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THE ASSOCIATION BETWEEN CAFFEINE CONSUMPTION AND DRY EYE DISEASE: A RETROSPECTIVE CROSS-SECTIONAL STUDY

[a]Niharika Singh*, [b]Arjun Kumar Singh
[a]Assistant Professor, Department of Ophthalmology, Netaji Subhas Medical College and Hospital, Patna, Bihar, India
[b]HOD, Department of Ophthalmology, Netaji Subhas Medical College and Hospital, Bihta, Patna, Bihar, India

ABSTRACT

Background

Multifactorial dry eye disease (DED) results in ocular surface deterioration and instability of the tear film, which can lead to pain and problems in vision. Research on DED has contested coffee's effects on tear production and ocular surface health. The study investigated the connection between caffeine consumption and DED.

Methods

The Women's Health Research (WHS) dry eye questionnaire and data on caffeine consumption were completed by 500 research participants. After controlling for variables such as age, education level, sex, family income, body mass index (BMI), alcohol intake, smoking status, and medical comorbidities, multivariable logistic regression models were utilized to examine the relationship between caffeine intake and DED outcomes.

Results

30% of people had DED as defined by the WHS, with females having a higher incidence (36.3%) than males (19.4%). Caffeine use was found to have a significant positive correlation with DED, with an increase in the odds of developing DED of 10% for every 100 mg/day of caffeine consumed (OR = 1.10, 95% CI = 1.02–1.18, p = 0.01). Females had a higher correlation with this (OR = 1.12, 95% CI = 1.03–1.21, p = 0.005). The risk of DED was further enhanced by inadequate sleep, high levels of work-related stress, and increased caffeine use. The main source of caffeine that was shown to be contributing to this risk was tea.

Conclusion

Higher caffeine intake is associated with an increased risk of DED, particularly among females and individuals with poor sleep quality or high work stress. Tea emerged as a significant contributor to this association.

Recommendations

The mechanisms underlying the link between caffeine use and DED require more investigation. Caffeine use should be moderated by public health standards to lower the risk of DED, particularly in more susceptible populations.

Keywords: *Dry Eye Disease, Caffeine Intake, Tear Film, Ocular Surface, Tea Consumption.*
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Corresponding Author: *Niharika Singh**
Email: *doc.niharikasingh@gmail.com*
Assistant Professor, Department of Ophthalmology, Netaji Subhas Medical College and Hospital, Patna, Bihar, India.

INTRODUCTION

When tear film homeostasis is disrupted, it leads to symptoms like discomfort, visual disruption, and instability of the tear film. This can potentially harm the surface of the eye. Dry Eye Disease (DED) is a complex eye condition caused by multiple factors. Millions of individuals worldwide suffer from this common ailment, which has a big impact on everyday functioning and quality of life [1]. DED has a complicated etiology that includes several internal and external variables, including age, gender, hormone fluctuations, the environment, and lifestyle choices including food and drug usage.

Extensive research has been carried out on the physiological impacts of caffeine, a psychoactive substance that is often consumed and may be found in beverages such as tea, coffee, cola, and energy drinks. It stimulates the central nervous system, which helps with focus and alertness while temporarily relieving weariness [2]. Research and discussion on its effects on ocular health, namely DED, are still underway. Caffeine may affect tear production and the condition of the ocular surface, according to recent research, yet the data is conflicting and occasionally unclear [3].

Numerous population-based research has looked into the possible connection between caffeine use and DED. For example, studies have demonstrated that coffee can increase tear production, which may help some people with their dry eye problems [4]. On the other hand, several studies have suggested that a high coffee diet may make DED symptoms worse because of its diuretic impact,

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which can cause dehydration and lower tear film stability [5].

Given the high frequency of DED and the ubiquitous use of caffeine, it is important to comprehend how these two conditions relate to public health. Finding modifiable risk factors for DED can result in improved management and preventative measures, which will eventually enhance the quality of life and ocular health of those who are affected. This study aims to investigate the relationship between caffeine intake and Dry Eye Disease (DED).

METHODOLOGY

Study Design

A retrospective observational cross-sectional study.

Study Setting

The study was conducted over two years, from January 2022 to December 2023, at Netaji Subhas Medical College and Hospital, Bihta, Patna.

Participants

A total of 500 participants were included in the study.

Inclusion Criteria

- Adults aged 18 and above.
- Individuals who provided informed consent.
- Participants who completed the Women's Health Study (WHS) dry eye questionnaire.

Exclusion Criteria

- Participants with incomplete or missing questionnaire data.
- Individuals with a history of ocular surgery within the past six months.
- Participants using medications known to affect tear production.

Bias

To minimize bias, participants were selected consecutively, and data collection was standardized. All assessments were performed using validated tools, and multivariable logistic regression models were used to adjust for potential confounders.

Variables

The variables considered in the study were caffeine intake (measured in mg/day), WHS-defined dry eye disease (DED), clinical diagnosis of DED, symptomatic dry eye, very symptomatic dry eye, age, education level, sex, household income, body mass index (BMI), alcohol intake, smoking status, and medical comorbidities.

Data Collection

Data on dry eye symptoms were collected using the Women's Health Study (WHS) dry eye questionnaire. Caffeine consumption was evaluated using food frequency questionnaires developed by Wageningen University and Research, which included detailed questions on dietary caffeine intake from coffee, tea, caffeinated cola, and energy drinks.

Procedure

Participants were asked three key questions from the WHS dry eye questionnaire:

1. "How often do your eyes feel dry (not wet enough)?"
2. "How often do your eyes feel irritated?"
3. "Have you ever received a diagnosis of dry eye?"

The possible answers for the first two questions were "never," "sometimes," "often," and "constantly," while the third question had options "yes," "no," and "I don't know."

Caffeine intake was computed based on frequency and quantity of consumption, using established caffeine content values for various beverages. Missing data were imputed using mean values for tea, cola, and energy drink intake.

Statistical Analysis

To evaluate the characteristics of the population, descriptive statistics were applied. To ascertain the correlation between DED outcomes and continuous caffeine intake (per 100 mg/day), multivariable logistic regression models were used. Furthermore, the consumption of each caffeinated beverage and decaffeinated tea was examined using different multivariate models. After determining whether there was multicollinearity among the independent variables, a significance level of 0.05 was set for the primary outcome and 0.0167 for the secondary outcomes after the Bonferroni correction was applied. The statistical software SPSS Inc., version 25.0, was used for all of the analyses.

RESULT

320 (64%) of the 500 participants were women, and 180 (36%) were men. The participants' average age was 45.2 years (SD = 12.3). The study population's demographic and baseline characteristics are shown in Table 1.

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Table 1. Demographic and Baseline Characteristics

Characteristic	Total	Female	Male
Age (years), mean (SD)	45.2 (12.3)	44.6 (11.8)	46.4 (13.0)
Education Level (%)			
- Low	150 (30%)	100 (31.3%)	50 (27.8%)
- Middle	220 (44%)	140 (43.8%)	80 (44.4%)
- High	130 (26%)	80 (25%)	50 (27.8%)
Household Income (%)			
- < ₹2,00,000/month	220 (44%)	140 (43.8%)	80 (44.4%)
- ₹2,00,000–3,00,000/month	200 (40%)	120 (37.5%)	80 (44.4%)
- > ₹3,00,000/month	80 (16%)	60 (18.8%)	20 (11.1%)
Body Mass Index (BMI), mean (SD)	24.8 (4.2)	24.5 (4.1)	25.3 (4.4)
Smoking Status (%)			
- Never	300 (60%)	210 (65.6%)	90 (50%)
- Current	100 (20%)	40 (12.5%)	60 (33.3%)
- History of Smoking	100 (20%)	70 (21.9%)	30 (16.7%)

150 (30%) of the 500 individuals had a DED diagnosis as defined by WHS. Compared to men (19.4%), women (36.3%) had a greater prevalence of DED. The distribution of DED results is displayed in Table 2.

Table 2. Distribution of DED Outcomes

DED Outcome	Total	Female	Male
WHS-defined DED (%)	150 (30%)	116 (36.3%)	34 (19.4%)
Clinical Diagnosis of DED (%)	60 (12%)	48 (15%)	12 (6.7%)
Highly Symptomatic Dry Eye (%)	90 (18%)	68 (21.3%)	22 (12.2%)
Symptomatic Dry Eye (%)	200 (40%)	144 (45%)	56 (31.1%)

The mean caffeine intake among participants was 200 mg/day (SD = 50 mg/day). Table 3 presents the caffeine consumption from different sources.

Table 3. Caffeine Consumption from Different Sources

Source	Mean (mg/day)	SD (mg/day)
Tea	120	30
Coffee	50	10
Caffeinated Cola	20	5
Energy Drinks	10	3

Multivariable logistic regression analysis revealed a significant correlation between caffeine intake and WHS-defined DED. Table 4 summarizes the logistic regression results.

Table 4. Logistic Regression Analysis of DED Outcomes and Caffeine Intake

Model	OR (95% CI)	P-value
Model 1: Basic Adjusted		
- WHS-defined DED	1.10 (1.02–1.18)	0.01
Model 2: Fully Adjusted		
- WHS-defined DED	1.08 (1.01–1.16)	0.03
- Clinical Diagnosis of DED	1.12 (1.03–1.22)	0.005
- Highly Symptomatic Dry Eye	1.09 (1.01–1.17)	0.02
- Symptomatic Dry Eye	1.06 (0.99–1.13)	0.07

Sex-stratified analysis indicated a stronger correlation between caffeine intake and DED in females. Table 5 presents the sex-stratified logistic regression results.

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Table 5. Sex-Stratified Logistic Regression Analysis (WHS-defined DED)

Model	OR (95% CI)	P-value
Female Participants	1.12 (1.03–1.21)	0.005
Male Participants	1.05 (0.94–1.17)	0.35

Participants with poor sleep quality and high job stress had a higher probability of developing DED with increased tea use, according to a stratified analysis based on these two variables. The findings of the stratified analysis are shown in Table 6.

Table 6. Stratified Analysis by Sleep Quality and Work Stress (WHS-defined DED)

Group	OR (95% CI)	P-value
Poor Sleep Quality	1.15 (1.06–1.25)	0.002
Good Sleep Quality	1.05 (0.96–1.15)	0.30
High Work Stress	1.13 (1.04–1.23)	0.01
Low Work Stress	1.04 (0.95–1.13)	0.40

Further analysis of specific beverages indicated that tea was the primary contributor to caffeine-related DED. Table 7 summarizes the multivariate analysis for each beverage type.

Table 7. Multivariate Analysis of Beverage Types

Beverage	OR (95% CI)	P-value
Tea	1.15 (1.07–1.24)	0.001
Coffee	1.02 (0.95–1.10)	0.60
Caffeinated Cola	1.03 (0.97–1.09)	0.30
Energy Drinks	1.01 (0.95–1.07)	0.75

DISCUSSION

The 500 participants in the study had their coffee consumption and DED examined, and important results were found. Compared to men (19.4%), women (36.3%) had a greater prevalence of DED. The individuals in this study drank 200 mg of caffeine on average per day, mostly from tea.

Caffeine use and WHS-defined DED were significantly positively correlated, according to multivariable logistic regression analysis. More specifically, the chance of getting DED increased by 10% for every additional 100 mg of caffeine consumed each day. Even after accounting for several confounding variables, this connection persisted.

A sex-stratified analysis revealed that there was a higher correlation in females than in males between caffeine use and DED. For every 100 mg/day increase in caffeine intake, there was a 12% increase in the probabilities of DED in females, whereas this link was not statistically significant in males. This raises the possibility of a sex-specific sensitivity to DED caused by caffeine.

Additional stratified analyses revealed that the link between caffeine intake and DED was strengthened by high levels of work stress and poor sleep quality. Compared to participants with good sleep quality or low job stress, individuals with poor sleep quality or high work stress had a greater chance of developing DED with increased tea consumption.

After beverage-specific research, it was found that tea contributed more significantly to caffeine-related DED than coffee, caffeinated cola, or energy drinks. This result emphasizes how crucial it is to take caffeine's source into account when evaluating its effects on DED.

Overall, this research shows a significant correlation between caffeine consumption and the prevalence of DED, with the correlation being larger in women and individuals who report high levels of work-related stress or poor sleep quality. The main source of caffeine associated with this elevated risk turned out to be tea. These results imply that reducing caffeine intake may be necessary for people, especially women, to lower their chance of having DED.

A large population-based study that looked at the connection between coffee drinking and DED was carried out in the Netherlands, and it used the Women's Health Study dry eye questionnaire. The study included 85,302 participants, and the average amount of caffeine they consumed each day was 285 mg. After adjusting for demographic factors, there was a decrease in the incidence of DED associated with higher caffeine intake. Even so, when accounting for medical comorbidities, there was no appreciable difference. A significant correlation was seen between drinking decaffeinated coffee and a higher risk of DED [6].

A cross-sectional study assessed the frequency of DED among Jordanian medical students and its correlations with coffee intake, sleep patterns, and the use of electronic devices. Caffeine use among the 1,223 participants had a slight impact on the incidence of DED, but the findings were not statistically significant. There was a strong

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correlation found between symptomatic DED and female gender, years of basic science education, and large screen time [7].

A cross-sectional study looked at 322 participants' modifiable lifestyle factors and their relationship to DED. While increasing exposure to digital screens was found to be a risk factor for DED, higher coffee consumption was found to be a protective factor ($p = 0.04$) [8].

The analysis of data from the Korea National Health and Nutrition Examination Survey used in a study showed no association between the frequency of coffee consumption and the risk of DED, even after several risk variables were taken into account. Increased coffee consumption was linked to a decreased incidence of DED, however, the correlation lacked statistical significance [9].

CONCLUSION

The results of this study, especially for the female participants, point to a strong correlation between caffeine consumption and the prevalence of dry eye disease. It was clear that increased tea consumption raised the incidence of DED, particularly in those with high levels of work-related stress and poor sleep quality. The primary factor contributing to this connection was found to be tea. According to the study's findings, consuming more caffeine is linked to a higher chance of developing dry eye disease. These findings highlight the need for additional research into the underlying mechanisms and the development of guidelines for caffeine use to lower the risk of DED.

Limitations

The limitations of this study include a small sample population who were included in this study. Furthermore, the lack of a comparison group also poses a limitation for this study's findings.

Recommendation

The mechanisms underlying the link between caffeine use and DED require more investigation. Caffeine use should be moderated by public health standards to lower the risk of DED, particularly in more susceptible populations.

Acknowledgment

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List of abbreviations

DED - Dry Eye Disease
WHS - Women's Health Study
BMI - Body Mass Index
OR - Odds Ratio
CI - Confidence Interval
SD - Standard Deviation

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No funding was received.

Conflict of interest

The authors have no conflicting interests to declare.

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