



# Research Paper: Study of Lag of Accommodation After Using a Smartphone

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## Conflict of interest

The authors declared no conflict of interest.

## ABSTRACT

**Background and Objectives:** With the pervasive use of digital devices, especially smartphones, concerns about their harmful effects on vision has increased. The aim of the present study was to evaluate the effect of long-term activity with a smartphone on the accuracy of lag of accommodation of two eyes.

**Methods:** In this cross-sectional study, 27(16 females and 11 males) students and staff (23 students and 4 staff) of the Iran University of Medical Science with a Mean±SD age of 25.29±4.72 years, with a visual acuity of 10/10, and emmetropic refraction with the available sampling method were selected. At first, the participants used a smartphone for an hour, and then, the lag of accommodation of two eyes was assessed with the monocular estimate method.

**Results:** Lag of accommodation of the right eye (P=0.001) and left eye (P=0.001) both statically increased significantly after one hour of smartphone use. However, no significant difference was found between the lag of accommodation of two eyes after near work with a smartphone (P=0.265).

**Conclusion:** The present study confirmed the relationship between long-term near work with a smartphone and increased lag of accommodation.

**Keywords:** Accommodation, Smartphone, Digital device, Accommodative lag



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↑ *What is “already known” in this topic:*

*Near work may affect visual performances. Short time usage of smart phone may cause some visual symptoms.*

→ *What this article adds:*

*Ocular accommodation may be affected in smart phone users in long time*

## Introduction

The application of digital screens has increased in recent decades. The use of computers in various fields of work has expanded significantly [1]. Among these technologies, smartphones are one of the most pervasive in the last decades [2, 3]. With the incidence of pandemic COVID-19 and the recommendation of social distancing and quarantine in most countries, the use of digital screens and smartphones has expanded [4].

Several studies have shown that about 90% of computer users have symptoms of computer vision syndrome [5, 6], which can be caused by ocular or non-ocular problems. Ocular symptoms are divided into two main categories: symptoms related to the accommodation system and binocular vision [7] and external symptoms related to dry eyes [3]. Ocular symptoms may be due to refractive errors [8], accommodation, and convergence fatigue [9]. The type of symptoms of handheld digital devices, such as tablets and smartphones, is not different from a desktop computer, and the source of these symptoms is the short-term or long-term effects of the accommodation system and surface of eyes [10, 11].

In addition to the symptoms overlap between digital handheld devices and computers, there are differences in the type of application and screen of these devices that can be the source of different symptoms [12]. Small screen and small size letters of smartphones create closer working distances, this shorter working distance requires more accommodation for retinal image resolution [13], and requires excessive contraction of ciliary muscles and extraocular muscles [14]. One of the main components of retinal resolution is the accuracy of accommodation [15]. Near work causes lag of accommodation, which is a factor that causes a focus plane that is formed behind the retina (hyperopic defocus) [16]. Nowadays, a lot of

attention is paid to the lag of accommodation after near work in different refractive groups [17]. It has been suggested that accommodation is a missing link between near work and myopia [18].

Lag of accommodation is the value of the dioptric difference between accommodation demand and accommodation responses for one object at a given working distance [19]. Symptoms, such as blurred vision, fatigue, and headache [20] can occur when the lag of accommodation increases. Hue et al. [21] examined the lag of accommodation after using an iPod and reading a printed paper. They showed an increase in the lag of accommodation after working with the iPod compared to the printed paper. In that study, the distance and angle use of both devices were fixed, which is different from the habitual conditions of using these devices. Park et al. [22] studied the effect of lag of accommodation after half an hour of reading a book and using smartphones. Their results indicated an increase in the lag of accommodation after using a smartphone compared to reading a book. Moulakaki et al. [14] examined various accommodation responses, including lag of accommodation among three different near activities, including tablet, smartphone, and relaxed accommodation position. This study was performed for 10 minutes at a fixed distance of 40 cm. The test results did not show statically significant differences between different activities; however, the number of participants in that study was small. Another study showed no significant difference in the mean of lag of accommodation after two near work, reading a book, and using a smartphone. [23]. In this study, the lag of accommodation, after 40 minutes of near work at a distance of 33 cm with a smartphone and reading book was examined. As a result, no significant difference in the mean lag of accommodation was found after the tests. In that study, the tests were performed randomly and immediately after each other, which may interfere with the second test.

Ocular dominance is an important factor in binocular vision. Ocular dominance refers to the preference of visual input information from one eye to the other [24] and is examined from different perspectives [25]. Sensory dominance means the preference of one eye's visual input information due to differences in resolution and color information. Previous research has shown that if there is a difference of more than 0.5 diopters between the amplitude of accommodation and more than two cycles per minute in the facility of accommodation of two eyes, it can cause accommodation anomalies [26, 27]. Various factors may cause inequality in accommodation between two eyes, including uncorrected refractive errors, functional amblyopia, and trauma. Inequality in accommodation may also occur due to ocular dominance. Better facility or amplitude of one eye can cause postural problems. Previous studies on the lag of accommodation of two eyes have been done without near work and after determining the eye dominance [28].

As mentioned earlier, the lag of accommodation has been studied in various studies after the use of smartphones. However, the results of these studies are contradictory and inconsistent. There is not enough information about the lag of accommodation of two eyes after one-hour near work with the smartphone and comparing this lag of accommodation between the two eyes.

The aim of the present study was to investigate the accuracy of accommodation after one hour of near work under habitual conditions of smartphone use. On the other hand, the lag of accommodation of the two eyes was compared in order to further review the condition of the two eyes.

## Methods

This prospective study was performed on 27 staff and students (4 staff and 23 students) of the Iran University of Medical Sciences, School of Rehabilitation Sciences, with available sampling, who were informed about the type of research and participated in this study voluntarily. The study was a cross-sectional analysis. All subjects (11 males and 16 females) were healthy normal subjects of the age group of 20-35 (Mean±SD: 25.29±4.72) years, emmetropic volunteers with visual acuity 10/10, who were not using topical or systemic medication that could affect accommodation. In addition, none of them had corneal refractive surgery or any other surgery that could distort the measurements in both eyes. All patients were informed about the details of this study. In this study, to prevent distortion of information, one-hour smartphone activity was performed in a fixed time from

8 a.m. to 12 p.m. In this study, the Huvits autorefractor/keratometer series HRK 8000A, made in Korea, and the Heine retinoscope series (Heine β-200) made in Germany were used to investigate refraction. Also, the Heine retinoscope series (Heine β-200) was used to examine the lag of accommodation.

After confirming the inclusion criteria, first, the individual's accuracy of accommodation was assessed by the monocular estimate method. Immediately after taking the accuracy of accommodation at the beginning of the test, participants did near work with a smartphone for up to an hour.

The location of the near visual activity with the smartphone to prevent environmental factors was the same for all participants. In this study, due to creating natural and habitual conditions of using a smartphone, no special near work was given to the person. People can do any kind of near activity at any working distance with their smartphone, even changing the working distance and angle of use of the smartphone during activity. Participants were asked to be careful and focused during the activity with the smartphone, and do not take their eyes off the screen. In order to confirm the accuracy of the test, the examiner was present with each participant during the test. Immediately after completion of near activity with a smartphone, lag of accommodation of the right eye and then the left eye was quickly re-assessed and the information was recorded on a form.

The collected information was entered into SPSS software (version 21, SPSS, Inc.). There was no missing information in this study. First, the Kolmogorov-Smirnov test was used to confirm the normal distribution of data. We obtained the mean and standard deviation of all data and the independent samples t-test was used to analyze the data and compare the mean of the lag of accommodation before and after the test and compare the mean of the two eyes. The significance level was  $p < 0.05$ .

## Results

Among 27 subjects, there were 11(40.7%) males and 16 (59.3%) females with a Mean±SD age of 25.29±4.72 years (range, 20-35 years). According to Table 1, there was a significant difference in the lag of accommodation of the right eye, before and after the test, which indicates an increase in the lag of accommodation of the right eye after one hour of near activity with the smartphone. There was a significant difference in the lag of accommodation of the left eye, before and after the test (Table 2).

**Table 1.** Mean±SD and significance level of activity with a smartphone in the right eye

Variable	Mean±SD		P
	Before Activity	After Activity	
Lag	0.67±0.20	0.81±0.28	0.001

**Table 2.** Mean±SD and significance level of activity with a smartphone in the left eye

Variable	Mean±SD		P
	Before Activity	After Activity	
Lag	0.68±0.21	0.84±0.31	0.001

**Table 3.** The significance level of mean difference of lag of accommodation of two eyes after near work

Variable	Mean±SD		P
	Right Eye	Left Eye	
Lag	0.81±0.28	0.84±0.31	0.265

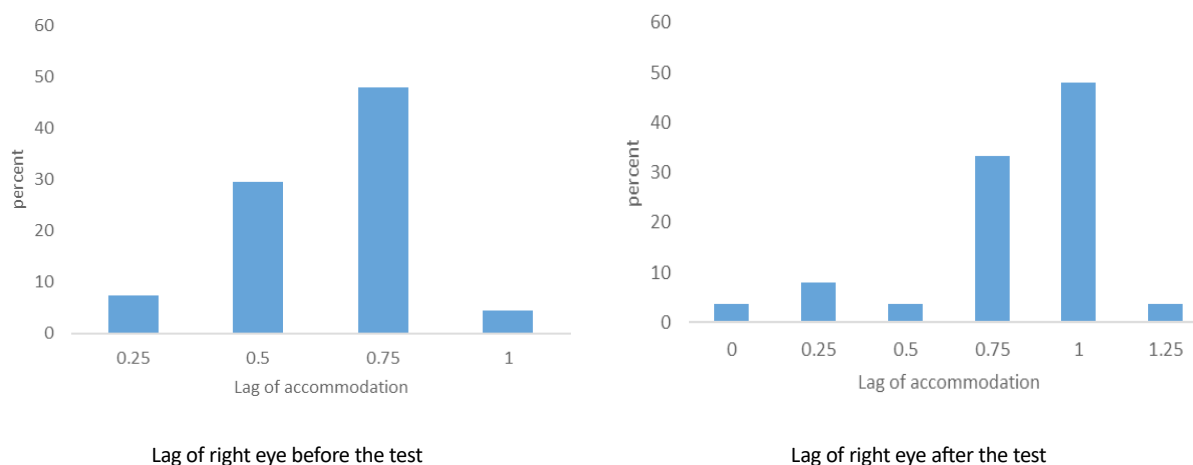
Figure 1 shows the lag of accommodation of the right eye of participants before and after the near work with a smartphone. According to Figure 1, the lag of accommodating distribution was inclined to the right side of the graph after performing near work, which indicates an increase in the lag of accommodation after smartphone use. Table 3 indicates no significant difference in the lag of accommodation of the right eye compared to the left eye after near work with a smartphone.

## Discussion

With the widespread use of digital screens, especially smartphones, concerns about the harmful effects of these devices have also increased. Previous studies have assessed the impact of lag of accommodation as a factor in

myopia progression for a long time [29] and in asthenopia in a short time [20]. Therefore, knowing the changes of this variable in the use of digital devices is important and necessary. Various studies have investigated the effect of different near work on the lag of accommodation. In previous studies, the lag of accommodation had not been studied for a one-hour duration and there was no comparison between lag of accommodation of two eyes. The aim of the present study was to investigate the effect of one-hour near work in the natural and habitual condition of smartphone usage on the accuracy of lag of accommodation of both eyes and compare them.

In this study, the lag of accommodation of both the right eye (P=0.001) and the left eye (P=0.001) increased significantly after near work (Tables 1 and 2). These

**Figure 1.** Lag of accommodating distribution in the right eye before and after near work with a smartphone

findings are consistent with the results of a study by Park et al. [22]. The results showed an increase in the lag of accommodation in 30-minute use of near activity with a smartphone compared to reading a book. In contrast, Padavettan [30] reported that the lag of accommodation after half an hour of activity with the smartphone increased. The results of both studies are consistent with the present study. Ha et al. [31] examined different accommodating responses, including lag of accommodation between different near activities, including using the smartphone, and showed an increase in the lag of accommodation after using the smartphone. Another study by Kim et al. [32] showed an increase in the lag of accommodation after using a smartphone dependent on the vergence function of the subject's eyes. Liang et al. [23] assessed the lag of accommodation after a 40-minute use of a smartphone and reading a printed paper and showed no increase in the lag of accommodation after near work, which is consistent with the results of a study by Kang et al. [12]. In their study, lag of accommodation was assessed after near activity with smartphone and tablet, and after using these devices no significant difference in the lag of accommodation was seen.

During near work, like using a smartphone, the accommodation system was affected by material and font size, and distance from visual media. Visual media of luminous screens put more burden on accommodation systems than non-luminous material [31]. Kang et al. [12] showed that the small size of smartphone screens has a negative effect on the performance of the accommodation system. Furthermore, the mean working distance when viewing a text message on a smartphone was closer than the typical near work distance of 40 cm when seeing hard copy text [33]. This luminous screen, closer working distance, and smaller font size of a smartphone will place increased demand on ocular accommodation and requires continuous contraction of ciliary muscles and extraocular muscles, especially if maintained for an extended period of time, which could exacerbate accommodation accuracy and increase lag of accommodation. In a study, Visual Display Terminal (VDT) operators experienced a high degree of visual strain after sustained near work that is strongly correlated with visually demanding tasks, depletion of accommodation, and visual fatigue [34].

To the best of our knowledge, this is the first study to explore and compare the lag of accommodation of both eyes after near work with a smartphone. In the present study, the lag of accommodation between the two eyes was compared after one hour of near activity. According to Table 3, there was no significant difference between

the lag of accommodation of the two eyes. Thus, the lag of accommodation in both eyes increased in the same way without ocular dominance.

Ocular dominance is an important factor in binocular vision. Previous research has shown that if there is a difference of more than 0.5 diopters between the amplitude of accommodation and more than two cycles per minute in the facility of accommodation of two eyes, it can cause accommodation anomalies [26, 27]. Previous studies have compared the lag of accommodation of two eyes without near activity or after determining the dominance of the eyes [28]. In some of these studies, the dominant eye had less lag of accommodation than the non-dominant eye [35]. In some others, no difference was found between the dominant and the non-dominant eye in terms of lag of accommodation [28].

## Conclusion

Near work with a smartphone for a one-hour duration showed a statically significant effect on the lag of accommodation of both eyes. Lag of accommodation can alter other parts of binocular vision and cause visual fatigue. Therefore, it may be recommended to have frequent breaks while working with smartphones. Further studies are warranted comparing different near activities in a wider range of refractive error.

## Ethical Considerations

### Compliance with ethical guidelines

This study was approved by the Ethics Committee of Iran University of Medical Sciences (Code: IR IUMS. REC.1398902-18/9/98).

### Funding

The paper was extracted from the MSc thesis of the first author, Department of optometry Faculty of rehabilitation sciences University of IUMS.

### Authors' contributions

Conceptualization, Supervision, Funding acquisition, Resources, and Writing – original draft: Mrs. Shahri, Dr. Jafarzadehpour, and Dr. Mirzajani; Investigation, Writing – review & editing: All authors.

### Conflict of interest

The authors declared no conflict of interest.

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## مقاله پژوهشی

### بررسی تأخیر تطابقی پس از استفاده از گوشی هوشمند

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## چکیده

**مقدمه:** با فراگیر شدن استفاده از صفحات دیجیتال به خصوص تلفن هوشمند، نگرانی از تأثیرات مضر آنها بر بینایی افزایش یافته است. هدف از مطالعه حاضر، تأثیر فعالیت طولانی مدت با تلفن هوشمند بر دقت تطابق دو چشم بود.

**مواد و روش‌ها:** در این مطالعه مقطعی تحلیلی، ۲۷ نفر (۱۶ زن و ۱۱ مرد) از دانشجویان و کارمندان دانشگاه علوم پزشکی ایران با میانگین سنی ۲۵/۲۹، با وضعیت انکساری امتریوپ با دید ۱۰/۱۰ و روش نمونه‌گیری در دسترس انتخاب شدند. ابتدا شرکت کنندگان یک ساعت با تلفن هوشمند به فعالیت پرداختند و سپس لگ تطابقی به روش MEM برای هر دو چشم بررسی شد.

**یافته‌ها:** لگ چشم راست ( $P=0/001$ ) و لگ چشم چپ ( $P=0/001$ ) هر دو بعد از استفاده یک ساعته از تلفن هوشمند به طور معناداری افزایش پیدا کردند. ولی بین لگ دو چشم بعد از استفاده از تلفن هوشمند تفاوت معناداری پیدا نشد ( $P=0/265$ ).

**نتیجه‌گیری:** مطالعه حاضر رابطه‌ای بین فعالیت طولانی مدت با تلفن همراه و افزایش لگ تطابقی را تایید می‌کند.

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## کلیدواژه‌ها:

تطابق، گوشی هوشمند، تجهیزات دیجیتال، تأخیر تطابقی

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