

Dry eye disease in aviators: impact of environmental exposure, blinking behaviour, and lifestyle



**Gabriela Kamińska^{1,2}, Szymon Chmiela¹, Radosław Różycki^{2,3},
Anna Maria Ambroziak^{2,4}**

¹ Faculty of Medicine, Medical University of Warsaw
Head: prof. Paweł Włodarski, MD, DMD, PhD

² Świat Oka, Ophthalmology Center, Warsaw
Scientific Director: Anna Maria Ambroziak, MD, PhD

² Military Institute of Aviation Medicine, Warsaw
Head: Radosław Różycki, MD, PhD

³ ORBITA, Medical Center in Warsaw
Head: Radosław Różycki, MD, PhD

⁴ Division of Optics, Institute of Experimental Physics, Faculty of Physics, University of Warsaw
Head: prof. Piotr Fita, PhD in physics

HIGHLIGHTS

This article highlights dry eye syndrome in aviators as an occupational condition arising from low cabin humidity, visual demands, altered blinking behaviour, and modifiable lifestyle factors. We provide an overview of the disease in this professional group and discuss the key pathophysiological mechanisms underlying its development.

ABSTRACT

This narrative review synthesizes current evidence on the prevalence and mechanisms of dry eye disease in pilots and aircrew. Included original papers evaluated ocular surface biomarkers, blinking behaviour, environmental exposures, and lifestyle factors under real or simulated flight conditions. Dry eye disease is common in aviators. In-flight conditions can destabilize the tear film and induce inflammatory changes, and specific visual demands during flight operation suppress spontaneous blinking. Recent studies also suggest that physical activity may influence tear film stability in this population. Collectively, these findings support a complex model of dry eye disease in pilots.

Key words: dry eye syndromes, aircrew, blinking, environmental exposure, occupational health

INTRODUCTION

Dry eye disease (DED) is more often recognized as an occupational health concern [1]. Pilots and other aircrew members are exposed to unique environmental and visual stressors, including low cabin humidity, continuous screen monitoring, high cognitive workload, and variable light conditions. All these factors may affect tear film stability and ocular surface integrity [2].

Studies have demonstrated that even mild ocular surface disruption can impair contrast sensitivity, reaction times, and sustained visual attention [3, 4] – parameters essential for safe and efficient flight. That shows the importance of diagnosing and managing DED in aviators. While previous research has begun to characterise the prevalence of DED in pilots, the latest research also provides insight into the molecular pathways underlying the disease and identifies factors that influence dry eye symptoms and parameters. The interplay between the aircrew lifestyle, their work conditions, and ocular surface physiology is the main focus of the recent studies. Factors inherent to a pilot's job, such as irregular daily routines, night shifts, and limited time for physical activity, can have a substantial impact on vision comfort. Therefore, not only physical factors and conditions on board the aircraft may be important, but also those resulting from the patient's choices.

DED and Meibomian gland dysfunction leading to DED can be characterised by parameters and scores for the diagnosis and monitoring of a patient's state, such as non-invasive tear breakup time (NIBUT), tear film osmolarity (Tosm), and tear meniscus height (TMH). However, in the context of aviation, the blinking behaviour, a functional component of DED, is particularly significant.

The present review synthesizes recent studies evaluating dry eye biomarkers, blinking behaviours, and environmental exposures with lifestyle-related factors among pilots and aircrew. Emphasis was placed on research that evaluated ocular surface parameters in simulated or in-flight performance settings in order to highlight mechanisms that may be specific to the aviation environment and to identify gaps requiring targeted future research. This approach allows for understanding how aviation conditions shape the pathophysiology of DED.

METHODS

A structured literature search was conducted using PubMed, Web of Science, and Scopus databases to identify original research articles published up to November 2025. Search terms included combinations of: "dry eye", "ocular surface", "tear film", "blink rate", "pilot", "aviator", "aircrew", "flight crew", "aviation." Boolean operators (AND/OR) were applied. Studies were selected based on thematic relevance rather than predefined quantitative criteria. Only

original studies were included. The research group comprised pilots, aircrew members, and individuals exposed to simulated or actual flight conditions, in whom ocular surface integrity and blinking parameters were evaluated. Both experimental and observational designs were eligible. Exclusion criteria included review articles, letters, case reports, and studies involving non-aviation populations. Articles without an accessible full text in English or lacking quantitative ocular outcomes were also excluded. Table 1 summarizes the included studies, compiling authors of the study, year of publication, type and design of the study, sample size, and main results.

Given the heterogeneity of study designs, outcome measures, and experimental conditions, a formal meta-analysis was not feasible. Instead, findings were synthesized qualitatively, with emphasis on identifying recurring patterns, mechanistic pathways, and areas of inconsistency or uncertainty within the existing literature.

RESULTS

Epidemiology and prevalence in aviators

Across civilian and military cohorts, DED and DED-like symptomatology are common among flight personnel. In a prospective observational study by Sight et al. [12] of Indian commercial pilots, DED was present in 34%, and total flight hours were higher for affected pilots ($p = 0.001$). The disease, in this study, was defined by non-invasive average tear break-up time (NIAvg-BUT) under 10 s. It underscores a dose-exposure relationship between flying time and tear film instability.

Similar results were found in European civilian aircrews. In the study by Fachinetti et al. [11], from an aviation medical centre, 12.7% of patients reported moderate to severe symptoms on the Standard Patient Evaluation of Eye Dryness (SPEED) questionnaire [14]. It is a validated tool designed to quantify the frequency and severity of common dry eye symptoms such as dryness, soreness, irritation, and visual fatigue. However, objective signs were more frequent. The result of the Schirmer test under 10 mm was present in 25.4% of patients, and the result of TBUT under 10 s in 24.9% of them. Notably, in 18.8% and 17.6% of asymptomatic crew members had abnormal Schirmer test results or TBUT, respectively. This demonstrates a dissociation of symptoms and signs in flight crews. The authors described this as a "stoic phenotype," in which individuals devalue or do not feel their symptoms of dryness, which are reflected in the objective evidence of impairment.

There is more epidemiological evidence from a study conducted by McCarty et al. [5]. Over 1200 Australian commercial pilots took part in a survey study. 72.3% of participants reported ocular dryness during the flight, while 5.4% of

TABLE 1

Characteristics of included studies.				
Author and year	Type of study	Study design	Sample size	Results
McCarty and McCarty [5], 2000	cross-sectional study	Questionnaire survey of Australian commercial pilots assessing self-reported dry eye symptoms.	1246 Australian commercial pilots	72.3% reported dry eye symptoms during flight
Uchiyama et al. [6], 2007	prospective experimental study	Exposure to 2 humidity ranges (20–25% vs. 40–45% RH) in simulating airplane cabins.	18 (patient with dry eye) + 11 (control group)	evaporative rate was increased by 99.72% under low humidity ($P < 0.001$); a significant effect observed across all study groups
Tesón et al. [7], 2013	prospective controlled study	Patients with DED exposed to simulated in-flight conditions (23°C, 5% relative humidity, localized air flow, and 750 mb). Control group: patients with DED exposed to simulated standard condition (23°C, 45% relative humidity, and 930 mb).	35 patients with DED (20 simulated in-flight conditions + 15 simulated standard condition)	after 2 h simulated in-flight conditions: symptoms increased; ↓TBUT ($\approx 2.18 \text{ s} \rightarrow 1.53 \text{ s}$); ↓PRTT; ↑corneal staining; ↑tear IL-6; ↑MMP-9 and ↓EGF; under simulated standard condition only mild staining changes were observed
Mowry and Ison [8], 2015	cross-sectional study	The study used a questionnaire mailed to pilots to assess exposure to computer displays and symptoms of CVS. Symptoms were grouped into three domains: eye-related, vision-related and posture-related.	178 U.S.-based pilots (including U.S. territories)	eye-related symptoms rose with more computer-based instrumentation used by pilots ($p = 0.03$)
Vera et al. [9], 2017	prospective experimental study	The study assessed tear osmolarity before and after a maximal treadmill test in military helicopter pilots, comparing results among trained and untrained groups.	19 pilots (10 trained and 9 untrained)	maximal exercise increased Tosm; the rise was greater in lower-fitness pilots
Zheng and Jie [10], 2019	prospective experimental study	A comparison of pilot's workload using NASA-TLX and eye BR across two environments (flight simulator vs. real aircraft) and 3 flight scenarios (standard instrument departure, manual departure, and standard instrument approach).	9 pilots	NASA-TLX scores increased and BR decreased under higher workload in simulator, but not in in-flight conditions
Fachinetti et al. [11], 2024	cross-sectional study	Study at an aviation medical centre. Subjective SPEED questionnaire was obtained, as well as objective ocular surface tests.	189 aircrew personnel	moderate to severe symptoms of DED occurred in 12.7% of crew, while objective tests showed reduced tear production or stability in 25.4%
Singh et al. [12], 2024	cross-sectional study	A pilots completed the OSDI questionnaire and underwent ophthalmological examinations.	100 civil pilots	DED prevalence 34% by NIAvg-BUT, but OSDI score was not elevated in any of participants; higher total flight hours were associated with DED ($p \approx 0.001$)
Schwerd and Schulte [13], 2024	prospective experimental study	The experiment in a flight simulator assessed 3 factors: task type (air vs. ground target classification), task difficulty (low vs. high), and task presence (single vs. dual task). The comparison of BR and NASA-TLX workload scores under different cognitive load levels was conducted.	10 pilots	↑BR with increasing task load and was lowest under dual-task conditions; blinks clustered after decision points and during task switches

BR – blink rate; CVS – computer vision syndrome; DED – dry eye disease; EGF – epidermal growth factor; IL-6 – interleukin 6; MMP-9 – matrix metalloproteinase 9; NASA-TLX – NASA Task Load Index; OSDI – Ocular Surface Disease Index; PRTT – phenol red thread test; RH – relative humidity; SPEED – Standard Patient Evaluation of Eye Dryness questionnaire; TBUT – tear break-up time; Tosm – tear osmolarity.

them reported these symptoms at other times. In a multi-variable model, two factors were independently associated with dry eye symptoms during flights: aircraft class (large jet vs. propeller) (OR = 1.75; 95% CI: 1.34–2.28) and weekly flight hours (OR = 1.58; 95% CI: 1.34–1.86).

Together, these studies indicate that DED is prevalent in aircrew when assessed with objective metrics such as NIAvg-BUT, TBUT, and the Schirmer test, as well as with subjective reports. A key modifier included aircraft type and cumulative exposure acting [5, 11, 12].

Environmental and occupational risk factors

Studies simulating airplane cabin conditions demonstrate changes in the tear film. In a study by Uchiyama et al. [6], both patients with DED and healthy controls were exposed to varying humidity levels. When relative humidity (RH) was reduced to 20–25% (conditions typical of aircraft cabins), aqueous tear evaporation increased almost 2-fold compared with 40–45% RH. The rise in evaporative rate was 99.7% ($p < 0.001$). The effect was statistically significant, indicating that cabin conditions are an important factor in the evaporative form of DED during flight.

To complement these findings, Tesón et al. conducted a study focusing on patients with established DED [7]. Participants were exposed for 2 h to simulated in-flight conditions (23°C, 5% RH, localized airflow, 750 mb). Compared with baseline and a standard-condition control (23°C, 45% RH, 930 mb), this exposure led to significant deterioration across several parameters. Tear stability worsened (TBUT decreased from 2.18 [±0.28] s to 1.53 [±0.20] s; $p < 0.05$), phenol red thread wetting (tear volume test) was reduced, and corneal fluorescein staining increased (0.50 [±0.14] to 1.25 [±0.19]; $p < 0.05$), with the inferior and central zones most affected. At the molecular level, simulated cabin conditions increased pro-inflammatory mediators: IL-6, MMP-9, and lowered tear epidermal growth factor (EGF), confirming a rapid inflammatory and homeostatic imbalance triggered by severe dryness.

Modern flight decks and simulators require pilots to spend long periods focusing on digital display systems. In Mowry and Ison's study [8], participants completed a survey assessing the type of cockpit instrumentation they usually used ("traditional" or "computer-based"), as well as self-reported symptoms relating to eye strain and posture. Results showed that greater computer-based cockpit exposure was significantly associated with eye-related symptoms ($p = 0.03$), as well as posture-related complaints ($p = 0.049$). The eye-related symptoms were described as "dry eyes, watery eyes, irritated eyes, burning eyes" (fig. 1).

It illustrates the study's key findings: the proportion of pilots reporting eye-related computer vision syndrome symptoms increases with greater use of computer-display-based instrumentation.

Beyond environmental stressors, the consequences of a sedentary type of work in pilots can modulate Tosm. Vera et al. [9] showed that in military helicopter pilots undergoing maximal treadmill testing with increments, Tosm increased overall from 303.7 (±6.8) to 310.6 (±8.8) mmol/L post-exercise. These responses diverged by participant fitness level. Untrained pilots exhibited a marked rise in tear osmolality after the test (+12.33 mmol/L), whereas in trained pilots the values were more stable (+1.45 mmol/L). Tosm change correlated positively with adiposity indices ($r = 0.77-0.89$) and negatively with VO_2max ($r = -0.75$) and performance (velocity $r = -0.75$; time-to-exhaustion $r = -0.67$). These data showed that lower cardiorespiratory fitness may increase tear hyperosmolality under exertional stress.

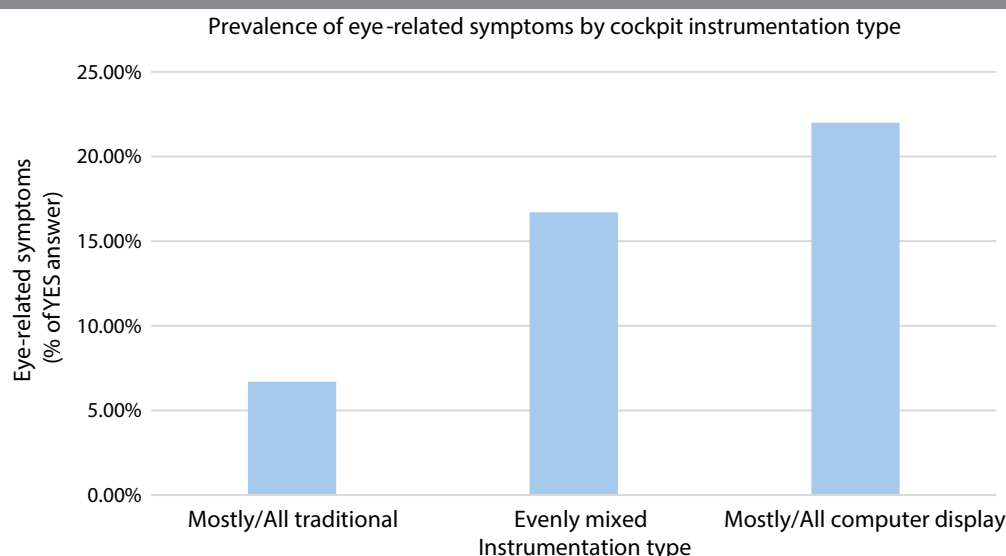
This evidence suggests that the special conditions and characteristics of pilots' and aircrew's work may influence the ocular surface. The level of desiccation destabilizes the tear film and provokes inflammatory changes at the molecular level. At the same time, sustained screen tasks are associated with feelings of dryness, irritation, and burning in the eyes [7, 8]. Coupled with a lower fitness level, which amplifies exertion-related tear hyperosmolality, these factors outline a convergent pathway to evaporative DED risk in flight operations [9].

Blinking behaviour and visual function

A mental workload in aviation is described as a cognitive effort required to manage flight tasks. Two aviation-focused studies showed complex results: when mental workload rises, pilots blink less frequently during the task itself, but the blink rate (BR) increases during task transitions or

FIGURE 1

Results from Mowry and Ison [8] showing the prevalence of eye-related symptoms by cockpit instrumentation type.



particularly demanding phases. The symptoms of dry eye may be exacerbated by both conditions – increased mental stress and decreased blinking frequency.

In a study conducted in a military flight simulator, Schwerd and Schutle [13] examined BR as a dynamic indicator of mental workload. Aerospace students performed two visual classification tasks (air vs. ground target identification) under varying difficulty levels (low vs. high) and task settings (single-task vs. dual-task with altitude control). BR was recorded by an eye-tracking system and analysed alongside the NASA-Task Load Index (NASA-TLX). It is a 6-factor scale measuring mental, physical, and temporal demands, performance, effort, and frustration, to quantify perceived workload. Results showed that BR decreased with increasing workload, particularly in the dual-task condition (fig. 2), and increased immediately after decisions and task switches, suggesting blinks mark cognitive transitions. The authors highlighted notable individual differences and potential fatigue effects.

Zheng and Jie [10] used similar parameters, comparing blink behaviour and subjective workload across simulator and in-flight conditions. The authors used the NASA-TLX to assess 3 flight scenarios of varying difficulty. Each scenario was executed first in a simulator and later repeated in an actual aircraft.

In the simulator, NASA-TLX scores and BR both varied with task demand. Higher workload scenarios were associated with decreased blink frequencies (14,08 vs. 9,83 blinks $\times$ min⁻¹) and higher subjective workload scores

(fig. 3). However, BR differentiated the tasks reliably only in the simulator. The authors concluded that BR can reflect changing cognitive demands under controlled conditions, but its expression in real flight is highly context-dependent, influenced by environmental factors, sensory load, and task pacing. They proposed using blink dynamics alongside subjective workload measures rather than as an independent workload indicator.

DISCUSSION

The narrative review integrates current state of research on DED among aviation professionals. Three studies quantified DED prevalence in pilots [5, 11, 12], including one in a broader aircrew population [11]. While these papers provide valuable insight into the scale of DED, studies conducted outside the aviation industry have gone a step further by assessing not only the prevalence itself, but also the performance implications of the disease. For instance, Deschamps et al. [15] demonstrated that DED significantly increased reaction times and reduced target detection during simulated driving, correlating these impairments with tear film instability and higher-order optical aberrations. To these functional impairments of DED also come reduced dynamic and functional visual acuity, which represents motion and real-world visual acuity rather than a static one [16, 17]. Despite clear differences in task complexity between driving and aircraft operations, these findings may indicate a broader perspective of DED, extending be-

FIGURE 2

Results from Schwerd and Schutle [13] study showing each participant's blink rate during single-task and dual-task during flying. It illustrates the study's key findings: blink rate consistently drops under a higher workload (dual-task).

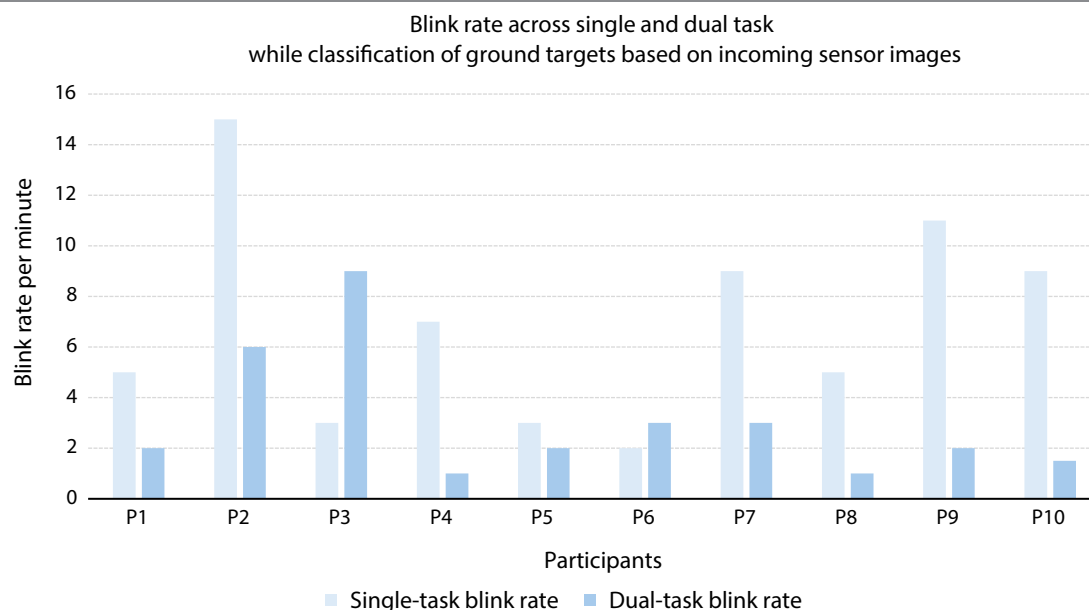
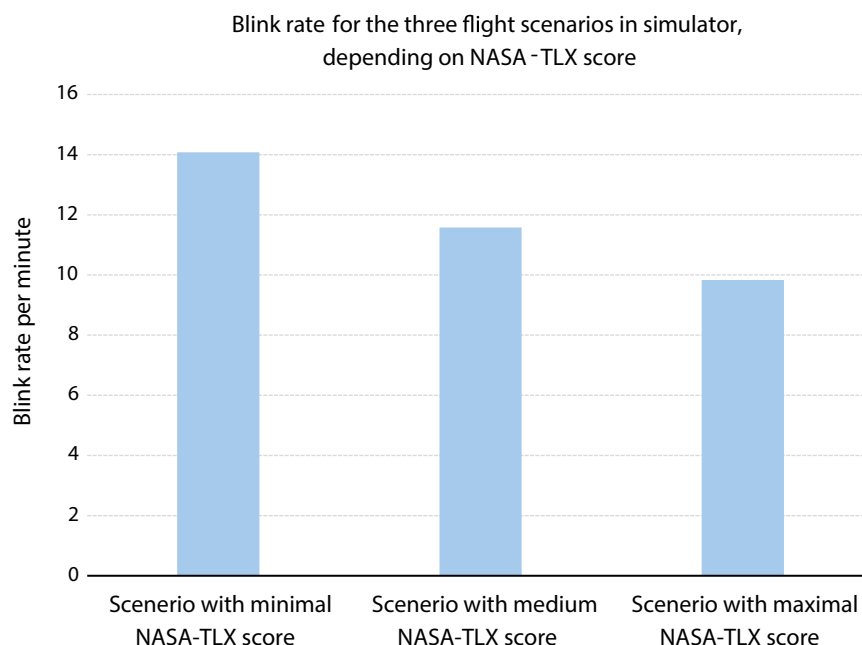


FIGURE 3

Results from Zheng and Jie study [10] showing blink rate across 3 different scenarios. It illustrates the study's key findings: blink rate decreased under higher-demand tasks (maximal NASA-TLX score).



yond subjective discomfort or symptoms during prolonged visual tasks. The observed impairments in reaction time, visual attention, and dynamic visual processing suggest that DED may have implications for operational performance and, potentially, safety in high-demanding environments such as aviation.

Such effects are particularly relevant to pilots, whose tasks require rapid visual detection and stable gaze. Although included studies confirm DED prevalence among aviators [5, 8, 11, 12], none have assessed its impact on flight performance. Only Singh et al. [12] explicitly called for research linking DED with pilot performance and flight crew and passenger comfort. Future studies should therefore connect ocular surface alterations with objective performance measures to clarify the operational consequences of DED in aviation.

Addressing eye issues or other significant comorbidities might be crucial for their mental and physical health [18]. Persistent dryness, sand sensation, or irritation is a daily, repetitive stressor. It affects concentration, visual comfort, and tolerance of prolonged tasks. Sustained fixation on a single visual target, characteristic of high-demand cockpit tasks, is associated with increased sympathetic activation and catecholamine release, leading to vasoconstriction, reduced lacrimal gland secretion, and subsequent decrease of tear film production [19]. Relief in DED symptoms could therefore improve comfort during the flight and help with daily duties [20].

An important insight is to perceive this occupational group as patients and treat dry eye symptoms holistically. Pilots spend a great part of their time on the flight deck, often during the night, which naturally causes fatigue and reduces physiologic reserve [21]. The characteristics of aviation work include isolation and irregular shifts, which, over time, may destabilize sleep, mood, and stress regulation. These components are risk factors for a lower quality of life in pilots and aircrew, as DED is [22, 23]. Ocular discomfort can both contribute to and cause broader functional strain. Physicians should remember that specific conditions of flight and work characteristics are associated with a higher burden of internal medicine comorbidities that can contribute directly to DED – hypercholesterolemia, metabolic syndrome and insulin resistance, hypertension, and sub-clinical cardiovascular disease [24]. These systemic conditions may promote DED through inflammation, vascular dysregulation, and altered Meibomian gland dysfunction [25]. Medications commonly used to manage these diseases (e.g., antihypertensives, antidepressants, antihistamines) may further aggravate tear film instability [26]. As a result, in pilots and aircrew, dry eye symptoms should be treated as a part of the broader picture of an aviator's health, by combining management of underlying diseases and introduction of health-promoting behaviours [27].

What seems particularly noteworthy is that lifestyle and physical activity are emerging as modifiable factors in DED and may be highly relevant to aircrew. A study by Vera et al.

[9], focusing on military pilots, revealed that trained aviators exhibited fewer changes in tear osmolarity compared with untrained participants. At the same time, recent research links sedentary behaviours and insufficient physical activity with higher DED prevalence and elevated inflammatory markers in tears [28]. On the molecular level, Tesón et al. [7] demonstrated that simulated in-flight cabin exposure increased tear IL-6 and MMP-9 and decreased EGF, highlighting the inflammatory cascade central to DED. Collectively, these findings are consistent with the TFOS DEWS III Lifestyle Report from 2025 [26], which emphasizes that regular physical activity, reduced sedentary behaviour, and balanced anti-inflammatory nutrition are essential to maintaining tear film homeostasis and mitigating ocular surface inflammation. Interestingly, pilots' body mass index (BMI) above 28.0 kg/m² is associated with sleep disorders [29], so physical activity as a modulator of BMI might be a key intervention. These lifestyle recommendations may be particularly relevant for pilots, offering a preventive framework to preserve ocular comfort and visual performance under demanding operational conditions.

Another aspect analysed in this review was the blinking behaviour, as it is a component of DED [30]. In the general population, the spontaneous BR is 15–20 blinks per minute [31], while the study by Schwerd and Schulte [13] showed that the BR in pilots decreased during classification of ground targets as low as 1–15 blinks per minute (fig. 2), and 1–21 during classification of air tracks based on altitude and velocity. Similarly, Zheng and Jie [10] observed that professional pilots exhibited a mean BR of approximately 9.83–14.08 blinks per minute across different simulated scenarios (fig. 3), confirming that higher workload and visual demand markedly suppress spontaneous blinking.

Both studies investigated cognitive demands alongside BR, since factors such as fatigue or challenging tasks can influence blink behaviour [32]. Collectively, these findings suggest that BR is not a simple or stable indicator of mental workload, but a dynamic context-dependent behaviour influenced by cognitive and visual load. Notably, both studies investigated the relationship between mental workload, quantified using NASA-TLX, and blinking patterns, but without assessing DED symptoms or diagnosis, leaving open questions about how such workload-related blink suppression may interact with ocular surface health in aviators. However, the results confirm that blinking suppression, as a risk factor of DED, occurs during complex flight operations.

Most risk factors in aviation cannot be eliminated. Sedentary work, irregular working hours, stress, and mental workload continue to be a huge part of the everyday life of aviators, especially pilots. As cockpit technology advances, aviators experience exposure to screens, including newer and more engaging technologies. This may contribute to

the onset of dry eye symptoms, increased workload, and fatigue among aviators. However, modifiable factors such as increasing cabin humidity and using eye protection technology in screens should be optimized to reduce vision discomfort. Importantly, all pilots require comprehensive optometric care and binocular vision correction to achieve this goal.

Several limitations should be considered when interpreting the findings summarized in this review. The available evidence is characterized by substantial heterogeneity in study designs, outcome measures, and experimental conditions, ranging from questionnaire-based surveys to controlled simulator and in-flight studies. Sample sizes in aviation-focused experimental studies were generally small, while epidemiological studies counted over 1200 participants. After collecting all included studies, the data were presented in the form of a narrative, integrational synthesis, rather than a quantitative and systematic comparison.

Future research should prioritize studies that integrate objective ocular surface biomarkers with functional visual metrics and task-related performance outcomes. Beyond safety and performance, increasing attention should be given to modifiable lifestyle factors, including physical activity, sleep patterns, hydration, and circadian disruption, as potential modulators of tear film stability in aircrew. The development of screening or prophylactic tools tailored to pilots, such as regular ocular surface assessments or screen technologies for vision protection, may facilitate early detection and preventive care. In addition, interventional studies evaluating combined strategies, including ophthalmologic treatment, lifestyle optimization, and ergonomic or environmental adjustments within the cockpit, are needed to define management strategies for this occupational group.

CONCLUSION

Dry eye symptoms are frequent among pilots and aircrew, resulting from chronic exposure to low cabin humidity, prolonged digital cockpit use, and high cognitive workload. Evidence consistently indicates that these conditions destabilize the tear film, increase inflammation, and suppress blink frequency, thereby compromising ocular comfort and increasing the risk of DED. Pilots should undergo regular ophthalmologic monitoring, maintain adequate cockpit humidity, and implement preventive measures such as artificial tears and proper eyelid margin hygiene. Future research should focus on linking dry eye symptoms, such as ocular surface biomarkers and blink dynamics, to flight performance, as well as defining personalized interventions and recommendations for pilots, including fitness optimization and anti-inflammatory nutrition, to mitigate DED risk in aviation.

CORRESPONDENCE

med. stud. Gabriela Kamińska

Faculty of Medicine, Medical University of Warsaw, Poland
02-091 Warszawa, ul. Żwirki i Wigury 61
e-mail: gabrielakaminska066@gmail.com

ORCID

Gabriela Kamińska – ID – <http://orcid.org/0009-0005-9454-8927>
Szymon Chmiela – ID – <http://orcid.org/0009-0008-2901-615X>
Radosław Różycki – ID – <http://orcid.org/0000-0001-7040-026X>
Anna Maria Ambroziak – ID – <http://orcid.org/0000-0002-6426-203X>

Cite as: Kamińska G, Chmiela S, Różycki R et al. Dry eye disease in aviators: impact of environmental exposure, blinking behavior, and lifestyle. *Ophththerapy*. 2026; 13(2): A280926.

References

- McCann P, Abraham AG, Mukhopadhyay A et al. Prevalence and Incidence of Dry Eye and Meibomian Gland Dysfunction in the United States. *JAMA Ophthalmol*. 2022; 140(12): 1181-92. <https://doi.org/10.1001/jamaophthalmol.2022.4394>.
- Al-Dossary SK. Environmental and Occupational Triggers of Dry Eye Symptoms in the Ahsa Region of Saudi Arabia: A Cross-Sectional Study. *Clin Ophthalmol*. 2024; 18: 2427-38. <https://doi.org/10.2147/opth.s474832>.
- Ren X, Wang Y, Wu T et al. Binocular dynamic visual acuity in dry eye disease patients. *Front Neurosci*. 2023; 17: 1108549. <https://doi.org/10.3389/fnins.2023.1108549>.
- Koh S, Maeda N, Ikeda C et al. The Effect of Ocular Surface Regularity on Contrast Sensitivity and Straylight in Dry Eye. *Invest Ophthalmol Vis Sci*. 2017; 58(5): 2647-51. <https://doi.org/10.1167/iovs.17-21894>.
- McCarty DJ, McCarty CA. Survey of dry eye symptoms in Australian pilots. *Clinical Exper Ophthalmology*. 2000; 28(3): 169-71. <https://doi.org/10.1046/j.1442-9071.2000.00294.x>.
- Uchiyama E, Aronowicz JD, Butovich IA et al. Increased Evaporative Rates in Laboratory Testing Conditions Simulating Airplane Cabin Relative Humidity: An Important Factor for Dry Eye Syndrome. *Eye & Contact Lens*. 2007; 33(4): 174. <https://doi.org/10.1097/01.icl.0000252881.04636.5e>.
- Tesón M, González-García MJ, López-Miguel A et al. Influence of a Controlled Environment Simulating an In-Flight Airplane Cabin on Dry Eye Disease. *Invest Ophthalmol Vis Sci*. 2013; 54(3): 2093-9. <https://doi.org/10.1167/iovs.12-11361>.
- Mowry C, Ison D. Assessing Computer Vision Syndrome Risk for Pilots. *Journal of Aviation/Aerospace Education & Research*. 2015; 24(2): 79-121. <https://doi.org/10.15394/jaaer.2015.1617>.
- Vera J, Jiménez R, Madinabeitia I et al. A maximal incremental effort alters tear osmolarity depending on the fitness level in military helicopter pilots. *Ocul Surf*. 2017; 15(4): 795-801. <https://doi.org/10.1016/j.jtos.2017.08.001>.
- Zheng Y, Jie Y. Study of NASA-TLX and Eye Blink Rates Both in Flight Simulator and Flight Test. In: Harris, D. (eds) *Engineering Psychology and Cognitive Ergonomics. HCII 2019. Lecture Notes in Computer Science*; vol. 11571. Springer, Cham 2019; 11571. https://doi.org/10.1007/978-3-030-22507-0_28.
- Fachinetti A, Marelli E, Velati P et al. Subjective Dry Eye Symptoms and Objective Ocular Surface Signs in a Civil Air Crew Population: A Cross-Sectional Study. *Cureus*. 2024; 16(1): e51447. <https://doi.org/10.7759/cureus.51447>.
- Singh AK, Singh M, Malik R et al. Prevalence of dry eye disease among Indian pilots: The role of noninvasive diagnostics. *Kerala Journal of Ophthalmology*. 2025; 37(2): 167. <https://journals.lww.com/kjop/toc/2025/05000>.
- Schwerd S, Schulte A. Evaluating Blink Rate as a Dynamic Indicator of Mental Workload in a Flight Simulator. In: *Proceedings of the 19th International Joint Conference on Computer Vision, Imaging and Computer Graphics Theory and Applications*. 2024: 362-8. <https://doi.org/10.5220/0012319100003660>.
- Ngo W, Situ P, Keir N et al. Psychometric properties and validation of the Standard Patient Evaluation of Eye Dryness questionnaire. *Cornea*. 2013; 32(9): 1204-10. <https://doi.org/10.1097/ico.0b013e318294b0c0>.
- Deschamps N, Ricaud X, Rabut G et al. The Impact of Dry Eye Disease on Visual Performance While Driving. *Am J Ophthalmol*. 2013; 156(1): 184-189.e3. <https://doi.org/10.1016/j.ajo.2013.02.019>.
- Ren X, Wang Y, Wu T et al. Binocular dynamic visual acuity in dry eye disease patients. *Front Neurosci*. 2023; 17: 1108549. <https://doi.org/10.3389/fnins.2023.1108549>.
- Tan LHP, Tong L. The Association of Dry Eye Disease with Functional Visual Acuity and Quality of Life. *J Clin Med*. 2023; 12(23): 7484. <https://doi.org/10.3390/jcm12237484>.
- van der Vaart R, Weaver M, Lefebvre Ch et al. The Association Between Dry Eye Disease and Depression and Anxiety in a Large Population-Based Study. *Am J Ophthalmol*. 2015; 159(3): 470-4.

19. Dartt DA. Neural regulation of lacrimal gland secretory processes: relevance in dry eye diseases. *Prog Retin Eye Res.* 2009; 28(3): 155-77. <https://doi.org/10.1016/j.preteyeres.2009.04.003>
20. Uchino M, Uchino Y, Dogru M et al. Dry eye disease and work productivity loss in visual display users: the Osaka study. *Am J Ophthalmol.* 2014; 157(2): 294-300. <https://doi.org/10.1016/j.ajo.2013.10.014>.
21. Castro M, Carvalhais J, Teles J. Irregular working hours and fatigue of cabin crew. *Work.* 2015; 51(3): 505-511. <https://doi.org/10.3233/wor-141877>.
22. Li M, Gong L, Chapin WJ et al. Assessment of Vision-Related Quality of Life in Dry Eye Patients. *Invest Ophthalmol Vis Sci.* 2012; 53(9): 5722-7. <https://doi.org/10.1167/iov.11-9094>.
23. O'Hagan AD, Issartel J, Nevill A et al. Flying Into Depression: Pilot's Sleep and Fatigue Experiences Can Explain Differences in Perceived Depression and Anxiety Associated With Duty Hours. *Workplace Health Saf.* 2017; 65(3): 109-17. <https://doi.org/10.1177/2165079916659506>.
24. Wilson D, Driller M, Johnston B et al. The Prevalence of Cardiometabolic Health Risk Factors among Airline Pilots: A Systematic Review. *Int J Environment Res Pub Health.* 2022; 19(8): 4848. <https://doi.org/10.3390/ijerph19084848>.
25. Tang YL, Cheng YL, Ren YP et al. Metabolic syndrome risk factors and dry eye syndrome: a Meta-analysis. *Int J Ophthalmol.* 2016; 9(7): 1038-45. <https://doi.org/10.18240/ijo.2016.07.17>.
26. Kam KW, Di Zazzo A, De Gregorio C et al. A review on drug-induced dry eye disease. *Indian J Ophthalmol.* 2023; 71(4): 1263-9. https://doi.org/10.4103/IJO.IJO_2782_22.
27. Jones L, Craig JP, Markoulli M et al. TFOS DEWS III: Management and Therapy. *American J Ophthalmol.* 2025; 279: 289-386. <https://doi.org/10.1016/j.ajo.2025.05.039>.
28. Kawashima M, Uchino M, Yokoi N et al. The Association between Dry Eye Disease and Physical Activity as well as Sedentary Behavior: Results from the Osaka Study. *J Ophthalmol.* 2014; 2014: 943786. <https://doi.org/10.1155/2014/943786>.
29. Shi R, Wang F, Xu W et al. Association of age and night flight duration with sleep disorders among Chinese airline pilots. *Front Public Health.* 2023; 11: 1217005. <https://doi.org/10.3389/fpubh.2023.1217005>.
30. Wang MTM, Power B, Xue AL et al. Blink completeness and rate in dry eye disease: An investigator-masked, prospective registry-based, cross-sectional, prognostic study. *Cont Lens Anterior Eye.* 2025; 48(3): 102369. <https://doi.org/10.1016/j.clae.2025.102369>.
31. Tsubota K, Hata S, Okusawa Y et al. Quantitative videographic analysis of blinking in normal subjects and patients with dry eye. *Arch Ophthalmol.* 1996; 114(6): 715-20. <https://doi.org/10.1001/archophth.1996.01100130707012>.
32. Page C, Liu CC, Meltzer J et al. Blink-Related Oscillations Provide Naturalistic Assessments of Brain Function and Cognitive Workload within Complex Real-World Multitasking Environments. *Sensors.* 2024; 24(4): 1082. <https://doi.org/10.3390/s24041082>.

Authors' contributions:

Conceptualization and study design: Gabriela Kamińska, Anna Maria Ambroziak, Radosław Różycki.

Methodology: Gabriela Kamińska, Anna Maria Ambroziak, Szymon Chmiela.

Literature search and study selection: Gabriela Kamińska, Anna Maria Ambroziak.

Data extraction, analysis, and interpretation: Gabriela Kamińska.

Writing—original draft preparation: Gabriela Kamińska, Szymon Chmiela.

Writing—review and editing: Anna Maria Ambroziak, Radosław Różycki.

Final approval of the version to be published: Anna Maria Ambroziak, Radosław Różycki.

Accountability: All authors agree to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of interest:

None.

Financial support:

None.

Ethics:

The content presented in the article complies with the principles of the Helsinki Declaration, EU directives and harmonized requirements for biomedical journals.