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RESEARCH ARTICLE
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"IMPACT OF DAILY DIGITAL DEVICE USAGE DURATION ON TEAR FILM STABILITY IN YOUNG ADULTS"

Abdul Qadeem Soomro[1*], Fayaz Ahmed Soomro[2], Abdul Sattar[3], Shoaib Ahmed Shaikh[4], Syed Saifullah Shah[5], Abdullah Laghari[6], Hina Khan[7]

[1*]Consultant Ophthalmologist, Alibrahim Eye Hospital, Isra Postgraduate Institution of Ophthalmology Malir, Karachi
Email: DRQADEEM@YAHOO.COM
[2]Consultant Ophthalmologist, Institute Al Ibrahim Eye Hospital Isra Postgraduate Institute of Ophthalmology Karachi
Email: DRFAYAZSOOMRO@YAHOO
[3]Consultant Ophthalmologist, Institute Al Ibrahim Eye Hospital Isra Postgraduate Institute of Ophthalmology Karachi
Email: sattarazad123@gmail.com
[4]Consultant Ophthalmologist, Institute Al Ibrahim Eye Hospital Isra Postgraduate Institute of Ophthalmology Karachi
Email: evermore_majestic_bojee@hotmail.com
[5]Consultant Ophthalmologist, Institute Al Ibrahim Eye Hospital Isra Postgraduate Institute of Ophthalmology Karachi
Email: saifulshah083@gmail.com
[6]Optometrist, Institute Al Ibrahim Eye Hospital Isra Postgraduate Institute of Ophthalmology Karachi
Email: LAGHARI08@GMAIL.COM
[7]Professor, Deputy Director Research and Postgraduate Affairs

***Corresponding Author:** Abdul Qadeem Soomro
*Email: DRQADEEM@YAHOO.COM

ABSTRACT

Background: There has been a sharp rise in the use of digital devices among young adults, which has raised concerns about how this might be affecting eye health, mainly the ocular surface. Spending extended hours in front of screens leads to a lower blink rate, a higher rate of tear evaporation, and tear film instability, all of which are significant factors causing dry eye disease. A stable tear film, which can be assessed by the Tear Breakup Time (TBUT), is crucial for both eye comfort and clear vision. Figuring out how daily use of digital devices affects tear film stability can help detect early signs of ocular surface problems.

Objective: Investigate the effect of the time spent daily on digital devices on the tear film stability of young adults through Tear Breakup Time measurements, and determine the relationship of screen exposure duration with tear film stability.

Methods: The work was conducted as a cross-sectional study at Isra Postgraduate institute of ophthalmology Al Ibrahim Eye Hospital, Pakistan, from January, 2024 to December, 2024. It involved 100 young adults aged 18-30. Based on the time spent on digital devices for daily activities, the participants were split into three groups (<3 hours, 3-6 hours, and >6 hours). Tear film stability was

measured by the Tear Breakup Time (TBUT) assay, which was done by slit lamp biomicroscopy after staining with fluorescein.
Results: The study found that people who used digital devices for a very long time (over 6 hours/day) had a much shorter TBUT (8.9 ± 2.7 seconds) than those with moderate (11.6 ± 2.4 seconds) and low usage (14.8 ± 2.1 seconds) groups. There were more cases of tear film instability in the group of heavy digital device users, indicating a very strong negative correlation between screen time and tear film stability.
Conclusion: Prolonged use of digital devices significantly impairs tear film stability in young adults. It is necessary to have preventive measures, such as limiting the time of using digital screens, keeping good digital hygiene, to mitigate these effects and keep the ocular surface health.

Keywords: Digital device usage, Tear film stability, Tear breakup time, Dry eye disease, Digital eye strain, Young adults, Ocular surface health

INTRODUCTION

The evolution of digital technology has deeply transformed the way people look at things. In particular, young adults who are always utilizing smartphones, laptops, and tablets for their studies, work, and entertainment have been affected the most. This ever-increasing interaction with digital screens has raised concern that people's eyes are not only being affected in general, but that the tear film is becoming unstable, a vital factor for a healthy cornea and good vision. The stability of the tear film is achieved through a very delicate balance between tear secretion, its spreading, and evaporation. Simply avoiding digital screens for a day could restore tear film stability to its normal level, and the fact that people use screens for hours on end disturbs that balance. Currently, a vast majority of young adults cannot stay away from their digital gadgets throughout the day. The rise in screen time happened simultaneously with the decline in tear film stability in the group of young adults. Young adults today are quite often suffering from ocular surface dysfunction because of too much screen time (1). The deterioration in young people's eye health today corresponds with a shift towards lifestyle diseases that were uncommon among the young generation of the past. The human body is activated in different ways when it is exposed to a digital screen, which eventually leads to tear film instability through the blink rate reduction, incomplete blinking, and increased tear evaporation. It has been discovered that the Ocular Surface Disease Index (OSDI), which is a scale to be used by doctors to evaluate the degree of dry eyes, is very much related to the duration of screen time and the tear film changes. Back in 2018, it was revealed that the group of young people who had longer screen exposure showed significantly higher OSDI scores and shorter tear breakup times, so their tear film was severely damaged (2). The health of the ocular surface is mainly influenced by behavioral and environmental factors. The results of the study demonstrate that these factors are mainly environmental and behavioral, especially around colleges and offices, which, by nature, are environments that utilize digital technologies intensively.

It seems that digital eye strain and tear film instability are evolving into more common issues among youth, and a serious public health problem is emerging. Prolonged screen exposure has been linked to both structural and functional changes in the ocular surface, such as meibomian gland dysfunction and tear film instability. A broad study of adolescents and young adults found that very long periods of digital device use were associated with a substantial decrease in tear film stability and an increase in dry eye symptoms (3). These discoveries point out that young people can be easily affected since their visual systems are now even more exposed to sustained near work and digital exposure. If we carefully observe the relationship between digital screen use and dry eye disease, we will see that the evidence is so overwhelming that it has been repeatedly confirmed by various clinical studies that the negative impact of prolonged digital exposure on tear film quality is undeniable. The use of digital devices has been linked to increased tear evaporation, ocular surface inflammation, and tear film instability. There is clinical evidence to support that exposure to screens over an extended period can change tear film composition and reduce tear film breakup time, which eventually leads to an unhealthy ocular surface (4). The previous facts may even cause persistent discomfort, visual fatigue,

and a decline in productivity, and further research on digital eye-related tear film abnormalities is needed.

Among lifestyle factors, prolonged use of digital devices, less time spent outdoors, and more sedentary behavior can greatly worsen tear film instability. Studies on children and adolescent demographics showed that more time spent in front of the screen was linked to a substantially greater chance of developing dry eye disease and having less stable tears. The data imply that using digital screens causes early tear film malfunction and can negatively affect one's eye health in the long run (5). This kind of proof advocates exploring tear film stability in the young adult demographic, specifically, as these youngsters represent the most at-risk group due to their high academic and digital involvement. Comparative research studies between digital device users and non-users have shown drastic differences in tear film stability and meibomian gland functionality. The group of digital device users had strikingly lower tear breakup durations and a greater extent of ocular surface abnormalities than the non-user group. The results demonstrate that digital exposure is a major contributor to tear film physiology and may trigger chronic ocular surface disorders if exposure is not limited or treated (6). This strengthens the notion that the daily length of time spent using a digital device is the major factor influencing tear film stability. Proper blinking is crucial in keeping the tear film stable, which is also why the use of digital devices changes the way we blink largely. For instance, children and adolescents who were exposed to screens were found to have decreased blinking rates and increased partial blinking that resulted in less stable tears. This situation caused less efficient tear film distribution over the eye surface, resulting in greater tear evaporation and ocular discomfort (7). Therefore, the decrease in blinking associated with digital screen use is the main natural physiological factor causing tear film disruption.

Use of digital devices not only alters visual performance but also degrades optical quality and tears components. Studies on people who are using computers commercially have shown that long hours at the screen cause a drop in the quality of tears and visual functions that can be measured. Tear film instability was highly correlated with visual fatigue, lowered contrast sensitivity, and increased ocular discomfort (8). Such results point out the great extent to which functional outcomes from tear film instability may also be affected, butin addition to changes in the structure of the ocular surface. Overindulgence in digital media has gained momentum as a global public health problem, and it has even been called an epidemic among adolescents and young adults in the 21st century. Digital overexposure has been linked not only to dryness of the eyes but also to sleep problems and lower visual comfort. Clinical data show that the longer the screen time, the higher the risk of digital eye strain and tear film dysfunction (9). Therefore, these results are a reflection of the overall health and eye conditions after overuse of digital devices.

Digital eye strain is a multifactorial condition including tear film instability, a feeling of tiredness of the eyes, and ocular discomfort. Complete clinical reviews have pinpointed tear film instability as a major underlying mechanism of digital eye strain. Doing digital tasks for a long time lowers blinking efficiency, and the tear evaporation increases, causing tear film breakup and dry eye surface (10). The changes in the body mentioned above are very important contributors to dry eye symptoms in digital device users. The use of a smartphone has been more clearly linked to a reduction in blink rate and an increase in dry eye symptoms. Experimental research with smartphone gaming indicated that the blink frequency was significantly decreased, and the tear film was more unstable, confirming the immediate effect of digital devices on the eye surface (11). These data allow us to conclude from the experiment that the usage of digital devices is associated with tear film dysfunction.

Tear film stability is easily disrupted by changes in surroundings and habits, including prolonged focus on visual tasks. Clinical studies exploring tear film reactions in healthy young people have revealed that visual stresses like watching a screen for a long time have a great impact on tear breakup time and tear volume (13). The results imply that digital exposure is a major environmental stressor that disrupts tear film homeostasis. Extremely intense smartphone use has been proven to significantly raise both the occurrence and the seriousness of dry eye disease. Using quantitative-based research, it was found that individuals with prolonged smartphone use have significantly lower tear stability and

higher-rated dry eye diagnosis (14). The results corroborate that the duration of use of digital devices is a major factor in determining tear film stability.

Studies performed on school children have also found that there is a pretty strong link between the use of digital devices and tear film dysfunction. More screen time was found to be significantly related to a decrease in tear breakup time and an increase in ocular discomfort (15). These results suggest that tear film instability starts pretty much with the children and can continue throughout their lives. Similarly, using digital displays has been linked to getting worse dry eye symptoms, especially in people who have been heavily using the screen. Clinical studies have confirmed that any rise in digital exposure has a great impact on the tear film quality and ocular surface condition (16). These results are really a clear indication that eye health is being affected by the ongoing accumulation of digital exposure.

Although digital eye strain is often associated with younger people, similar tear film abnormalities have been observed across age groups. Research on adult subjects revealed that extended use of digital screens has a major impact on the stability of the tear film and the comfort of the eyes (17). Therefore, the evidence from these studies points to the fact that tear film instability due to exposure to digital devices happens to everyone. Large-scale population-based epidemiological studies have confirmed a strong association between digital media use and the development of dry eye disease. With more digital exposure, the risk of tear film instability and ocular surface dysfunction has been raised substantially (18). The paper's findings call for further research on the effects of digital exposure on the stability of the tear film.

The latest clinical viewpoints started with the fact that digital eye strain and tear film instability are not only the eye health problems of an individual but also represent the challenges of global ocular health in the future. The length of time that is spent using a digital device is, among other factors, one of the most easily changed risk factors that can have an impact on tear film stability. Long-term exposure to digital devices leads to dysfunction of the tear film and is a major factor in the development of ocular surface disease (19). Since young adults are more and more dependent on digital devices and there is already a high prevalence of tear film instability, it is necessary to check how the duration of daily digital device usage is related to the tear film stability. This knowledge will give an insight into the early changes of the ocular surface and will help in formulating the prevention strategies that are aimed at maintaining eye health in the digital world.

Objective:

The objective of this study was to analyze the effect of prolonged use of daily digital devices on tear film stability in young adults. For this purpose, the tear break-up time was measured, and its correlation with the screen exposure duration was determined.

MATERIALS AND METHODS

Study Design: This was a cross-sectional hospital-based analytical study.

Study Setting: The research took place in the Isra Postgraduate institute of ophthalmology Al Ibrahim Eye Hospital, Pakistan. It is a tertiary care teaching hospital that offers advanced ophthalmic diagnostic and clinical services.

Duration of Study: January, 2024 to December, 2024.

Sample Size: A total of 100 young adult participants were included through non-probability, consecutive sampling.

Inclusion Criteria:

The study focused on young adults between the ages of 18 and 30 years. Participants needed to be habitual users of digital devices such as smartphones, laptops, or tablets for any combination of academic, occupational, and recreational purposes. There were no individuals with any ocular conditions included. All participants were informed and consented to the test and were, at the same time, comfortable and capable of being examined for tear film stability using the slit lamp biomicroscope and tear breakup time measurement. To conduct a comparative study on tear film

stability, the recruiting criteria were such that participants had to have different durations of daily screen exposure.

Exclusion Criteria:
Patients with pre-existing conditions of the ocular surface, such as dry eye disease, conjunctivitis, keratitis, or meibomian gland dysfunction, were not allowed to participate in this study. The study further excluded individuals who sported contact lenses or used topical and systemic medications that could affect tear production. Ocular surgery, trauma, autoimmune disease, diabetes mellitus, and systemic diseases that could affect tear film physiology in the patient's history were among the reasons for the exclusion of the patients. Participants who had acute ocular infections, allergies, or inflammatory ocular conditions at the time of examination were also excluded. These exclusion criteria were used to ensure that the measurements of tear film stability were due to the effects of digital devices and not the influence of other clinical conditions.

Methods
Participants had a comprehensive eye examination by Isra Postgraduate institute of ophthalmology Al Ibrahim Eye Hospital, Pakistan. Demographic characteristics were gathered by means of a structured questionnaire, which also served as an instrument for measuring average daily digital device usage in hours per day. Daily screen time was the criterion on which participants were separated into three groups: low usage (<3 hours), moderate usage (3- 6 hours), and high usage (>6 hours). Tear film stability was evaluated through Tear Breakup Time (TBUT), which is a clinically accepted marker of tear film integrity. Fluorescein was introduced into the conjunctival sac, and tear breakup time was recorded through slit lamp examination under cobalt blue illumination. Three replicas were made for every eye, and the mean value was documented. Decreased TBUT readings denoted lesser tear film stability. A trained ophthalmologist conducted all the tests at a standardized clinical setting to guarantee the accuracy, reliability, and consistency of the tear film measurement of all the study participants.

Results
The present study, conducted at Isra Postgraduate institute of ophthalmology Al Ibrahim Eye Hospital, Pakistan, recruited 100 young adult participants. The mean age of the participants was 23.4 ± 3.1 years, and the gender distribution was 54% males and 46% females. All the subjects were habitual users of digital devices, and the time for which they exposed their eyes to the screen each day was different. Tear film stability was evaluated with the help of Tear Breakup Time (TBUT), and the results showed a significant relation between the duration of digital device exposure and the stability of the tear film.

Table 1: Demographic Characteristics of Participants (n = 100)

Variable	Frequency (n)	Percentage (%)
Age 18–21 years	32	32.0
Age 22–25 years	41	41.0
Age 26–30 years	27	27.0
Male	54	54.0
Female	46	46.0

Most of the participants (41%) were in the age group 22-25 years. There were slightly more males than females in the gender distribution. Such a demographic pattern is typical in young adults who are frequent users of digital devices.
The participants were divided into three groups according to the amount of time they spent using digital devices daily.

Table 2: Distribution Based on Daily Digital Device Usage Duration

Screen Time Duration	Frequency (n)	Percentage (%)
< 3 hours	24	24.0
3–6 hours	38	38.0
> 6 hours	38	38.0

The majority of participants (76%) reported spending over 3 hours daily on digital devices, indicating a high level of digital exposure among young adults.

Tear film stability was measured using Tear Breakup Time (TBUT), and notable differences between screen time groups were observed.

Table 3: Mean Tear Breakup Time Across Screen Time Groups

Screen Time Duration	Mean TBUT (seconds)	Standard Deviation
< 3 hours	14.8	2.1
3–6 hours	11.6	2.4
> 6 hours	8.9	2.7

Those participants who were less engaged with screens (<3 hours) displayed significantly higher tear breakup time, which is an indicator of good tear film stability. Conversely, people who spent a long time in front of a screen (>6 hours) had greatly lowered their TBUT values, which is a sign of deteriorated tear film stability.

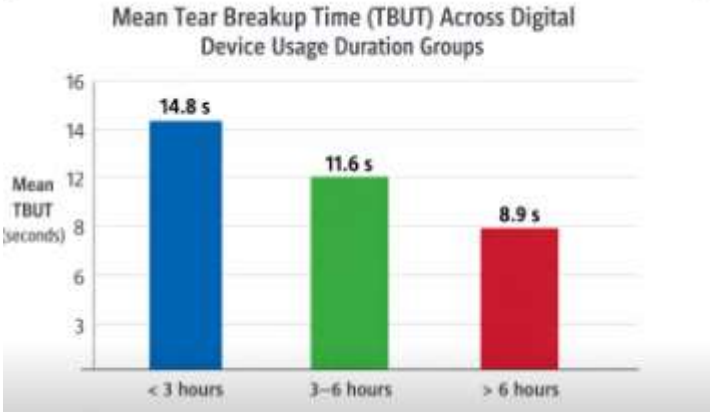
The prevalence of tear film instability was also evaluated by categorizing TBUT values.

Table 4: Prevalence of Tear Film Instability Based on TBUT Values

TBUT Category	Frequency (n)	Percentage (%)
Normal (>10 seconds)	52	52.0
Borderline (8–10 seconds)	29	29.0
Abnormal (<8 seconds)	19	19.0

Almost 20% of the study participants showed abnormal tear film stability, and the majority of these cases occurred in the high-screen exposure group.

Figure 1: Relationship Between Screen Time and Mean Tear Breakup Time



The graphical representation clearly illustrates a progressive decline in tear film stability with increasing digital device usage duration. Participants with prolonged screen exposure demonstrated significantly reduced TBUT values compared to those with lower screen time. Overall, the findings

indicate a strong inverse relationship between daily digital device usage duration and tear film stability. Increased screen exposure was associated with reduced tear breakup time and a higher prevalence of tear film instability. These results suggest that prolonged digital device usage significantly compromises tear film integrity in young adults.

Discussion

This research, conducted at the Isra Postgraduate institute of ophthalmology Al Ibrahim Eye Hospital, Pakistan, has revealed a statistically significant negative correlation between the number of hours spent using a digital device and tear film stability in young adults. The subjects who lay in front of screens the longest had their tear film compartment evidenced by a drastically lowered average Tear Breakup Time (TBUT). These observations are in line with those of other researchers, which visually support the idea that an extended period of screen staring alters the fundamental components of the tear film. In the paper by Zahid et al., the researchers observed a strong correlation between time spent in front of a screen and tear film stability among young adults (1). They further asserted that prolonged digital exposure of the eyes dramatically increases the risk of tear film dysfunction and ocular discomfort. The current data confirm the need to raise public awareness of the impact of excessive digital device use on the ocular surface, and young people should be encouraged to limit their use of digital devices to preserve ocular health. The diminution in the stability of the tear film brought about by prolonged digital device exposure may stem from biological changes linked to intense visual focusing over long periods of time. It has been noted that when a person is engaging in a task involving a digital display, he or she blinks less often and many times with incomplete blinks. The decrease in the blink rate and the increase in incomplete blinks due to digital device usage cause the tear film to be redistributed less effectively over the ocular surface. Manna and Arvind found that elevated scores on the ocular surface disease index and reduced tear breakup times were very tightly PR correlated with increased digital screen time, essentially supporting the notion that tears are compromised by digital exposure (2). These gradual physiological changes culminate in excessive tear evaporation, disrupted tear film layers, and increased surface damage to the eye. The results of this research, in particular, participants who reported prolonged digital screen exposure, who, in this regard, are vulnerable to ocular surface disorders, are also showing a significantly lower tear breakup time (TBUT) as compared to non-users.

This study's findings echo clinical results that show using screens for a long time leads to early tear film dysfunction and dry eye symptoms. Muntz et al. found that long screen time greatly impacted tear film stability in young people, which means that exposing oneself to screens for long hours can cause the eyes' surface to become abnormal even in healthy individuals (3). Similarly, Al-Mohtaseb et al. in their study came to the decision that the use of digital screens for a long period significantly harms the tear film and causes inflammation of the ocular surfaces along with the development of dry eye (4). If eye drops are not being used frequently, digital eye discomfort and eye fatigue may persist. Furthermore, lifestyle and behavioral factors related to digital device use contribute significantly to tear film instability. Wang et al. showed that lower physical activity, combined with higher digital screen time, is associated with a greater risk of dry eye disorder and tear film instability in young people (5). Lack of outdoor activities and more near work causes ocular surface stress and tear film dysfunction. The current study results are consistent with this line of evidence, and participants with higher daily screen exposure had significantly shorter tear breakup time than those with lower screen time. Changing one's lifestyle may be crucial in maintaining tear film stability.

The current results are also in line with the findings of comparative clinical studies that evaluated digital device users and non-users. Balaji et al. found markedly lower tear breakup time and impaired meibomian gland function in digital device users compared to non-users, confirming the direct effect of screen exposure on tear film physiology (6). Meibomian gland dysfunction leads to a decrease in the lipid layer of the tear film, an increase in tear evaporation, and a decrease in tear stability. This mechanism might have been responsible for the lower tear breakup time seen in high digital device users in the current study. Blinking dynamics are vital for maintaining tear film stability, and digital device use drastically changes blink patterns. Chidi-Egboka et al. confirmed that screen exposure

drastically decreases blink frequency and raises incomplete blinking, which results in tear film instability and ocular surface dryness (7). The present findings in high screen exposure participants, who demonstrated reduced tear breakup time, have a physiological basis explained by the above-mentioned studies. During extended digital tasks, less blinking due to uninterrupted concentration leads to an inadequate tear film redistribution, resulting in localized tear film breakup and eye discomfort.

Visual performance and tear film quality are both affected by digital device usage. Talens-Estarelles and colleagues found that long computer work hours lead to a marked decline in the tear film quality, eye fatigue, and discomfort (8). Tear film instability leads to decreased optical quality and visual performance. Therefore, the detrimental effects of prolonged digital exposure on functional aspects are evident. The current study results are in line with these findings, as it was demonstrated that the tear film stability was significantly lower in individuals with long screen time. Excessive use of digital devices has been identified as a potential major public health issue that threatens eye health globally. Şambel Aykutlu et al. have shown that long digital exposure dramatically escalates the levels of eye strain and tear film instability, mainly in young people living in urban areas (9). The current results are in agreement with this expanding line of literature and point to the importance of the issue of digital devices related eye health. Digital eye strain is a condition characterized by tear film instability, visual fatigue, and eye discomfort. Kaur et al. have shown that tear film instability is among the major factors necessary for digital eye strain to occur and have also stressed that tear film stability is a key element in maintaining ocular surface health (10). The observations made in the present work on the low values of TBUT in the high screen exposure group entirely correspond to the above findings.

Experimental studies with smartphone usage have evidenced a blink rate reduction and an increase in tear film instability. Chidi-Egboka et al. revealed that the use of a smartphone (cell phone) drastically decreases the number of blinks and increases the symptoms of dry eye, validating the physiological drop of digital devices on tear film after a direct impact (11). Such results also corroborate the outcomes of this research. Similarly, Environmental and behavioral factors affect tear film stability. Sabucedo-Villamarin et al. showed that the tear film is quite vulnerable to visually stressful situations, such as long-term digital exposure (13). Such results underscore the need to avoid extremely long screen time. High smartphone use has been linked to a significant increase in dry eye prevalence and tear film instability. Wang et al. revealed that extended smartphone use leads to greater severity of dry eye (14). Such results are very consistent with the present study findings.

Similar relationships between increased screen time and deteriorated tear film stability, along with more eye discomfort, have been documented in younger immortal school-aged kids (15). Talens-Estarelles et al. also demonstrated that exposure to a digital display greatly influences the stability of the tear film (16). Moore et al. found similar results in an adult population, suggesting that digital exposure adversely impacts tear film stability not only in adults but also in other age groups (17). Studies based on populations confirm that the risk of becoming unstable with one's tear film is greatly increased by exposure to devices (18). A few recent clinical studies highlight that digital eye strain and destabilization of the tear film are among the major global ocular health issues emerging (19). In general, the current research has demonstrated that extended personal use of digital devices during the day markedly weakens the stabilizing effect of the tear film in young adults. The results speak in favor of advocating digital hygiene measures such as regular screen breaks, proper blinking habits, and refraining from prolonged screen exposure in order to maintain tear film homeostasis and avert long-term damage to the ocular surface.

Conclusion

This research, conducted at the Isra Postgraduate institute of ophthalmology Al Ibrahim Eye Hospital, Pakistan, revealed a strong inverse relationship between the time young adults spend using digital devices daily and their tear film stability. Those who were exposed to the screen for a long time showed a very low Tear Breakup Time (TBUT), indicating compromised tear film integrity and a higher risk of ocular surface dysfunction. In fact, the excessive usage of digital devices has been confirmed as a major factor leading to the instability of tear film, even in young people who are

otherwise healthy. The findings uncover how behavioral and lifestyle factors, especially extended screen exposure, contribute to the disruption of normal tear film physiology. It is crucial to diagnose tear film instability at the earliest stage in digital device users so that its progression to symptomatic dry eye disease can be prevented. The introduction of preventive measures such as limiting the time of continuous screen exposure, blinking frequently, and following good digital hygiene habits is likely beneficial in maintaining a stable tear film and long-term ocular surface health in young adults.

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