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The Effect of Active and Passive Smoking on Tear Film Integrity Among the Saudi Population

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Abstract

Purpose: This study aimed to assess the impact of various forms of smoking active and passive on the stability and quality of the precorneal tear film using a combination of questionnaires, clinical evaluations, and non-invasive keratography. Additionally, the study sought to raise public awareness regarding the risks of dry eye disease and its association with smoking.

Methods: A prospective cross-sectional design was employed, involving 33 participants aged between 17 and 40 years. Subjects were categorized into three groups: non-smokers (control), passive smokers, and active smokers. The control and passive smoker groups comprised exclusively female participants (100%), while the active smoker group included both males (45.5%) and females (54.5%). There were no statistically significant differences among the groups in terms of spherical equivalent ($p = 0.403$). Participants completed a validated dry eye questionnaire, followed by comprehensive ophthalmologic examinations. Clinical assessments included Tear Break-Up Time (TBUT) and Schirmer tests, alongside non-invasive keratographic evaluations.

Results: Based on questionnaire responses, all participants in the control group exhibited no signs of dry eye. In the passive smoker group, 54.5% were identified as having dry eye, while 45.5% were not. Similarly, 54.5% of the active smokers were classified as having dry eye symptoms, with the remaining 45.5% unaffected. TBUT and Schirmer test outcomes showed no statistically significant differences among the three groups ($p = 0.095$ and $p = 0.993$, respectively). However, non-invasive keratography revealed a statistically significant difference in TBUT values ($p = 0.026$), though the decrease in tear meniscus height (TMH) among active smokers was not statistically significant ($p = 0.283$).

Conclusion: The study indicates that chronic exposure to cigarette smoke, particularly in active smokers, adversely affects the ocular surface by altering certain tear film parameters. These results underscore the potential for long-term smoking to compromise ocular surface health and highlight the importance of public health efforts to mitigate smoking-related ocular conditions.

Keywords: Tobacco Exposure; Tear Film Break-Up Time (TBUT); Schirmer Test; Tear Meniscus Height (TMH); Non-Invasive Keratography

Abbreviations: TBUT: Tear Film Break-Up Time; TMH: Tear Meniscus Height; DED: Dry Eye Disease; SPSS: Statistical Package for the Social Sciences

Background

The tear film is a vital component of ocular surface health, maintaining corneal hydration, providing nutrients, and serving as a protective barrier against environmental insults. Disruptions in the tear film can result in dry eye disease (DED), a multifactorial condition that affects the quality of life and visual function. Epidemiological studies have shown that both intrinsic and extrinsic factors, including environmental exposures such as smoking, can significantly influence tear film stability and composition [1]. Cigarette smoke contains numerous toxic chemicals, including formaldehyde, acrolein, and reactive oxygen species, which can directly irritate the ocular surface and alter tear film dynamics. These compounds have been linked to increased tear evaporation, reduced tear production, and ocular surface inflammation, all of which are key features of dry eye disease. Furthermore, long-term exposure to cigarette smoke, whether through active or passive means, has been associated with Meibomian gland dysfunction and decreased tear quality [2,3].

Passive smoking - or secondhand smoke exposure - poses similar risks, particularly in enclosed environments where smoke

concentration is high. Studies have shown that even low-level exposure can lead to significant ocular irritation, discomfort, and early signs of tear film instability. This is of particular concern in regions where indoor smoking is prevalent and non-smokers, especially women and children, may be disproportionately affected [4]. In Saudi Arabia, where smoking remains a significant public health issue among both men and women, there is a growing need to understand its broader systemic and ocular effects. Despite existing data from international populations, limited research has been conducted within the Saudi context to evaluate the specific impact of smoking-both active and passive-on tear film characteristics. Addressing this gap is crucial for guiding targeted health interventions and increasing community awareness of smoking-related ocular conditions [5].

Materials and Methods

This cross-sectional study included a total of 33 participants, all of whom provided written informed consent prior to enrollment. The age of participants ranged from 17 to 40 years, with a mean age of 26.5 ± 5.8 years. Participants were categorized into three groups: (1) Control group comprising non-smokers with no history of tobacco exposure within their household or close social circles (n = 11), (2) Passive smokers exposed to secondhand smoke (n = 11), and (3) Active smokers, all of whom had smoked more than 20 cigarettes recently. Within the active smoking group, 82% reported smoking for less than 10 years, while 18% had smoked for more than 10 years (n = 11).

The control and passive smoker groups consisted entirely of female participants (100%), while the active smoker group included 45.5% males and 54.5% females (Figure 1). No statistically significant differences were found among the three groups with regard to spherical equivalent (p = 0.403). All participants completed a validated dry eye questionnaire for symptom evaluation, followed by comprehensive ophthalmologic examinations. Clinical assessment of tear film function included the Tear Break-Up Time (TBUT) test and Schirmer test. In addition, non-invasive keratographic evaluations were performed to assess tear film parameters.

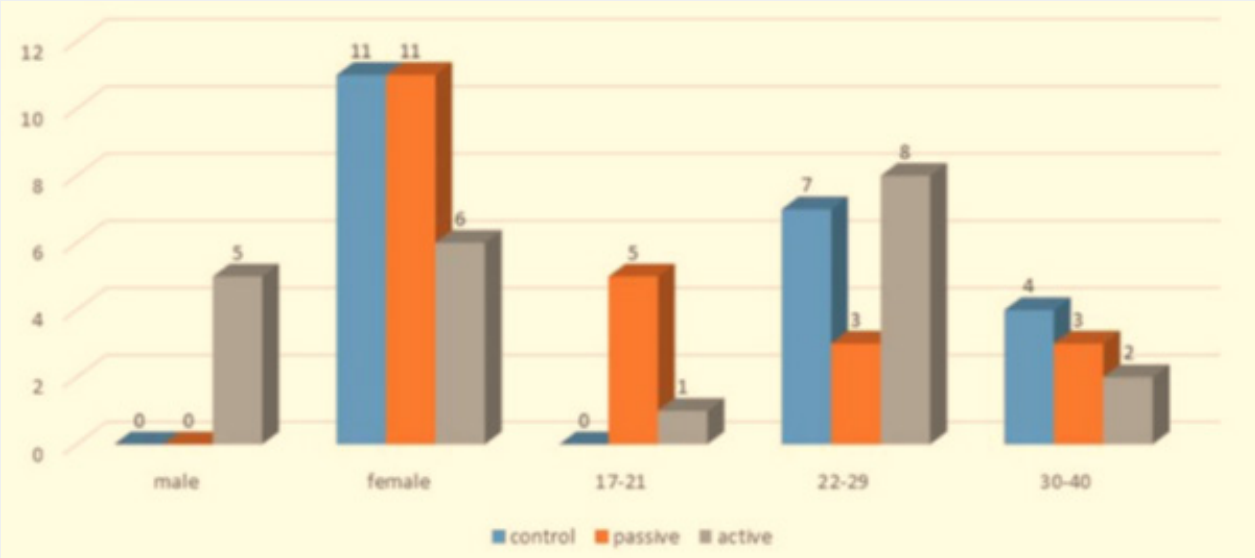

Figure 1: Age and sex distribution in three studied groups.

Participants with any history of ocular allergies, keratitis, ocular surface disease, contact lens wear, glaucoma, previous ocular trauma or surgery, or those undergoing systemic or ocular pharmacologic treatment were excluded from the study. Furthermore, subjects were instructed to discontinue the use of systemic or topical anti-inflammatory, antihistaminic, antibiotic, NSAID, or corticosteroid medications prior to their initial clinic visit to avoid confounding effects on tear film assessment.

Statistical Analysis

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS), version 25.0 (IBM Corp., Armonk, NY, USA). Ocular surface parameters were obtained from both eyes (oculus uterque, OU) of all study participants. The normality of data distribution was assessed using the Kolmogorov–Smirnov test. To compare the mean tear film stability measures among the three study groups (control, passive smokers, and active smokers), a one-way analysis of variance (ANOVA) was performed. Additionally, independent sample t-tests were applied to investigate the relationship between clinical tear film stability (TBUT) and non-invasive keratographic TBUT within each group. A p-value of <0.05 was considered statistically significant.

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Results

Analysis of the dry eye questionnaire [6] responses showed: all individuals in the control group reported no symptoms indicative of dry eye, classifying them as normal. In the passive smoker group, 54.5% of participants exhibited symptoms consistent with dry eye, whereas 45.5% did not. Similarly, among active smokers, 54.5% were identified as having dry eye symptoms, while the remaining 45.5% reported no signs of dryness [7,8].

Descriptive Analysis of Dry Eye Ophthalmic Parameters

Table 1 presents the results of the clinical dry eye assessments, specifically Tear Break-Up Time (TBUT) and the Schirmer test, across the three study groups. The mean TBUT values were 8.41 ± 2.91 seconds in the control group, 7.64 ± 3.14 seconds in the passive smoker group, and 10.31 ± 2.52 seconds in the active smoker group. For the Schirmer test, mean values were 14.75 ± 8.76 mm, 14.30 ± 10.82 mm, and 14.49 ± 7.77 mm in the control, passive smoker, and active smoker groups, respectively. One-way ANOVA analysis revealed no statistically significant differences among the groups for either TBUT (p = 0.095) or Schirmer test results (p = 0.993). These findings suggest that the clinical tear film measurements were comparable across the three groups, with no substantial variation in tear volume or stability.

Table 1: Changes in clinical TBUT and Schirmer test in each group (One-way Anova).

Parameters	Non-Smoker (n=22 eyes)	Passive Smoker (n=22 eyes)	Active Smoker (n=22 eyes)	f-test	P Value
TBUT (sec)	8.41 ± 2.91	7.64 ± 3.14	10.31 ± 2.52	2.545	0.095
Schirmer test (mm)	14.75 ± 8.7	14.295 ±10.8	14.49 ± 7.76	0.007	0.993

Table 2: Changes in TBUT and TMH tests using noninvasive keratograph in each group (One-way Anova).

Parameters	Non-smoker (n=22 eyes)	Passive Smoker (n=22 eyes)	Active Smoker (n=22 eyes)	f-test	P Value
TBUT (sec)	8.26 ± 2.82	6.31 ± 1.97	9.54 ± 3.03	4.134	0.026*
TMH (μm)	0.41 ± 0.19	0.42 ± 0.19	0.32 ± 0.07	1.316	0.283

Table 3: Correlation between clinical and noninvasive keratograph TBUT using independent sample t-test test.

Group	Non-Smoker	Passive Smoker	Active Smoker
Clinical	8.41 ± 2.90	7.63 ± 3.15	10.32 ± 2.52
Non invasive	8.25 ± 2.82	6.31 ± 1.97	9.54 ± 3.03
t-test	0.165	1.645	1.341
p. value	0.872	0.131	0.21

Noninvasive Keratograph Assessment of Tear Film Parameters

Table 2 presents the results of the noninvasive keratographic evaluations of tear film stability, specifically TBUT and Tear Meniscus Height (TMH), across the three study groups. The mean noninvasive TBUT values were 8.26 ± 2.82 seconds in the control group, 6.31 ± 1.97 seconds in the passive smoker group, and 9.54 ± 3.03 seconds in the active smoker group. Corresponding TMH values were 0.41 ± 0.19 mm for the control group, 0.42 ± 0.19 mm for passive smokers, and 0.32 ± 0.07 mm for active smokers. Statistical analysis using one-way ANOVA indicated a significant difference in noninvasive TBUT among the groups (p = 0.026), suggesting variation in tear film stability associated with smoking exposure. However, although the TMH values were slightly reduced in the active smoker group, this difference did not reach statistical significance (p = 0.283).

Comparison Between Clinical and Noninvasive TBUT Measurements

As shown in Table 3, there were no statistically significant differences in TBUT values among the three groups (non-smokers, passive smokers, and active smokers) when comparing results obtained through clinical examination and noninvasive keratography. The p-values for these comparisons were 0.872, 0.131, and 0.210, respectively. These findings indicate a strong correlation between clinical TBUT and noninvasive keratograph TBUT measurements, suggesting that both methods provide consistent results and may be used interchangeably in clinical practice.

Discussion

The present study investigated the influence of active and passive smoking on tear film stability in a Saudi population using both clinical and noninvasive diagnostic tools. Our findings from

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the dry eye questionnaire revealed that a notable proportion of both passive and active smokers reported symptoms indicative of dry eye, whereas all individuals in the control group were asymptomatic. These results align with previous literature indicating that exposure to cigarette smoke-whether direct or secondhand-can disrupt the ocular surface and contribute to the development of dry eye symptoms [3,4]. Clinical tests, including TBUT and Schirmer's test, did not reveal statistically significant differences between the three study groups. These findings may reflect the inherent variability in these tests or suggest that early or mild tear film dysfunction caused by smoking may not be fully captured by traditional clinical assessments. While previous studies have demonstrated reduced tear production and increased tear evaporation in smokers, such effects may vary based on duration and intensity of exposure [9,10].

In contrast, the noninvasive keratograph TBUT values showed statistically significant differences among the groups, with passive smokers exhibiting the lowest tear film stability. This suggests that noninvasive TBUT may be more sensitive to subtle changes in tear film dynamics associated with smoke exposure. Interestingly, the active smoker group showed slightly higher TBUT values than passive smokers, which may be influenced by individual variability or adaptive mechanisms, though this warrants further investigation [11]. Regarding tear meniscus height (TMH), no significant differences were observed across the groups, although a slight, non-significant reduction was noted in the active smoker group. TMH reflects tear volume rather than stability, which could explain the lack of statistically significant changes in this parameter. Prior research suggests that smoking primarily impacts tear film quality and stability rather than volume alone [12].

Lastly, the comparison between clinical and noninvasive TBUT measurements showed no significant differences, suggesting that both assessment methods provide comparable results and may be used interchangeably in clinical settings. This supports previous studies advocating for the integration of noninvasive technologies, such as keratography, into routine ophthalmic practice for a more comprehensive evaluation of tear film integrity [13].

Conclusion

The results of this study indicate that chronic exposure to cigarette smoke, both active and passive, has a detrimental impact on the ocular surface by altering certain tear film parameters. Prolonged irritative effects of tobacco smoke may compromise the ocular surface's natural defense mechanisms, potentially contributing to the development or exacerbation of dry eye disease.

Future Recommendations

Further research with a larger and more diverse sample size is recommended to validate these findings. Additionally, future studies should explore the dose-dependent relationship between the quantity of cigarettes smoked per day and changes in tear film parameters, particularly TBUT and Schirmer test values, to better understand the extent of smoking-related ocular surface dysfunction.

Conflicts of Interest

The authors declare no conflicts of interest related to the authorship or publication of this article.

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