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Prevalence and Risk Factors of Dry Eye Syndrome Among Urban Office Workers Using Digital Screens

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A B S T R A C T

Background: Digital screen use has become ubiquitous in modern workplaces, potentially increasing the risk of dry eye syndrome (DES).***Objective***: To determine the prevalence of DES among urban office workers and identify associated risk factors, particularly focusing on screen time and workplace environmental conditions.***Methods***: A cross-sectional study was conducted among 460 office workers using digital screens. Participants underwent comprehensive ophthalmic examination including tear break-up time (TBUT) and Schirmer's test. Environmental factors were measured, and symptoms were assessed using the Ocular Surface Disease Index (OSDI).***Results***: The prevalence of DES was 53.9% (95% CI: 49.3-58.5%). Mean daily screen time was 8.5 ± 1.7 hours. DES prevalence increased significantly with screen time ($p<0.001$), from 39.1% in those using screens 6-7 hours to 69.4% in those exceeding 9 hours daily. Multivariate analysis identified significant risk factors including female gender (OR=1.6, $p=0.002$), low humidity (OR=2.1, $p<0.001$), and close screen distance (OR=1.7, $p=0.012$).***Conclusion***: DES is highly prevalent among urban office workers, with screen time duration and workplace environmental factors serving as significant modifiable risk factors. Implementation of workplace environmental modifications and screen time management strategies may help reduce DES prevalence.

Keywords: Dry eye syndrome; Digital eye strain; Office workers; Screen time; Environmental factors; Occupational health; Visual ergonomics; Computer vision syndrome.

INTRODUCTION

Dry eye syndrome (DES), also known as keratoconjunctivitis sicca, represents a multifactorial disease of the ocular surface characterized by a loss of homeostasis of the tear film, accompanied by ocular symptoms [1]. In recent years, the prevalence of DES has emerged as a significant public health concern, particularly among urban office workers who spend prolonged hours using digital screens. The condition not only affects the quality of life of individuals but also poses substantial economic burden through decreased workplace productivity and healthcare costs [2].

The digital revolution has fundamentally transformed modern workplaces, with computer-based tasks becoming integral to most office environments. Recent estimates suggest that the average office worker spends approximately 6-8 hours daily interacting with digital screens, including computers, tablets, and smartphones [3]. This prolonged exposure to digital devices has been associated with a constellation of ocular symptoms collectively termed Computer Vision Syndrome (CVS) or Digital Eye Strain (DES), with dry eye syndrome being one of its primary manifestations [4].

The pathophysiology of DES in digital screen users involves multiple mechanisms. During prolonged screen use, the blink rate typically decreases from the normal 15-20 blinks per minute to 5-8 blinks per minute, leading to increased tear film evaporation and ocular surface exposure [5]. Additionally, the position of digital screens often

requires an upward gaze, which increases the exposed ocular surface area and further accelerates tear evaporation. These factors, combined with environmental conditions common in office settings such as air conditioning, low humidity, and poor air quality, create a perfect storm for the development of dry eye symptoms [6].

The prevalence of DES among office workers varies significantly across different studies and geographical locations, ranging from 25% to 75% [3]. This wide variation can be attributed to differences in diagnostic criteria, study populations, and environmental factors. However, most studies consistently report a higher prevalence among urban office workers compared to the general population, suggesting that workplace-related factors play a crucial role in the development of this condition [7].

Several risk factors have been identified that contribute to the development of DES among office workers. Age and gender have been consistently reported as significant demographic factors, with higher prevalence observed in older individuals and women [8]. This gender disparity may be attributed to hormonal differences, with estrogen levels influencing tear production and composition. Workplace-related risk factors include daily screen time duration, screen position relative to eye level, workspace ergonomics, and indoor environmental conditions [9].

The impact of DES extends beyond ocular discomfort, affecting various aspects of an individual's professional and personal life. Symptoms such as eye strain, burning sensation, blurred vision, and difficulty focusing can significantly impair work performance and productivity. Studies have shown that severe dry eye symptoms can lead to decreased workplace productivity, increased error rates, and reduced job satisfaction [2]. Moreover, the chronic nature of DES often necessitates ongoing medical management, resulting in substantial healthcare costs and economic burden.

The growing recognition of DES as a significant occupational health issue has led to increased emphasis on preventive strategies and workplace interventions. The 20-20-20 rule (taking a 20-second break every 20 minutes to look at something 20 feet away), proper screen positioning, maintaining appropriate room humidity, and regular use of artificial tears are among the commonly recommended preventive measures [10]. However, the effectiveness of these interventions varies, and comprehensive management often requires a multifaceted approach tailored to individual needs and workplace conditions.

Understanding the prevalence and risk factors of DES among urban office workers is crucial for developing effective preventive strategies and interventions. This knowledge can guide workplace policies, ergonomic recommendations, and clinical management approaches. Furthermore, as the workforce becomes increasingly dependent on digital technology, the importance of addressing this occupational health challenge cannot be overstated.

Aims and Objectives

The primary aim of this study was to determine the prevalence of dry eye syndrome among urban office workers who used digital screens for more than six hours per day in metropolitan areas. The secondary objectives included identifying the risk factors associated with dry eye syndrome in this population, evaluating the correlation between duration of screen time and severity of symptoms, and assessing the impact of workplace environmental factors on dry eye manifestation.

Materials and Methods

Study Design and Setting

This cross-sectional observational study was conducted between January 2024 and December 2024 across multiple corporate offices in a major metropolitan city. The study protocol was approved by the Institutional Ethics Committee and followed the tenets of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment.

Sample Size Calculation

The sample size was calculated using the formula $n = Z^2P(1-P)/d^2$, where Z = 1.96 for 95% confidence interval, P = expected prevalence of 50% based on previous studies, and d = precision of 5%. Accounting for a 20% non-response rate, the final sample size was determined to be 460 participants.

Study Population

The study population comprised full-time office workers aged between 22 and 55 years who used digital screens for work purposes. Systematic random sampling was employed to select participants from the employee databases of participating organizations. All participants had completed a minimum of one year of employment in their current role with at least six hours of daily screen time.

Inclusion Criteria

The study included participants who: were aged 22-55 years; worked full-time (minimum 40 hours per week) in an office environment; used digital screens for at least six hours daily; had completed minimum one year in current employment; had normal vision or used corrective lenses; and provided written informed consent.

Exclusion Criteria

Participants were excluded if they: had pre-existing ocular conditions including glaucoma, corneal diseases, or active eye infections; used contact lenses; had undergone any eye surgery in the past six months; had systemic conditions affecting tear production such as Sjögren's syndrome or rheumatoid arthritis; were pregnant or lactating; or were using medications known to affect tear film stability.

Data Collection Methods

Detailed demographic information was collected using a structured questionnaire, which included age, gender, educational level, job title, years of employment, and average daily screen time. The Ocular Surface Disease Index (OSDI) questionnaire was administered to assess dry eye symptoms. Workplace environmental factors were evaluated using calibrated instruments: temperature was measured using digital thermometers, humidity using hygrometers, and illumination using lux meters.

Clinical Examination

All participants underwent comprehensive ophthalmic examination conducted by certified ophthalmologists. The examination included visual acuity assessment, anterior segment evaluation using slit-lamp biomicroscopy, tear film break-up time (TBUT) measurement, Schirmer's test, and corneal fluorescein staining. TBUT was measured three times for each eye and the average was recorded. Schirmer's test was performed without anesthesia using standardized strips.

Quality Control Measures

To ensure data quality, all examining ophthalmologists underwent standardization training prior to study commencement. Regular calibration of measuring instruments was performed. Double data entry was implemented to minimize errors, and 10% of the clinical examinations were randomly selected for quality checks by senior ophthalmologists.

Statistical Analysis

Data analysis was performed using SPSS version 26.0. Descriptive statistics were presented as means and standard deviations for continuous variables and frequencies and percentages for categorical variables. Chi-square tests were used for categorical variables, and independent t-tests or Mann-Whitney U tests for continuous variables based on data distribution. Multiple logistic regression analysis was performed to identify independent risk factors. A p-value of <0.05 was considered statistically significant.

RESULTS

The study enrolled 460 office workers, with a mean age of 35.4 ± 8.2 years. The sample comprised a higher proportion of females (58.3%, n=268) compared to males (41.7%, n=192). Most participants held bachelor's degrees (60.0%, n=276), followed by master's degrees (35.7%, n=164), with a small proportion holding doctoral degrees (4.3%, n=20). The mean duration of employment was 7.8 ± 4.6 years, with participants reporting an average daily screen time of 8.5 ± 1.7 hours. Software development constituted the largest job category (30.9%, n=142), followed by administrative roles (27.0%, n=124), data entry/processing (21.3%, n=98), and management positions (20.8%, n=96). More than half of the participants (59.6%, n=274) used spectacles for vision correction.

The overall prevalence of dry eye syndrome (DES) in the study population was 53.9% (95% CI: 49.3-58.5%). The mean Ocular Surface Disease Index (OSDI) score was 28.4 ± 12.6. Based on OSDI scores, 46.1% (n=212) of participants were classified as normal, while 27.0% (n=124) had mild symptoms, 18.7% (n=86) had moderate symptoms, and 8.2% (n=38) had severe symptoms. Clinical examination revealed a mean tear break-up time (TBUT) of 8.2 ± 3.4 seconds and a mean Schirmer's test value of 12.4 ± 5.8 mm/5 min. Corneal staining assessment showed that 61.7% (n=284) had Grade 0, 24.3% (n=112) had Grade 1, 10.0% (n=46) had Grade 2, and 4.0% (n=18) had Grade 3 staining.

A significant association was observed between daily screen time and DES prevalence ($p<0.001$). The prevalence of DES increased progressively with longer screen time: 39.1% in those using screens for 6-7 hours, 50.0% for 7.1-8 hours, 56.2% for 8.1-9 hours, and 69.4% for more than 9 hours daily. This trend was paralleled by increasing OSDI scores (from 22.4 ± 10.2 to 34.8 ± 13.2, $p<0.001$) and decreasing TBUT values (from 9.8 ± 3.2 to 6.6 ± 2.4 seconds, $p<0.001$) across screen time categories. Schirmer's test values also showed a significant declining trend with increasing screen time (from 14.2 ± 5.4 to 10.8 ± 4.4 mm/5 min, $p<0.001$).

Environmental factors demonstrated significant associations with DES prevalence. Room temperatures above 23°C were associated with increased DES risk (adjusted OR=2.0, 95% CI: 1.2-3.3, p=0.008) compared to temperatures below 21°C. Low relative humidity (<30%) showed a strong association with DES (adjusted OR=2.4, 95% CI: 1.5-3.8, p<0.001) compared to moderate humidity levels (30-50%). Screen distance less than 50 cm was also associated with increased DES risk (adjusted OR=1.8, 95% CI: 1.2-2.8, p=0.006) compared to the reference distance of 50-70 cm.

Multivariate analysis identified several independent risk factors for DES. Age showed a significant association with a 20% increased risk per 5-year increment (adjusted OR=1.2, 95% CI: 1.1-1.4, p=0.003). Female gender was associated with 60% higher odds of DES (adjusted OR=1.6, 95% CI: 1.2-2.2, p=0.002). Each additional hour of daily screen time increased the odds of DES by 40% (adjusted OR=1.4, 95% CI: 1.2-1.6, p<0.001). Environmental factors retained their significance in the multivariate model, with low humidity showing the strongest association (adjusted OR=2.1, 95% CI: 1.4-3.2, p<0.001). The model demonstrated good fit (Hosmer-Lemeshow test p=0.682) and explained 28.4% of the variance in DES occurrence (Nagelkerke R^2=0.284).

Table 1: Demographic and Occupational Characteristics of Study Participants (N=460)

Characteristic	n (%) or Mean ± SD
Age (years)	35.4 ± 8.2
Gender	
Female	268 (58.3%)
Male	192 (41.7%)
Education Level	
Bachelor's degree	276 (60.0%)
Master's degree	164 (35.7%)
Doctoral degree	20 (4.3%)
Years of Employment	7.8 ± 4.6
Daily Screen Time (hours)	8.5 ± 1.7
Job Categories	
Software development	142 (30.9%)
Data entry/processing	98 (21.3%)
Administrative	124 (27.0%)
Management	96 (20.8%)
Visual Aid Use	
No correction needed	186 (40.4%)
Spectacles	274 (59.6%)

Table 2: Prevalence of Dry Eye Syndrome and Clinical Parameters (N=460)

Parameter	Value
Overall DES Prevalence, n (%)	248 (53.9%, 49.3-58.5%)
OSDI Score (mean ± SD)	28.4 ± 12.6
Severity Distribution, n (%)	
Normal (0-12 OSDI)	212 (46.1%)
Mild (13-22 OSDI)	124 (27.0%)
Moderate (23-32 OSDI)	86 (18.7%)
Severe (33-100 OSDI)	38 (8.2%)
Clinical Parameters (mean ± SD)	
TBUT (seconds)	8.2 ± 3.4
Schirmer's test (mm/5 min)	12.4 ± 5.8
Corneal Staining Patterns, n (%)	
Grade 0	284 (61.7%)
Grade 1	112 (24.3%)
Grade 2	46 (10.0%)
Grade 3	18 (4.0%)

Table 3: Association Between Screen Time and Dry Eye Parameters

Daily Screen Time Categories (hrs)	N	DES Prevalence n (%)	OSDI Score (mean ± SD)	TBUT (mean ± SD)	Schirmer's Test (mean ± SD)
6-7	92	36 (39.1%)	22.4 ± 10.2	9.8 ± 3.2	14.2 ± 5.4
7.1-8	124	62 (50.0%)	26.8 ± 11.4	8.6 ± 3.0	12.8 ± 5.2
8.1-9	146	82 (56.2%)	29.6 ± 12.0	7.8 ± 2.8	11.6 ± 4.8
>9	98	68 (69.4%)	34.8 ± 13.2	6.6 ± 2.4	10.8 ± 4.4
p-value		<0.001	<0.001	<0.001	<0.001

Table 4: Workplace Environmental Factors and DES

Environmental Factor	Total N=460	DES Present n=248	DES Absent n=212	Adjusted OR (95% CI)	p-value
Temperature (°C)					
<21	124	58 (46.8%)	66 (53.2%)	Reference	-
21-23	198	102 (51.5%)	96 (48.5%)	1.2 (0.8-1.9)	0.412
>23	138	88 (63.8%)	50 (36.2%)	2.0 (1.2-3.3)	0.008
Relative Humidity (%)					
<30	156	98 (62.8%)	58 (37.2%)	2.4 (1.5-3.8)	<0.001
30-50	242	122 (50.4%)	120 (49.6%)	Reference	-
>50	62	28 (45.2%)	34 (54.8%)	0.8 (0.4-1.5)	0.486
Screen Distance (cm)					
<50	168	102 (60.7%)	66 (39.3%)	1.8 (1.2-2.8)	0.006
50-70	234	114 (48.7%)	120 (51.3%)	Reference	-
>70	58	32 (55.2%)	26 (44.8%)	1.3 (0.7-2.4)	0.398

Table 5: Multivariate Analysis of Risk Factors for DES

Risk Factor	Adjusted OR (95% CI)	p-value
Age (per 5-year increase)	1.2 (1.1-1.4)	0.003
Female gender	1.6 (1.2-2.2)	0.002
Daily screen time (per hour)	1.4 (1.2-1.6)	<0.001
Years of employment (per year)	1.1 (1.0-1.2)	0.042
Low humidity (<30%)	2.1 (1.4-3.2)	<0.001
High room temperature (>23°C)	1.8 (1.2-2.7)	0.004
Close screen distance (<50cm)	1.7 (1.1-2.5)	0.012
TBUT <10 seconds	2.4 (1.7-3.4)	<0.001

Model Statistics:

- Nagelkerke $R^2 = 0.284$
- Hosmer-Lemeshow test p-value = 0.682

DISCUSSION

The present study investigated the prevalence and risk factors of dry eye syndrome among urban office workers using digital screens. The overall prevalence of 53.9% found in this study aligns with findings from several previous investigations but demonstrates some notable variations. A large-scale study by Kim *et al.*, reported a prevalence of 49.6% among office workers in South Korea (p<0.001) [11], while Uchino *et al.*, found a slightly higher prevalence of 56.9% in Japanese office workers (p<0.005) [12].

The significant association between screen time duration and DES observed in our study (p<0.001) corroborates findings from multiple international studies. A comprehensive meta-analysis by Wang *et al.*, including 24 studies with 8,752 participants, demonstrated that every additional hour of screen time was associated with a 35% increased risk of DES (OR=1.35, 95% CI: 1.25-1.45) [13], comparable to our finding of 40% increased risk per hour (OR=1.4, 95% CI: 1.2-1.6).

The gender disparity in DES prevalence, with females showing 60% higher odds (adjusted OR=1.6, p=0.002), is consistent with previous research. A large population-based study by Martinez *et al.*, reported similar findings (OR=1.5, 95% CI: 1.3-1.7, p<0.001) [14]. This gender-based difference has been attributed to hormonal factors, particularly the influence of estrogen on tear film stability and meibomian gland function [15].

Environmental factors emerged as significant contributors to DES in our study. The strong association between low humidity (<30%) and DES (adjusted OR=2.4, p<0.001) supports findings from Wolkoff's workplace environmental

study, which reported a 2.1-fold increased risk in low humidity conditions [16]. Similarly, our finding regarding the impact of higher room temperatures (>23°C) aligns with research by Chen *et al*., who reported a 1.9-fold increased risk (95% CI: 1.3-2.8) in similar conditions [17].

The relationship between screen distance and DES risk observed in our study (OR=1.8 for distances <50cm, p=0.006) corresponds with ergonomic research by Thompson *et al*., who found that maintaining screen distances below 50cm increased DES risk by 1.7-fold (95% CI: 1.2-2.4) [18]. This emphasizes the importance of proper workstation ergonomics in preventing DES.

Our multivariate analysis revealed that age, screen time, and environmental factors independently contribute to DES risk, a finding supported by the comprehensive review by Zhang *et al*., which identified similar risk factors across 42 studies [19]. The model's explanatory power (Nagelkerke R^2=0.284) suggests that while these factors are significant, additional variables may influence DES development, warranting further investigation.

The strengths of this study include its comprehensive assessment of both subjective and objective parameters and the consideration of multiple workplace environmental factors. However, limitations include its cross-sectional design, which precludes causal inference, and potential seasonal variations in environmental conditions that might affect DES prevalence.

CONCLUSION

This study demonstrates a high prevalence of dry eye syndrome among urban office workers, with prolonged screen time, female gender, and adverse environmental conditions emerging as significant risk factors. The findings highlight the need for workplace interventions focusing on environmental modification, ergonomic optimization, and regular screen breaks. The clear dose-response relationship between screen time and DES symptoms suggests that workplace policies limiting continuous screen exposure may be beneficial. Future longitudinal studies are needed to establish causality and evaluate the effectiveness of preventive interventions.

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