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Updates on eyelid hygiene influence on the ocular surface health

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HIGHLIGHTS

This paper discusses the updated knowledge about impact of various environmental factors and lifestyle on the ocular surface as well as the role of the eyelid hygiene.

ABSTRACT

The ocular surface diseases including dry eye syndrome are still increasing issue among patients worldwide. This is related to climatic changes, nutrition, lifestyle, environment of work, and other factors. Symptoms and signs occur in patients of different age-groups. One of the important element of prophylaxis and treatment of the ocular surface disorders is eyelid margin hygiene. Non appropriate management might be ineffective and even may lead to some complications.

Key words: ocular surface, dry eye syndrome, eyelid hygiene, tea tree oil

INTRODUCTION

In common usage, the ocular surface is understood as the visible portion of the eye, i.e., the cornea, conjunctiva, and the tear film covering them. In specialized terminology, however, the definition is broader: anatomically and functionally, the ocular surface comprises the corneal and conjunctival epithelium, the ocular adnexa, and the lacrimal glands and ducts. The tear film, together with the specialized immune system of the eye (EALT, eye-associated lymphoid tissue), plays a crucial role in maintaining the integrity and homeostasis of the ocular surface [1].

The importance of the ocular surface and its maintenance is reflected in the steadily increasing number of publications devoted to this topic, the establishment of the international Tear Film and Ocular Surface Society (TFOS) by leading experts, and the launch of the American peer-reviewed quarterly The Ocular Surface in 2003.

The ocular surface, being in direct contact with the external environment, is continuously exposed to a wide range of factors, including antigens and microorganisms. Ongoing environmental changes increasingly contribute to ocular surface disorders and diseases, with symptoms reported by patients representing a significant clinical problem that adversely affects both physical and psychological well-being.

THE IMPACT OF ENVIRONMENTAL FACTORS AND LIFESTYLE ON THE CONDITION OF THE OCULAR SURFACE

It is now well established that ocular surface disease (OSD) and dry eye syndrome (DES) are closely related entities. A milestone in the advancement of knowledge on DES was the publication of the TFOS DEWS report in 2007 [2]. Ten years later, the TFOS DEWS II report was released, comprising over 400 pages and involving 150 experts from 23 countries. This document provided, among other contributions, an updated and still valid definition of DES as a multifactorial disease [3], along with recommendations for its diagnosis and management [4]. Since the 2017 publication, more than 8,000 articles on dry eye have been published, highlighting the global scale of the problem. In 2023, TFOS experts addressed the influence of environmental and lifestyle factors on ocular surface health, presenting their findings in a comprehensive 10-part report with an executive summary [5]. Particular attention was given to factors such as contact lens use, cosmetics, the digital environment, selected medications and therapies, environmental conditions, lifestyle, nutrition, and social determinants. The present article discusses selected aspects from this extensive report.

THE ROLE OF ENVIRONMENTAL FACTORS

Environmental factors affecting the ocular surface (fig. 1) can be divided into climatic factors, such as sunlight (UV radiation), temperature, humidity, wind speed, evaporation, and allergens, and environmental pollutants, both outdoor and indoor. Relevant parameters include the levels of gases such as carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and ozone (O_3), as well as aerosols and the concentration of suspended particulate matter, both organic and inorganic. Due to climate change, driven not only by natural fluctuations but predominantly by human activity, these environmental parameters are undergoing significant alterations. Extreme temperatures and humidity are well recognized as having adverse effects on the ocular surface. Elevated temperatures (approximately 40°C) can alter the properties of lipids secreted by the Meibomian glands, thereby disrupting tear film homeostasis. However, even minor deviations may negatively impact the surface of a healthy eye, and even more so in eyes with preexisting abnormalities. Low temperatures induce symptoms of dryness and discomfort more rapidly in patients with DES compared with control groups. Similarly, low relative humidity contributes to ocular irritation and tear film instability, regardless of intraocular pressure status. This effect is primarily related to accelerated tear film evaporation and can be experienced, for example, in the cabin of an airplane. A study of office workers demonstrated that subjective symptoms such as ocular dryness, irritation, and pruritus were more prevalent when working in environments with lower humidity (20–30%) compared to rooms with higher humidity (30–40%). These findings were corroborated by objective deterioration in clinical examination parameters [6].

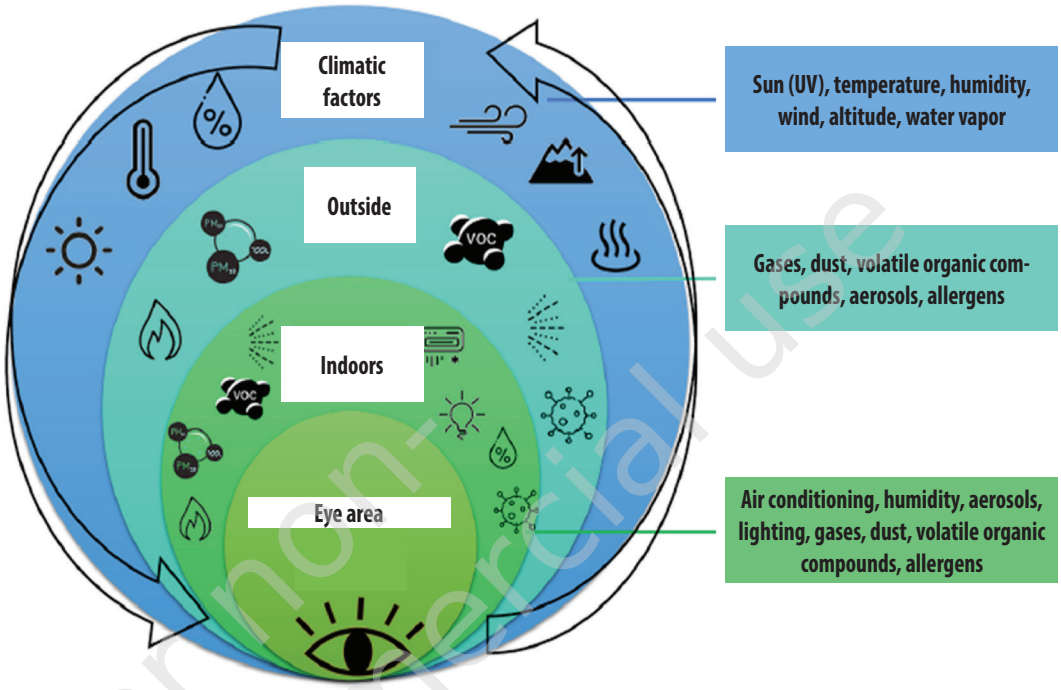
Air pollution is primarily assessed by the concentration of particulate matter (PM) and nitrogen dioxide (NO_2). Sources of airborne particulate matter include both natural processes – such as volcanic eruptions, rock erosion, forest fires, sea salt spray, wind and sandstorms, and reactions between gaseous emissions and soil particles – and anthropogenic activities, including industry, transportation, agriculture, and domestic sources. Traffic-related pollution is of growing concern worldwide, with particulate matter generated not only from exhaust emissions but also from brake and tire abrasion and resuspension of road dust.

Therefore, it is difficult to determine whether remaining indoors or outdoors in urban areas is more favorable for ocular surface health.

As noted, the ocular surface contains unique lymphoid tissue and is richly vascularized, rendering it particularly susceptible to allergens. Environmental changes, including rising temperatures and altered precipitation patterns, have led to prolonged pollen seasons and persistently elevated concentrations of mold spores both indoors and outdoors. These factors contribute substantially to the increasing prevalence of ocular allergic disease, affecting an estimated 6–30% of the general population and up to 30% of the pediatric population [7].

FIGURE 1

Interactions between environmental factors and the ocular surface (adapted from [6]).



Prolonged exposure to an unfavorable indoor environment has a detrimental impact on human health, a phenomenon referred to as sick building syndrome (SBS) [8]. Ocular surface disorders represent one of the potential manifestations of this condition. Such problems may arise in both occupational settings (e.g., offices) and residential environments. The primary contributors to indoor air pollution include chemicals released from building materials, paints, and cleaning agents; emissions from furnishings, computer equipment, and household appliances; contaminants associated with air conditioning and ventilation systems; as well as microbes, dust allergens, particulate matter, and tobacco smoke. The detrimental effects of these factors are not always fully appreciated. In the context of indoor work, the literature frequently refers to conditions such as office eye syndrome and digital eye fatigue. Exacerbation of ocular surface symptoms not only reduces work productivity but also contributes to absenteeism, thereby constituting a relevant socioeconomic problem.

Ocular surface disorders (OSD) and DES are statistically more prevalent in the elderly population. However, in recent decades, as a consequence of climate change and lifestyle modifications, OSD has been observed across all age groups, from childhood to advanced age. Young children are particularly exposed to household chemicals as well as cleaning and disinfection products. Older children are subject to both indoor (home, school) and outdoor environmental factors, and this period often coincides with the onset of allergic conditions. In adults, the number and diversity of contributing factors increase further. In this population, ocular surface health is influenced by a combination of indoor factors (workplace, home environment), external environmental exposures, the use of stimulants, and the presence of comorbidities, including lifestyle-related (civilization) diseases. Elderly individuals are statistically more likely to present with both systemic and ophthalmic diseases, require chronic pharmacotherapy, and undergo surgical procedures (iatrogenic factors). In addition, age-related anatomical and hormonal changes occur, and biofilm formation is not uncommonly observed in ocular surface structures, such as the meibomian glands.

The balance between outdoor and indoor exposure is largely determined by an individual's lifestyle.

THE ROLE OF LIFESTYLE

Lifestyle encompasses social, psychological, and physical (psychosomatic) factors. Elements such as occupational environment, leisure activities, stress, diet, correction of refractive errors with contact lenses, use of cosmetics, and exposure to stimulants all contribute to lifestyle-related influences on ocular health. Cigarette smoking, in particular, represents a harmful addiction with well-documented systemic and ocular consequences. Tobacco smoke contains more than 6,000 chemical compounds. Even brief exposure to tobacco smoke induces alterations in the lipid layer of

the tear film, including increased lipid peroxidation products, apoptosis of corneal epithelial cells, inflammation with elevated pro-inflammatory cytokines, oxidative DNA damage, and impaired autophagy. These mechanisms lead to tear film instability, manifested by accelerated evaporation and reduced tear film break-up time (BUT), ultimately contributing to ocular surface damage in chronic smokers. Imaging techniques such as meibography and confocal microscopy have demonstrated that smokers exhibit structural and functional alterations of the Meibomian glands. Specifically, gland density and goblet cell counts are reduced, which may account for the shorter tear film break-up time (BUT) observed in this population. In contrast, passive smokers wearing contact lenses also show reduced BUT, but without significant changes in tear evaporation rate or corneal epithelial integrity. Active smoking further increases the risk of squamous metaplasia, keratoconjunctivitis, and delays corneal wound healing [9].

Diet, as another key lifestyle component, plays an important role in maintaining systemic health, including the integrity and function of the ocular surface. The potential beneficial and adverse effects of selected dietary substances and comorbidities are illustrated in figure 2 [10].

Another lifestyle-related factor is the use of cosmetics for cleansing, care, or aesthetic purposes, such as eye makeup. Their composition is often overlooked, with the assumption that products approved for sale are inherently safe. In practice, the full chemical composition is not always disclosed on packaging, and many products contain substances with toxic or allergenic potential. For example, gold was identified as a contact allergen in the United States as early as 2001. Epidemiological data indicate that approximately 10% of the U.S. population exhibits type IV hypersensitivity reactions to gold. Cosmetic products often contain preservatives; among the most commonly used is benzalkonium chloride (BAK), which is well known for its ocular surface toxicity in ophthalmic preparations [11]. Some eyelash products incorporate prostaglandin analogs, whose adverse effects are familiar to glaucoma patients. Toners and makeup removers may contain terpinen-4-ol (T4O) at concentrations exceeding 1%. Daily, long-term use of T4O has not been proven entirely safe, as demonstrated in published studies [12].

THE ROLE OF EYELID MARGIN HYGIENE

Since the publication of guidelines for the management of AMS, the concept of eyelid margin hygiene has become an integral component in the treatment of both dry eye disease and other ocular surface disorders [4]. Furthermore, advances in the understanding of ocular demodicosis have led to the development and availability of numerous formulations – including solutions, impregnated wipes, and ointments – designed for the management of eyelid margin inflammation. The 2023 TFOS report highlighted particularly important data on tea tree oil, a substance with proven efficacy.

Tea tree oil (TTO) and its most active component, terpinen-4-ol (T4O), are effective in reducing the number of mites in Demodex-induced eyelid margin inflammation and are regarded as the most potent agents against blepharitis of this etiology. However, chronic use of T4O-containing preparations may have detrimental effects on the ocular surface. In vitro studies on cell cultures have demonstrated that Meibomian gland epithelial cells undergo cell death following exposure to T4O within 90 min at a concentration of 1%, 24 h at 0.1%, and 5 days at 0.01% [13]. In addition, tea tree oil exhibits endocrine-disrupting properties, demonstrating anti-androgenic effects at a concentration of 0.005% T4O and anti-estrogenic effects at 0.025% T4O. Since androgen deficiency is a major risk factor for the development of Meibomian gland dysfunction and dry eye disease, this may have clinical relevance.

Tea tree oil also possesses bactericidal properties and has been reported to be effective against fungal infections; however, concentrations of 0.1–0.25% may induce antibiotic resistance.

Chronic use of T4O-containing preparations may have adverse, potentially toxic effects on the ocular surface; therefore, establishing the duration of safe therapy requires further investigation. While in vitro results provide an important basis for safety assessment, they cannot always be directly extrapolated to in vivo conditions, particularly in light of the natural replacement of the tear film. If T4O enters the ocular surface, it is diluted more than tenfold every 10 min, meaning that an initial concentration of 100% T4O decreases to approximately 1% after 20 min and to 0.1% after 30 min [13]. Other substances found in eyelid hygiene preparations include clary sage oil (with biocidal activity against parasites [14]); poloxamer 188, a surfactant that effectively removes dirt and accumulated secretions from the eyelids and their margins, while also stabilizing damaged cell membranes – an effect particularly beneficial in protecting cells from mechanical, chemical, or oxidative stress [15]; aloe vera and Fucocert, which alleviate irritation, itching, and burning; D-panthenol (provitamin B_5), which supports epidermal regeneration; and emollients such as Olivem 300 and sodium hyaluronate.

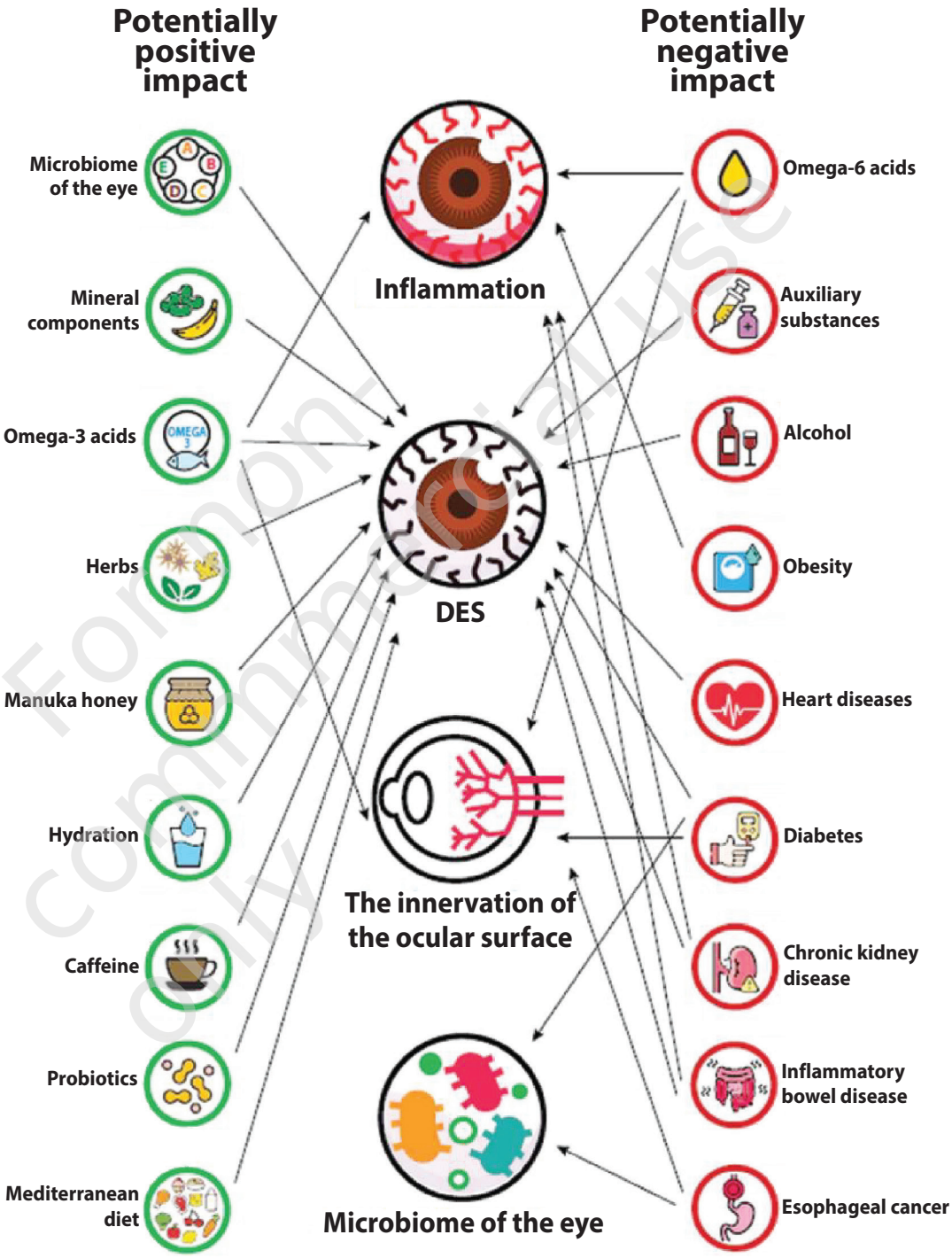
CONCLUSIONS

OSD therapy should be individualized, taking into account the patient's lifestyle and environmental exposures, whose influence is increasingly significant in a changing world.

Daily eyelid margin hygiene with appropriate preparations has a beneficial effect on ocular surface health, serving

FIGURE 2

Factors with potentially beneficial and adverse effects on the ocular surface (adapted from [10]).



both preventive and therapeutic purposes. Eyelid margin hygiene, together with preservative-free tear substitutes, constitutes the first-line treatment and remains a fundamental component at every stage of the multistep therapy for OSD and dry eye disease. However, it should be emphasized that although T4O-containing preparations are effective in the treatment of ocular demodicosis, they should not be used chronically in adults, and are strictly contraindicated in children. Anti-inflammatory therapy with TTO and T4O preparations should be intensive but time-limited. To maintain therapeutic effects and support ocular surface health, the use of fluids and wipes containing cleansing, cytoprotective, and regenerative agents is recommended.

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References

1. Knop N, Knop E. Regulation of the inflammatory component in chronic dry eye disease by the eye-associated lymphoid tissue (EALT). Dev Ophthalmol. 2010: 45: 23-39.
2. 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.
3. Craig JP, Nichols KK, Akpek EK et al. TFOS DEWS II Definition and Classification Report. Ocul Surf. 2017; 15(3): 276-83.
4. Jones L, Downie LE, Korb D et al. TFOS DEWS II Management and Therapy Report. Ocul Surf. 2017; 15(3): 575-628.
5. Craig JP, Alves M, Wolffsohn JS et al. TFOS Lifestyle Report Executive Summary: A Lifestyle Epidemic – Ocular Surface Disease. Ocul Surf. 2023; 30: 240-53.
6. Alves M, Asbell P, Dogru M et al. TFOS Lifestyle Report: Impact of environmental conditions on the ocular surface. Ocul Surf. 2023; 29: 1-52.
7. Leonardi A, Castegnaro A, Valerio AL et al. Epidemiology of allergic conjunctivitis: clinical appearance and treatment patterns in a population-based study. Curr Opin Allergy Clin Immunol. 2015; 15: 482-88.
8. Redlich CA, Sparer J, Cullen MR. Sick-building syndrome. Lancet. 1997; 349: 1013-6.
9. Matsumoto Y, Dogru M, Goto E et al. Alterations of the tear film and ocular surface health in chronic smokers. Eye. 2008; 22: 961-8.
10. Markoulli M, Ahmad S, Arcot J. TFOS Lifestyle: Impact of nutrition on the ocular surface. Ocul Surf. 2023; 29: 226-71.
11. Malik A, Claoue C. Transport and interaction of cosmetic product material within the ocular surface: beauty and the beastly symptoms of toxic tears. Contact Lens Anterior Eye. 2012; 35: 47-259.
12. Sullivan DA, da Costa AX, Del Duca E et al. TFOS Lifestyle: Impact of cosmetics on the ocular surface. Ocul Surf. 2023; 29: 77-130.
13. Chen D, Wang J, Sullivan DA et al. Effects of terpinen-4-ol on meibomian gland epithelial cells in vitro. Cornea. 2020; 39: 1541-6.
14. Sędzikowska A, Osęka M, Grytner-Zięcina B et al. Wpływ preparatów zawierających metronidazol tlenek rtęci i olejki eteryczne na przeżywalność nużeńców w warunkach in vitro. Okulistyka. 2014; 17(4): 64-6.
15. Steinhardt RA, Alderton JM. Poloxamer 188 Enhances Endothelial Cell Survival in Bovine Corneas in Cold Storage. Cornea. 2006; 25(7): 839-44.

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