RESEARCH ARTICLE

The effect of beverages containing caffeine on the tear film parameters: An observational study

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Abstract

Objective: To assess the short-term effect of consuming two beverages containing caffeine on tear film parameters.

Method: The observational study was conducted at the King Saud University, Riyadh, Saudi Arabia, from March 5 to April 28, 2016, and comprised males aged 18-34 years. The subjects were randomised into three equal groups. Group A consumed Pepsi (355mL), group B consumed Mountain Dew (355mL), and group C consumed nothing. The phenol red thread, tear ferning, and tear breakup time tests were performed in both eyes of each subject at the baseline and an hour after consumption. Data was analysed using SPSS 22.

Results: Of the 105 male subjects with mean age 23.6±3.5 years, 35(33.3%) were in group A with mean age 23.8±3.8 years, 35(33.3%) were in group B with mean age 23.8±3.7 years, and 35(33.3%) were in group C with mean age 23.4±3.4 years. Significant differences were noted in the phenol red thread and tear breakup time scores in groups A and B compared to the baseline ($p<0.05$), while the difference was not significant ($p>0.05$) for tear ferning grades. Group C showed no significant difference ($p>0.05$) on any count.

Conclusion: The consumption of two caffeinated drinks significantly altered tear film stability and volume. Tear breakup time was increased, while tear volume decreased, but there was no significant effect on tear quality.

Keywords: Males, Dry eye syndromes, Eye abnormalities, Risk factors, Anticholinergic agents. (JPMA 75: 1397; 2025)

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Introduction

The tear film is essential for vision and healthy eyes. The disturbance in tear film stability, osmolarity and homeostasis causes several disorders.[1] Dry eye is one of the most common ocular disorders and affects 5-50% of people.[1,2] The most commonly known dry eye symptoms are foreign body sensation, dryness, irritation, inflammation, discomfort and pain.[3] Dry eye disorder has a significant economic and social effect.[4] It is essential to discover the factors associated with the discomfort symptoms to prevent and manage the condition. The use of digital screens, wearing contact lenses, smoking, systemic illnesses and some medications are the most common factors that induce dry eye.[1]

Meibomian glands secrete the lipid layer of the tear film. Therefore, its dysfunction causes a high level of tear evaporation.[5] Meanwhile, the disruption in lacrimal gland function causes aqueous deficiency.[6] Several tests should be used to assess dry eye since each test detects a different parameter. A combination of phenol red thread (PRT), Schirmer, non-invasive tear breakup time (NITBUT), tear ferning (TF), osmolarity, and tear evaporation tests can be used to detect dry eye.[7-12]

Caffeine, 1,3,7-trimethylxanthine, is a commonly ingested bioactive substance. It is found in various nuts, seeds and fruits, but it is mainly sourced from coffee beans. The consumption of caffeine-containing beverages is enormous worldwide, and it is legal and socially acceptable to consume caffeine in most cultures. It has many beneficial effects on human health. Beverages that contain caffeine are known to help prevent drowsiness and decrease fatigue. In addition, it improves cognitive performance, short-term memory, and alertness. However, caffeine has diverse effects. The association between caffeine and dry eye needs to be clarified.[13,14]

Pepsi is a carbonated drink that contains different ingredients. A can of Pepsi (355mL) contains carbohydrates (41g), sodium (30mg) and caffeine (39mg). Meanwhile, a can of Mountain Dew (355mL) contains 55mg of caffeine.[15] Based on the large consumption of beverages containing caffeine, it is essential to be aware of their effect on the tear film and the eye. The current study was planned to evaluate if the presence of caffeine in soft drinks affects tear film parameters.

Subjects and Methods

The observational study was conducted at the King Saud University, Riyadh, Saudi Arabia, from March 5 to April 28,

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2016, and comprised male subjects aged 18-34 years. They were randomised into three equal groups. Group A consumed Pepsi (355mL), group B consumed Mountain Dew (355mL), and group C consumed nothing. The sample size was calculated using Open Epi[16] with confidence level 95% and significance level 0.05. The sample was raised using a non-random sampling method from among university students. Those included were young males with healthy tear films and no eye diseases or disorders. Individuals with a history of ocular surgery, anaemia, hypertension, smoking were excluded, and so were those wearing contact lenses. Approval was obtained from the institutional ethcis review board, and written informed consent was obtained from each subject. Group allocation was done randomly. The subjects were assigned numbers from 1 to 105, with the first group consisting of numbers 1-35, the second group 36-70, and the third group 71-105.

The PRT, TF and TBUT tests were performed in both eyes of each subject. The first round of measurements was taken before the drinks were consumed, while the second round was taken an hour after consumption. For the control group, the two measurements were performed with one-hour difference. After the first measurement, the subjects were kept in a room with air conditioning for one hour (20°C with humidity <20%). During that hour, drinks, food, smoking, watching screens, or any other activities were not allowed. The participants and the investigator were blinded to the intervention.

The PRT test used a thread impregnated with phenol red dye. The strip was inserted between the globe and the tarsal conjunctiva of the lower lid from the temporal side. The subjects were asked to blink as usual while looking straight ahead for 15 seconds. The red portion of the strip from the edge of the lid was measured to determine the PRT test score. A measurement of <10mm indicated a dry eye.

This was followed by the TF test. From the lower meniscus of either the right or left eye, a glass capillary tube (10µL) was used to collect a tear sample (1µL). The tears were dropped on a glass slide and allowed to dry for 10 minutes at 20°C with humidity <20%. The ferns obtained were observed directly using an Olympus DP72 digital light microscope (Olympus Corporation; Tokyo, Japan) with 10× magnification. The ferns were graded using the five-point grading scale based on 0.1 increments.

The TBUT test was conducted three times for each eye, and the average time was recorded. Fluorescein drops were used in the conjunctival sac with a cobalt blue filter to give a green appearance to the pre-corneal tear film. A time <10 seconds indicated dry eye. For normal vision, TBUT ranged 10-15 seconds.

Data was analysed using SPSS 22. Data was expressed as frequencies and percentages, mean±standard deviation or as median with interquartile range (IQR). Kolmogorov-Smirnov test was used to determine the normality. The Wilcoxon signed-rank test was used for intragroup assessments, and the Wilcoxon rank sum test was used to compare intergroup medians at baseline and post-intervention. P<0.05 was considered significant. Even though measurements were performed in both eyes at both time points, scores for the right eye were used for statistical analysis as there was no significant difference in the scores of the left and right eyes (p>0.05).

Results

Of the 105 male subjects with mean age 23.6±3.5 years, 35(33.3%) were in group A with mean age 23.8±3.8 years, 35(33.3%) were in group B with mean age 23.8±3.7 years, and 35(33.3%) were in group C with mean age 23.4±3.4 years (p>0.05). Significant differences were noted in the PRT and TBUT scores in groups A (Figure 1) and B (Figure 2) compared to the baseline (p<0.05), while the difference was not No significant (p>0.05) for TF grades. Group C showed no significant difference (p>0.05) on any count (Table).

In group A, PRT scores decreased after consumption in 19(54.3%) subjects, increased in 11(31.4%), and remained

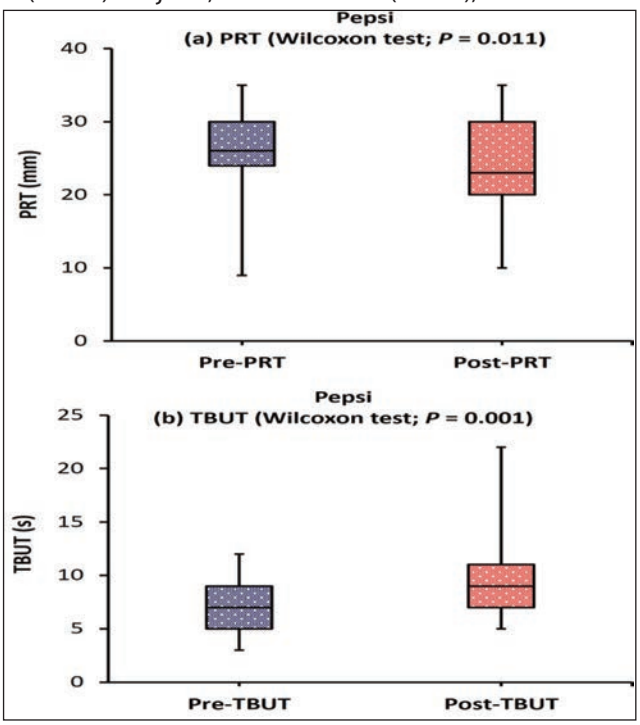

Figure-1: Boxplots (a) for phenol red thread (PRT) and (b) tear breakup time (TBUT) at baseline and post-intervention scores in group A.
PRT: Phenol red thread, TBUT: Tear breakup time, TF: Tear ferning.

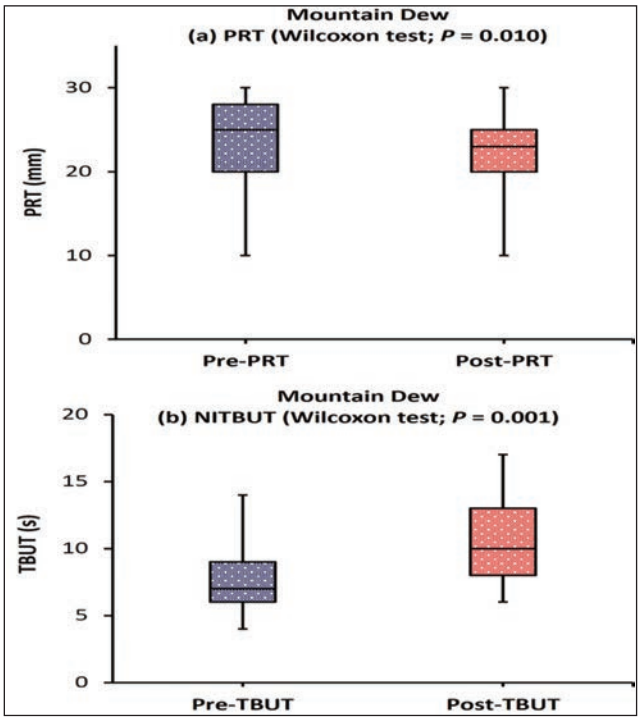

Figure-2: Boxplots (a) for phenol red thread (PRT) and (b) tear breakup time (TBUT) at baseline and post-intervention scores in group B.

Table: Average age and PRT, TF and TBUT scores of the subjects.

Parameter	**Pepsi** (n=35)		**Mountain Dew** (n=35)		**Control** (n=35)	
	Average	***p*-value**	**Average**	***p*-value**	**Average**	***p*-value**
Age (year)	23.8 ± 3.8	-	23.8 ± 3.7	-	23.4 ± 3.4	-
Pre-PRT (mm)	24.9 ± 5.3	0.010	25.0 ± 8.1	0.011	24.9 ± 2.7	0.651
Post-PRT (mm)	24.3 ± 5.5		24.0 ± 5.2		24.8 ± 3.2	
Pre-TBUT (s)	6.9 ± 2.5	0.001	7.8 ± 2.6	0.001	8.0 ± 2.1	0.518
Post-TBUT (s)	9.7 ± 4.1		10.4 ± 3		7.9 ± 2.3	
Pre-TF	1.7 ± 0.8	0.510	1.9 ± 1.8	0.177	1.6 ± 0.8	0.553
Post-TF	1.6 ± 0.7		1.9 ± 1.5		1.6 + 0.7	

PRT: Phenol red thread, TBUT: Tear breakup time, TF: Tear ferning.

unchanged in 5(14.3%). However, 30(85.7%) subjects experienced an increase in their TBUT score, 3(8.6%)had a decrease, and 2(5.7%)reported no change. In group B, PRT scores decreased in 27(77.1%) subjects, increased in 7(20%), and remained unchanged in 1(2.9%).TBUT scores remained unchanged in 3(8.6%) individuals, and increased in 32(91.4%).

Discussion

To our knowledge, the current study is the first to focus on the relationship between tear film parameters and caffeine-containing beverages and their association with dry eye. The results indicated that soft drinks containing caffeine had a positive effect on tear film stability. On the other hand, they had a negative impact on tear volume among the subjects. Pepsi and Mountain Dew were foud to be linked to a significant increase in TUBT score and a decrease in tear volume. The two beverages containing caffeine had diverse effects on the tear film parameters. While they stabilised the tear film, and led to a reduction in tear volume, there were no changes in the quality of the tears.

A recent study indicated that dietary caffeine from different sources is not likely to be a risk factor for dry eye disorder based on a dry eye questionnaire in a large population (n=85,302).[17] The effect of caffeine in males and females was similar. Drinking coffee that contains caffeine resulted in a reduction in the symptoms of dry eye. On the other hand, consuming decaffeinated coffee or tea increased the symptoms of dry eye.[17] However, the assessment of caffeine intake in such a study was based on a self-reported food frequency questionnaire, which could have been affected by recall bias. Additionally, no tests were used to assess the tear film parameters. Similarly, a decreased risk for dry eye was found to be associated with drinking more caffeinated beverages.[18] In Australia, women consuming large quantities of caffeinated beverages were found to have good tear volume and stability.[19]

Visual acuity and contrast sensitivity were increased after the consumption of energy drinks containing caffeine in a study, but the changes were not significant.[20] The collection of data in that study was done at different timings of the day. In addition, the dietary control (e.g., drinks or food that the participants consumed pre-assessment) was poor. Moreover, the results were limited to the age and body mass index (BMI) group studied.[20] A high consumption of diet soft drinks (e.g., 4 cans a week) was found to be associated with an increased risk of proliferative diabetic retinopathy by more than two-fold in diabetic patients.[21] On the other hand, no association was found for the consumption of regular soft drinks with either diabetic macular oedema or diabetic retinopathy.[21]

Caffeine affects the symptoms of dry eye separately from tear film parameters (e.g., tear secretion and stability). A moderate dose of caffeine inhibits the receptors of adenosine, and it affects the lacrimal glands and tear production.[22-24] Caffeine antagonises adenosine, and, therefore, can stimulate the central nervous system (CNS) and regulate tear production.[14,25] It could lead to neuronal activity inhibition, and, in return, affect lacrimal gland secretion.[22,23] Caffeine has anticholinergic effects, leading to a decrease in tear secretion. However, caffeine can also increase exocrine gland secretion, which may increase tear

production.[24] Additionally, lifestyle has an impact on the health of tear film and the vision system.[26]

The present study has a few limitations. The participants were recruited from a single location, the sample size was relatively small, and the study was conducted a long time ago, in 2016. Moreover, the study only included male subjects and examined the impact of only two drinks that contained caffeine using a few tests to assess the changes in the tear film parameters. Further studies are required to validate the current findings.

Conclusion

The consumption of two caffeinated drinks significantly altered tear film stability and volume. Tear breakup time increased, while the tear volume decreased, but there was no significant effect on tear quality.

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Author Contribution:

ESA: Data curation, formal analysis, funding acquisition, software, validation, visualisation, writing, review and editing.

GAREH: Concept, data curation, formal analysis, funding acquisition, methodology, project administration, supervision, validation, visualisation, writing-original draft, writing, review and editing.

FMA & MMAG: Investigation, visualisation, writing, review and editing.

MSA: Data curation, formal analysis, software, validation, visualisation, writing, review and editing.

AMM: Concept, methodology, supervision, visualisation, writing, review and editing.