Analysis of Tear Film in Computer Users

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Short title: Tear Film in Computer Users

Abstract:

Purpose: This study aimed to assess tear film stability, tear volume, and dry eye symptoms in computer users.

Methods: Two hundred participants (400 eyes) participated in the study. Demographic data, tear film breakup time (TBUT), tear meniscus height (TMH), Schirmer I test results, and Ocular Surface Disease Index (OSDI) scores were collected. TBUT was measured using both Fluorescein Breakup Time (FBUT) and Non-Invasive Breakup Time (NIBUT). Pearson's correlation analysis was conducted to evaluate the relationships between these parameters.

Results: The mean age of participants was 32.5 ± 8.4 years, with 90 males and 110 females. The average duration of computer use was 6.2 ± 1.8 hours per day over 7.5 ± 3.2 years. Mean TBUT values were 5.8 ± 2.1 seconds (FBUT) and 7.1 ± 2.4 seconds (NIBUT), with NIBUT being significantly longer ($p < 0.05$). Mean TMH was 0.20 ± 0.05 mm, and Schirmer I test results averaged 10.8 ± 3.5 mm. The mean OSDI score was 25.4 ± 10.2, indicating mild to moderate dry eye symptoms. Significant correlations were found between the TBUT, TMH, Schirmer I test results, and OSDI scores. FBUT was positively correlated with NIBUT ($r = 0.65$, $p < 0.01$), TMH ($r = 0.34$, $p < 0.05$), and Schirmer I test results ($r = 0.28$, $p < 0.05$), and negatively correlated with OSDI scores ($r = -0.50$, $p < 0.01$). The NIBUT showed similar patterns of correlation.

Conclusion: The study highlights the significant prevalence of tear film instability and dry eye symptoms among computer users. NIBUT demonstrated superior reliability and accuracy compared to FBUT in assessing tear film stability, supporting its application as a preferred diagnostic tool for clinical evaluation and management of dry eye disease.

Keywords: Tear meniscus height, Schirmer I test, Ocular Surface Disease Index (OSDI) scores, Fluorescein Breakup Time, Non-Invasive Breakup Time

INTRODUCTION

The proliferation of digital devices in modern life has led to a significant increase in the prevalence of Computer Vision Syndrome (CVS), or Digital Eye Strain. CVS encompasses **various** ocular and visual symptoms, with dry eye disease (DED) being **a** common complaint among computer users. DED is characterized by a disturbance in the tear film, with symptoms of dryness, irritation, and VA disturbances. Prolonged computer use is associated with decreased blink rates and incomplete blinking, both of which can contribute to tear film evaporation and instability, exacerbating dry eye symptoms.[1,2.]

Tear film is a complex structure that plays an important role in maintaining ocular surface health, providing a smooth optical surface, and protecting against environmental insults. It formed of 3 layers: a lipid layer, an aqueous layer, and a mucin layer. Disruption can lead to tear film instability and dry eye symptoms. **An a**ccurate assessment of the tear film is essential for diagnosing DED and evaluating the effectiveness of treatment interventions.[3-6.]

Traditional methods for assessing tear film stability include the FBUT, **in which** a fluorescein dye is applied to the ocular surface, and the time taken for the first dry spot to appear is measured[7]. **Although** widely used, FBUT can be invasive and uncomfortable for patients, potentially altering the natural behavior of the tear film[8]. NIBUT methods, on the other hand, offer a more patient-friendly alternative by using instruments such as videokeratoscopy to assess tear film stability without the need for dyes[9].

Despite the growing awareness of the impact of prolonged computer use on ocular health, there is a limited body of research comparing the efficacy of non-invasive tear breakup time (NIBUT) and fluorescein breakup time (FBUT) specifically in computer users. While FBUT is the standard diagnostic tool, its invasive nature may disrupt the tear film, thus compromising its accuracy. Non-invasive methods like NIBUT are gaining attention for their potential to provide a more accurate and natural assessment of tear film stability. However, a direct comparison between these methods in the context of computer users remains understudied. This study aims to fill this gap by evaluating the performance of both methods in diagnosing dry eye disease (DED) and assessing their clinical applicability in this specific population.

This study aimed to compare the efficacy of NIBUT and FBUT in diagnosing and evaluating dry eye symptoms in computer users. By analyzing the tear film characteristics in this population, we **sought** to better understand the impact of prolonged computer use on ocular surface health and identify reliable, non-invasive diagnostic tools for clinical practice.

SUBJECTS AND METHODS

Study Design

This observational study was conducted at the Ophthalmology Departments of Misr University for Science and Technology , Fayoum University and Beni-Suef University, to investigate tear film abnormalities and dry eye symptoms **among** computer users. The study was conducted in accordance with the principles of the Declaration of Helsinki, and informed consent was obtained from all **the** participants. Beni-Suef Ethical approval no FMBSUREC/01092024/Goda

Study Population

A total of 200 random individuals (400 eyes) who regularly used computers for at least 4 hours per day were recruited for the study. Participants were aged between 18 and 60 years and had no history of ocular surgery, systemic diseases affecting the eye, or use of medications that could influence tear production. Individuals with a history of COVID-19 infection or signs of ocular infection were excluded from the study.

Examination Procedures

Ocular Surface Examination

All participants underwent a comprehensive ocular surface examination using a slit lamp biomicroscope. The examination included:

- Assessment of the eyelids and conjunctiva for any abnormalities.
- Evaluation of the cornea and tear film.

Tear Film Breakup Time (TBUT)

The TBUT was assessed using two methods:

1. **FBUT:**
   - A fluorescein strip was applied to the conjunctiva inferior fornix.
   - Ask the patient to blink several times to ensure even distribution of the dye.
   - A cobalt blue filter Used, the time from the last complete blink to the appearance of the first dry spot on the cornea was measured.
   - The average of three measurements was recorded as the TBUT.
2. **NIBUT:**
   - NIBUT was measured using the CSO Sirius Scheimpflug/Placido topographer. (CSO, Firenze, Italy)
   - The patient was instructed to blink naturally and then keep his/her eyes till complete capture of images.
   - The topographer captured images of the tear film, and the record time taken for the first disruption in the tear film.

- The average of three measurements was documented as the NIBUT.

Tear Film Stability and Volume

- **TMH:**
  - TMH was measured using the CSO Sirius Scheimpflug/Placido topographer.
  - A cross-sectional image of the lower tear meniscus was obtained, and the height was measured in millimeters.
- **Schirmer I Test:**
  - Schirmer strips were carefully placed in the lower fornix without anesthesia.
  - After 5 minutes, the length of the wetting on the strip was measured in millimeters.

Dry Eye Symptom Questionnaire

The OSDI questionnaire consists of 12 questions assessing the frequency and severity of dry eye symptoms, their impact on visual function, and the influence of environmental factors. Each question is scored on a scale from 0 to 4, with higher scores indicating more severe symptoms.

The final score is calculated using the formula:

$$\text{OSDI Score} = \left(\frac{\text{Total Score of All Questions}}{\text{Number of Questions Answered} \times 4}\right) \times 1$$

Interpretation:

- 0–12: Normal
- 13–22: Mild Dry Eye
- 23–32: Moderate Dry Eye
- ≥33: Severe Dry Eye

The questionnaire was introduced in a written survey format, and participants were asked to complete it independently. For non-Arabic speakers, the standard English version was used. For Arabic-speaking participants, a validated Arabic translation of the OSDI questionnaire was provided, ensuring cultural relevance and comprehension.

Data Analysis

Statistical analysis was performed using IBM SPSS version 23. The following statistical methods were employed:

- Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population.
- Paired t-tests to compare the FBUT and NIBUT measurements.
- Pearson's correlation analysis to evaluate the relationship between TBUT, TMH, Schirmer I test results, and OSDI scores.

A p-value of less than 0.05 was considered statistically significant.

RESULTS

The study included 200 participants (400 eyes), with a mean age of 32.5 ± 8.4 years. The gender distribution was nearly balanced, comprising 90 males and 110 females. Participants reported an average daily computer usage duration of 6.2 ± 1.8 hours, with a mean duration of computer use extending over 7.5 ± 3.2 years. These findings provide an overview of the study sample, which is representative of individuals with significant computer exposure, a known risk factor for dry eye symptoms and tear film instability as shown in table 1.

Table 1: Demographic and Clinical Profile of the Study Participants

Characteristic	Value
Participants	200
Number of Eyes	400
Age (yrs)	32.5 ± 8.4
Gender (Male/Female)	90/110
Duration of Computer Use (hours/day)	6.2 ± 1.8
Duration of Computer Use (years)	7.5 ± 3.2

Table 2 presents the Tear Breakup Time (TBUT) measurements in seconds, highlighting both Fluorescein Breakup Time (FBUT) and Non-invasive Breakup Time (NIBUT) values. The mean FBUT was 5.8 ± 2.1 seconds, with a range of 2.0 to 12.0 seconds, indicating shorter tear film stability as measured using fluorescein dye. In contrast, the mean NIBUT was 7.1 ± 2.4 seconds, with a broader range of 3.0 to 14.0 seconds, reflecting relatively longer tear film stability when measured non-invasively. These findings suggest a consistent difference between the two methods, with NIBUT yielding higher values, likely due to the absence of interference from fluorescein dye in the measurement process.

Table 2: TBUT Measurements (seconds)

Measurement	Mean ± SD	Range
FBUT	5.8 ± 2.1	2.0 - 12.0
NIBUT	7.1 ± 2.4	3.0 - 14.0

Table 3 summarizes the Tear Meniscus Height (TMH) and Schirmer I Test results, providing key measurements of tear film volume and production among the study participants. The mean TMH was 0.20 ± 0.05 mm, with a range of 0.10 to 0.30 mm, indicating variability in tear reservoir capacity across the sample. The Schirmer I Test, used to evaluate baseline aqueous tear production, showed a mean value of 10.8 ± 3.5 mm, with a range spanning from 5.0 to 20.0 mm. These findings suggest a broad spectrum of tear production levels within the population, highlighting interindividual differences in tear dynamics.

Table 3: TMH and Schirmer I Test Results

Measurement	Mean ± SD	Range
TMH (mm)	0.20 ± 0.05	0.10 - 0.30
Schirmer I Test (mm)	10.8 ± 3.5	5.0 - 20.0

Table 4 presents the Ocular Surface Disease Index (OSDI) scores, which provide an assessment of the severity of dry eye symptoms among the study participants. The mean OSDI score was 25.4 ± 10.2, indicating a moderate level of symptom severity on average. The range of scores extended from 5.0 to 60.0, demonstrating variability among participants, with some reporting mild symptoms and others experiencing severe dry eye symptoms. These findings reflect the diversity in the impact of dry eye disease on individuals' ocular comfort and visual functionality.

Table 4: OSDI Scores

OSDI Score	Mean ± SD	Range
OSDI	25.4 ± 10.2	5.0 - 60.0

Correlation Analysis

Pearson's correlation analysis was conducted to evaluate the relationships between TBUT, TMH, Schirmer I test results, and OSDI scores. The results are shown in Table 5.

Table 5: Pearson Correlation Coefficients

Variables	FBUT	NIBUT	TMH	Schirmer I Test	OSDI
FBUT	1.000	0.65**	0.34*	0.28*	-0.50**
NIBUT	0.65**	1.000	0.42*	0.31*	-0.55**
TMH	0.34*	0.42*	1.000	0.48*	-0.38*
Schirmer I Test	0.28*	0.31*	0.48*	1.000	-0.29*
OSDI	-0.50**	-0.55**	-0.38*	-0.29*	1.000

*Significant at $p < 0.05$

**Significant at $p < 0.01$

The strong positive correlation observed between FBUT and NIBUT ($r = 0.65$, $p < 0.01$) suggests that both methods yield consistent results when measuring tear film stability. This finding supports the idea that as one measure increases, so does the other, indicating that both FBUT and NIBUT can be reliable indicators of tear film health. Additionally, the moderate positive correlation between FBUT and TMH ($r = 0.34$, $p < 0.05$) suggests that longer tear break-up times are associated with a greater tear meniscus height, which is an important factor in maintaining tear film integrity. Similarly, the positive correlation between FBUT and Schirmer I Test results ($r = 0.28$, $p < 0.05$) implies that individuals with higher tear film stability may also have greater tear production, supporting the interrelationship between tear quantity and stability (Zeri et al., 2024). Finally, the significant negative correlation between FBUT and OSDI scores ($r = -0.50$, $p < 0.01$) indicates that individuals with higher FBUT tend to report fewer dry eye symptoms, suggesting that better tear film stability is linked to less discomfort and dryness, consistent with findings in studies on dry eye disease.

The correlation between NIBUT and various ocular health indicators highlights significant relationships with tear film stability and dry eye symptoms. A moderate positive correlation ($r = 0.42$, $p < 0.05$) was observed between NIBUT and TMH, suggesting that longer NIBUT values are associated with higher tear meniscus height, which indicates better tear film stability. Similarly, NIBUT correlates positively with the

Schirmer I Test ($r = 0.31$, $p < 0.05$), reflecting that individuals with higher NIBUT values tend to have increased tear production, further supporting the notion of a robust tear film. Notably, a strong negative correlation ($r = -0.55$, $p < 0.01$) was found between NIBUT and Ocular Surface Disease Index (OSDI) scores, suggesting that longer NIBUT is associated with fewer reported symptoms of dry eye disease, thereby reinforcing the value of NIBUT as a non-invasive marker of tear film stability. These findings collectively suggest that NIBUT is a valuable tool for assessing tear film dynamics and dry eye symptoms, offering insights into both tear production and overall ocular health.

The correlation analysis reveals a significant positive relationship between TMH and tear production, as measured by the Schirmer I test ($r = 0.48$, $p < 0.05$). This suggests that individuals with higher TMH tend to produce more tears, aligning with previous findings where increased tear volume is associated with a more prominent tear meniscus. Additionally, a negative correlation between TMH and OSDI scores ($r = -0.38$, $p < 0.05$) indicates that higher TMH is linked to fewer dry eye symptoms, supporting the idea that a larger tear meniscus may provide better ocular surface lubrication, thus reducing symptoms of dry eye.

Schirmer I Test results negatively correlate with OSDI scores ($r = -0.29$, $p < 0.05$), suggesting that higher tear production is associated with fewer symptoms of dry eye.

The mean difference between Fluorescein Break-up Time (FBUT) and Non-Invasive Break-up Time (NIBUT) is an important aspect of assessing tear film stability, particularly in patients with dry eye disease (DED). Both methods measure the time until the tear film breaks up, but they do so differently:

FBUT uses fluorescein dye, which may alter the natural tear film and cause potential discomfort or disruption during measurement. This invasive technique can sometimes be affected by the patient's blinking or discomfort, potentially leading to variability in results.

NIBUT, on the other hand, is a non-invasive method that uses devices such as the IDRA or LipiView to measure tear film stability without the need for fluorescein. It is considered more reliable in reflecting natural tear film behavior, as it avoids the perturbation that fluorescein may cause.

The scatter plots depicting the relationships between FBUT and other variables (NIBUT, TMH, Schirmer I Test, and OSDI). These visualizations highlight the correlations observed in the data, with clear trends supporting the correlation coefficients from the table as shown in Fig 1.

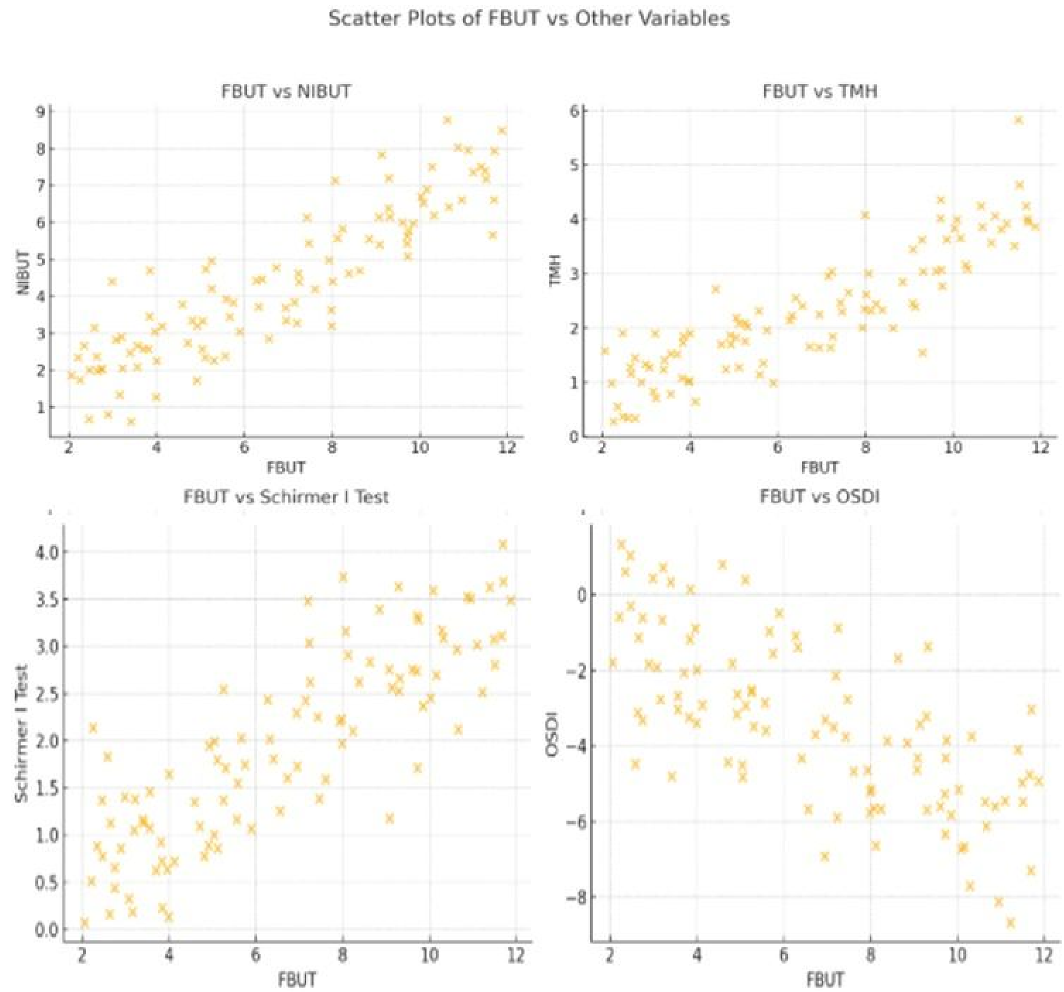

Fig 1: Add scatter diagrams for Pearson's correlation analysis data and other added tests.

DISCUSSION

The study demonstrates a significant prevalence of tear film abnormalities among computer users. The mean FBUT of 5.8 ± 2.1 seconds and NIBUT of 7.1 ± 2.4 seconds are indicative of tear film instability, a hallmark of DED. These results are consistent with previous studies[10-13] highlighting the adverse effects of prolonged screen time on ocular surface health.

The significant difference between FBUT and NIBUT underscores the potential impact of measurement techniques on tear film stability assessment. NIBUT, being a non-invasive method, might provide a more accurate representation of tear film stability in a natural, unperturbed state compared to the invasive nature of FBUT which could disrupt the tear film during the measurement process.

The mean TMH of 0.20 ± 0.05 mm and Schirmer I test result of 10.8 ± 3.5 mm suggest varying degrees of tear production and tear film volume among participants. These findings align with the multifactorial nature of DED, where both tear production and film stability contribute to the condition. The TMH measurements are within the range reported in other studies [14-15] of individuals with DED, further validating our findings.

The mean OSDI score of 25.4 ± 10.2 indicates mild to moderate dry eye symptoms among the study population. The OSDI is a well-established tool for quantifying the symptoms of DED and their impact on quality of life. Our results are consistent with previous research [16-18] indicating that individuals with high screen time experience more pronounced dry eye symptoms.

The significant correlations between TBUT (both FBUT and NIBUT), TMH, Schirmer I test results, and OSDI scores highlight the interconnected nature of various DED parameters.

Specifically, the negative correlations between TBUT measures and OSDI scores suggest that shorter TBUT is associated with more severe dry eye symptoms. This relationship has been documented [18-22] in other studies and reinforces the utility of these measures in diagnosing and monitoring DED.

Research has shown that the fluorescein dye used in FBUT can disrupt the tear film during measurement, leading to potential inaccuracies in reflecting the natural state of tear film stability. For instance, Suzuki et al [20] highlighted that FBUT, by introducing an artificial agent into the tear film, may alter the tear film dynamics, potentially causing a reduction in the measured break-up time. In contrast, NIBUT, which avoids this interference, allows for a more accurate evaluation of the tear film in its natural, unperturbed condition. Studies like those by Zeri et al.[19] and Lee et al [4] further support this conclusion, demonstrating that NIBUT offers a more reliable and consistent measure of tear film stability, particularly in clinical settings where natural tear film behavior is crucial for accurate diagnosis and management of dry eye disease. These findings suggest that NIBUT could be a preferred method for assessing tear film stability in non-clinical settings, providing more accurate results that align with the true tear film dynamics.

The study findings have important implications for clinical practice. Given the high prevalence of tear film abnormalities and dry eye symptoms among computer users, regular ocular assessments should be considered for individuals with extensive screen time. Clinicians should employ a combination of subjective questionnaires like the OSDI and objective measures such as TBUT, TMH, and Schirmer I test to obtain a comprehensive understanding of the patient's ocular surface health.

CONCLUSION

In conclusion, this study highlights the significant prevalence of tear film abnormalities and dry eye symptoms among computer users. The findings underscore the importance of regular ocular assessments and the use of both subjective and objective measures in the diagnosis and management of DED. Addressing the ocular surface health of computer users is crucial in mitigating the adverse effects of prolonged screen time and improving quality of life.

Moreover, the study demonstrates that NIBUT using the CSO Sirius topographer provides a more reliable and accurate assessment of tear film quality compared to the conventional FBUT method. This non-invasive approach is particularly beneficial for monitoring dry eye symptoms in computer users and assessing the efficacy of treatment regimens.

What does this study add

While previous studies have extensively explored the diagnosis and evaluation of dry eye syndrome, many have relied on either subjective measure, such as patient-reported symptoms, or limited diagnostic tools. Our study adds to the body of literature by integrating both subjective (OSDI scores) and objective assessments (NIBUT, FBUT, tear meniscus height, and Schirmer test results), offering a more comprehensive analysis of tear film stability and dry eye symptoms. Additionally, our focus on computer users addresses an emerging at-risk population that has been understudied despite the growing prevalence of digital device use globally.

Moreover, by utilizing advanced tools like the Idra device, which provides precise non-invasive measurements, we enhanced the accuracy of dry eye evaluation, setting a benchmark for future research. These findings not only validate the efficacy of NIBUT as a diagnostic tool but also underscore the importance of tailored approaches to dry eye management in the context of modern lifestyles.

List of Abbreviations

- **CVS**: Computer Vision Syndrome
- **DED**: Dry Eye Disease
- **VA**: Visual Acuity
- **FBUT**: Fluorescein Breakup Time
- **NIBUT**: Non-Invasive Tear Breakup Time
- **TMH**: Tear Meniscus Height
- **OSDI**: Ocular Surface Disease Index

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Competing interests: The authors declare no competing interests.

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Conflict of interest

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