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Determinants of Digital Eye Strain Among Office Workers: Individual, Device-Related, and Environmental Factors

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ABSTRACT

Frequent use of digital devices among office workers contributes to a high risk of Digital Eye Strain (DES), with a reported prevalence of 69.0%, which can adversely affect visual performance, sleep quality, and work productivity. This study aimed to analyze the association between individual, device-related, and environmental factors with DES among office workers using a cross-sectional design involving 66 respondents. Data were analyzed using Chi-square and Mann–Whitney tests. The prevalence of DES was 69.7%, with common symptoms including itchy eyes, eye discomfort, and light sensitivity. Key individual factors significantly associated with DES were unsafe digital device use behavior (OR = 11.25; 95% CI: 1.169–30.280), lack of 20-20-20 rest practice (OR = 10.00; 95% CI: 2.895–30.542), and refractive error (OR = 8.20; 95% CI: 2.287–23.399). Among device-related factors, improper computer screen position (OR = 4.263; 95% CI: 1.323–13.736) was identified as a significant predictor. Environmental factors such as inadequate lighting (OR = 5.455; 95% CI: 1.595–18.657) also showed a strong association with DES. In conclusion, DES among office workers is predominantly influenced by behavioral factors, particularly unsafe digital device use and inadequate eye rest practices, which demonstrated the strongest associations. Preventive strategies should prioritize behavioral interventions, ergonomic improvements, and optimization of workplace environmental conditions.

Keywords : Anti-Glare; Digital Eye Strain; Light Intensity; Rest Pattern

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INTRODUCTION

Digital Eye Strain (DES), or Computer Vision Syndrome, is a group of visual and ocular symptoms that arise from prolonged exposure to digital screens without adequate rest. The condition typically manifests as dry eyes, blurred vision, eye fatigue, headaches, watery eyes, and a burning or stinging sensation [1]. This condition has become a significant global health issue; recent meta-analytical data involving 66,577 respondents estimate a global prevalence of 69.0%, with nearly 90% of individuals using computers for over three hours daily being at risk [2,3] Beyond immediate physical discomfort, DES can lead to chronic complications, including reduced visual acuity, impaired sleep quality, and diminished cognitive function. Consequently, these effects not only compromise individual well-being but also pose broader occupational challenges by decreasing work productivity and creating economic burdens for organizations [4,5].

The high prevalence of DES aligns with the widespread and increasing use of digital technology globally. In 2024, smartphone ownership has become nearly universal, accompanied by extensive internet use reaching 5.45 billion users worldwide, with an average daily screen time exceeding six hours [6]. In Indonesia, similar trends are observed, with high mobile phone ownership and even longer daily online duration, averaging more than seven hours [7]. Although computer ownership is relatively lower, its usage remains substantial at several hours per day [8]. These patterns indicate not only widespread access but also prolonged and continuous exposure to digital screens, which collectively increase the risk of DES in the population.

Along with the rapid advancement of information and communication technology, work patterns have shifted toward more flexible and digitally driven models. This transition was further accelerated during the COVID-19 pandemic, leading to the widespread adoption of remote working practices across various sectors. As a result, workers increasingly rely on digital devices to perform tasks, attend meetings, and communicate virtually. This shift has substantially increased daily screen exposure while reducing opportunities for adequate visual rest. Prolonged and continuous screen use is a well-established risk factor for DES [9–11]. During the COVID-19 pandemic, a large-scale study involving 10,337 participants reported that approximately 74% of individuals experienced eye strain associated with digital device use [12].

The etiology of DES is multifactorial, involving a complex interaction of individual, device-related, and environmental determinants. Individual-level risk factors include personal characteristics such as screen time, age, gender, length of employment, underlying health conditions, history of medication use, presence of refractive errors, adherence to the 20-20-20 rule, level of knowledge about DES, use of corrective lenses, and behavior when using digital devices [5,13–16]. Device-related factors play a critical role as well. Improper screen positioning, inadequate eye-to-screen distance, and lack of anti-glare screen protection can exacerbate visual fatigue by placing strain on the eye muscles [14,17–19]. In addition, the environmental context in which digital work is performed significantly influences eye health. Suboptimal lighting, inappropriate temperature, and low humidity levels are known to exacerbate the severity of DES [14,15,20]. Workspaces lacking ergonomic and environmental standards can amplify discomfort and reduce workers' efficiency.

All workers of Directorate X use computers or laptops as the primary tools to complete administrative and technical work, resulting in prolonged and continuous exposure to digital screens. Despite the growing evidence on DES, studies examining the combined influence of individual, device-related, and environmental factors in specific workplace settings remain limited. Therefore, this study aims to analyze the association between individual, device-related, and environmental factors and the occurrence of DES among office workers in Directorate X. The findings are expected to provide an evidence-based foundation for developing preventive strategies to reduce the negative health impacts of digital device use and to improve worker productivity.

METHOD

This study employed a cross-sectional design conducted at Directorate X of Ministry Y between February and May 2025. The total population of 66 office workers was included using a total sampling technique. The dependent variable was Digital Eye Strain (DES), while the independent variables were categorized into three groups: individual factors (computer duration, digital device duration, age, gender, working period, history of illness, history of drug consumption, refractive errors, rest patterns, knowledge, use of refractive glasses, behavior using digital devices), device-related factors (eye-to-computer distance, use of anti-glare coating, computer screen position), and environmental factors (lighting, temperature, and humidity). Data were collected using self-administered questionnaires for DES symptoms and individual risk factors. DES was measured using the Computer Vision Syndrome Questionnaire (CVS-Q), which assesses the frequency and severity of 16 symptoms. Symptom frequency was scored as 0 (never), 1 (sometimes), and 2 (always), while severity was scored as 1 (moderate) or 2 (severe). The final CVS-Q score was derived from a symptom-specific algorithm, with a score of ≥7 indicating the presence of DES [13,21]. The CVS-Q instrument demonstrated high reliability (Cronbach's Alpha = 0.909).

Rest patterns are one of the aspects assessed in the individual risk factor questionnaire. This means workers rest their eyes after every 20 minutes of computer usage by looking at an object 20 feet (± 6 meters) away for at least 20 seconds [22]. The application of the 20-20-20 break technique was measured using three questions: the frequency of breaks in one working hour, the duration of the break, and the type of activity performed during the break. Respondents were considered to apply the 20-20-20 technique if they took a break every ≤ 20 minutes and performed activities that did not involve digital screens, such as looking away, walking around, or closing their eyes for a moment. Resting activities that continued using digital devices, such as smartphones, were not categorized as applying the 20-20-20 technique.

Knowledge was measured through 15 multiple-choice questions to determine respondents' understanding of DES's definition, symptoms, impact, risk factors, and preventive measures. The questionnaire was valid and reliable (Cronbach's Alpha = 0.755). The safe behavior of using digital devices was measured through 10 questions to determine the frequency of applying the 20-20-20 technique, adjusting viewing distance, using anti-glare coating, adjusting computer screen position, using blue light glasses, using eye drops, blinking habits, adjusting font type and size, and adjusting screen brightness. Each question used a five-point Likert scale: never, rarely, sometimes, often, and always. The statements in the questionnaire were divided into two categories, namely positive statements (favorable) and negative statements (unfavorable). The questionnaire was valid and reliable (Cronbach's Alpha = 0.887).

In addition to the questionnaire, this study measured aspects of the device. Eye-to-computer distance is measured using a measuring tape by measuring directly from the respondent's eyes to the computer screen, and the position of the computer screen is measured through visual documentation using a camera to capture the respondent's position while working. The photos taken were then analyzed with the help of the Angle Meter application. The analysis of the angle of vision was done by importing the photo into the application and then setting three reference points, namely: (1) the point of the respondent's eye position, (2) a horizontal line straight ahead of the eye, and (3) the focal point of the gaze to the center of the screen. Two lines are drawn: one horizontal line from the eye to the front and one line from the eye to the focal point of the gaze. The application will display the angle between the two lines, as shown in Figure 1.

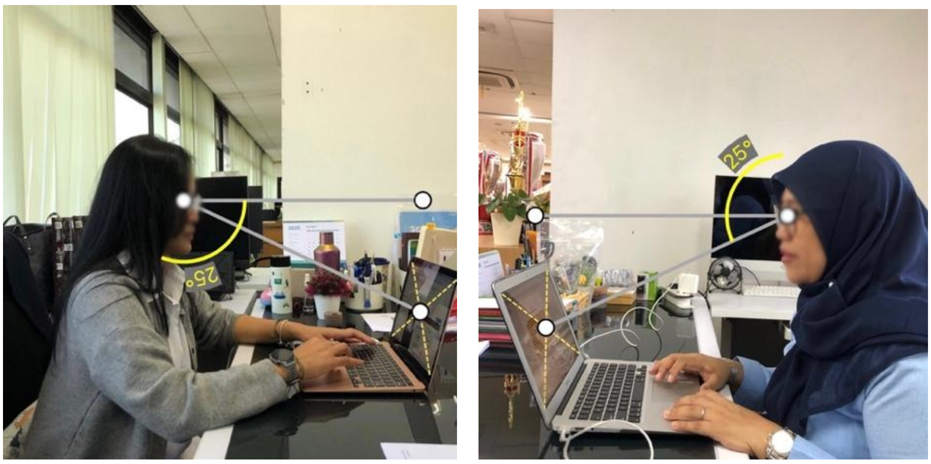

Figure 1. Example of Angle of Vision Analysis

Environmental factors were evaluated by measuring workspace lighting, temperature, and humidity. Lighting was assessed using a lux meter in reference to the Indonesian National Standard (SNI 7062:2019). Temperature and humidity were measured using a digital thermohygrometer. Data were analyzed in a bivariate way using the Chi-Square and Mann-Whitney tests. The chi-square test analyzed the relationships between 15 categorical independent variables and DES. Meanwhile, the Mann-Whitney test was used to analyze the relationships between duration of computer use, duration of digital device use, and eye-to-computer distance and DES. The p-value determined the decision criteria. If the p-value was ≤ 0.05, the two variables had a significant relationship. This research received ethical approval from the Health Research Ethics Committee, Faculty of Health Sciences, UIN Syarif Hidayatullah Jakarta, with the number Un.01/F.10/KP.01.1/KE.SP/02.08.015/2025.

RESULTS

Overview of Digital Eye Strain

An overview of Digital Eye Strain can be seen in Table 1.

Table 1. Distribution of Digital Eye Strain to Office Workers

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Digital Eye Strain	n	%
DES (+)	46	69.7
DES (-)	20	30.3
Total	66	100.0

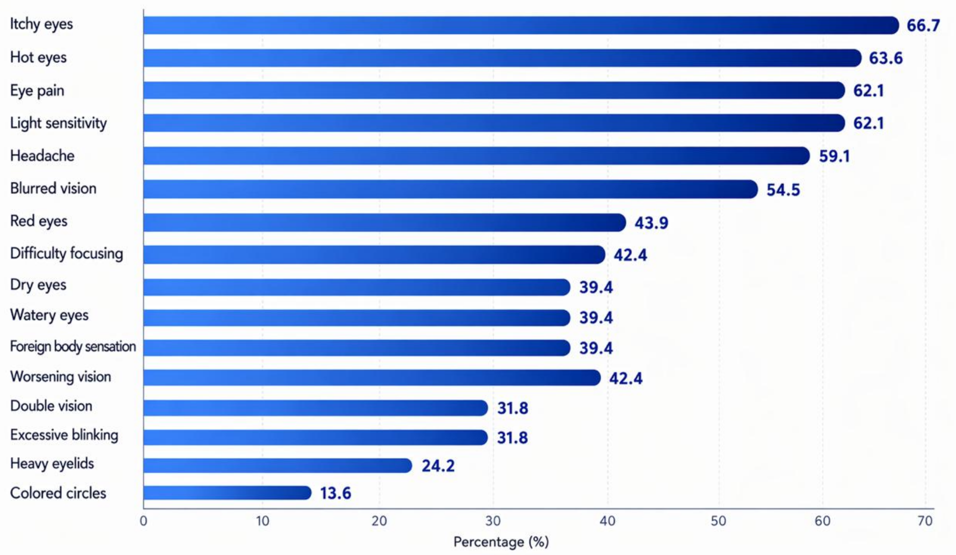

Figure 2. Distribution of Digital Eye Strain Symptoms among Office Workers

Based on Table 1 and Figure 2, it is known that 46 out of 66 workers experienced Digital Eye Strain (69.7%), with the most experienced symptoms, namely itchy eyes (66.7%), hot eyes (63.4%), eye pain (62.1%), and sensitivity to light (62.1%).

Overview of Computer Duration, Digital Device Duration, and Eye-to-Computer Distance

The relationship between individual factors, device-related, and environmental factors with Digital Eye Strain can be seen in Tables 2 and 3.

Based on Tables 2 and 3, the dominant risk factors for DES varied across categories. Among individual factors, unsafe digital device use behavior (OR = 11.25; 95% CI: 1.169–30.280), lack of adherence to the 20-20-20 rest practice (OR = 10.00; 95% CI: 2.895–30.542), and refractive error (OR = 8.20; 95% CI: 2.287–23.399) were identified as the strongest predictors.

Table 2. The Relationship between Duration of Digital Device Use and Eye-to-Computer Distance with Digital Eye Strain in Office Workers

Variable	N	Mean	Min-Max	SD	*p value*
Computer Duration for Work					
DES (+)	46	9.1	8 - 12	1.1	0.000**
DES (-)	20	7.3	6 - 9	0.9	
Digital Device Duration					
DES (+)	46	19.8	14 - 24	2.6	0.000**
DES (-)	20	14.8	10 - 18	2.8	
Eye-to-Computer Distance					
DES (+)	46	53.5	43 - 71	8.3	0.001*
DES (-)	20	60.6	48 - 88	12.5	

* : Significant (p-value < 0.05) ** : Highly Significant (p-value < 0.01)

Table 3. The Relationship between Individual Factors, Device-Related, and Environmental With Digital Eye Strain in Office Workers

Variable	*Digital Eye Strain*				Total		*p value*	OR (95% CI)
	DES (+)		DES (-)					
	n	%	n	%	N	%		
Individual Factors								
Age (Years)								
≥ 45	26	83.9	5	16.1	31	47.0	0.037*	3.900 (1.213 - 12.541)
< 45	20	57.1	15	42.9	35	53.0		
Gender								
Female	29	69.0	13	31.0	42	100	1.000	0.919 (0.307 - 2.750)
Male	17	70.8	7	29.2	24	100		
Working Period (Years)								
≥ 16	33	84.6	6	15.4	39	59.1	0.004*	5.923 (1.872 - 18.739)
< 16	13	48.1	14	51.9	27	40.9		
History of Disease								
Yes	17	85.0	3	15.0	20	100	1.000	1.193 (0.281 - 5.060)
No	38	82.6	8	17.4	46	100		
History of Drug Consumption								
Yes	33	82.5	7	17.5	40	100	0.011*	4.714 (1.537 - 14.460)
No	13	50.0	13	50.0	26	100		
Refractive Error								
Yes	41	80.4	10	19.6	51	100	0.001*	8.200 (2.287 - 23.399)
No	5	33.3	10	66.7	15	100		

Variable	*Digital Eye Strain*				Total		*p value*	OR (95% CI)
	DES (+)		DES (-)					
	n	%	n	%	N	%		
Rest Pattern 20-20-20								
Yes	40	83.3	8	16.7	48	100	0.000**	10.000 (2.895 - 30.542)
No	6	33.3	12	66.7	18	100		
Knowledge								
Poor	21	87.5	3	12.5	24	100	0.036*	4.760 (1.225 - 18.501)
Good	25	59.5	17	40.5	42	100		
Refractive Glasses								
Yes	41	80.4	10	19.6	51	100	0.001*	8.200 (2.287 - 23.399)
No	5	33.3	10	66.7	15	100		
Digital Device Usage Behavior								
Unsafe	45	73.6	16	26.2	61	100	0.027*	11.250 (1.169 - 30.280)
Safe	1	20.0	4	80.0	5	100		
Device-Related Factors								
Anti-Glare Coating on Digital Device								
Not Using	23	79.3	6	20.7	29	43.9	0.047*	4.259 (1.194 - 15.198)
Using on 1 Device	14	77.8	4	22.2	18	27.3	0.117	3.859 (0.930 - 16.255)
Using on 2 Device	9	47.4	10	52.6	19	28.8	-	-
Computer Screen Position								
Not in Eye Level	27	84.4	5	15.6	32	100	0.024*	4.263 (1.323 - 13.736)
Eye Level	19	55.9	15	44.1	34	100		
Environmental Factors								
Lighting Level								
At risk (< 270 or > 330 lux)	40	78.4	11	21.6	51	100	0.011*	5.455 (1.595 - 18.657)
Not at risk (270 - 330 lux)	6	40.0	9	60.0	15	100		
Temperature								
At risk (< 23°C or > 26°C)	26	86.7	4	13.3	30	100	0.014*	5.200 (1.503 - 17.989)
Not at risk (23°C - 26°C)	20	55.6	16	44.4	36	100		
Humidity								
At risk (< 40% or > 60%)	23	85.2	4	14.8	27	100	0.045*	4.000 (1.159 - 13.805)
Not at risk (40% - 60%)	23	59.0	16	41.0	39	100		

* : Significant (p-value < 0.05)
** : Highly Significant (p-value < 0.01)

Among device-related factors, improper computer screen position (OR = 4.263; 95% CI: 1.323–13.736) emerged as the most dominant factor. Meanwhile, among environmental factors, inadequate lighting (OR = 5.455; 95% CI: 1.595–18.657) was identified as the primary contributor to DES. These findings indicate that behavioral factors play a more prominent role, supported by device-related and environmental conditions, in influencing the development of DES among office workers.

DISCUSSION

Prevalence of Digital Eye Strain

A total of 69.7% of workers experienced DES, indicating a substantial burden of visual complaints in this population. Prolonged and continuous exposure to digital screens plays a central role in the development of DES by increasing visual demand and disrupting normal ocular function [23]. Sustained near work requires constant accommodation, leading to ciliary muscle fatigue. At the same time, reduced blinking frequency during screen use accelerates tear film evaporation, contributing to ocular surface dryness and irritation. In addition, exposure to blue light may further increase light sensitivity and exacerbate visual discomfort [23–25].

Relationship Between Individual Factors and Digital Eye Strain

Duration of Computer

The duration of computer and digital device use was shown to have a significant relationship with DES. This finding is consistent with the research of Cantó-Sancho (2023) and Tesfaye (2022). The strength of this association can be explained by the cumulative visual load resulting from prolonged and uninterrupted screen exposure. Continuous near work requires sustained accommodation and convergence, which increases ciliary muscle fatigue over time. In addition, prolonged screen use reduces blink frequency and destabilizes the tear film, leading to ocular surface dryness. The absence of adequate rest further limits ocular recovery, thereby amplifying visual discomfort. Exposure to blue light may also contribute by increasing light sensitivity and exacerbating eye strain [13,15,26–28].

Age

The results showed that workers aged ≥ 45 years old had a 3.9 times higher risk of DES. This finding is consistent with the research of Alemayehu (2014) and Zenbaba (2020) As we age, the elasticity of the eye's lens decreases due to the process of protein denaturation, which results in a decrease in accommodation ability. This encourages individuals to bring their gaze closer to the screen, increasing the risk of eye strain. A decrease in pupil size and response to light also leads to less light entering the eye, so older individuals require adequate lighting and are more sensitive to low contrast[16,29–34].

Gender

Gender was shown to have no significant relationship with DES. This finding is consistent with the research of Assefa (2017) and Uba-Obiano (2022). Women are physiologically and hormonally more susceptible to ocular surface disorders due to lower tear production and the influence of the hormone estrogen, which accelerates tear evaporation. However, the risk can be minimized by several protective factors such as young age, no comorbidities, safe use of digital devices, good knowledge, and an ergonomic environment [35–38].

Working Period

The results showed that workers with ≥ 16 years of service had a 5.9 times higher risk of DES. This finding is consistent with the research of Derbew (2024) and Nopriadi (2019). This increased risk is likely related to prolonged cumulative exposure to digital devices over time, leading to sustained visual load and chronic ocular strain. Longer working periods may also contribute to gradual declines in visual function, further increasing susceptibility to DES symptoms [28,30,31].

History of Disease

The history of disease did not have a significant association with DES. This finding is consistent with the research of Assefa (2017), Derbew (2021), and Ekemiri (2024). Several diseases, such as hypertension, diabetes mellitus, Sjögren's syndrome, rheumatoid arthritis, thyroid disorders, glaucoma, and cataracts, are known to increase the risk of DES Nonetheless, individual variability in disease response and protective factors, such as medication adherence and healthy device use behaviors, may reduce the risk [35,39–41].

History of Drug Consumption

The results showed that workers who took medication were at 4.7 times higher risk of DES. Some medications, such as diuretics, antihistamines, decongestants, antidepressants, antipsychotics, and antihypertensives, are known to decrease tear production, increasing the risk of irritation and light sensitivity. Medications that affect the central nervous system can also interfere with accommodation and pupillary response, adding to the visual burden of using digital devices [23,42].

Refractive Error

The results showed that workers with refractive errors had an 8.2 times higher risk of experiencing DES. This finding is consistent with the research of Ababil (2023) and Agusti (2021) Individuals with refractive errors require more eye muscle work to maintain focus. During digital screen use, this load increases as the eyes must focus on close objects continuously, thus accelerating the onset of visual fatigue [23,31].

Rest Pattern 20-20-20

The results showed that workers who do not apply the 20-20-20 rest pattern are at 10 times higher risk of experiencing DES. This finding is consistent with the research of Derbew (2024) and Lema (2022)[5,39]. The 20-20-20 method recommends that users of digital devices look at an object ±6 meters away for 20 seconds every 20 minutes. This strategy helps to stimulate the eye muscles, increase blinking frequency, and prevent dry eyes [22,23,43,44].

Knowledge

The results showed that workers with poor DES knowledge had a 4.7 times higher risk of experiencing DES. This finding is consistent with the research of Lema (2022) and Lemma (2020). A good understanding of DES's causes, symptoms, and prevention encourages individuals to implement healthy work behaviors. This knowledge is important in shaping awareness of maintaining eye health in the digital era [5,45–47].

Use of Refractive Glasses

The results showed that workers who used refractive glasses had an 8.2 times higher risk of DES. This finding is consistent with the research of Cantó-Sancho (2023) and Zayed (2021). Refractive glasses that do not meet visual needs when working in front of a screen can increase the risk of DES. Lenses that are not updated or not specifically designed for computer use cause the eyes to work harder to accommodate, triggering visual fatigue[13,23,48,49].

Digital Device Use Behavior

The results showed that workers with unsafe digital device use behavior had an 11.2 times higher risk of experiencing DES, making it the strongest determinant identified in this study. This finding is consistent with the research of Tesfaye (2022) and Zayed (2021). Safe behaviors in using digital devices, such as applying the 20-20-20 method, adjusting screen position and distance, and adjusting brightness and font size, aim to reduce eye strain from prolonged screen exposure. Neglecting these behaviors increases the risk of digital eye strain, so their implementation is a form of self-protection against visual impairment [15,23,43,48].

Relationship Between Device-Related Factors and Digital Eye Strain

Eye-to-Computer Distance

The results showed a significant relationship between eye-to-computer distance and DES. This finding is consistent with the research of Das (2022), Nadhiva (2020), and Zayed (2023). The ideal distance between the eyes and the computer screen is 50-100 cm. A distance that is too close taxes accommodation and convergence of the eyes, while a distance that is too far decreases visual acuity, encouraging postural compensation and excessive facial expressions, ultimately increasing visual fatigue [43,48,50–52].

Use of Anti-Glare Coating

The results showed that workers who did not use anti glare coating on all devices were at 4.2 times higher risk of experiencing DES. This finding is consistent with the research of Ranasinghe (2016) and Sengo (2023). Anti-glare coatings can reduce reflected light from external sources, thus lowering the high contrast between the screen and the environment. This helps ease the burden of adapting the eyes to lighting differences and improves visual comfort [18,23,53,54].

Computer Screen Position

The results showed that workers who positioned the computer screen out of eye level had a 4.2 times higher risk of DES. This finding is consistent with the research of Nopriadi (2019) and Rochamayani (2021). The ideal screen position is 15-20° below the horizontal line of sight of the eyes A too-high screen accelerates tear evaporation, while a too-low position can interfere with posture, leading to decreased eye contact[17,52,55].

Relationship between Environmental Factors and Digital Eye Strain Lighting Level

The results showed that workers working in nonstandard lighting conditions had a 5.4 times higher risk of DES. This finding is consistent with the research of Gasheya (2024) and Tesfaye (2022) The ideal workspace lighting in the office is 300 lux [22]. Lighting not up to standard causes the eyes to work harder to adjust visual conditions, thus increasing eye muscle strain. In addition, glare from direct light or screen reflections can disrupt focus, slow blinking, and cause dry eyes [15,20,23,24].

Temperature and Humidity

The results showed that workers working in nonstandard temperature conditions had a 5.2 times higher risk of DES. In addition, workers working in nonstandard humidity were at 4 times higher risk of DES. The ideal temperature and humidity in the office are 23–26°C and 40–60%. High temperature and low humidity accelerate the evaporation of the tear film, leading to hyperosmolarity and an increase in salt concentration in tears. This can damage corneal and conjunctival epithelial cells, cause inflammation, and exacerbate eye discomfort [22,56–58].

CONCLUSIONS AND RECOMMENDATIONS

The prevalence of DES among office workers was 69.7%, with common symptoms including itchy eyes, eye discomfort, and light sensitivity. The strongest risk factors identified were unsafe digital device use behavior, lack of adherence to the 20-20-20 rest practice, and refractive error. In addition, improper screen position and inadequate lighting were also significant contributors. These findings indicate that behavioral factors play a primary role in the development of DES, supported by ergonomic and environmental conditions. Therefore, preventive efforts should prioritize promoting safe digital device use behaviors, including regular eye rest and proper screen ergonomics. Management should support these efforts by optimizing workplace lighting conditions, ensuring appropriate device setup, and providing education and reminders to encourage healthy visual practices.

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