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Original Research Article

To study the effect of short-term use of mobile phones on accommodation and convergence in adults

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Abstract

Background: With the advent of digital technology, mobile phone usage has surged dramatically, becoming an integral part of daily life. Prolonged screen exposure has been associated with visual strain, impacting key ocular functions such as accommodation and convergence. Understanding these effects is crucial, especially in young adults, who are among the highest users of mobile devices. This study investigates the short-term impact of mobile phone usage on accommodative and vergence parameters to provide insights into potential visual health implications.
Aim: This study aims to assess the effect of short-term use of mobile phones on accommodation and convergence in adults.
Materials and Methods: An observational study with the duration of 3 months done at Department of Optometry, Parul University, Vadodara, Gujarat. 310 healthy subjects include both males and females with age group ranging between (18-25 years) were chosen using random sampling method. Participants underwent a comprehensive eye examination, encompassing ocular and systemic histories, objective and subjective refraction, near point of accommodation, amplitude of accommodation, accommodative facility, near point of convergence, and vergence facility assessments. Following assessment, they watched a 3-hour movie on smartphones uninterrupted. After a 5-minute break, participants were re-evaluated, and tests were repeated.
Results: The study involved 310 participants, 49% male, 51% female, with mean age 20.97 ± 1.97. Monocular accommodative parameters were affected, while vergence facility significantly decreased post-mobile phone use. Using t-test, In males, right eye accommodative facility was affected, whereas in females, most measures showed statistical differences near point of accommodation, amplitude of accommodation, accommodative facility and Vergence facility (NPA, AA, AF, and VF) Pre- and post-test NPC (break and recovery) differed between genders ($p < 0.05$).
Conclusion: The study investigated changes in accommodative and vergence parameters after short-term mobile phone use. Significant alterations were noted in monocular accommodative metrics, especially NPA, AA, and AF. Gender-specific analysis revealed males had compromised accommodative facility, while females showed broader alterations. These findings stress the importance of gender-specific interventions in visual health, especially concerning contemporary device usage.

Keywords: Near point of accommodation, Amplitude of accommodation, Accommodative facility, Near point of convergence, Vergence facility.

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1. Introduction

The use of smartphones has increased drastically in the past few years. Many college students dedicate a significant amount of their time to using their mobile phones.[1] Due to most of the work on phones, the dependency has increased in the past few years. Over usage of mobiles not only create an impact on the eyes but also affects general health. Overuse of mobile devices may result in psychological disorders such as nomophobia, computer vision syndrome, weak thumbs and wrists, stiff necks, more frequent dry eyes, and computer vision syndrome.[2] Student smartphone addiction is currently

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around 24.8% and 27.8%, and it is steadily becoming worse every year.[3] Constantly checking your phone for no reason, feeling anxious or restless without it, waking up in the middle of the night to check your messages, a delay in professional performance due to prolonged phone use, and becoming distracted by smartphone apps are all symptoms of smartphone addiction.[4] The most popular portal for information and communication technologies is the mobile phone. Sociologists, psychologists, and researchers in the field of mobile addiction have become aware of the mental damage brought on by contemporary technology.[5] Myopia, which is a key contributor to correctable vision impairment, has emerged as a significant global public health concern, particularly in Asian nations. Myopia is reported to be becoming more common due to environmental factors such as rigorous schooling, more close work, and less time spent outside.[6] The condition known as near work-induced transient myopia (NITM) is a myopic accommodative aftereffect brought on by the crystalline lens's inability to properly and quickly regain its capacity to focus on distance after prolonged near activity.[7] Both myopic adults and kids show delays in adaption while working close up. One significant observation is that, in contrast to emmetropes and stable myopes, accommodation lag is clearly enhanced in advancing myopes.[8] As a result, this is a present problem. Many earlier studies of NITM were conducted in the late 1990s or early 2000s using printed text accommodative stimuli, so it is important to see if the switch to electronic displays has altered the accommodative behavior. This is due to the increasing shift from printed to electronically produced text over the past three decades. Mobile phone usage has a considerable effect on accommodation (the ability to focus) and convergence (the inward movement of the eyes), both of which are crucial for maintaining clear vision at close distances. When devices are held at a close range, they necessitate prolonged focus and convergence, which can result in eye strain, headaches, and potentially blurred or double vision.[6,7] Extended periods of use may lead to accommodative fatigue and could accelerate the progression of myopia, particularly among younger individuals. Researching these effects is vital for developing eye care strategies that help manage symptoms of digital eye strain and encourage healthier visual habits. Our research sought to determine if using the mobile screen for even a short term can impact accommodation reactions and convergence.[9]

The purpose of this study is to assess the accommodative and convergence changes occurring due to the short-term use of mobile phones. We hypothesized that their accommodation and convergence value increases even after the short-term usage of mobile phones.

2. Materials and Methods

This study has been approved by the Parul University Institutional Ethics Committee for Human Research (PUIECHR/PIMSR/00/081734/6412). According to tenets of Helsinki declaration in the beginning the informed consent has been given and the procedure explained clearly to the participants.

All subjects were first subjected to a thorough eye examination that included an in-depth review of their ocular and systemic histories as well as objective refraction, subjective refraction, near point of accommodation, amplitude of accommodation, accommodative facility, near point of convergence, and vergence facility. After assessing all the values, we provided each individual with a movie to watch on their smartphone for a period of three hours with 100% brightness level of the phone without any break under constant normal room conditions with similar viewing distance of 35cm from the eyes, chair and table size.[10]

With a break of 5 minutes after watching the entire movie, all the subjects were evaluated once again and all the tests were performed once again and noted down.

2.1. Objective refraction

This method was used to assess the refractive error without the involvement of the patient. A retinoscope is an instrument used to find out the refractive error under dim room illumination. The patient is asked to look at 6m of distance and the examiner emits the light in the patient’s eye and neutralizes the glow in the patient’s eye, which gives us the refractive error value of the eye.[11]

2.2. Subjective refraction

This method used to assess the refractive error with the involvement of the patient. In this procedure, various trial lenses are placed in front of the patient’s eyes to get the response from the patient for the clearest view and the final power is verified using the duochrome test, in which overcorrection or under correction of the subjective power is being assessed.[12]

2.3. Near point of accommodation

This test was done to assess the ability of the eyes to focus on near objects. It determines the closest point to which a person can see clearly without any blur. During this test, an N8-size horizontal alphabet target is moved toward the patient until the target gets sustained blur. This test is being done monocularly and binocularly both. This gives us the NPA values in cm, normative values for this test are monocularly 8-10cm and binocularly 7-9cm.[12]

2.4. Amplitude of accommodation

This test was done to assess the range of focusing power from distant to near objects. It measures the flexibility and functionality of the eye’s accommodative system. It is typically measured in diopters (D). By dividing NPA values by 100, we get the value of the amplitude of accommodation. There are multiple other methods to measure AA like minus lens test, push-up test, etc.[13]

2.5. Accommodative facility

This test was performed to assess the speed of the eyes to relax or stimulate the accommodation. In this test, a rock card and accommodative flippers with plus and minus lenses are used. This test starts with the plus lenses in front of the patient's eyes. Rapidly the side of the flipper is changed in front of the patient's eyes for 1 minute. It is typically measured in cycles per minute (CPM). Each box of the rock card is having 0.5cpm value. Normative values for this test are 10-12cpm.[14]

2.6. Near point of convergence

This test was done to evaluate the ability of the eyes to turn inward with getting double vision. This test is also used to assess the overall coordination and flexibility of the eye muscles responsible for convergence. In this test, the patient is instructed to concentrate on a small target held at arm's length, such as the tip of a pen or a letter on a card. Until the patient reports double vision or is no longer able to retain clear vision, the examiner gradually pushes the target closer to the patient's face along the midline. The near point of convergence is the distance at which this happens, measured, and noted. Normative values for this test are 6-8cm.[15]

2.7. Vergence facility

This test was used to assess the ability to switch between focusing on close and distant things efficiently and correctly by changing the eye's convergence (turning inward or outward). It assesses how rapidly and easily the eyes may change their convergence point in response to shifting visual demands. In this test 3 prism base-in and 12 prism base-out prism flippers are being used. The base-in prism flippers are placed in front of the patient's eyes to begin this test. For one minute, the flipper side is quickly swapped in front of the patient's eyes. The standard unit of measurement is cycles per minute (CPM). The value of each box on the rock card is 0.5cpm. Normative values for this test are 10-15cpm.[16]

After collecting the data, it was analyzed using IBM SPSS Statistics version 29.

3. Results

It is observed that among 310 participants, 49% were males and 51% were females **(Figure 1),** with the mean age 20.97 ± 1.97, shown in **Table 1.**

3.1. Comparison of pre and post NPA, AA, AF, NPC, VF.

This section presents the comparison of pre and post values of near point of accommodation, amplitude of accommodation, accommodative facility, near point of convergence and vergence facility. For this paired t test was applied. From the **Table 2**, it is revealed that there was a difference ($p < 0.05$) in Near Point of Accommodation (right eye and both eyes together), Amplitude of Accommodation (right eye and both eyes together), Accommodative Facility (Both eyes), and Vergence Facility from pre-test to post-test. This shows that the accommodative parameters got affected monocularly whereas vergence facility was significantly affected after the short-term usage of mobile phone. The comparison is shown graphically in **Figure 2**.

3.2. Comparison of NPA, AA, AF, NPC, and VF within gender

This section presents the comparison of near point of accommodation, amplitude of accommodation, accommodative facility, near point of convergence and vergence facility within the gender. For this paired t test was used. From the **Table 3**, it is observed that there was a difference ($p < 0.05$) in AF (OD) among males, and among females a difference ($p < 0.05$) was found in NPA (OD, OS and OU), AA (OU), AF (OU), and VF. This depicts that monocularly in right eye accommodative facility is affected in the males but maximum measure (NPA, AA, AF, and VF) has shown statistical difference in the female participants. The comparison is shown graphically in **Figure 3**.

3.3. Comparison of NPA, AA, AF, NPC, and VF between males and females

This section presents the comparison of NPA, AA, AF, NPC, and VF between males and females. As in the **Table 4**, it is revealed that the independent sample "t" test was used to compare NPA, AA, AF, NPC, and VF according to gender. There was a difference ($p < 0.05$) in NPC (Both break and recovery) between males and females during pre-test as well as post-test.

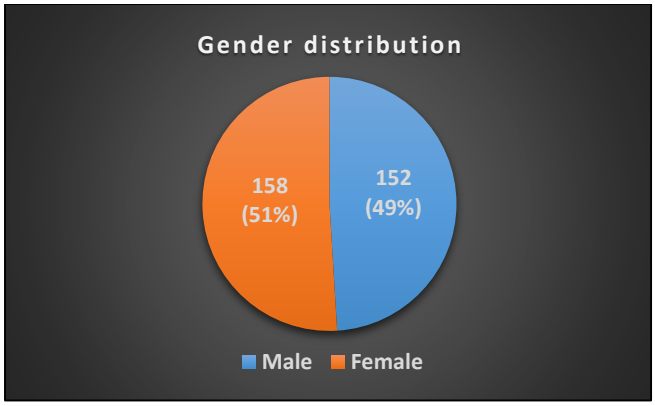

Figure 1: Distribution of gender

Table 1: Descriptive statistics for age

Minimum	Maximum	Mean	Std. Deviation
18	24	20.97	1.97

Table 2: Pre to post-test comparison of NPA, AA, AF, NPC, and VF

			Mean	S.D.	"t"	p-value
NPA	OD	Pre-test	8.23	2.02	-2.42	0.016*
		Post-test	8.45	2.07		
	OS	Pre-test	8.16	2.11	-1.63	0.103
		Post-test	8.32	2.13		
	OU	Pre-test	7.95	2.15	-2.12	0.035*
		Post-test	8.14	2.19		
AA	OD	Pre-test	12.97	3.81	2.22	0.027*
		Post-test	12.56	3.15		
	OS	Pre-test	13.10	3.81	1.65	0.099
		Post-test	12.79	3.20		
	OU	Pre-test	13.48	3.81	2.10	0.037*
		Post-test	13.08	3.20		
AF	OD	Pre-test	8.10	4.87	-1.45	0.150
		Post-test	8.37	5.16		
	OS	Pre-test	8.39	4.84	-1.58	0.115
		Post-test	8.66	5.26		
	OU	Pre-test	9.60	4.84	-2.18	0.030*
		Post-test	9.98	5.12		
NPC	Break	Pre-test	6.33	2.14	-0.50	0.617
		Post-test	6.38	2.29		
	Recovery	Pre-test	8.10	3.02	1.42	0.157
		Post-test	7.91	3.04		
VF		Pre-test	12.27	4.02	-3.62	< 0.001*
		Post-test	12.87	3.94		

Table 3: Comparison of NPA, AA, AF, NPC, and VF within gender

			Male				Female			
			Mean	**S.D.**	**"t"**	**p value**	**Mean**	**S.D.**	**"t"**	**p-value**
NPA	OD	Pre-test	8.11	2.11	-1.42	0.158	8.34	1.92	-1.98	**0.050***
		Post-test	8.28	1.95			8.60	2.17		
	OS	Pre-test	8.12	2.14	-0.18	0.856	8.21	2.09	-2.02	**0.045***
		Post-test	8.14	1.96			8.48	2.27		
	OU	Pre-test	8.06	2.37	-0.01	0.992	7.84	1.91	-2.81	**0.006***
		Post-test	8.06	2.30			8.22	2.08		
AA	OD	Pre-test	13.34	4.53	1.91	0.058	12.63	2.94	1.16	0.248
		Post-test	12.76	3.10			12.36	3.21		
	OS	Pre-test	13.29	4.48	0.96	0.340	12.92	3.03	1.45	0.148
		Post-test	13.00	3.16			12.59	3.23		
	OU	Pre-test	13.47	4.43	0.59	0.555	13.48	3.12	2.73	**0.007***
		Post-test	13.29	3.34			12.88	3.05		
AF	OD	Pre-test	7.71	5.15	-2.14	**0.034***	8.47	4.57	-0.09	0.929
		Post-test	8.24	5.51			8.49	4.81		
	OS	Pre-test	8.11	5.15	-1.12	0.264	8.65	4.52	-1.13	0.259
		Post-test	8.35	5.47			8.95	5.04		
	OU	Pre-test	9.19	5.22	-0.99	0.326	9.99	4.43	-2.05	**0.042***
		Post-test	9.43	5.49			10.52	4.70		
NPC	Break	Pre-test	6.06	2.14	-0.21	0.831	6.59	2.11	-0.47	0.639
		Post-test	6.09	2.20			6.66	2.36		
	Recovery	Pre-test	7.66	3.06	0.87	0.388	8.52	2.92	1.12	0.263
		Post-test	7.52	2.93			8.29	3.10		
VF		Pre-test	12.03	4.37	-1.73	0.086	12.50	3.66	-3.38	**0.001***
		Post-test	12.44	4.41			13.28	3.39		

Table 4: Comparison of NPA, AA, AF, NPC, and VF between males and females

			Pre-test				Post-test			
			Mean	**S.D.**	**"t"**	**p value**	**Mean**	**S.D.**	**"t"**	**p-value**
NPA	OD	Male	8.11	2.11	-1.02	0.311	8.28	1.95	-1.37	0.172
		Female	8.34	1.92			8.60	2.17		
	OS	Male	8.12	2.14	-0.35	0.727	8.14	1.96	-1.41	0.161
		Female	8.21	2.09			8.48	2.27		
	OU	Male	8.06	2.37	0.92	0.361	8.06	2.30	-0.65	0.518
		Female	7.84	1.91			8.22	2.08		
AA	OD	Male	13.34	4.53	1.64	0.102	12.77	3.09	1.12	0.263
		Female	12.63	2.94			12.36	3.21		
	OS	Male	13.29	4.48	0.86	0.391	13.00	3.16	1.14	0.257
		Female	12.92	3.03			12.59	3.23		
	OU	Male	13.47	4.43	-0.02	0.981	13.29	3.34	1.12	0.264
		Female	13.48	3.12			12.88	3.05		
AF	OD	Male	7.71	5.15	-1.37	0.171	8.24	5.51	-0.43	0.666
		Female	8.47	4.57			8.49	4.81		
	OS	Male	8.11	5.15	-0.98	0.327	8.35	5.47	-1.01	0.313
		Female	8.65	4.52			8.95	5.04		
	OU	Male	9.19	5.22	-1.46	0.145	9.43	5.49	-1.88	0.061
		Female	9.99	4.43			10.52	4.70		
NPC	Break	Male	6.06	2.14	-2.16	**0.031***	6.09	2.20	-2.19	**0.029***
		Female	6.59	2.11			6.66	2.36		
	Recovery	Male	7.66	3.06	-2.52	**0.012***	7.52	2.93	-2.23	**0.026***
		Female	8.52	2.92			8.29	3.10		
VF		Male	12.03	4.37	-1.04	0.301	12.44	4.41	-1.89	0.059
		Female	12.50	3.66			13.28	3.39		

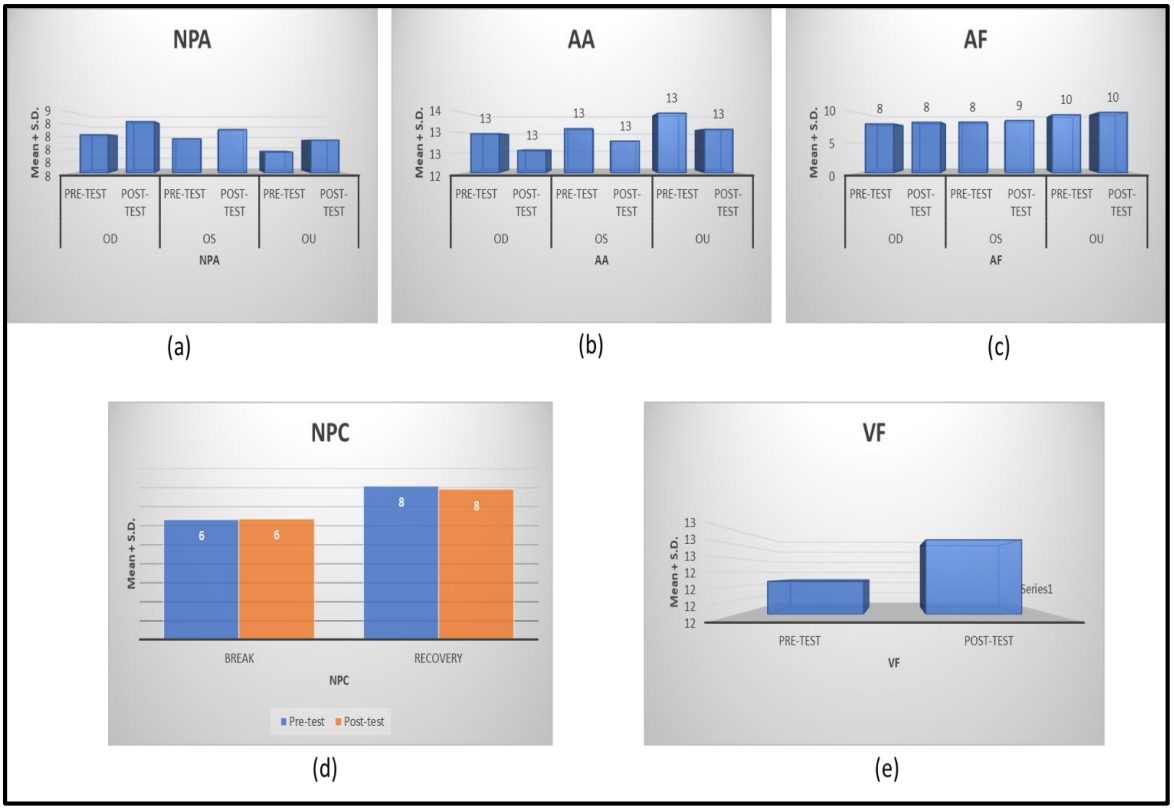

Figure 2: Comparison of pre and post NPA (**a**), AA (**b**), AF (c), NPC (**d**), and VF (**e**)

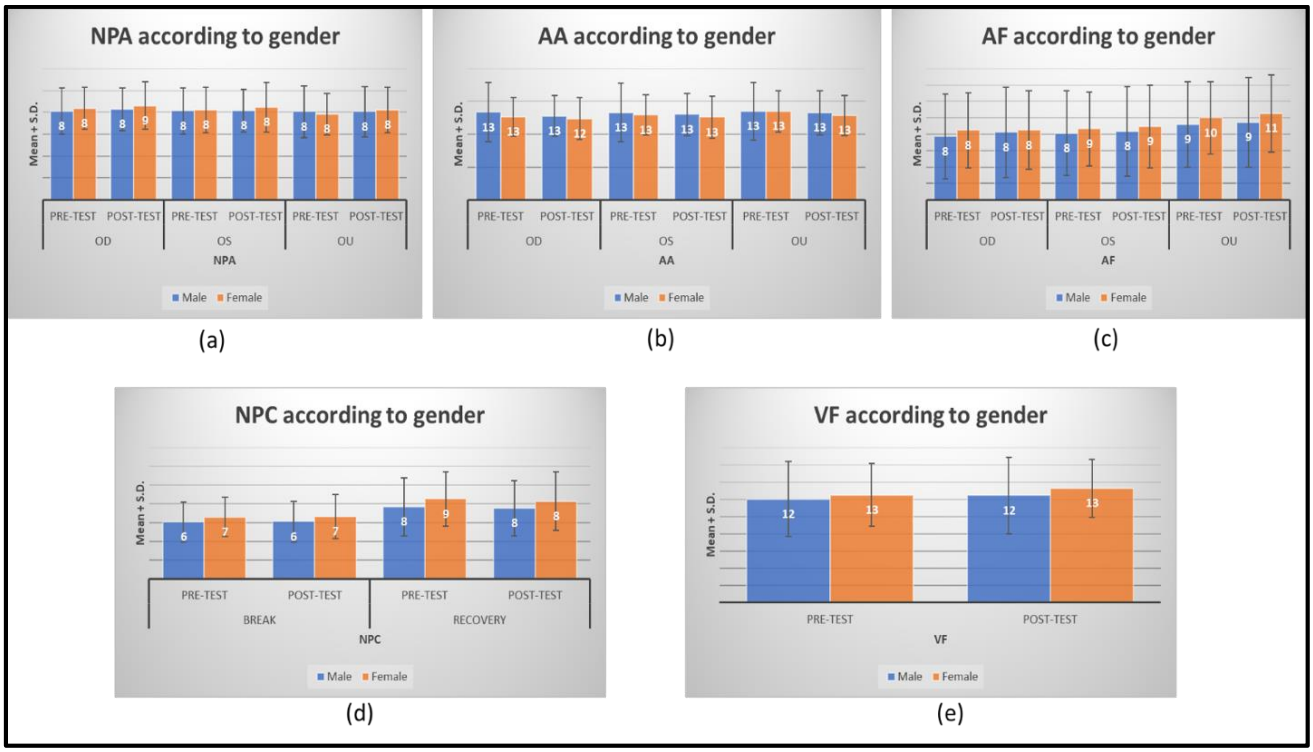

Figure 3: Comparison of NPA, AA, AF, NPC, and VF within gender

4. Discussion

The findings of this study reveal significant alterations in accommodative, convergence and vergence facility parameters following short-term mobile phone usage of 3 hours without any breaks.

4.1. Impact of short-term mobile phone usage

A similar study investigating the association between clinical and objective measures of accommodation and near point symptoms also aligns with the current study findings which concluded reduced accommodative function in the symptomatic group based on their convergence insufficiency symptom survey scores.[12]

Additionally, the current study concludes increase in the monocular and binocular AF and VF pre and post mobile phone usage which aligns with the study by Alvin J et al stating that binocular accommodative facilities and vergence facilities increased after 25 min of VR gaming in emmetropic participants under 30 years of age.[14]

Notably, NPC was receded pre and post short term mobile phone usage which is consistent with the previous research.[15]

4.2. Gender-based differences

Current study reports gender based differences with respect to the NPC; with females having receded NPC with longer recovery time as compared to males. A meta-analysis of sex differences in presbyopia suggested that increased association of presbyopia for women is not due to a physiologic difference in accommodation but rather due to other sex differences, such as tasks performed and viewing distances which could be a contributing factors for the gender based findings of the current study.[16]

Males demonstrated compromised accommodative facility, whereas females exhibited broader alterations across parameters. This suggests that gender-specific differences may play a role in how individuals respond to short-term mobile phone usage.

These findings underscore the importance of considering both short-term device usage. Addressing the impact of mobile phone usage on visual function could be crucial in mitigating potential long-term ocular health issues, especially among college students who are heavy users of smartphones.

5. Conclusion

In conclusion, the study elucidates the significant changes in accommodative and vergence parameters following short-term mobile phone usage. Monocular accommodative parameters, particularly NPA, AA, and AF, were notably affected. Gender-based analysis reveals varying impacts, with males exhibiting compromised accommodative facility, while females showed broader alterations across parameters. These findings underscore the importance of considering both short-term device usage and gender-specific differences in visual health interventions. Based upon the current study, the recommended hours for continuous mobile phone usage should be less than 3hrs per day and that too with frequent breaks because prolong continuous mobile phone usage can lead to asthenopic symptoms to the user. To avoid that every

user should follow 20-20-20 rule to avoid eye strain and mobile phone associated dry eyes.

6. Source of Funding

None.

7. Conflict of Interest

None.

8. Ethical Number

Ethical No.: PUIECHR/PIMSR/00/081734/6412.

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