RESEARCH ARTICLE

Acute effects of caffeine on intraocular pressure

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Abstract

Objective: To examine the acute effects of caffeine on the intraocular pressure among healthy young individuals.

Method: The quasi-experimental study was conducted from January to May 2023 at the Superior University, Lahore, Pakistan, while data was collected from Al-Khair Trust Eye Hospital, Lahore. The sample comprised subjects aged 18-27 years who had healthy eyes and were non-habitual consumers of coffee. Blood pressure and intraocular pressure were measured at baseline and then again at 30, 60 and 90 minutes after coffee ingestion. Individuals were given freshly produced instant coffee with caffeine. After an interval of two days, the same group was given instant decaffeinated coffee. Data was analysed using SPSS 25.

Results: Of the 73 subjects, 46(63%) were males and 27(37%) were females. The overall mean age was 22.52±2.08 years (range: 19-27 years). Caffeine consumption raised intraocular pressure ($p<0.001$) and blood pressure ($p=0.007$) significantly compared to the baseline. Group B show no significant change ($p>0.05$).

Conclusion: There was a significant increase in intraocular pressure and blood pressure after coffee ingestion in the caffeinated group, while there was no significant change in the decaffeinated group.

Key Words: Caffeine, Intraocular pressure, Glaucoma.

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Introduction

In many parts of the world, no matter their age or socioeconomic background, individuals regularly drink caffeine. Beverages, like coffee, tea, soft drinks, energy drinks, chocolate, and other foods, as well as some medicines contain caffeine that is isolated on a large scale from the plant Coffea Arabica (Rubiaceae), which originated in Ethiopia. All of these products are distinguished by the presence of xanthine in the shape of caffeine, theophylline and theobromine, the most potent of them being caffeine. This substance, which can be consumed through infusions, pharmaceuticals or caffeine-laced soft beverages, affects brain activity in both favourable and unfavourable ways.[1] It can be found in a variety of beverages and foods, but coffee is the most potent source.[2] Caffeine has both acute and chronic pharmacological effects on several physiological variables.[3] This includes the eye.[4] According to a study, caffeine consumption has favourable benefits on a variety of chronic diseases, including many types of malignancies as well as neurological, cardiovascular and metabolic ailments.[5] In recent years, the effect of frequent and acute coffee use on health status has been up for a debate.[3,6]

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Many studies have been conducted to investigate the effects of caffeine consumption on a range of ocular indices, such as retinal vessel diameter,[7] choroidal thickness,[8] tear secretion,[9] amplitude of accommodation, and 10 oculomotor control, among others.[11]

Caffeine's effects on intraocular pressure (IOP) have also been studied by various researchers due to its potential importance in the initiation and progression of glaucoma.[12] Most studies indicate that caffeine consumption induces a transitory increase in IOP, with these effects starting after a few minutes and persisting for several hours.[4,13] These IOP fluctuations are strongly reliant on regular caffeine ingestion, with low-caffeine consumers experiencing a more rapid IOP spike than high-caffeine consumers.[14] There is no consensus among researchers regarding the physiological biomechanics of the eye that explain the IOP rises related to caffeine.[15] IOP is affected by a variety of daily activities, including mentally challenging situations[15] and physical exercise.[16] A precise IOP measurement is a crucial component of the glaucoma examination.[17] Several eye illnesses can result in irreversible vision loss, with glaucoma being the main cause of irreversible loss of vision worldwide.[18] Caffeine's pathophysiological effects on the eye have received little attention. Yet, coffee consumption has been linked to a transitory increase in IOP in glaucoma patients.[19]

In addition, the effect of acute and regular coffee drinking on health status has been the subject of debate and controversy in recent years.[20,21] Recent evidence suggests that coffee consumption has beneficial effects in a variety

of chronic diseases, such as cancer, neurological and metabolic conditions, while potential adverse effects for pregnancy-related outcomes (e.g., low birth weight) and cardiovascular conditions have been described, though the latter may be influenced by the confounding effect of smoking.[20,22]

Despite the extensive usage of caffeine and other cola nut compounds, nothing is known about the link between IOP and caffeine. As a result, initial studies on the effect of caffeine on IOP in this part of the world are needed. The current study was planned to fill the gap in literature by examining the acute effects of caffeine on IOP among healthy young individuals.

Subjects and Methods

The quasi-experimental study was conducted from January to May 2023 at the Superior University, Lahore, Pakistan, while data was collected at Al-Khair Trust Eye Hospital, Lahore. The sample size was estimated using the formula: n = $Z2(1 - P)$ /$d2$ with P=5%[14], confidence interval (CI) 95% and margin of error 5%. The sample was raised using purposive sampling technique. The majority of the participants were selected from among the students of the Superior University after taking informed consent.

Individuals with glaucoma, hypertension or pregnancy, as well as those with IOP >22mmHg were excluded. Although it cannot be ruled out, none of the individuals reported a glaucoma-related family history. Those included were subjects aged 18-27 years who had healthy eyes and were non-habitual consumers of coffee. Each subject's eyes were tested to ensure they were healthy and free of ocular pathology. In this manner, each participant served as his or her own experimental and control group. For at least one week before data collection, all individuals abstained from caffeine-containing goods, such as cola nuts, etc. During the experiment, they also did not consume any food or beverages.

For data collection, a self-designed proforma was used. All data was taken between 9am and 3:30pm. IOP was measured using a non-contact air puff tonometer. IOP values were taken at the baseline, and then at 30, 60 and 90 minutes after consuming coffee. Before and after each usage, the tonometer was cleaned and disinfected using cotton wool and methyl alcohol. Individuals were given freshly produced instant coffee with caffeine. After an interval of two days, the same group was given instant decaffeinated coffee. The coffee was produced in a teacup with water as the solvent. In keeping with local custom, each cup of coffee came with a cube of sugar.

Typically, each member was required to sit for the assessment. Each participant's blood pressure (BP) was taken twice with an automatic digital blood pressure monitor, and the average of the two readings was recorded. Two tonometric measurements were taken, and the overall average of the two was recorded. Measured with a weighing balance, the subject then drank 100mL (half-a-cup) of coffee made with 30-50mg of caffeinated coffee. The participants were not told how quickly they should consume the coffee. As a result, the ingestion time varied, but did not surpass 2 minutes. After two days, the process was repeated, but this time each participant received 2mg of decaffeinated coffee. The participants and examiners were not told whether their coffee was caffeinated or decaffeinated. Although decaffeinated coffee includes caffeine, it was chosen as a control instead of water due to its added masking benefit. Participants who had >22mmHg IOP before or after drinking coffee were sent to the clinic for additional examination and a glaucoma workup.

The Superior University Ethics Committee accepted the report (ref no: IRB/FAHS/DOVS/1/24/OV-3342), which followed the Declaration of Helsinki's tenets.

Data was analysed using SPSS 25. Data was expressed either as frequencies and percentages or as mean ± standard deviation, as appropriate. Data was tested for normality by using the Shapiro-wilk test, and was found to have normal distribution. A paired sample t-test was used. To compare and determine the relationship of caffeine with IOP and BP, line graph and scatter plots were used. $P<0.05$ was considered statistically significant.

Results

Of the 73 subjects, 46(63%) were males and 27(37%) were females. The Majority (62 out of 73) of the study participants were recruited from Superior University. While, 09 individuals were recruited from the Al-Khair Trust Eye Hospital. The overall mean age was 22.52±2.08 years (Range: 19-27 years).

The mean IOP at all points of time kept increasing in the caffeinated group, but that was not the case in the decaffeinated group (Table 1). The same was the case with BP (Table 2) The mean change in IOP in the right eye after ingestion of caffeinated coffee at 30, 60, and 90 minutes was 1.0±0.96, 2.11±1.82, and 5.26±3.04mmHg, while the corresponding values for the left eye were 1.01±0.98, 2.10±1.79 and 6.41±3.11mmHgThere was an average increase in IOP in the caffeinated coffee group from 7% to 44% (Figure 1).

The mean change after the ingestion of decaffeinated

Table-1: Intraocular pressure (IOP) variations pre- and post-consumption of caffeinated and decaffeinated coffee.

	Caffeinated Coffee IOP (mmHg)		Decaffeinated Coffee IOP (mmHg)	
	Right Eye	**Left Eye**	**Right Eye**	**Left Eye**
Baseline	15.12±2.04	15.12±2.36	14.61±1.81	14.11±2.17
30 minutes	15.93±1.99	16.11±2.09	14.38±2.12	14.20±2.30
60 minutes	17.23±2.74	17.13±2.85	14.26±1.71	14.06±2.22
90 minutes	20.38±4.35	21.53±3.65	14.63±2.47	14.81±2.44

Table-2: Blood pressure (BP) pre- and post-ingestion of caffeinated and decaffeinated coffee.

Caffeinated Coffee					
BP	**Time (Minutes)**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Systolic	0	100.00	141.00	118.65	11.36
Diastolic	0	65.00	113.00	77.75	10.24
Systolic	30	90.00	140.00	118.87	12.18
Diastolic	30	60.00	93.00	76.09	8.03
Systolic	60	94.00	132.00	121.20	4.44
Diastolic	60	65.00	90.00	78.43	6.55
Systolic	90	100.00	145.00	123.82	11.52
Diastolic	90	64.00	90.00	79.13	7.14
Decaffeinated Coffee					
BP	**Time (Minutes)**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Systolic	0	100.00	140.00	116.68	8.96
Diastolic	0	60.00	90.00	74.01	6.82
Systolic	30	95.00	140.00	118.20	9.38
Diastolic	30	60.00	90.00	74.35	6.58
Systolic	60	90.00	130.00	118.06	11.33
Diastolic	60	50.00	90.00	73.35	8.16
Systolic	90	86.00	135.00	117.42	12.24
Diastolic	90	60.00	90.00	73.56	6.53

coffee in the right eye at 30, 60 and 90 minutes was -0.23±1.03, -0.35±1.21 and 0.02±2.14mmHg, while the corresponding values for the left eye were 0.09±0.86, 0.041±1.07 and 0.70±1.94mmHg. The right eye IOP increased 0.35%, while the left eye IOP increased from

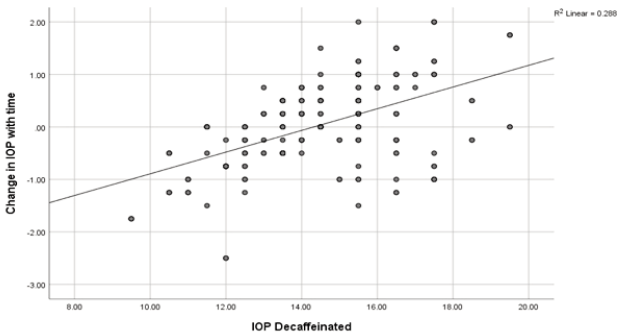

Figure-1: Mean change in intraocular pressure (IOP) with time in the caffeinated group.

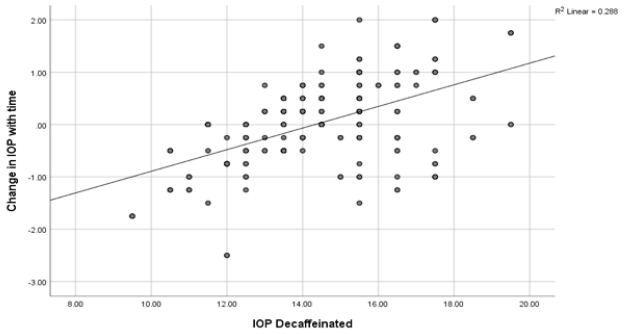

Figure-2: Mean change in intraocular pressure (IOP) with time in the decaffeinated group.

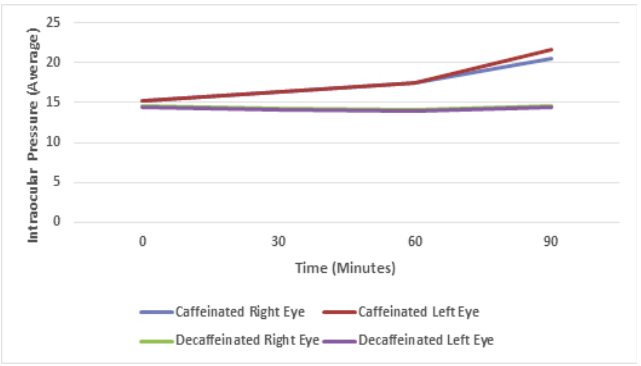

Figure-3: Intergroup comparison at different time points.

0.64% to 0.29% after drinking decaffeinated coffee. Overall, decaffeinated coffee increased IOP by 0.25-2.9% (Figure 3).

The systolic BP (SBP) before the ingestion of caffeinated coffee was 118.67±11.36mmHg, and diastolic BP (DBP) was 77.75±10.24mmHg. The mean SBP increased to 118.87±12.18mmHg, 121.20±4.44mmHg and 123.82±11.52mmHg at 30, 50 and 90 minutes after the ingestion of caffeinated coffee. The DBP increased to 77.71±8.03mmHg, 78.65±6.55mmHg and 79.10±7.14mmHg, respectively.

Table-3: Changes in intraocular pressure (IOP) and blood pressure (BP) before and after the ingestion of coffee.

	Before Caffeine	**After Caffeine**	**T-test**	**P-value**
Caffeinated Coffee Group				
Right Eye IOP	15.12±2.04	17.85±2.39	-11.72	<0.001*
Left Eye IOP	15.12±2.36	18.26±2.03	-15.204	<0.001*
BP	98.20±9.70	106.15±82.23	2.768	0.007*
Decaffeinated Coffee Group				
Right Eye IOP	14.62±1.81	14.42±1.89	1.120	0.267
Left Eye IOP	14.11±2.17	14.36±2.04	-1.140	0.163
BP	95.34±6.36	95.83±7.62	-1.576	0.119

*Statistically significant values.

Caffeine consumption raised IOP ($p<0.001$) and BP ($p=0.007$) significantly compared to the baseline, while there was no significant change after decaffeinated coffee ($p>0.05$) (Table 3).

Discussion

Even though several studies[14,23] have been conducted to investigate the effects of caffeine on IOP, the duration of its effects, and the likely causes of the rise in IOP after caffeine consumption, these studies were conducted predominantly in white individuals and Africans. The current study provided a glimpse of the influence of caffeine on IOP in an Asian setting. Several of the subjects in the present study had average IOP readings that differed between the right (17.85±2.39) and left eyes (18.26±2.03). These differences were not significant in the aggregate. This perspective is compatible with current understanding, which shows that in the two eyes, IOP is generally similar.[24] Additionally, anecdotal clinical data also supports it.

A study[24] found that caffeine ingestion increased IOP, and the elevation — while it varied between patients — lasted for some minutes. The mean rise across patients grew gradually with post-ingestion time and by nearly 4mmHg, which corresponded to the current study in which the average mean IOP after consumption of caffeinated coffee increased by 2.73mmHg for the right eye and 3.14mmHg for the left eye.

Unlike an earlier investigation,[23] the current study included non-glaucomatous patients. The experimental group (caffeinated) saw a variable rise in IOP, but on average, the IOP rose by around 1.0-5.26mmHg for the right eye and 1.01-6.41mmHg for the left eye from the baseline by 30-90 minutes following the consumption of caffeinated coffee. Caffeine intake caused an acute IOP rise ($p=0.005$, $\eta 2=0.403$) in an earlier study.[23] In the control (decaffeinated) group, there was a slight change or no change in IOP for the right eye ($p=0.267$) and the left eye ($p=0.163$). The experimental group's results were consistent with prior research that found a rise in IOP after caffeine use.[14,23] The current investigation was limited to effects 90 minutes following coffee consumption. A study reported no significant difference 90 minutes after caffeine administration, implying that caffeine's effects on IOP were temporary.[4,14] This finding did not diminish the risk of IOP elevation in patients consuming significant amounts of caffeine.

The current study demonstrated increase in SBP and DBP after consuming caffeinated drink, which was consistent with prior research.[25,26] The rise in SBP and DBP pressures were also comparable. The rise in 90-minute post-ingestion time mirrored the increase in IOP. However, there is no explanation for this resemblance. Caffeine can raise IOP in two different ways. Caffeine causes increase in intracellular cyclic adenosine monophosphate (AMP), as a phosphodiesterase inhibitor[27], which may promote ciliary body cell production of aqueous humour. This impact could result in the closure of the fenestrae and tone loss in the smooth muscle of the anterior angle through which the aqueous humour drains into the Schlemm canal. As a result of these two actions, IOP could rise. Therefore, a study[28] using beagles demonstrated that caffeine causes increase in IOP perhaps due to increasing aqueous humour production rather than decreasing aqueous drainage through the trabecular meshwork. The importance of the second mechanism will be minimised if IOP increases are dependent on BP increases.

Conclusion

There was a significant increase in IOP of both eyes and BP after the ingestion of coffee in the caffeinated group, while there was no significant change in IOP and BP after the consumption of decaffeinated coffee.

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AUTHOR'S CONTRIBUTION:
IR: Script writing.
MF: Conception.
FZ: Data analysis and interpretation.
SN: Tables formatting.
HAN: Final approval.
M: Proof reading.