

CHARACTERISTICS OF DRY EYE SYNDROME AMONG TOURISTS ENGAGING IN WATER SPORTS AT BEACH TOURISM DESTINATIONS

I Made Yudhaswara Viryavan¹, Anak Agung Mas Putrawati Triningrat², Putu Yuliawati², Ni Made Laksmi Utari²

¹Medical Student, Faculty of Medicine, Udayana University

²Department of Ophthalmology, Faculty of Medicine, Udayana University
e-mail: yuda.id81@gmail.com

ABSTRACT

Background: Dry eye syndrome (DES) is a common ocular surface disorder influenced by sociodemographic characteristics, environmental conditions, and exposure to seawater during water sports activities. Beach tourism destinations present multiple risk factors that may contribute to DES among tourists.

Methods: This study employed a prospective descriptive analytic observational design involving 65 tourists engaging in water sports at beach tourism destinations in Bali. Participants were recruited using consecutive sampling. Data were collected using a structured questionnaire to assess sociodemographic and environmental factors, followed by the Ocular Surface Disease Index (OSDI) questionnaire one week later. DES was defined as an OSDI score ≥ 13 . Data were analyzed descriptively and analytically using SPSS.

Results: Most respondents were classified as normal (76.9%), while 23.1% experienced DES, predominantly mild (20%) and moderate (3.1%), with no severe cases. Higher proportions of DES were observed among females, participants aged ≥ 30 years, those in watersport facilities site, those with longer activity duration (≥ 60 minutes), primary water sports participants, exposure to UV index ≥ 5 , higher environmental temperatures, and those not using eye protection; however, none of these individual factors showed statistically significant associations ($p > 0.05$). A significant association was found between the accumulation of multiple risk factors and DES incidence ($p = 0.011$).

Conclusion: The incidence of DES among tourists engaging in water sports is influenced by the cumulative presence of multiple risk factors rather than single exposures, highlighting the multifactorial nature of this condition.

Keywords : dry eye syndrome, tourists, water sports

INTRODUCTION

Beach tourism destinations offer a wide range of attractions, including natural scenery, warm climate, cultural elements, and recreational activities that attract large numbers of tourists each year.¹ However, recreational activities in beach environments also pose potential health risks to visitors, originating from environmental exposure and direct contact with seawater.² Water-based tourism destinations have been associated with various health problems caused by toxic substances, pathogenic microorganisms, and chemical contaminants present in aquatic environments.³ Although data on water-related diseases in Indonesian coastal tourism settings remain limited, reports from the United States estimate that recreational waterborne illnesses affect approximately 1.8–3.5 million individuals annually, highlighting the global relevance of this issue.⁴

Ocular diseases represent one of the most common health problems experienced after recreational exposure to

seawater.⁵ These conditions fall under the category of water-related ocular diseases (WRODs), which include ocular disorders caused by exposure to contaminated water, allergens, chemical irritants, infectious agents, and mechanical trauma.⁴ Many water sports commonly performed at beaches involve direct contact with seawater and are classified as primary contact activities, such as swimming, surfing, diving, and snorkeling. These activities have been identified as potential risk factors for various ocular conditions, including dry eye syndrome (DES), due to exposure to high salinity, air and water pollution, elevated temperature, wind, and intense solar radiation.⁶

Dry eye syndrome is one of the most prevalent ocular surface disorders and is currently defined as a multifactorial disease characterized by tear film instability, hyperosmolarity, ocular surface damage, and neurosensory abnormalities.⁷ Dry eye syndrome is a group of conditions affecting the tear film that result in reduced tear production

and/or excessive tear evaporation. This dysfunction originates from tear film instability, which subsequently leads to damage of the ocular surface epithelium.⁸ The etiology of DES is complex and involves both intrinsic and extrinsic factors, including age, sex, environmental exposure, and lifestyle-related conditions.⁹ These risk factors are commonly encountered by tourists engaging in water sports activities at beach destinations, linking recreational exposure to potential ocular surface disturbances.

Although DES has been extensively studied in clinical and occupational settings, limited data are available regarding its characteristics among tourists participating in water sports in beach tourism areas. Given the overlap between known DES risk factors and environmental conditions present in beach settings, understanding the distribution of DES based on sociodemographic and environmental variables is essential. Therefore, this study aimed to describe the characteristics of DES among tourists engaging in water sports activities at beach tourism destinations, providing evidence that may support preventive strategies and ocular health promotion in coastal tourism contexts.

Therefore, the objective of this study was to describe the characteristics of DES among tourists engaging in water sports activities at beach tourism destinations. Specifically, this study aimed to analyze DES characteristics based on sex, age, location, duration and type of activity, ultraviolet (UV) index, environmental temperature, and use of eye protection.

MATERIALS AND METHODS

This study employed a descriptive analytic observational design with a prospective approach to describe the characteristics of DES among tourists engaging in water sports activities at beach tourism destinations. The study protocol received ethical approval from the Research Ethics Committee, Faculty of Medicine, Udayana University, under ethical clearance number 0608/UN14.2.2.VII.14/LT/2025, following an approved amendment to the initial ethical clearance (No. 1926/UN14.2.2.VII.14/LT/2024).

The study population consisted of domestic and international tourists who participated in water sports activities at selected beach tourism destinations in Bali, including Krisna Watersports, Bayu Suta Dive and Watersports, Kuta Beach, and Canggu Beach. Data collection was conducted on-site during the study period. Potential participants were identified through direct observation at water sports operators and public beach areas. Tourists who had just completed to perform water sports activities were approached directly by the research team and screened for eligibility based on predefined inclusion and exclusion criteria.

Participants were recruited using a non-probability consecutive sampling technique, whereby all eligible tourists encountered consecutively at each study site during the data collection period were invited to participate until the minimum required sample size was achieved. Recruitment was carried out across multiple study locations to capture variations in environmental exposure and types of water sports activities.

The inclusion criteria were tourists engaging in water sports activities, able to read and communicate effectively, and willing to provide written informed consent. Tourists who did not complete the questionnaire or reported a previous clinical diagnosis of dry eye syndrome or dry eye disease were excluded from the study.

The minimum sample size was calculated using the Lemeshow formula for estimating prevalence in a population of unknown size. Assuming a dry eye disease prevalence of 20.1% in Asia¹⁰, with a 95% confidence level and a 10% margin of error, the minimum sample size required was 62 participants.

After providing informed consent, participants first completed a baseline structured questionnaire collecting information on sociodemographic characteristics and potential internal and external risk factors for DES, including sex, age, location, duration and type of activity, ultraviolet (UV) index, environmental temperature, and use of eye protection. Participants were then instructed to observe any ocular symptoms experienced over the following seven days. One week after the initial assessment, participants were contacted using the communication details provided and asked to complete the Ocular Surface Disease Index (OSDI) questionnaire to assess the presence and severity of DES.

Dry eye syndrome status was determined using the OSDI score and classified as normal (0–12) or indicative of DES (≥ 13). All data were analyzed using the Statistical Package for the Social Sciences (SPSS), and results were presented descriptive and analytically in frequencies and percentages to characterize the distribution of DES among the study population.

RESULTS

The incidence of DES among tourists engaging in water sports activities at beach tourism destinations was presented in **Table 1**. Based on OSDI score calculations from 65 respondents who completed the questionnaire, most participants were classified as normal (50 respondents; 76.9%). Mild DES was identified in 13 respondents (20%), while 2 respondents (3.1%) were categorized as having moderate DES. No cases of severe DES were observed in this study.

Table 1. Incidence of dry eye syndrome among tourists engaging in water sports at beach tourism destinations

Degree of DES	Number	Percentage (%)
Normal	50	76.9
Mild	13	20
Moderate	2	3.1
Severe	0	0
Total	65	100

DES: dry eye syndrome

The distribution of DES according to sex, age, location, duration and type of activity, ultraviolet (UV) index, environmental temperature, and use of eye protection was summarized in **Table 2**. Female respondents showed a higher proportion of DES (31%) compared with males (16.7%), with a relative risk (RR) of 1.856; however, this association was not statistically significant ($p = 0.172$). Respondents aged ≥ 30 years demonstrated a higher DES prevalence (30.8%) than those aged < 30 years (17.9%), yielding an RR of 1.72 ($p = 0.229$).

Regarding study location, DES was observed in 24.3% of respondents at watersport facilities and 21.4% of those at beach tourism sites (RR = 1.135; $p = 0.784$). A longer duration of water sports activity (≥ 60 minutes) was associated with a higher DES prevalence (27.5%) compared with durations < 60 minutes (16%), resulting in an RR of 1.719 ($p = 0.284$). Participants engaged in primary water

sports experienced a higher proportion of DES (27.3%) than those involved in secondary water sports (14.3%), with an RR of 1.909 ($p = 0.35$).

Exposure to a UV index ≥ 5 was associated with a DES prevalence of 24.4%, compared with 20.8% among respondents exposed to a UV index < 5 (RR = 1.173; $p = 0.743$). At environmental temperatures of 29–31°C, DES occurred in 31.8% of respondents, compared with 18.6% at temperatures of 27–28°C (RR = 1.709; $p = 0.232$). Additionally, respondents who did not use eye protection demonstrated a higher prevalence of DES (29.4%) compared with those who used eye protection (16.1%), with an RR of 1.826 ($p = 0.204$). Overall, none of the individual risk factors showed a statistically significant association with DES incidence ($p > 0.05$), although all variables exhibited a tendency toward increased risk.

The relationship between the number of accumulated risk factors and DES incidence was presented in **Table 3**. No respondents were identified in the zero- or one-risk-factor categories. Among participants with two and three risk factors, 14.3% experienced DES. The proportion of DES increased to 15.8% in the four-risk-factor group, 21.4% in the five-risk-factor group, and 28.6% in the six-risk-factor group. All respondents in the seven- and eight-risk-factor groups were classified as having DES (100%). Statistical analysis demonstrated a significant association between the number of concurrent risk factors and DES incidence ($p = 0.011$).

Table 2. Distribution of dry eye syndrome incidence among tourists engaging in water sports at beach tourism destinations according to various variables

Variables	Category				Total		RR	P-Value
	DES		Normal		n	%		
	n	%	n	%				
Sex								
Female	9	31	20	69	29	100	1.856	0.172
Male	6	16.7	30	83.3	36	100		
Age								
≥ 30 years old	8	30.8	18	69.2	26	100	1.72	0.229
< 30 years old	7	17.9	32	82.1	39	100		
Location of water sports activity								
Watersport facilities	9	24.3	28	75.7	37	100	1.135	0.784
Beach tourism sites	6	21.4	22	78.6	28	100		
Duration of water sports activity								
≥ 60 minutes	11	27.5	29	72.5	40	100	1.719	0.284
< 60 minutes	4	16	21	84	25	100		
Type of water sports activity								
Primary	12	27.3	32	72.7	44	100	1.909	0.35
Secondary	3	14.3	18	85.7	21	100		
Ultraviolet (UV) index								
≥ 5	10	24.4	31	75.6	41	100	1.173	0.743
< 5	5	20.8	19	79.2	24	100		
Environmental temperature								
29–31 °C	7	31.8	15	68.2	22	100	1.709	0.232
27–28 °C	8	18.6	35	81.4	43	100		
Use of eye protection								

Did not use	10	29.4	24	70.6	34	100	1.826	0.204
Use	5	16.1	26	83.9	31	100		

DES: dry eye syndrome; n: sample size; RR: relative risk; UV: ultraviolet; °C: degree celsius

Table 3. Distribution of dry eye syndrome incidence among tourists engaging in water sports at beach tourism destinations according to number of risk factors

Number of Risk Factors	Category				Total		P-Value
	DES		Normal				
	n	%	n	%	n	%	
0	0	0	0	0	0	100	0.011*
1	0	0	0	0	0	100	
2	1	14,3	6	85,7	7	100	
3	2	14,3	12	85,7	14	100	
4	3	15,8	16	84,2	19	100	
5	3	21,4	11	78,6	14	100	
6	2	28,6	5	71,4	7	100	
7	3	100	0	0	3	100	
8	1	100	0	0	1	100	

DES: dry eye syndrome; n: sample size; *: significant

DISCUSSION

This study found that only 15 out of 65 respondents (23.1%) experienced DES, while the majority remained in the normal category. The relatively low incidence observed in this study could be explained by the complex and multifactorial nature of DES, in which the presence of risk factors did not always result in overt clinical manifestations. Previous literature reported that mild DES cases were often underrecognized due to symptom variability and individual physiological adaptation.¹¹ In addition, biological predisposition played a crucial role, as individuals without baseline tear film vulnerability could remain asymptomatic despite exposure to similar environmental stressors, whereas susceptible individuals were more likely to develop DES.¹² Therefore, the low observed incidence in this study might have reflected the presence of subclinical cases that were not detected by symptom-based assessment tools such as the OSDI.

Physical activity, including water sports, was also suggested to exert a physiological protective effect on tear film function. Experimental studies demonstrated that aerobic exercise increased tear secretion and tear film stability, as reflected by higher Schirmer values, prolonged tear breakup time (TBUT), and reduced oxidative stress markers in DES patients.¹³ These mechanisms indicated that physical activity could stimulate reflex tear secretion and help maintain ocular surface hydration. Consequently, although beach environments presented several environmental risk factors, physiological responses during exercise might have partially counterbalanced the potential drying effects.

The humid tropical beach environment might have further contributed to the relatively low DES incidence. High ambient humidity slowed tear evaporation, in contrast to dry or cold climates that were known to increase DES risk.¹² Although humidity was not directly measured in this

study, repeated exposure to moist beach air and seawater spray might have provided a mild protective or flushing effect on the ocular surface. Supporting this notion, isotonic seawater application was shown to reduce dry eye symptoms and ocular surface inflammation more effectively than artificial tears.¹⁴

Regarding individual risk factors, female sex showed a higher proportion of DES compared to males, with a risk ratio (RR) of 1.856, although this association did not reach statistical significance ($p = 0.172$). This finding was consistent with previous studies reporting higher DES prevalence among females, likely related to hormonal influences on tear film stability and lifestyle factors.^{11,15} Similarly, respondents aged ≥ 30 years exhibited a higher DES risk ($RR = 1.72$; $p = 0.229$), which aligned with evidence that aging was associated with reduced tear production and meibomian gland dysfunction, despite inconsistent statistical significance across studies.¹²

Environmental and activity-related factors also demonstrated positive but non-significant associations. Participants engaging in water sports at designated watersport facilities had a slightly higher DES risk than those at regular beaches ($RR = 1.135$; $p = 0.784$). Longer exposure duration (≥ 60 minutes) showed an increased risk ($RR = 1.719$; $p = 0.284$), supporting the concept that prolonged exposure to wind, sunlight, and seawater could destabilize the tear film.¹⁶ Primary water sports involving direct contact with seawater exhibited the highest RR (1.909), although statistical significance was not achieved ($p = 0.35$). This finding was consistent with studies on water sport athletes reporting ocular irritation due to repeated exposure to saline or chlorinated water.¹⁷

Higher UV index (≥ 5) and elevated environmental temperature ($29\text{--}31^\circ\text{C}$) were also associated with increased DES risk ($RR = 1.173$ and 1.709 , respectively), although these associations were not statistically significant.

Ultraviolet radiation and high temperatures were known to increase tear evaporation and induce oxidative stress on the ocular surface.^{18,19} The absence of eye protection was similarly associated with increased DES risk (RR = 1.826; $p = 0.204$), consistent with evidence showing the protective role of swimming goggles or diving masks in reducing ocular surface irritation.²⁰

Importantly, while individual risk factors did not show statistically significant associations, the accumulation of risk factors demonstrated a significant relationship with DES incidence. Respondents with seven or eight concurrent risk factors exhibited a 100% DES incidence, and statistical analysis confirmed a significant association between the number of risk factors and DES occurrence ($p = 0.011$). This pattern strongly supported the multifactorial nature of DES, in which cumulative exposure played a more critical role than single isolated factors.¹⁵ Similar findings were reported by Alqurashi *et al.* and Najmi *et al.*, who observed worsening DES severity with increasing numbers of simultaneous risk factors.^{21,22}

The use of a questionnaire in this study represents a limitation due to its subjective nature and reliance on respondents' perceptions of DES symptoms. A research in 2022 highlighted that the inherently subjective nature of the OSDI score represents a potential limitation as individual differences in symptom sensitivity may influence the results.²³ Moreover, research in 2024 reported no significant correlation between OSDI scores and objective parameters such as tear break-up time (TBUT), the Schirmer test, or conjunctival staining using the Oxford scale, indicating that subjective symptoms do not always correspond with objective clinical findings.²⁴ Additional limitations include the short follow-up period and the lack of assessment of non-water sports-related DES triggers, which may limit the interpretation of chronic disease progression. Therefore, future studies should incorporate more objective diagnostic methods, such as non-invasive tear break-up time (NIBUT), the Schirmer test, tear meniscus height measurement, tear film lipid layer thickness analysis, and meibography, as well as longer follow-up periods to improve the validity of the findings.

Overall, this study highlighted that DES among tourists engaging in water sports was influenced by a complex interaction of individual, environmental, and activity-related factors. Although no single factor showed a statistically significant effect, the cumulative burden of multiple risk factors significantly increased DES risk, underscoring the importance of comprehensive preventive strategies.

CONCLUSION AND RECOMENDATION

Based on the findings of this study on the characteristics of DES among tourists engaging in water sports activities at beach tourism destinations, involving 65 respondents who met the inclusion criteria, it can be concluded that the majority of participants were classified as normal (76.9%), while 23.1% experienced DES,

predominantly of mild severity (20%) and to a lesser extent moderate severity (3.1%), with no cases of severe DES identified. Higher proportions of DES were observed among females, participants aged ≥ 30 years, those engaging in activities at watersport facilities, individuals with longer exposure durations (≥ 60 minutes), participants involved in primary water sports, those exposed to higher UV indices (≥ 5), individuals experiencing higher environmental temperatures (29–31°C), and respondents who did not use eye protection. Among the examined risk factors, participation in primary water sports demonstrated the highest relative risk (RR = 1.909). Furthermore, a significant association was identified between the cumulative number of risk factors and the incidence of DES, with all participants possessing seven to eight risk factors experiencing DES, underscoring the multifactorial nature of this condition.

Tourists without DES are encouraged to maintain ocular health through preventive behaviors, such as the use of eye protection and adequate hydration. Individuals experiencing mild to moderate DES should consider minimizing exposure to irritative environmental conditions, increasing blink frequency, and reducing screen time. For those with more pronounced symptoms, the use of preservative-free lubricating eye drops and consultation with an ophthalmologist are recommended to ensure appropriate management. For future research, longer study durations and larger sample sizes are suggested to improve generalizability. Additionally, incorporating objective clinical assessments, such as tear film stability tests, alongside subjective instruments like the OSDI, would enhance diagnostic accuracy. Addressing the limitations related to short follow-up periods and reliance on self-reported symptoms may contribute to a more comprehensive understanding of DES among tourists engaging in water sports activities.

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