Group A, which received the conventional treatment the mean SPEED score decreased from19.2 before the intervention to 16.58 after the intervention. For Group B, which received the treatment, the mean SPEED score decreased from 19.22 before the intervention to 14. 6 after the intervention. The extremely significant p-value for Group B indicates that the treatment had a substantial impact on alleviating symptoms of dry eye.

Table 3. Comparison of Pre-Post speed test score for dry eye

	$\bar{X}$		SD		P- value	Result
	Pre	Post	Pre	Post		
Group A Conventional	19.2	16.58	3.295	3.351	<0.001	Significant
Group B Treatment	19.22	14.6	3.099	3.785	<0.0001	Extremely significant

Table 4 depicts the eye fatigue questionnaire score, in which the eye fatigue level was more before the intervention which was decreased post-intervention. In Group A, which received the conventional intervention, the change in eye fatigue This study was carried out among 100 chronic smartphone users. According to statistical analysis, the effect of the ocular exercise program was significantly effective for selected visual impairment. There was a significant reduction in eye fatigue (P<0.0001) in Group B than in Group A. Dry eye scores according to the speed test were also significantly reduced (P<0.0001) and visual acuity by Snellen's chart was significant (p<0.0001) in Group B than Group A. Scores were statistically significant (p-value < 0.0002). In Group B, which received the treatment, the change in eye fatigue scores was even more significant (p-value < 0.0001). This indicates that the treatment had an extremely strong effect on reducing eye fatigue levels.

Table 4. Comparison of Pre-Post visual eye fatigue questionnaire score

	$\bar{X}$		SD		P-value	Result
	Pre	Post	Pre	Post		
Group A Conventional	2.82	2.02	1.044	1.134	<0.0002	Significant
Group B Treatment	2.52	0.86	1.328	0.808	<0.0001	Extremely significant

Table 5. shows a comparison of Pre and Post-mean values of Snellen's chart for visual acuity. For Group A, the mean visual acuity score improved from 47.2 before the intervention to 32.5 after the intervention. For Group B, the mean visual acuity score improved from 46.5 before the intervention to 29.1 after the intervention. The p-value for the comparison between pre and post-scores for group A was found to be <0.0002, indicating a statistically significant improvement, and for Group B less than 0.0001, indicating an extremely significant improvement in visual acuity after the treatment.

Table 5. Comparison of Pre-Post values of snallen's chart score for visual acuity

	$\bar{X}$		SD		P-value	Results
	Pre	Post	Pre	Post		
Group A Conventional	47.2	32.5	36.255	15.625	0.0002	Significant
Group B Treatment	46.5	29.1	36.059	15.57	<0.0001	Extremely significant

Table 6 shows a comparison of post-test mean values of speed score between Group A and Group B. The mean post-test speed score for participants in Group A is 19.22 and for Group B is 15.59. The comparison between Group A and Group B is Extremely significant.

Table 6. Comparison of Pre and Post-test mean scores for the dry eye within Group A and Group B

SPEED SCORE	$\bar{X}$-Post (Group A)	$\bar{X}$ -Post (Group B)	P- Value	Result
Group A vs Group B	19.22	15.59	<0.0001	Extremely significant

Table 7 shows a comparison of post-test mean values of the eye fatigue scale between Group A and Group B. The mean post-test eye fatigue level for participants in Group A is 2.82 and Group B is 2.02. The p-value is less than 0.0001 and the comparison between Group A and Group B is Extremely significant.

Table 7. Comparison of post mean score of Eye fatigue within Group A and Group B

Eye Fatigue Level	X̄-Post (Group A)	X̄ Post (Group B)	P- Value	Result
Group A vs Group B	2.82	2.02	<0.0001	Extremely significant

Table 8 shows a comparison of Post-test mean values of Snellen's chart for visual acuity between Group A and Group B. Both the values were found to be statistically extremely significant (P<0.0001).

Table 8. Comparison of post and post values of visual acuity within Group A and Group B

Vısual Acuity	X̄- Post (Group A)	X̄- Post (Group B)	P- Value	Result
Group A Vs Group B	46.5	29.1	<0.0001	Extremely significant

DISCUSSION

The results from the current study indicate that after 4 weeks of ocular exercises, there was a significant reduction in the eye fatigue level, visual acuity, and dry eye. In addition, participants in the exercise group had a significant decrease in eye fatigue levels over a 4-week period, whereas those in the control group had no reduction in eye fatigue levels. These findings were similar to the previous study that reported that yoga ocular exercises reduce the eye fatigue symptoms score by increasing the efficiency of extraocular muscles (Telles et.al., 2006).

The study carried out in the year 2020, named " Effect of yoga ocular exercises on eye fatigue" included 32 undergraduate optometry students who were symptomatic based on a validated eye fatigue questionnaire were included after a baseline comprehensive eye examination. In the exercise group, there was a statistically significant reduction in eye fatigue scores, whereas the eye fatigue scores showed a significant increment in the control group after 6 weeks (Satish Kumar Gupta et.al., 2020). The reliability and validity of the visual eye fatigue questionnaire value are 0.75 indicating that the visual eye fatigue questionnaire has a moderate level of reliability and validity (Rajabi–Vardanjani et. al., 2014).
Performing blinking exercises has previously been demonstrated to lead to decreased partial blinking and an improved proportion of functional meibomian glands in dry eye patients. A.D. Kim et. Al undertook a research study with the purpose of the effects of blinking exercises on blink patterns and clinical signs and symptoms of dry eye disease. This study revealed that it is possible that Blinking exercises can modify poor blinking patterns and improve dry eye, with modest changes in objective measures of tear film quality. Fifty-four participants with dry eye symptoms received instructions to perform a ten-second cycle of blinking exercises every 20 min during waking hours for four weeks. The findings of the study reinforce the potential role blinking plays in influencing meibomian gland function and tear film integrity (A.D. Kim et.al., 2021).

Also, a recent study was carried out on female basketball players, which was about to investigate the effect of ocular-motor exercises on dynamic visual acuity and stability. The athletes in the intervention group participated in the designed four-week program of oculomotor exercises and the control group did just their own daily routine exercises. It concluded that oculomotor exercises can be used to enhance the limit of stability and dynamic visual acuity in basketball players. (Minoonejad et. al., 2019). A reliability value of 0.95 indicates a very high level of consistency and agreement in the measurements obtained from the Snellen chart (Lovie-kitchen et.al., 1988).

A systematic review of literature on the association between visual display terminal use and dry eye was carried out in 2021 in which people with dry eye symptoms were included. This study revealed that the prevalence of definite or probable dry eye among video display terminal and office workers ranged from 26% to 70% in the included studies. Overall, VDT use was highly associated with dry eye disease and DED-related signs and symptoms.

DED has repeatedly been found to reduce work productivity and increase days spent away from the office, thereby providing a substantial indirect financial loss. İn this study there is a decrease in dry eye symptoms (Stapleton et. al., 2017; Sivakumar et. al., 2021). A reliability value for the SPEED test is 0.88 to 0.95 indicating that the patient evaluation method is highly reliable, it produces consistent results across different assessments or time points. A validity value of 0.923 suggests that the patient evaluation method is highly valid (Ngo et.al.,2013). Using a smartphone can be used for a variety of things, including communication and entertainment through texts, music, multimedia, internet access, photos, and games (S. Shinde et.al., 2022). During prolonged usage of the smartphone, individuals have eye problems like dry eye, eye fatigue, and visual acuity.

The study's findings helped in improving the development of targeted ocular exercise programs that can be prescribed by physiotherapists to chronic smartphone users experiencing visual impairments. These exercises may help alleviate symptoms and improve visual function, reducing the potential long-term impact of smartphone use on the eyes. The novelty of this study lies in its focus on chronic smartphone users and the particular integrated ocular exercise program to treat their visual deficiencies. While previous studies investigated the impact of ocular exercises on eye health and fatigue, this study focuses on a specific population that is becoming increasingly afflicted by excessive smartphone use. In this study, the mentioned 20-20-20 rule was followed, which stated that every 20 minutes, look 20 feet apart for 20 seconds. This relieves the continuous screen gazing and enhances relaxation. Moreover, one of the strategies for reducing eye fatigue is taking regular breaks while using visual displays, in accordance with the study by Galinsky et al, which reported that breaks reliably minimized eye discomfort (Galinsky et al., 2007). By taking all the results into consideration, we can say that an integrated ocular exercise program was useful among chronic smartphone users for reducing their eye discomforts like eye fatigue, dry eyes, and visual acuity.

Conclusion

This study presents evidence that the Integrated ocular exercise program was useful among chronic smartphone users for reducing their eye discomforts like eye fatigue, dry eyes, and visual acuity. The application of the exercise program along with the conventional treatment by the ophthalmologist in a systematic manner makes it a successful approach. It is recommended that the integrated ocular exercise program can be used as a preventive as well as a treatment tool under the guidance of a physiotherapist and ophthalmologist for treating eye impairments.

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Declaration of Conflicting Interests

All authors declare no conflicts of interest.

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Ethics Statement

The study protocol was approved by the Krishna Institute of Medical Sciences Ethics Committee

(Protocol no. 298/2022-2023) and written informed consent was obtained from the participants before starting the study.

Authors Contribution:

Study Design, TM, VK; Data Collection, TM, SS, VK, PP; Statistical Analysis, TM; Data Interpretation, TM, SS; Manuscript Preparation, TM, VK; Literature Search, TM. All authors have read and agreed to the published version of the manuscript.

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