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Environmental Risk Factors for Dry Eye Syndrome: A Literature Review on Air Conditioner Exposure, Gadget Use, and Reading Activity

Yuda Nabella Prameswari[1], Rossa Amelia[2]
[1]Department of Medical Biology, Faculty of Medicine and Health Science, Sultan Ageng Tirtayasa University, Banten, Indonesia
[2]Department of Physiology, Faculty of Medicine and Health Science, Sultan Ageng Tirtayasa University, Banten, Indonesia

(Correspondency: rossa.amelia@untirta.ac.id, +6281 22655 7745)

ABSTRACT

Dry Eye Syndrome (DES) is a multifactorial disorder of the tear film and ocular surface characterized by discomfort, visual disturbances, and tear film instability that has the potential to damage the ocular surface. Environmental factors play a role in increasing the risk of DES, including exposure to air from air conditioners (AC), prolonged use of gadgets, and intense reading activities. This condition may result in reduced tear production or increased tear evaporation, contributing to the progression of dry eye symptoms. People regularly exposed to these factors are at higher risk of developing DES, especially when working in dry environments or focusing on screens for extended periods without sufficient rest. This review aims to examine the literature regarding the relationship between AC exposure, gadget use, and reading activities with the incidence of Dry Eye Syndrome and its implications for eye health. A better understanding of these risk factors is expected to serve as a basis for effective prevention and management of DES.

Keywords : dry eye syndrome, AC exposure, gadget use, reading activities

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INTRODUCTION

The eyes are the main sensory organs that function to recognize the surrounding environment. However, many individuals pay little attention to eye health, thereby increasing the risk of visual disturbances, including Dry Eye Syndrome (DES). DES is a multifactorial disorder of the tears and ocular surface that causes discomfort, visual disturbances, and tear film instability, which can lead to damage of the ocular surface. The main causes of DES include tear hyperosmolarity due to reduced tear production or excessive evaporation of the tear film[1].

Epidemiological studies show that the prevalence of DES is quite high. The Women's Health Study (WHS) and Physician's Health Study (PHS) reported that approximately 4.8 million people in the United States over the age of 50 experience DES. The Beaver Dam Study reported a higher prevalence of DES in women (16.7%) compared to men[2]. In Indonesia, a study by Lee et al. (2011)[3] found that the prevalence of DES in individuals under the age of 21 was 27.5%, in the 21–29 age group was 19.2%, and in those over 60 years old was 30.0%. In general, the prevalence of DES in Southeast Asia ranges from 20% to 52.4%, with risk increasing with age and occurring more frequently in women than in men[4].

Environmental and modern lifestyle factors contribute to the increased incidence of DES. One contributing factor is exposure to air conditioners (AC), which reduces air humidity and accelerates tear evaporation[5]. In addition, prolonged use of gadgets and intensive reading activities can decrease blink frequency, which affects the stability of the tear film[6]. In academic and professional settings, the use of AC, gadgets, and reading books is common, thereby increasing the risk of DES[7]. Therefore, this study aims to review the relationship between AC exposure, gadget use, and reading activities with the incidence of DES and its implications for eye health.

DISCUSSION

Anatomical And Physiological Structure Of The Eye

The eyeball or bulbus oculi is spherical in shape. The structure of the eyeball consists of three main layers: the sclera, uvea, and retina. The sclera is the outermost layer that functions to protect the eyeball, while the uvea, which consists of the iris, ciliary body, and choroid, plays a role in blood supply and regulation of light entering the eye. The retina, as the innermost layer, contains photoreceptor cells that convert light into nerve impulses to be transmitted to the brain[8].

The lacrimal system plays a role in the production and excretion of tears. The main lacrimal gland is located in the superior part of the orbital cavity and is responsible for tear secretion, which functions to moisten and protect the eyes. The excretory system consists of the lacrimal puncta, lacrimal canaliculi, lacrimal sac, and nasolacrimal duct, which function in the drainage of tears into the nasal

cavity[9].

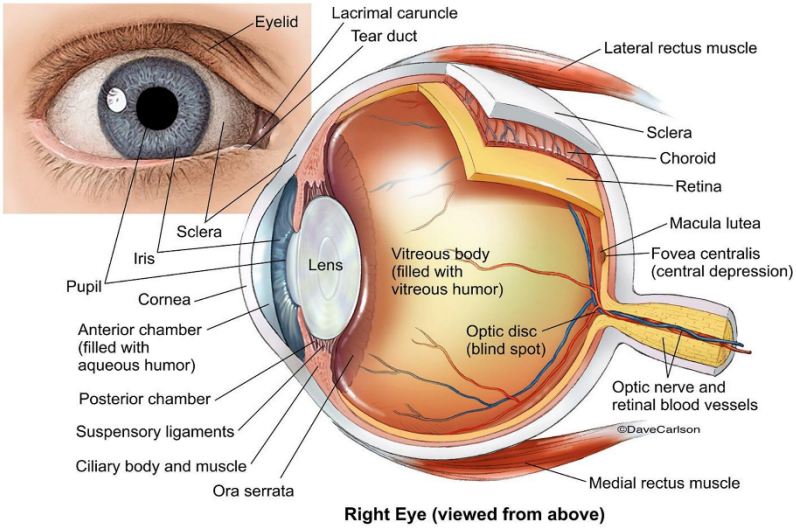

Figure 1. Anatomy of the eye[10]

The conjunctiva is a membrane that covers the sclera and the inner surface of the eyelids. This membrane contains Goblet cells that produce mucin to maintain eye moisture. The tear film consists of three main components: the lipid layer, aqueous layer, and mucin layer, which function to maintain the health and clarity of the ocular surface and protect it from infection[11]. The cornea is the transparent layer at the front of the eye that functions as the main refractive medium in the optical system. The structure of the cornea consists of several layers: the epithelium, Bowman's membrane, stroma, Descemet's membrane, and endothelium. In addition, the mechanisms of tear secretion and drainage involve the action of nerves and muscles around the eye to ensure optimal tear distribution and excretion[12].

Dry Eye: Definition, Etiology, And Pathophysiology

Dry eye, or keratoconjunctivitis sicca, is a disorder resulting from an imbalance between tear production and evaporation, leading to suboptimal lubrication of the ocular surface. This condition causes tear film instability and increased tear film osmolarity, which can trigger inflammation and damage to the corneal and conjunctival epithelium. The main symptoms include irritation, burning sensation, itching, redness, and visual disturbances symptoms that can significantly impair a patient's quality of life[13]. In general, dry eye is classified into two main types: Aqueous Deficient Dry Eye (ADDE) and Evaporative Dry Eye (EDE)[14].

The etiology of dry eye is multifactorial. Tear deficiency may result from conditions such as Sjögren's syndrome and idiopathic lacrimal gland atrophy. Moreover, mucin layer abnormalities often due to Goblet cell damage are seen in diseases like trachoma and Stevens-Johnson syndrome, contributing to tear film instability. Lipid layer dysfunction, commonly associated with chronic blepharitis and acne rosacea, and eyelid abnormalities, such as reduced blink reflex in Bell's palsy, further aggravate the condition[15].

The pathophysiology of dry eye is primarily linked to tear film imbalance. Tear hyperosmolarity is considered a central mechanism that initiates inflammation and ocular surface damage. This hyperosmolarity may be caused by either decreased tear production or increased evaporation, ultimately stimulating the release of inflammatory mediators. The resulting inflammatory response induces epithelial cell apoptosis, Goblet cell loss, and reduced mucin secretion, leading to further tear film instability and the progression of the dry eye condition[16].

Damage to the ocular surface and tear film disruption establish a self-perpetuating inflammatory cycle that exacerbates symptoms. Notably, tear film instability can also occur in the absence of hyperosmolarity, triggered by factors such as environmental exposure, contact lens use, or neurological disorders affecting tear production. Therefore, dry eye should not be regarded as a purely ocular condition, but rather as a disorder involving systemic inflammatory pathways, warranting a multidisciplinary management approach[17].

Risk Factors And Clinical Symptoms Of Dry Eye

Dry Eye Syndrome (DES) is a multifactorial disease of the ocular surface, characterized by tear film instability, increased tear osmolarity, and chronic inflammation, all of which negatively impact visual comfort and the overall quality of life[18]. In recent years, the growing prevalence of DES has been closely linked to modern lifestyle changes, increased digital exposure, and a rise in life expectancy, making it essential to understand the risk factors and clinical manifestations of this condition.

The risk factors for DES encompass a wide range of influences, including demographic variables, systemic health conditions, ocular disorders, iatrogenic effects from medical interventions, and various lifestyle-related factors[19]. Among the most prominent is the excessive use of electronic devices such as smartphones, tablets, and computers, which has been shown to significantly increase the risk of DES[20]. These activities can worsen dry eye because it causes us to blink less frequently and incompletely, leading to greater exposure of the ocular surface to the environment, accelerate tear film evaporation, contributing to tear film instability[21]. Prolonged exposure to air-conditioned (AC) environments is another contributing factor, as it reduces ambient humidity and accelerates tear evaporation, exacerbating dry eye symptoms[22]. Similarly, extended reading activities, especially those requiring intense visual concentration, lead to a diminished blink reflex and contribute to the onset of DES symptoms[18].

The clinical symptoms of DES vary in severity, depending on the underlying cause and disease progression. Common complaints include dryness, burning sensation, stinging, eye fatigue, blurred vision, and photophobia (light sensitivity). These symptoms are often exacerbated following prolonged screen time or reading without adequate breaks. Some patients also report reduced visual comfort when spending extended periods in air-conditioned environments[22]. Symptom evaluation typically involves tools such as the Ocular Surface Disease Index (OSDI) questionnaire, tear break-up time (TBUT)

examination, and Schirmer test for tear production. Recent studies have also highlighted the role of dry environmental exposure and static visual tasks in accelerating meibomian gland dysfunction (MGD), a key contributor to evaporative dry eye[18].

The Influence Of Environmental Factors On Dry Eye Syndrome

Environmental factors and visual habits play a pivotal role in increasing the risk of Dry Eye Syndrome (DES). Numerous studies have highlighted how exposure to air conditioning (AC), prolonged digital device use, and intensive reading activities contribute to tear film instability and reduced visual comfort[5,23–25]. Prolonged AC exposure can significantly reduce indoor humidity, accelerating tear film evaporation. This disruption affects the tear film's protective function over the ocular surface and leads to an imbalance particularly in the lipid and aqueous layers. The resulting condition may cause ocular surface irritation, dryness, and inflammation of the conjunctiva and cornea. Observational data suggest that individuals working in air-conditioned environments for more than eight hours a day exhibit a higher prevalence of DES symptoms than those working in naturally ventilated or humid environments[5,25].

Likewise, extended digital screen use whether on smartphones, tablets, or computers imposes significant visual strain. Continuous screen interaction has been shown to reduce the spontaneous blink rate from an average of 15–20 times per minute to as few as 5–7 times per minute. This reduction hinders proper tear distribution and accelerates evaporation, resulting in a burning sensation, foreign body sensation, and visual disturbances[23]. Furthermore, exposure to blue light emitted from digital devices may exacerbate oxidative stress in corneal and conjunctival epithelial cells, worsening inflammation and promoting ocular surface degeneration[25].

Intensive reading activities, especially under poor lighting or non-ergonomic posture, produce similar effects. These conditions reduce blink frequency, increase ciliary muscle strain, and impair both tear secretion and distribution. Populations such as students, academics, and professionals who read for more than three hours daily, particularly without regular breaks are more likely to develop mild to moderate symptoms of DES[24–26].

The negative impact of these factors is often compounded when they occur simultaneously, such as in individuals who work on computers in air-conditioned spaces while reading digital content for prolonged periods. This combination represents a multifactorial disruption of tear film homeostasis. Thus, preventive strategies are essential. Recommended measures include applying the 20-20-20 rule (every 20 minutes, look at something 20 feet away for 20 seconds), using humidifiers, ensuring adequate lighting, and installing blue light filter screens. Additionally, educational interventions targeting individuals at high risk for DES should be promoted to foster awareness and encourage proactive eye care practices[25–27]. Given the growing reliance on technology and the prevalence of air-conditioned workspaces, the incidence of DES is expected to continue increasing. Therefore, integrating health

education, workplace environment adjustments, and the promotion of healthy visual habits should become a priority in efforts to protect and preserve ocular health.

CONCLUSION

Dry Eye Syndrome (DES) is a multifactorial disorder affecting the tear film and ocular surface, which can be triggered by various environmental factors. Based on this literature review, exposure to air conditioning (AC), prolonged use of digital devices, and intensive reading activities significantly contribute to the increased risk of DES. AC exposure reduces ambient humidity and accelerates tear evaporation, while extended use of digital devices and prolonged reading reduce blink frequency, leading to tear film instability.

Individuals frequently exposed to these factors, especially in low-humidity environments and during extended visual activities are more susceptible to experiencing DES symptoms. Therefore, preventive efforts such as maintaining indoor humidity, applying the 20-20-20 rule during screen use or reading, and raising awareness about the impact of environmental conditions on eye health are crucial in DES management. This review highlights the need for further research to develop more effective mitigation strategies to prevent and manage environmentally-induced DES.

REFERENCES

1. Lemp MA, Baudouin C, Baum J, Dogru M, Foulks GN, Kinoshita S, et al. The definition and classification of dry eye disease: Report of the definition and classification subcommittee of the international Dry Eye WorkShop (2007). Ocul Surf. 2007;5(2):75–92.
2. Paulsen AJ, Cruickshanks KJ, Fischer ME, Huang GH, Klein BEK, Klein R, et al. NIH Public Access Author Manuscript Am J Ophthalmol. Author manuscript; available in PMC 2015 April 01. Published in final edited form as: Am J Ophthalmol. 2014 April ; 157(4): 799–806. doi:10.1016/j.ajo.2013.12.023. Dry Eye in the Beaver Dam Offspring St. Am J Ophthalmol. 2014;157(4):799–806.
3. Lee AJ, Lee J, Saw SM, Gazzard G, Koh D, Widjaja D, et al. Prevalence and risk factors associated with dry eye symptoms: A population based study in Indonesia. Br J Ophthalmol. 2002;86(12):1347–51.
4. Asyari F. *Pedoman Nasional Pelayanan Kedokteran Dry Eye.* Jakarta, Indonesia. 2008;282.
5. Sari DP, Sari M. Hubungan Penggunaan Air Conditioner (AC) di Ruang Kelas dengan Kejadian Sindrom Mata Kering pada Mahasiswa. *Jurnal Kesehatan.* 2020;11(1), 45-52.
6. Al-Mohtaseb Z, Schachter S, Lee BS, Garlich J, Trattler W. The relationship between dry eye disease and digital screen use. Clin Ophthalmol. 2021;15:3811–20.
7. López-Miguel A, Tesón M, Martín-Montañez V, Enríquez-De-Salamanca A, Stern ME, Calonge

M, et al. Dry eye exacerbation in patients exposed to desiccating stress under controlled environmental conditions. Am J Ophthalmol. 2014;157(4).

8. Smith JR. Immune Response and the Eye. Clin Experiment Ophthalmol. 2008;36(2):188–188.

9. Kels BD, Grzybowski A, Grant-Kels JM. Human ocular anatomy. Clin Dermatol [Internet]. 2015;33(2):140–6. Available from: http://dx.doi.org/10.1016/j.clindermatol.2014.10.006

10. Netter F. Atlas of Clinical Anatomy fourth edition. Vol. 53, Journal of Chemical Information and Modeling. 2019. 1689–1699 p.

11. Bron AJ, de Paiva CS, Chauhan SK, Bonini S, Gabison EE, Jain S, et al. TFOS DEWS II pathophysiology report. Ocul Surf [Internet]. 2017;15(3):438–510. Available from: http://dx.doi.org/10.1016/j.jtos.2017.05.011

12. Pflugfelder SC, Stern ME. Biological functions of tear film. Exp Eye Res. 2020;197:1–16.

13. Sheppard J, Shen Lee B, Periman LM. Dry eye disease: identification and therapeutic strategies for primary care clinicians and clinical specialists. Ann Med [Internet]. 2023;55(1):241–52. Available from: https://doi.org/10.1080/07853890.2022.2157477

14. Jones L, Downie LE, Korb D, Benitez-del-Castillo JM, Dana R, Deng SX, et al. TFOS DEWS II Management and Therapy Report. Ocul Surf [Internet]. 2017;15(3):575–628. Available from: http://dx.doi.org/10.1016/j.jtos.2017.05.006

15. Dogru M, Kojima T, Simsek C, Tsubotav K. Potential role of oxidative stress in ocular surface inflammation and dry eye disease. Investig Ophthalmol Vis Sci. 2018;59(14 Special Issue):DES163–8.

16. Kojima T, Dogru M, Kawashima M, Nakamura S, Tsubota K. Advances in the diagnosis and treatment of dry eye. Prog Retin Eye Res [Internet]. 2020;78(January):100842. Available from: https://doi.org/10.1016/j.preteyeres.2020.100842

17. Craig JP, Nelson JD, Azar DT, Belmonte C, Bron AJ, Chauhan SK, et al. TFOS DEWS II Report Executive Summary. Ocul Surf. 2017;15(4):802–12.

18. Britten-Jones AC, Wang MTM, Samuels I, Jennings C, Stapleton F, Craig JP. Epidemiology and Risk Factors of Dry Eye Disease: Considerations for Clinical Management. Medicina (B Aires). 2024;60(9):1458.

19. García-Marqués JV, Talens-Estarelles C, García-Lázaro S, Wolffsohn JS, Cerviño A. Systemic, environmental and lifestyle risk factors for dry eye disease in a mediterranean caucasian population. Contact Lens Anterior Eye. 2022;45(5).

20. Balasopoulou A, Kokkinos P, Pagoulatos D, Plotas P, Makri OE, Georgakopoulos CD, et al.

Symposium Recent advances and challenges in the management of retinoblastoma Globe - saving Treatments. BMC Ophthalmol [Internet]. 2017;17(1):1. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28331284%0Ahttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC5354527%5Cnhttp://bmcpsychiatry.biomedcentral.com/articles/10.1186/1471-244X-11-49%5Cnhttp://bmcophthalmol.biomedcentral.com/articles/10.1186/s12886

21. Qian L, Wei W. Identified risk factors for dry eye syndrome: A systematic review and meta-analysis. PLoS One [Internet]. 2022;17(8 August):1–18. Available from: http://dx.doi.org/10.1371/journal.pone.0271267

22. Stapleton F, Velez FG, Lau C, Wolffsohn JS. Dry eye disease in the young: A narrative review. Ocul Surf [Internet]. 2024;31(September 2023):11–20. Available from: https://doi.org/10.1016/j.jtos.2023.12.001

23. Putri AM, Rahmawati I. Hubungan Derajat Sindrom Mata Kering terhadap Durasi Penggunaan Gadget pada Mahasiswa Fakultas Kedokteran. *Fitrah Medika: Jurnal Kedokteran dan Kesehatan,* 2021;11(2): 567-573.

24. Latupono S, Tualeka S, Taihuttu Y. Hubungan Penggunaan Media Elektronik Visual Dengan Kejadian Sindroma Mata Kering Di Fakultas Kedokteran Universitas Pattimura. Molucca Medica. 2021;14(April):22–35.

25. Smith JA, Albenz J, Begley C, Caffery B, Nichols K, Schaumberg D, et al. The epidemiology of dry eye disease: Report of the epidemiology subcommittee of the international Dry Eye WorkShop (2007). Ocul Surf. 2007;5(2):93–107.

26. Afandi URN. Prevalensi Dry Eye Syndrome Pada Mahasiswa Preklinik Fakultas Kedokteran Uin Syarif Hidayatullah Jakarta Selama Proses Pembelajaran Jarak Jauh Pada Masa Pandemi Covid-19. Vol. 1, Program Studi Fakultas Kedokteran, UIN Syarif Hidayatullah Jakarta. 2022. 15–17 p.

27. Irwan ZKK. Kualitas hidup mahasiswa preklinik Fakultas Kedokteran UIN Syarif Hidayatullah Jakarta yang menderita sindrom mata kering (Skripsi Sarjana). Fakultas Kedokteran, UIN Syarif Hidayatullah Jakarta 2024.