International Journal of General Medicine

Dovepress
Taylor & Francis Group

Open Access Full Text Article

ORIGINAL RESEARCH

Analysis of Sleep Quality Evaluation Factors Affecting Dry Eye Syndrome

Heejae Jeong[1],*, Sewon Park[2],*, Hyojin Kim[3,4], Mihajlo Jakovljevic[5–7],*, Munjae Lee[2],*

[1]Department of Convergence Healthcare Medicine, Ajou University, Suwon, Gyeonggi-do, Republic of Korea; [2]Department of Medical Science, Ajou University School of Medicine, Suwon, Gyeonggi-do, Republic of Korea; [3]Department of Optometry, Graduate School of Christian Studies, Baekseok University, Seoul, Republic of Korea; [4]Department of Optometry, Division of Health Science, Baekseok University, Cheonan, Chungcheongnam-do, Republic of Korea; [5]UNESCO-The World Academy of Sciences (TWAS), Trieste, Italy; [6]Shaanxi University of Technology, Hanzhong, Shaanxi, 723099, People's Republic of China; [7]Department of Global Health Economics and Policy, University of Kragujevac, Kragujevac, Serbia

*These authors contributed equally to this work

Correspondence: Munjae Lee, Department of Medical Science, Ajou University School of Medicine, Suwon, Gyeonggi-do, 16499, Republic of Korea, Email emunjae@ajou.ac.kr; Mihajlo Jakovljevic, UNESCO-The World Academy of Sciences (TWAS), Trieste, Italy, Email sidartagothama@gmail.com

Purpose: The purpose of this study was to investigate the relationship between sleep quality and dry eye syndrome, with a specific focus on identifying the sleep-related factors that increase the risk of developing dry eye syndrome.

Patients and Methods: We utilized the PSQI-K (Korean version of the Pittsburgh Sleep Quality Index) and MQ (McMonnies Dry Eye Questionnaire) to assess sleep quality and dry eye syndrome in 221 participants. The seven subfactors of sleep measured were subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction.

Results: There was a significant correlation between poor sleep quality and higher scores of dry eye syndrome. Factors such as lower subjective sleep quality, longer sleep latency, shorter sleep duration, frequent sleep interruptions, and increased daytime dysfunction were associated with worse dry eye scores. The primary disruptors of sleep included sleep fragmentation and unsuitable thermal environments during sleep.

Conclusion: Sleep disruptions, particularly those caused by modern lifestyle factors such as excessive use of digital devices and mental health issues like depression, anxiety, and stress, significantly contribute to the likelihood of developing dry eye syndrome. Addressing these sleep-disrupting factors through comprehensive management of sleep habits and mental health is crucial for preventing dry eye syndrome. Even in individuals not currently classified with dry eye syndrome, preemptive management of identified risk factors is recommended to mitigate potential future onset.

Keywords: dry eye syndrome, sleep quality, PSQI-K, dry eye questionnaire, lifestyle

Introduction

Dry eye syndrome is an eye disease with a worldwide prevalence of 5–50%, which is caused by insufficient tear production, lacrimation disorder, excessive evaporation of tears, instability of the tear film, etc.[1,2] It shows symptoms such as glare, pain, and burning sensation, and is one of the diseases that reduces the quality of life as it can interfere with individual everyday activities depending on its severity.[3] Particularly since the increasing use of digital devices has led to the common occurrence of dry eye syndrome, tear-film homeostasis must be maintained for its prevention.[4]

The lacrimal functional unit consists of the ocular surface, lacrimal glands, and innervation, which is a major element that regulates lacrimation and plays an important role in maintaining the homeostasis of tears and the ocular surface. The use of contact lenses, ophthalmic surgery, and decline in lacrimal gland function with age are known to be representative causes of homeostasis loss.[5,6] However, Li et al reported that sleep deprivation excessively increases the level of ROS (Reactive Oxygen Species) in the cornea and tear film and inhibits antioxidant capacity, thereby disrupting the redox homeostasis of the tear film. In addition, long-term sleep deprivation has been shown to roughen or dry the ocular

Received: 20 November 2024
Accepted: 24 March 2025
Published: 31 March 2025

surface, causing the cornea to lose its transparency.[7] Wolffsohn et al stated that dry eye syndrome is related to an individual's lifestyle and that a decrease in sleep time causes dry eye syndrome.[8] Additionally, Ayoubi et al asserted that ocular pain causes sleep disorders and that dry eye syndromes have a negative impact on daily activities, causing chronic stress and anxiety, which will ultimately impede subjective sleep quality.[9] As such, a vicious cycle is being repeated where dry eye syndromes interfere with sleep, where lowered sleep quality triggers the behaviors that can aggravate the symptoms of dry eye syndrome and others; thus, it is necessary to understand the association between dry eye syndromes and sleep.

Sleep is an important factor in determining the quality of life; sleep disorders can cause symptoms such as insomnia, sleep apnea, and REM sleep behavior disorder (RBD), while poor sleep is linked to diseases, including cardiovascular disease, stroke, and depression, which then increase the risk of death.[10–12] In 2022, the American Heart Association (AHA) added sleep to the essential elements for cardiovascular health, and in Korea, PSG (polysomnography) was included in the scope of national health insurance benefits from July 2018, suggesting that the importance of sleep is increasing globally. These health care reforms and policy changes play a significant role in improving public access to health care and solving health problems.[13,14] For instance, the inclusion of polysomnography in the national health insurance coverage in Korea provides an opportunity to detect and treat sleep quality issues early, thereby contributing to the prevention of related health problems such as cardiovascular diseases and dry eye syndrome. This is similar to the positive impact of the 2009 cancer coverage expansion policy on medical expenditures and health equity, demonstrating how structural changes in the healthcare system can benefit public health.[15]

Existing studies on the association between sleep disorders and dry eye syndromes have stated that sleep deprivation is related to the autonomic nervous system and endocrine function and that sleep deprivation affects the ocular surface since lacrimation is controlled by neurological factors and hormones.[16,17] Furthermore, in the study that evaluated the relationship between sleep quality and dry eye syndrome, good and bad sleep was analyzed using PSQI-K (Korean version of the Pittsburgh sleep quality index), which showed that good sleep can help prevent dry eye syndromes.[18] As such, although the correlation between sleep quality and dry eye syndrome has been confirmed, the current state of the research lacks detailed analysis of the correlation between each factor, which determines sleep quality, and dry eye syndrome. Therefore, in this study, we aimed to individually evaluate the correlation between dry eye syndrome and the 7 sub-elements of PSQI-K.

Materials and Methods

Research Participant

This study involved 221 students and staff of Baekseok University (Republic of Korea), who voluntarily participated after being informed about the study objectives and procedures. The sample size was calculated using the G-power program 3.1.9.7. (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). As a result of applying a two-tailed test, a significance level of 0.05 and a statistical power of 0.95, 138 people were required; a higher number was set considering the dropout rate. Those who had a history of ophthalmic surgery or were under treatment after being diagnosed with dry eye syndrome or sleep disorders were excluded. The survey was conducted from December 30, 2023, to January 20, 2024, through the Naver Form (https://form.naver.com); before the start of the survey, the purpose and content of the research were explained, and written consent for participation in the study was obtained from the patients included in the study. The questionnaire was designed for them to respond in a self-administered way to the PSQI-K (Korean version of the Pittsburgh Sleep Quality Index), which can measure the quality of sleep, and the MQ (McMonnies Dry Eye Syndrome Questionnaire) to measure dry eye syndrome. This study complied with the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of Baekseok University (Approval number: BUIRB-202312-HR-047).

Sleep Quality Assessment

In this study, sleep quality was evaluated using the PSQI-K (Pittsburgh Sleep Quality Index) translated into Korean by Sohn et al[19,20] There are no simplifications or changes in the PSQI-K version from the original PSQI questionnaire, and the reliability and validity issues due to translation errors, among others, have been proven in precedent studies.[21]

The PSQI-K is a questionnaire based on the subjective evaluation of sleep quality over the past month, consisting of 7 sub-elements. These include subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, sleep medication use, and daytime dysfunction. Each area is scored from 0 to 3 points, and a total of 21 points are calculated. The calculated score is categorized as good and bad sleep based on the cut-off point, suggesting that the lower the score, the better the sleep quality. Buysse et al classified a total score of 5 or more as "bad sleepers" at the time of PSQI development,[19] and in another study in which PSQI-K was utilized, Sohn et al suggested 8.5 points as the optimal cut-off point. Subsequently, Shin et al verified the reliability and validity of PSQI-K for early adults to render 6 points as the optimal cut-off point for distinguishing sleep quality.[21] Based on the precedent study, this study set the cut-off point measured by PSQI-K, to 6 points.

Dry Eye Assessment

The MQ, known as a reliable and valid tool, was used to measure dry eye syndrome.[22] It includes a questionnaire on risk factors for dry eye syndrome in each item, making it effective in differentiating dry eye syndrome.[22,23] In this study, the original version of the MQ was used, and in cases where participants had difficulty understanding English, the examiner provided explanations before administering the questionnaire. The score is calculated reflecting 12 items related to dry eye syndrome: general characteristics of sex, age, whether to wear contact lenses, etc; self-awareness symptoms related to dry eye syndrome; presence or absence of systemic diseases, such as arthritis, thyroid abnormalities, etc, related to dry eyes. For the questions on the following: treatment or prescription history of dry eyes, history of arthritis or thyroid abnormalities, presence or absence of exposure of the ocular surface during sleep, and post-dormant eye irritation, "Yes" is given 2 points, "No" is given 0 points, and "I don't know" is given 1 point; for the presence of dry eye symptoms and the medication being taken, each is given 1 point; for the frequency of ocular symptoms and the experience of dry mucous membranes, "Always" is given 3 points, "Often" is given 2 points, 'Sometimes' is given 1 point, and "Never" is given 0 points. In the items about sensitivity to the surrounding environment, such as cigarette smoke, smog, air-conditioner wind, etc, and about eye irritation after swimming or on the day after drinking, "Yes" is given 2 points, "Sometimes" is given 1 point, and "No" is given 0 points, where it is classified as dry eye supposing that the total converted score is greater than 14.5.

Examining the precedent studies using the MQ, in the study on the effect of smoking on the dry ocular surface by Mohidin et al, 14.5 points were set as the cut-off point for indicating dry eye syndrome.[24] Additionally, even in the study on the oral and ocular recovery after head and neck cancer treatment with radiation therapy by Westgaard et al, the cut-off point for dry eye syndrome was set to 14.5 points.[25] Therefore, we also distinguished normal eyes from dry eye syndrome, based on 14.5 points, in this study.

Statistical Analysis

In the current study, the collected data were analyzed using IBM SPSS software ver.22.0 (IBM Corp., Armonk, NY, USA), where the statistical significance probability (p-value) was set to 0.05. The specific analysis methods are as follows:

First, frequency analysis, *t*-test, and ANOVA were conducted to identify the differences according to the sex and occupation of the research participants.[26,27] Second, Pearson's correlation coefficient was used to understand the correlation between sleep quality and dry eye syndrome. Third, logistic regression analysis was utilized to evaluate the occurrence risk of dry eye syndrome according to the 7 items that constitute the total score of PSQI-K.

Results

General Characteristics and the Relationship Between PSQI-K and MQ

The study included 221 participants, with a mean age of 27.62±6.40. Looking at the general characteristics of the participants, there were 93 males (42.1%) and 128 females (57.9%), indicating a higher percentage of females. In terms of age, there were more in their 20s with 130 people (58.8%), followed by those in their 30s with 91 people (41.2%). For occupation, students comprised the majority with 93 people (42.1%), followed by office workers (mainly computers) with 49 people (22.2%), professionals with 46 people (20.8%), office workers (other than computers) with 21 people (9.5%), and outside-job workers with 12 people (5.4%) (Table 1).

A significant difference was found in sex for the PSQI-K scores, whereas no significant difference was found for age and occupation. The PSQI score was higher in females at 7.07±2.97 than in males at 6.27±2.87, suggesting that the sleep quality in females was worse than that in males. On the other hand, the MQ showed significant differences in sex, age, and occupation. In terms of sex, it was higher in women at 10.68±5.12 than in men at 6.19±3.83. For age, the scores were 7.62±4.93 for those in their 20s and 10.46±4.94 for those in their 30s, with the 30s showing significantly higher scores. This shows a similar result to previous studies that the prevalence of dry eye syndrome appeared to be higher in females and increased with age.[28,29] Regarding occupation, there was a significant difference between groups, with office workers (other than computers) showing higher scores of 11.43±5.36 than professionals at 11.17±5.32, and students showing the lowest score at 6.50±4.52.

Comparison Analysis of PSQI-K and MQ Index

This study aimed to confirm the sleep quality and the presence of dry eye in the study participants. To this end, a comparative analysis was conducted after dividing them into good or bad sleep based on the PSQI-K score and into normal eyes and dry eye based on the MQ score (Table 2). The sleep quality of the study participants was an average of

Table 1 PSQI-K and MQ by General Characteristics

Characteristic	N (%)	PSQI-K		MQ	
		Mean±SD	P-value	Mean±SD	P-value
Sex					
Male	93 (42.1)	6.27±2.87	0.046**	6.19±3.83	<0.001***
Female	128 (57.9)	7.07±2.97		10.68±5.12	
Age					
20–29	130 (58.8)	6.74±3.06	0.974	7.62±4.93	<0.001***
30–39	91 (41.2)	6.73±2.80		10.46±4.94	
Job					
Office work (mainly computers)	49 (22.2)	6.74±2.83	0.305	9.80±4.19	<0.001***
Office work (other than computers)	21 (9.5)	7.24±2.84		11.43±5.36	
Outside job	12 (5.4)	6.08±2.64		9.25±4.90	
Student	93 (42.1)	6.38±3.10		6.50±4.52	
Professionals	46 (20.8)	7.39±2.84		11.17±5.32	

Notes: **p<0.05, ***p<0.001.
Abbreviations: PSQI-K, Korean version of Pittsburgh Sleep Quality Index; MQ, McMonnies dry eye questionnaire.

Table 2 Mean Scores of Qualities of Sleep and Dry Eye Index

Characteristic		Mean±SD	N	%	P-value
PSQI-K	Total	6.73±2.95	221	100	
	Good sleep	3.80±1.38	81	36.7	
	Bad sleep	8.43±2.19	140	63.3	<0.001***
MQ	Total	8.79±5.12	221	100	
	Normal	7.34±3.78	190	86	
	DES	17.71±2.67	31	14	<0.001***

Note:***p<0.001.
Abbreviations: DES, Dry eye syndrome; PSQI-K, Korean version of Pittsburgh Sleep Quality Index; MQ, McMonnies dry eye questionnaire.

6.73±2.95 points, and there was a significant difference in PSQI scores between the good and bad sleep groups. The average for good sleep was 3.80±1.38 points, accounting for 81 people (36.7%), whereas the average for bad sleep was 8.43±2.19 points with 140 people (63.3%). The dry eye score averaged 8.79±5.12 points, showing a significant difference in the MQ scores between the normal eyes and dry eye groups. The average for normal eyes was 7.34±3.78 points, accounting for 190 people (86%), while the average for dry eye was 17.71±2.67 points with 31 people (14%).

Relationship Between Sleep Quality and Dry Eye According to PSQI-K and MQ Index

The correlation between the total score of PSQI-K and the MQ score was analyzed, indicating a significant positive correlation (Table 3). In addition, the correlation between the 7 sub-factors that comprise PSQI-K and the MQ score was analyzed individually. As a result, the dry eye score worsened as subjective sleep quality was lower (r=0.141, p=0.036), sleep latency was longer (r=0.155, p=0.021), and sleep duration was shorter (r=0.164, p=0.014). Furthermore, the dry eye score worsened when there were sleep disturbances (r=0.338, p<0.001) and daytime dysfunctions (r=0.265, p<0.001). No significant correlation was shown in habitual sleep efficiency (r=0.044, p=0.514) and sleep medication use (r=0.13, p=0.054).

The difference in sleep quality was identified after dividing them into normal eyes and dry eye using the MQ score (Table 4). As a result of the analysis, the dry eye group had significantly higher scores in subjective sleep quality, sleep disturbance, and daytime dysfunction than the normal eye group. In the case of subjective sleep quality, normal eyes

Table 3 The Correlation Between PSQI-K and MQ

PSQI-K	MQ	
	r	***P*-value**
Total PSQI-K score	0.312**	<0.001
Subcategories of PSQI-K		
Subjective sleep quality	0.141*	0.036
Sleep latency	0.155*	0.021
Sleep duration	0.164*	0.014
Habitual sleep efficiency	0.044	0.514
Sleep disturbance	0.338**	<0.001
Sleep medication use	0.130	0.054
Daytime dysfunction	0.265**	<0.001

Notes: **Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed); P-value, statistically significant.
Abbreviations: PSQI-K, Korean version of Pittsburgh Sleep Quality Index; MQ, McMonnies dry eye questionnaire.

Table 4 Comparison of Normal Eye and Dry Eye PSQI-K (All Components of the PSQI-K)

Subcategories of PSQI-K	Normal	DES	t	*P*-value
Subjective sleep quality	1.26±0.63	1.52±0.72	−2.031	0.044**
Sleep latency	1.40±1.03	1.65±0.98	−1.239	0.217
Sleep duration	1.27±1.04	1.61±0.92	−1.705	0.09
Habitual sleep efficiency	0.17±0.52	0.26±0.73	−0.84	0.402
Sleep disturbance	1.04±0.49	1.32±0.54	−2.904	0.004**
Sleep medication use	0.79±0.46	0.19±0.60	−1.23	0.22
Daytime dysfunction	1.27±0.91	1.65±0.88	−2.155	0.032**

Note: **p<0.05.
Abbreviations: DES, Dry eye syndrome; PSQI-K, Korean version of Pittsburgh Sleep Quality Index.

Table 5 Odds Ratios for Dry Eye Disease in Relation to Components of the PSQI-K Based on MQ Cut-off Points (14.5)

Subcategories of PSQI-K	Normal	OR (95% CI)	*P*-value
Subjective sleep quality	Ref	1.082 (0.53 to 2.21)	0.829
Sleep latency	Ref	1.035 (0.65 to 1.65)	0.883
Sleep duration	Ref	1.379 (0.87 to 2.19)	0.173
Habitual sleep efficiency	Ref	0.804 (0.36 to 1.78)	0.591
Sleep disturbance	Ref	2.463 (1.06 to 5.70)	0.035**
Sleep medication use	Ref	1.590 (0.80 to 3.16)	0.186
Daytime dysfunction	Ref	1.482 (0.93 to 2.35)	0.095

Notes: 95% CI, 95% confidence interval; **p<0.05.
Abbreviations: PSQI-K, Korean version of Pittsburgh Sleep Quality Index; MQ, McMonnies dry eye questionnaire; OR, odds ratio.

scored 1.26±0.63 and dry eye 1.52±0.72; for sleep disturbance, normal eyes scored 1.04±0.49 and dry eye 1.32±0.54; for daytime dysfunction, normal eyes scored 1.27±0.91 and dry eye 1.65±0.88. In other words, among the sub-items measuring the PSQI-K, subjective sleep quality, sleep disturbance, and daytime dysfunction appeared as factors that can degrade the sleep quality in the dry eye group.

Logistic Regression Analysis

A logistic regression analysis was conducted to evaluate the risk of dry eye syndrome (Table 5). As a result of the analysis, sleep disturbance had a significant effect on the presence or absence of dry eye syndrome, and the increased by 2.463 times when sleep was disturbed. In addition, the results of examining sleep disturbance factors in detail are shown in Figure 1. Among the factors that disturb sleep, the highest incidence rate occurred in cases of waking up in the middle of the night or at dawn, accounting for 24.9%. Furthermore, 22.3% of people experienced sleep disturbances related to the thermal environment during sleep, of which 19.7% felt hot and 2.6% felt cold. Other important disturbance factors included using the bathroom (17.1%), coughing or nasal congestion (12.8%), and nightmares (10.4%). On the other hand, the inability to breathe comfortably accounted for the lowest incidence rate of 3.4%.

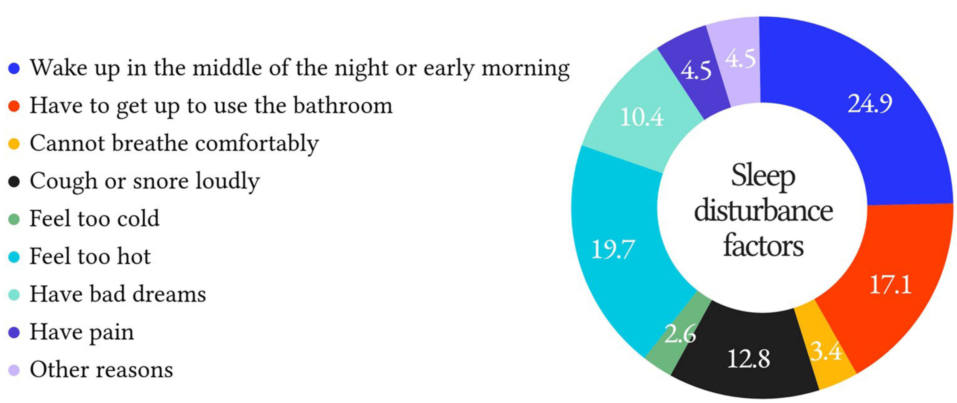

Figure 1 Frequency analysis of sleep disturbance factors (%).

Discussion

Dry eye syndrome is recognized as a modern public-health problem, so efforts are needed to identify the causes and then prepare to establish management solutions to prevent it. To date, the causes of dry eye syndrome have been considered to be dry surrounding environments, factors related to systemic diseases, the utilization of local or systemic drugs, etc.[1,30,31] However, recently, due to the increased use of digital devices and factors related to mental health, sleep is emerging as a major factor.[32,33]

The results of this study showed a significant correlation between sleep quality and dry eye syndrome, which is consistent with previous research results that sleep quality affects dry eye syndrome.[34,35] Sleep disorders are associated with dysautonomia, which affects the parasympathetic nerves to reduce lacrimation from the lachrymal glands.[32] Before excessive evaporation of tears, reduced lacrimation from the lacrimal glands can act as a primary cause of dry eye syndrome. Additionally, there is a higher risk of developing dry eye syndrome with short sleep time than with optimal sleep time.[33] Therefore, it seems that if sleep quality is improved by securing sleep time and maintaining homeostasis of lacrimation, it will be helpful in preventing dry eye syndrome. Demir et al stated that excessive smartphone use could be a cause that lowers sleep quality and induces drowsiness during the day.[36] Additionally, Lane et al stated that high dependence on smartphones and its addiction have a negative impact on sleep quality, sleep latency, and daytime dysfunction, so prevention and countermeasures are necessary.[37] Sleep latency refers to the time it takes to fall asleep after going to bed; if sleep latency becomes longer, the usual sleep pattern is broken and the total sleep time decreases. Lee et al noted that a lack of sleep can induce hyperosmotic pressure of tears and reduced lacrimation can worsen the symptoms of ocular surface diseases.[32] In this study, it was also found that the longer the sleep latency and the shorter the sleep duration, the worse the dry eye syndrome scores became. In this way, excessive use of digital devices, including smartphones, acts as a major factor not only degrading sleep quality but also negatively affecting eye health. During the use of digital devices, decreased blinking and increased eye-exposure time can destabilize the tear film, causing evaporative dry eye syndrome – which accounts for 80% of the total dry eye syndrome.[38] When these dry eye symptoms are felt, artificial tears are used to relieve discomfort, but they can only provide temporary pain relief. For radical symptom relief, fundamental management measures are necessary in a more comprehensive dimension regarding digital device usage habits, sleep habits, etc.

Meanwhile, as a result of evaluating the risk of dry eye syndrome for each of the 7 sub-items, the risk of dry eye syndrome was shown to increase significantly only in the "sleep disturbance", which differed from precedent research results.[34] It is thought that this was due to the dry eye syndrome questionnaire tool. In precedent studies, OSDI (Ocular Surface Disease Index) was utilized as a screening tool for dry eye syndrome. The OSDI is a questionnaire designed to evaluate the impact of observable symptoms of the ocular surface on vision-related functions.[39] On the other hand, the MQ is a questionnaire that focuses on risk factors for dry eye syndrome, thus it has different cut-off points because the questions include not only dry eye syndrome symptoms but also include medical conditions, medication usage, etc, related to dry mucous membranes and dry eye syndrome.[40] In this study, we used the effective MQ as a diagnostic questionnaire that can not only diagnose dry eye syndrome but also detect its causes. Furthermore, because the dependent variable in the logistic regression analysis was set as the presence or absence of dry eye syndrome, it is thought that the results are different from questionnaires with different cut-off points for dry eye diagnosis.

The results of this study showed that the risk of dry eye syndrome increased when sleep was disturbed, and the most common cause was sleep fragmentation. Previous studies on sleep fragmentation have shown that stress can disrupt deep sleep and cause repeated awakenings and can induce poor sleep quality and feelings of fatigue.[41] Heat was the second cause of sleep interruption. Previous research on the effect of temperature on sleep has found that the thermal environment can promote sleep disturbances.[42] Because excessive inappropriate heat and humidity in the sleeping environment can prevent you from entering the deep sleep state, keeping a pleasant sleeping environment is preferable. In addition to the items that are included in the PSQI-K questionnaire as sleep disturbance factors, there are various causes of sleep disturbance. In particular, in modern society, factors related to mental health such as depression, anxiety, and stress can cause sleep disturbance. A negative cycle emerges, in which mood disorders disturb normal sleep patterns, lack of sleep can cause mood disorders, anxiety worsens sleep quality, and sleep disorders, in turn, worsen anxiety.[43,44]

Therefore, mood disorders such as depression and anxiety, caused by stress, can negatively affect quality of life by degrading sleep quality and causing or worsening dry eye syndrome. To prevent and manage dry eye syndrome, these sleep-disrupting factors must be eliminated. To this end, it is deemed necessary to comprehensively manage sleep disorders and dry eye syndrome by maintaining regular sleep habits and managing mental health, by utilizing digital therapeutics for the treatment of sleep and anxiety disorders.

The limitations of this study are as follows. First, the study participants are limited to young adults. Dry eye syndrome can occur at any age, and the prevalence of dry eye syndrome generally tends to be higher in those in their 40s or older due to aging. However, considering that dry eye syndrome is increasing among young adults due to the recent increase in the use of digital devices, this study targeted only young adults. In future studies that target various age groups, it will be possible to identify factors affecting both dry eye syndrome and sleep quality, and then to seek age-specific management measures. Second, a self-perceived evaluation tool was utilized as a method of screening for dry eye syndrome. The multidimensional assessment, such as test results or doctor's diagnosis that can quantify and measure dry eye syndrome, was not included. If studies, including this one, are conducted by increasing the screening accuracy for dry eye syndrome, more effective measures can be presented.

Conclusion

The present study examined the factors of sleep quality that may contribute to dry eye syndrome and proposed measures for its prevention and management. In order to reduce the risk of dry eye syndrome caused by poor sleep quality, it is suggested that in addition to sufficient and regular sleep, stress that interferes with sleep should be managed, an appropriate sleep environment should be created, and digital therapeutics should be used to comprehensively manage mental health such as depression and anxiety. If the fundamental cause of sleep interference is improved and quality sleep is promoted, it is expected to have a positive effect on dry eye syndrome.

Abbreviations

PSQI-K, Korean version of the Pittsburgh Sleep Quality Index; MQ, McMonnies Dry Eye Questionnaire; OSDI, Ocular Surface Disease Index.

Data Sharing Statement

All data generated or analyzed during this study are included in this article. Further enquiries can be directed to the corresponding author.

Statement of Ethics

This study was approved by the Institutional Review Board (IRB) of Baekseok University in accordance with the Declaration of Helsinki (approval number: BUIRB-202312-HR-047), and written informed consent for participation in the study was obtained from the patients included in the study.

Acknowledgments

Heejae Jeong and Sewon Park are co-first authors for this study. Mihajlo Jakovljevic and Munjae Lee are co-correspondence authors for this study. We are grateful for the support from the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2023S1A3A2A05095298), Bio-convergence Technology Education Program through the Korea Institute for Advancement Technology (KIAT) funded by the Ministry of Trade, Industry and Energy (No. P0017805).

Author Contributions

All authors made a significant contribution to the work reported, whether in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas. Specifically, H.J and S.P wrote the paper with help from H.K in collecting and analyzing data. M.J and M.L, as corresponding authors, coordinated the research, provided guidance throughout the study, and critically reviewed the work for important intellectual content. All authors have agreed on the journal to which the article has been submitted and agree to be accountable for all aspects of the work.

Funding

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2023S1A3A2A05095298), Bio-convergence Technology Education Program through the Korea Institute for Advancement Technology (KIAT) funded by the Ministry of Trade, Industry and Energy (No. P0017805).

Disclosure

The authors declare no conflicts of interest in this work.

References

1. Stapleton F, Alves M, Bunya VY, et al. Tfos dews ii epidemiology report. *Ocular Surf*. 2017;15(3):334–365. doi:10.1016/j.jtos.2017.05.003
2. Storås AM, Strümke I, Riegler MA, et al. Artificial intelligence in dry eye disease. *Ocular Surf*. 2022;23:74–86. doi:10.1016/j.jtos.2021.11.004
3. Pflugfelder SC, Geerling G, Kinoshita S, et al. Management and therapy of dry eye disease: report of the management and therapy subcommittee of the International Dry Eye WorkShop (2007). *Ocul Surf*. 2007;5(2):163–178.
4. Al-Mohtaseb Z, Schachter S, Shen Lee B, Garlich J, Trattler W. The relationship between dry eye disease and digital screen use. *Clin Ophthalmol*. 2021;Volume 15:3811–3820. doi:10.2147/OPTH.S321591
5. Stern ME, Gao J, Siemasko KF, Beuerman RW, Pflugfelder SC. The role of the lacrimal functional unit in the pathophysiology of dry eye. *Exp Eye Res*. 2004;78(3):409–416. doi:10.1016/j.exer.2003.09.003
6. Ahn JM, Lee SH, Rim THT, et al. Prevalence of and risk factors associated with dry eye: the Korea National Health and Nutrition Examination Survey 2010–2011. *Am J Ophthalmol*. 2014;158(6):1205–1214.e7. doi:10.1016/j.ajo.2014.08.021
7. Li S, Tang L, Zhou J, et al. Sleep deprivation induces corneal epithelial progenitor cell over-expansion through disruption of redox homeostasis in the tear film. *Stem Cell Rep*. 2022;17(5):1105–1119. doi:10.1016/j.stemcr.2022.03.017
8. Wolffsohn JS, Wang MT, Vidal-Rohr M, et al. Demographic and lifestyle risk factors of dry eye disease subtypes: a cross-sectional study. *Ocular Surf*. 2021;21:58–63. doi:10.1016/j.jtos.2021.05.001
9. Ayoubi M, Cabrera K, Mangwani S, Locatelli EVT, Galor A. Associations between dry eye disease and sleep quality: a cross-sectional analysis. *BMJ Open Ophthalmol*. 2024;9(1):e001584. doi:10.1136/bmjophth-2023-001584
10. Augner C. Associations of subjective sleep quality with depression score, anxiety, physical symptoms and sleep onset latency in young students. *Cent Eur J Public Health*. 2011;19(2):115–117. doi:10.21101/cejph.a3647
11. Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Sleep duration and all-cause mortality: a systematic review and meta-analysis of prospective studies. *Sleep*. 2010;33(5):585–592. doi:10.1093/sleep/33.5.585
12. Mensah GA, Fuster V, Murray CJ, Roth GA; Diseases GBoC, Collaborators R. Global burden of cardiovascular diseases and risks, 1990–2022. *J Am Coll Cardiol*. 2023;82(25):2350–2473. doi:10.1016/j.jacc.2023.11.007
13. Jakovljevic M, Liu Y, Cerda A, et al. The Global South political economy of health financing and spending landscape–history and presence. *J Med Econ*. 2021;24(sup1):25–33. doi:10.1080/13696998.2021.2007691
14. Jakovljevic M, Chang H, Pan J, et al. Successes and challenges of China's health care reform: a four-decade perspective spanning 1985—2023. *Cost Eff Resour Allocation*. 2023;21(1):59. doi:10.1186/s12962-023-00461-9
15. Lee C. The effect of the 2009 cancer coverage expansion policy in Korea. *Global Health Econ Sustainability*. 2024;2001:1.
16. Altevogt BM, Colten HR. *Sleep Disorders and Sleep Deprivation: An Unmet Public Health Problem*. National Academies Press; 2006.
17. Li S, Ning K, Zhou J, et al. Sleep deprivation disrupts the lacrimal system and induces dry eye disease. *Exp mol Med*. 2018;50(3):e451.
18. Park H-W, Kim T-H. A study on the correlation between quality of sleep and dry eye in workers. *Korean J Vis Sci*. 2018;20(1):77–86. doi:10.17337/JMBI.2018.20.1.77
19. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research. *Psychiatry Res*. 1989;28(2):193–213. doi:10.1016/0165-1781(89)90047-4
20. Sohn SI, Kim DH, Lee MY, Cho YW. The reliability and validity of the Korean version of the Pittsburgh Sleep Quality Index. *Sleep Breathing*. 2012;16:803–812. doi:10.1007/s11325-011-0579-9
21. Shin S, Kim SH. The reliability and validity testing of Korean version of the Pittsburgh Sleep Quality Index. *J Converg Inf Technol*. 2020;10(11):148–155.
22. McMonnies CW, Ho A. Patient history in screening for dry eye conditions. *J Am Optom Assoc*. 1987;58(4):296–301.
23. Lee BJ, Hong JH, Jung D, Park M. A study on the confidence of dry eye diagnosis methods. *J Korean Ophthalmic Opt Soc*. 2008;13(1):15–20.
24. Mohidin N, Jaafar AB. Effect of smoking on tear stability and corneal surface. *J Curr Ophthalmol*. 2020;32(3):232–237. doi:10.4103/JOCO.JOCO_70_20
25. Westgaard KL, Hynne H, Amdal CD, et al. Oral and ocular late effects in head and neck cancer patients treated with radiotherapy. *Sci Rep*. 2021;11(1):4026. doi:10.1038/s41598-021-83635-w
26. Matsumoto K, Ito M, Cheung DS-K, Tan SB, Hayashi S, Kirino M. Homebound elderly with dementia and their family caregivers: examining the situation in Hong Kong, Singapore, and Japan before COVID-19. *Global Health Econ Sustainability*. 2024;2(1):1954. doi:10.36922/ghes.1954
27. Amarra MS, de Los Reyes F. Assessment of the intake and sources of total sugar among Filipino children and adolescents based on national consumption data. *Global Health Econ Sustainability*. 2024;2(1):2060. doi:10.36922/ghes.2060
28. McCarty CA, Bansal AK, Livingston PM, Stanislavsky YL, Taylor HR. The epidemiology of dry eye in Melbourne, Australia. *Ophthalmology*. 1998;105(6):1114–1119. doi:10.1016/S0161-6420(98)96016-X

29. Lamberts DW, Foster CS, Perry HD. Schirmer test after topical anesthesia and the tear meniscus height in normal eyes. *Arch Ophthalmol*. 1979;97(6):1082–1085. doi:10.1001/archopht.1979.01020010536004
30. Janine A. The epidemiology of dry eye disease: report of the epidemiological subcommittee of the international dry eye workshop. *Ocul Surf*. 2007;5(2):93–107.
31. Jones L, Downie LE, Korb D, et al. TFOS DEWS II management and therapy report. *Ocular Surf*. 2017;15(3):575–628. doi:10.1016/j.jtos.2017.05.006
32. Lee YB, Koh JW, Hyon JY, Wee WR, Kim JJ, Shin YJ. Sleep deprivation reduces tear secretion and impairs the tear film. *Invest Ophthalmol Vis Sci*. 2014;55(6):3525–3531.
33. Lee W, Lim -S-S, Won J-U, et al. The association between sleep duration and dry eye syndrome among Korean adults. *Sleep Med*. 2015;16(11):1327–1331. doi:10.1016/j.sleep.2015.06.021
34. Yu X, Guo H, Liu X, et al. Dry eye and sleep quality: a large community-based study in Hangzhou. *Sleep*. 2019;42(11):zsz160. doi:10.1093/sleep/zsz160
35. Magno MS, Utheim TP, Snieder H, Hammond CJ, Vehof J. The relationship between dry eye and sleep quality. *Ocular Surf*. 2021;20:13–19. doi:10.1016/j.jtos.2020.12.009
36. Demir YP, Sümer MM. Effects of smartphone overuse on headache, sleep and quality of life in migraine patients. *Neurosci J*. 2019;24(2):115–121. doi:10.17712/nsj.2019.2.20180037
37. Lane H-Y, Chang C-J, Huang C-L, Chang Y-H. An investigation into smartphone addiction with personality and sleep quality among university students. *Int J Environ Res Public Health*. 2021;18(14):7588. doi:10.3390/ijerph18147588
38. Rouen PA, White ML. Dry eye disease: prevalence, assessment, and management. *Home Healthc Now*. 2018;36(2):74–83. doi:10.1097/NHH.0000000000000652
39. Schiffman RM, Christianson MD, Jacobsen G, Hirsch JD, Reis BL. Reliability and validity of the ocular surface disease index. *Arch Ophthalmol*. 2000;118(5):615–621. doi:10.1001/archopht.118.5.615
40. Nichols KK, Nichols JJ, Mitchell GL. The reliability and validity of McMonnies dry eye index. *Cornea*. 2004;23(4):365–371. doi:10.1097/00003226-200405000-00010
41. Smith J, Honig-Frand A, Antila H, et al. Regulation of stress-induced sleep fragmentation by preoptic glutamatergic neurons. *Curr Biol*. 2024;34(1):12–23.e5. doi:10.1016/j.cub.2023.11.035
42. Refinetti R, Menaker M. The circadian rhythm of body temperature. *Physiol Behav*. 1992;51(3):613–637.
43. Peterson MJ, Benca RM. Sleep in mood disorders. *Sleep Med Clin*. 2008;3(2):231–249. doi:10.1016/j.jsmc.2008.01.009
44. Chellappa SL, Aeschbach D. Sleep and anxiety: from mechanisms to interventions. *Sleep Med Rev*. 2022;61:101583. doi:10.1016/j.smrv.2021.101583