



The Effect of Graded Doses of Caffeine on Intraocular Pressure in Niger Delta, Nigeria

Nwosu, Fidelma¹ and Ejimadu, Chibuike Sydney^{2*}

¹City Specialist Eye Clinic and Surgery, Port Harcourt, Nigeria.

²Department of Ophthalmology, University of Port Harcourt Teaching Hospital, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author NF designed the study, performed the statistical analysis and managed the literature searches. Author ECS wrote the protocol, the first draft of the manuscript and managed the analyses of the study. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMMR/2019/v29i930117

Editor(s):

(1) Dr. Barbara Giambene, MD, Eye Clinic – Department of Translational, Surgery and Medicine – University of Firenze, Italy.

Reviewers:

(1) Tayo Julius Bogunjoko, Eye Foundation Hospital Group, Nigeria.

(2) Igor Iskusnykh, University of Tennessee Health Science Center, USA.

Complete Peer review History: <http://www.sdiarticle3.com/review-history/47682>

Received 12 December 2018

Accepted 21 February 2019

Published 02 May 2019

Original Research Article

ABSTRACT

Aim: To determine the effect of graded doses of caffeine on intraocular pressure in a Nigerian population.

Methods: This was a prospective, observer-masked, cross-over study carried out in the Eye clinic of the Ahoada General Hospital.

A total One hundred subjects comprising 46 males and 54 females aged 20 – 76 years were chosen. Graded doses of caffeine were administered to the subjects in four groups. The fourth group was the control and subjects here were given water only without caffeine.

Intra Ocular Pressure of each subject was determined at different times after oral ingestion of coffee.

Data was analysed using SPSS program for windows (statistical package for the social sciences Inc., version 16).

Results: The group which consumed 3.5 mg/kg body weight of caffeine had the maximum mean increase in IOP (5.20 ± 0.08 mmHg) after 60 minutes, the pressure remained the same after 90 minutes and then reduced to 4.28 ± 0.13 mmHg after the 120 minutes while Group A which

*Corresponding author: E-mail: theraphaproject@yahoo.com;

consumed 0.7mg/kg body weight of caffeine had the minimum mean increase in intraocular pressure (2.32 ± 0.82 mmHg) after 60 minutes, 2.2 ± 0.65 mmHg after 90 minutes and then reduced to 1.4 ± 0.81 mmHg after the 120 minutes ($p < 0.005$).

Maximum effect was observed after 60 minutes of ingesting caffeine and gradually returned to baseline values after 120 minutes. There was no significant change in IOP of subjects who ingested only water.

Conclusion: This study revealed a significant rise in intraocular pressure in normotensive human eyes and this increase was dose-dependent. Moderation in caffeine consumption remains very vital and calls for more public awareness platforms. Therefore we recommend that caffeine be consumed with caution especially in patients with glaucoma. Future studies relating to caffeine's effects via inhalation and monitoring of caffeine's effect on IOP beyond 120 minutes is equally important.

Keywords: Caffeine; graded doses; intraocular pressure; niger delta.

1. INTRODUCTION

Caffeine boosts the central nervous system to enhance prolonged wakefulness, cognition, motivation and alertness by increasing the stimulation of dopamine and norepinephrine neural pathway in the brain [1]. The degree of central nervous system stimulation relatively varies with the type of stimulant, dosage and individual physiologic and genetic make-up. 3,4 Methylenedioxymethamphetamine (MDMA) blocks pre-synaptic auto receptors that transmit regulatory impulse (i.e. serotonin) causing mydriasis and increased intraocular pressure among other effects which could be dangerous at doses greater than 500 mg [1].

Caffeine action takes effect within 15 - 20 minutes of intake on the neural system via the inhibition of adenosine actions and phosphodiesterase etc [2]. Caffeine also induces the elevation of IOP in people with open angle glaucoma or ocular hypertension and causes ocular surface discomforts due to dry eye [3].

Exfoliation glaucoma (EG) mostly affects people 50 years and above with family history of glaucoma who are heavy coffee consumers. [4] Regular caffeine (coffee) intake gives about 66% risk of developing the condition. There is a link between drinking caffeinated coffee and open-angle glaucoma in those with a family history of the condition [5].

A measure of 2 cups of tea make up 1 cup of coffee, 100 g of average cola contains 8 mg of caffeine while low sugar varieties contain up to 15 mg [6]. Ammo energy drinks (100 g) contains 570mg of caffeine equivalent to 14 cups of coffee [7]. Some chewable like jelly beans, energy-added potato chips also contain high amount of

caffeine [8]. Some adult sweeties such as Foosh energy mints contain 5,555 mg of caffeine per 100 g (139 cups of coffee); followed by Buzz Bites Chocolate with 1,639 mg of caffeine per 100 g [8].

Aspirin contains 65mg of caffeine while Repan contains 40 mg of caffeine. Many of the weight-loss drugs contain high caffeine [6]. Conditions like sleep or mood disorders, nasal or sinus congestion are managed by a range of caffeine tablets widely available in dosages between 175mg and 200 mg [6].

There is no recognised level of safe daily intake. However, dosage effect of caffeine depends on body weight, metabolic rate and individual sensitivity to caffeine e.g. children can experience anxiety in doses of about 3 mg of caffeine per kilogram of bodyweight per day [9].

High intraocular pressure increases the risk of optic nerve head damage leading to vision loss. Studies have shown that coffee drinking affects body fluid osmotic dynamism which causes transient elevation in intraocular pressure.[4]

Caffeine's effect on IOP can be by several mechanisms [2]. Firstly, as a phosphodiesterase inhibitor, promotes the increase of intracellular cAMP, which may increase aqueous humour formation. However, evidence suggests that inhibition of phosphodiesterase activity is at high caffeine blood levels (more than 2-3 cups of coffee). Secondly, a study finding showed that caffeine's adenosine receptor antagonism could inhibit aqueous outflow by decreasing smooth muscle tone in the filtration system which can lead to trabecular fenestrae closure and lastly through blood pressure-elevation due to increase level of adrenaline, dopamine and other

neurotransmitters as a result of adenosine site blockade. Studies revealed caffeine (IV) injection in rats caused an ultra-structural change of the non-pigmented ciliary epithelium, suggesting aqueous transportation enhancement. However, 1mmHg eye pressure elevation following caffeine intake, is balanced with 1mmHg elevation in ocular perfusion pressure and this negates the pressure increase [5].

The common sources of caffeine are coffee, tea, cocoa, and kola nut. They are used in drinks, food and drugs as additive for pain relief or anaesthetic drugs. Some literatures on effect of caffeine on IOP and BP are as follows: The life style dietary contribution on regular coffee consumption worldwide has shown from a multi-analysis study, an increase in the risk of potential progression of glaucoma disease by 8.1 folds [9,11].

A review on eye pressure in healthy Nigerian adults showed a mean increase of 4 mmHg in IOP after caffeine intake which persisted for quiet long [10].

The discovery of exfoliation glaucoma in heavy coffee drinkers in a research carried out at Brigham Hospital in Boston also showed women to be at higher risk of developing this condition. About 78,977 female nurses and 41,202 men (both were 40 years and above) who had no glaucoma history were involved in the Louis Pasquale RTC (follow-up) study following continuous eye test from 1980s to 2008 on heavy coffee drinker (3 cups of caffeinated coffee) versus other caffeinated products aside coffee [5].

Jennifer Ebeigbe and Eki Obahiagbon review showed a significant decline in IOP reading after energy drink which had no effect on blood pressure of young undergraduate students at the University of Benin, Nigeria, though taurine and caffeine were the main content in the energy drink (Red Bull) collaborating a similar finding in Ghana by Ilechie and Tetteh as result of decreased IOP value was observed 60minutes and 90minutes post energy drink intake [7].

Life style research study showed correspondence of certain physical activities and dietary consumption of caffeinated coffee which was observed to cause a transient increase in IOP of 1 – 4 mmHg at least 90 minutes post intake compared with some Yoga positions which increased IOP by 2-folds, weight lifting caused

an increase by 4mmHg work on different caffeine products and rise in IOP with higher effect recorded with glaucoma patients and those at risk [11].

Study of IOP variation factors reviews show correlation of high IOP in water drinking test versus coffee intake. Also a correlation on the relationship between body mass index and intraocular pressure, body mass index and blood pressure and body mass index and age and result showed that obesity or overweight are risk factors for high eye pressure and blood pressure in aging population [12]

2. METHODS

This was a prospective, observer-masked, cross-over study carried out in the Eye clinic of the Ahoada General Hospital.

A total One hundred (100) subjects comprising 46males and 54females aged 20 – 76 years were chosen at random from a three-day organized free eye test program.

Subjects who met the following conditions were selected: (1) Normal IOP 12 – 21 mmHg, (2) absence of anterior segment laser procedure, cataract or glaucoma surgery in the prior 6 months (4) absence of high refractive error or infection.

Informed consent was obtained from each participant after detailed explanations of the procedures have been made known to them. Approval for the study was granted by the ethics and research committee of the Hospital Management Board Port Harcourt, Rivers State and was performed in accordance with the 1975 Declaration of Helsinki.

They were grouped equally into four groups (A-D) of 25 subjects.

Subjects were asked to abstain from caffeine 48hours before the study. They were weighed had comprehensive ocular examination.

The cups of coffee were labelled A, B, C and D and administered to the subjects in each group at doses: 0.7 mg/kg body weight of Nescafé classic coffee in 600 ml of warm water, 2.1 mg/kg body weight of Nescafé classic coffee in 600 ml of warm water, 3.5 mg/kg body weight of Nescafé classic coffee in 600ml of warm water and 600ml of warm water respectively. Group D was the

control and subjects here ingested 600mls of water only without caffeine.

Data was recorded as means (\pm standard deviation), differences between measured variables were tested for using paired t-tests. The pre-test and post-test data were analysed using a paired-sample t-test. Level of significance was set at $P < 0.05$, using SPSS program for windows (statistical package for the social sciences Inc., version 16). The study was limited by irregularities in the intraocular pressure as a result of the frequent use of topical anaesthetic eye drop for tonometry at 60, 90 and 120 mins intervals.

3. RESULTS

From Table 1, an increase in the mean intraocular pressure (IOP) was observed in groups A, B, C and D subjects which peaked at 60 minutes and gradually decreased at 90 and 120 minutes, going towards baseline values. The maximum mean increase in IOP occurred in group C; where subjects consumed the maximum dose of caffeine. Therefore the change in intraocular pressure is dose-dependent. This indicates that the higher the dose of caffeine ingested, the higher the increase in the intraocular pressure.

Fig. 1 Graph showing the mean change in intraocular pressure at 60, 90 and 120 minutes for each group (A, B, C, and D respectively), after the oral administration of 0.7 mg/kg, 2.1 mg/kg, and 3.5 mg/kg body weight of caffeine in 600 mls of water at the different time of

assessment. Group D was the control and subjects in group D ingested 600 mls of water only without caffeine. With the time interval being the reference or basis of comparison, the mean change in IOP differed significantly at the different time intervals among groups A, B, C and D at the 60th, 90th and 120th minute, which was indicated in Fig. 1

From the above graph, group C which consumed 3.5 mg/kg body weight of caffeine had the maximum mean increase in IOP (5.20 ± 0.08 mmHg) after 60 minutes, the pressure remained the same after 90 minutes and then reduced to 4.28 ± 0.13 mmHg after the 120 minutes while group A which consumed 0.7 mg/kg body weight of caffeine had the minimum mean increase in intraocular pressure (2.32 ± 0.82 mmHg) after 60 minutes, 2.2 ± 0.65 mmHg after 90 minutes and then reduced to 1.4 ± 0.81 mmHg after the 120 minutes.

From the Table, the mean change in the intraocular pressure at 60 minutes post caffeine oral intake is statistically significant for groups: A ($p = 0.027$), B and C ($p = 0.000$) while the mean change in the intraocular pressure at 60 minutes after 600ml warm water consumption is not statistically significant for group D subjects ($p = 0.774$).

Using the post-hoc test (LSD) to determine at what time the elevation in intraocular pressure became most significant in groups A, B and C, the mean change in intraocular pressure were statistically significant ($p = 0.027$) and ($p = 0.000$) at 60 minutes after caffeine consumption.

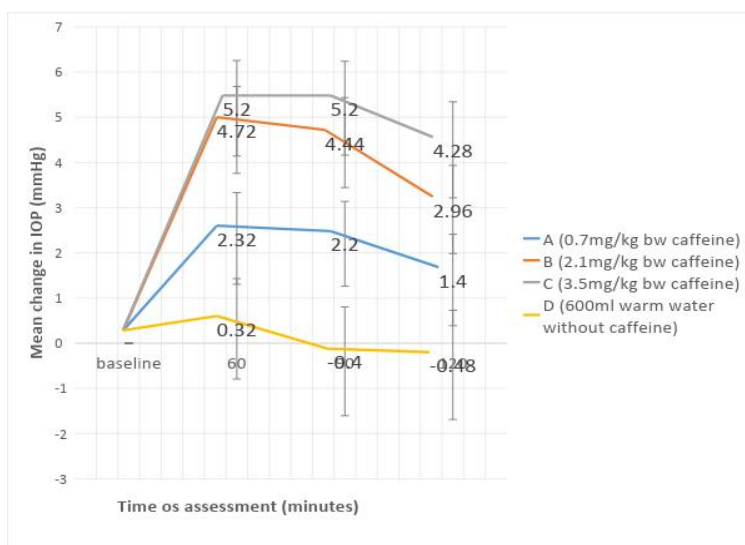


Fig. 1.

Table 1. Mean intraocular pressure measurement of each group at the different times of assessment

Groups	Mean intraocular pressure (mmHg) at the different time intervals			
	Baseline	60 minutes	90 minutes	120 minutes
Group A	15.64 ± 3.15	17.96 ± 3.97	17.84 ± 3.80	17.04 ± 3.96
Group B	15.20 ± 3.33	19.92 ± 3.46	19.64 ± 3.70	18.16 ± 3.57
Group C	14.52 ± 3.69	19.72 ± 3.77	19.72 ± 4.01	18.80 ± 3.82
Group D	14.72 ± 3.49	15.04 ± 4.32	14.32 ± 4.91	14.24 ± 4.93

Table 2. Result of unpaired T test of the maximum mean change in intraocular pressure measurement at 60 minutes intervals within each group

Groups of subjects	Maximum mean difference in IOP at 60 minutes (mmHg)	p-value	Level of significance
A	2.32 ± 2.03	0.027***	Significant difference
B	4.72 ± 1.92	0.000***	Significant difference
C	5.20 ± 2.11	0.000***	Significant difference
D	0.32 ± 2.22	0.774	No significant difference

Table 3. Result of unpaired T test between baseline intraocular pressure and intraocular pressure at different time of assessment in each group with their p-values

Groups of subjects	Mean difference in IOP at 60 minutes (mmHg)	Mean difference in IOP at 90 minutes (mmHg)	Mean difference in IOP at 120 minutes (mmHg)
A	2.32 ± 2.03 <i>p</i> =0.027	2.20 ± 1.88 <i>P</i> =0.031	1.40 ± 2.02 <i>P</i> =0.173
B	4.72 ± 1.92 <i>p</i> =0.000	4.44 ± 1.99 <i>p</i> =0.000	2.96 ± 1.95 <i>p</i> =0.004
C	5.20 ± 2.11 <i>p</i> =0.000	5.20 ± 2.08 <i>p</i> =0.000	4.28 ± 2.12 <i>p</i> =0.000
D	0.32 ± 2.22 <i>p</i> =0.774	0.40 ± 2.41 <i>p</i> =0.741	0.48 ± 2.42 <i>p</i> =0.693

4. DISCUSSION

In all groups except group D, a significant increase in IOP was observed at the 60th minute with the highest recorded in group C who were shown to have consumed the highest dose of 3.5mg/kg body weight of caffeine. Beyond 120 minutes there was a decline in IOP readings (across the groups). Within the groups, IOP significantly varied in groups A, B and C while among the groups, it also varied significantly with respect to caffeine dose ingested. This indicated that as the dosage of caffeine increased, IOP increased significantly [3]. In agreement with our findings, some studies have it that caffeine ingestion leads to elevation of IOP in normal individuals and the effect is more in those with family history of glaucoma [10]. Although there have been studies which showed that caffeine reduced intraocular pressure [7].

Beck et al in their study of caffeine's effect in various foods and drinks showed that ocular tissues are affected by the resultant high IOP

produced over time leading to the damage of the optic nerve especially in those with the family history [9].

Dietary habits play a role in the health or disease progression as shown in a study on the relationship between progression of glaucoma and life style by Pasquale and Kang. It showed that the coffee brew caused a significant increase IOP (*p*=0.001) in glaucoma patients [11].

Study by Ajayi et al on the acute caffeine's effect on IOP and BP of a healthy people in Nigerian revealed a mean IOP increase of 4mmHg post caffeine ingestion [10].

A study by Jennifer Ebeigbe and Eki Obahiagbon in 2013 showed a significant decline in IOP after energy drink which collaborates a similar review carried out in Ghana by Ilechie and Tetteh where a decreased IOP was observed 60minutes and 90minutes post energy drink intake however their study was based on the pressure reducing effect of taurine [7]. Another study showed that IOP

remained same after caffeine intake in normal individuals but significantly increased in glaucoma or those with ocular hypertension and is dose dependent [1].

5. CONCLUSION

This study showed a significant dose dependent rise in intraocular pressure in normotensive human eyes after caffeine ingestion.

Though caffeine is used in foods, drinks, and beverages and as additive in painkiller or anaesthetic drugs, moderation in its consumption remains very vital and calls for more public awareness. Over dose of caffeine come with health risks (especially ingestion of combination of variety of different products of caffeine) and cannot be overemphasized. Future studies should be carried out on the effect of caffeine via inhalation and also on monitoring its effect on IOP beyond 120 minutes.

Therefore more glaucoma screening is encouraged owing to the high consumption rate of caffeine in Nigeria and its effect on the progression of the disease.

CONSENT

Informed consent was obtained from each participant after detailed explanations of the procedures have been made known to them.

ETHICAL APPROVAL

Approval for the study was granted by the ethics and research committee of the Hospital Management Board Port Harcourt, Rivers State and was performed in accordance with the 1975 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Olakitan Y. All you want to know – Caffeine in Nigeria”. Available: <https://yemiolakitans.blogspot.com>
2. Thorn CF, Aklillu E, McDonagh EM, Klein TE, Altman RB. Caffeine pathway. Pharm GKB summary. 2012;22(5): 389–395.
3. Alan D, Harold A, David M, Barry E, Daniel M. Does drinking coffee increase glaucoma risk? Eye News. 2012;119:112-118.
4. Levine B. Caffeinated coffee linked to vision loss. Science Daily: "Exfoliation Syndrome." Glaucoma Foundation; 2012. DOI: 10/121003132012.
5. Avisar R, Avisar E, Weinberger D. Effect of coffee consumption on intraocular pressure. Ann Pharmacother. 2002;36(6): 992-5.
6. McNight C. List of foods & drinks that contain caffeine: [Livestrong.com/245410](http://www.livestrong.com/245410); 2014.
7. Jennifer E, Eki O. Acute effects of consumption of energy drink on intraocular pressure and blood pressure-pilot study. African Journal of Medical and Health Sciences. 2013;12(1):20-24.
8. de Pietro M. Kola nut: Uses, benefit and side effects medical news today. Available: <https://www.medicalnewstoday.com/article/319626>
9. Eleven B. Caffeine-How-young-is-too-young. Available: <http://www.stuff.co.nz/life-style/well-good/8632765>
10. Ajayi OB, Ukwade MT. Caffeine and intraocular pressure in a Nigerian population. J Glaucoma. 2001;10:25-31.
11. Pasquale LR, Kang JH. Lifestyle, Nutrition and Glaucoma. J Glaucoma. 2009; 18(6):423–428.
12. George GO, Ajayi OB. Relationship between Body Mass Index, Intraocular Pressure, Blood Pressure and Age in Nigeria population. J Clin Exp Ophthalmol. 2015;6:461. DOI: 10.4172/2155-9570.1000461

© 2019 Fidelma and Sydney; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://www.sdiarticle3.com/review-history/47682>