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ARTICLE

ASSOCIATION OF CAFFEINE INTAKE WITH PUPIL SIZE AND VISUAL ACUITY

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ABSTRACT

OBJECTIVE: *This research was done to check the association of dietary caffeine intake with pupil size and visual acuity. As caffeine itself is an autonomic stimulant drug and pupil size is controlled by smooth muscles of iris, stimulated by autonomic nervous system. Pupil size changes visual acuity by altering ocular aberrations.*

METHODS: *Caffeine consumers who drink coffee at-least 3 times per week or tea at-least 2 times per day were included in this comparative cross-sectional study. After taking their general history, pupil size was measured both in dim illumination and bright light conditions with the help of mm ruler and pen torch. Visual acuity for distance and near was assessed using logMAR (E-chart) and near acuity chart respectively.Mean values of dVA, nVA, PS(dim) and PS(illuminated) of caffeine consumers were compared to standard values of dVA(0.00) in logMAR , nVA(N=6.00), mean pupil size under dim light (6.00mm) and mean pupil size under bright light (3.00mm) respectively using One-Sample t Test.*

RESULTS: *Distance visual acuity (dVA) of caffeine consumers was significantly different from standard logMAR value(0.00) as p -value was 0.000, near visual acuity (nVA) of caffeine consumer was also significantly different from standard value (6.00) as p-value was 0.000. Similarly, mean pupil size under dim and bright light conditions of caffeine consumers were significantly different from mean of normal value of pupil diameter under dim and bright and light conditions respectively and p values were 0.001 and 0.000 for dim light pupil size and bright light comparisons with normal values mean respectively.*

CONCLUSION: *In habitual caffeine consumers near and distance visual acuity and pupil size for both dim and bright light conditions were different from the standard value of visual acuity and pupil size present in literature.*

KEY WORDS: *Caffeine, visual acuity, pupil size.*

INTRODUCTION

Caffeine is a drug which influences various biological actions at its physiological concentrations by antagonizing adenosine receptor. Adenosine does its action by stimulating a GTP- binding protein (Gi), which is inhibitory in nature and performs its action by inhibiting cAMP production. Hence, caffeine increases the level of cAMP in body, which further triggers the stimulation of neurons and neurotransmitter release. In this way caffeine increases CNS activity and person feels alert after caffeine consumption.[1]

Caffeine's effects on nervous system and vascular system are well known but its effects on eye is still under investigation.[2] Caffeine is a majorly used psychostimulant due to its beneficial effects for psychomotor, cognitive and physiological performance. In past few years, some interest is shown to positive effects of caffeine on visual system. Caffeine affects the visual system by raising rapid eye movements' velocity. Some recent studies show that caffeine affects different visual functions such as accommodation, ocular

aberration and contrast sensitivity. Moreover, caffeine ingestion helps in visual stimulus detection, preparation of response and to increase visual processing.[3]

According to a survey conducted in Karachi, most widely consumed caffeine beverage in Pakistan is tea. Most population of caffeine consumers in Pakistan, takes 2 cups tea per day and when caffeine is not consumed withdrawl symptoms are experienced by the habitual consumers such as headache, body pain and dizziness etc. [4]

Caffeine is present in many beverages and products those are consumed on daily basis, such as tea, coffee, energy drinks, chocolate, soft drinks, and cocoa beverages etc. In many countries coffee and other caffeinated beverages are part of their daily diet now a days.[5] Caffeine has many advantages along with its disadvantages, but it is commonly accepted that up to 400 mg consumption of daily caffeine by a healthy individual (~5.5 mg kg-1 for a 75 kg individual) is not injurious to health.[6,7]

Caffeine has been also associated with retinal and choroidal thickness, pupil size and changes in intraocular pressure (IOP). Iris has dual innervations from sympathetic and parasympathetic system. Constriction of pupil is associated with parasympathetic outflow from Edinger Westphal nucleus. Previous studies show that dilator papillae (dilator muscle) has alpha adrenergic stimulation and sphincter papillae (constrictor muscle) has cholinergic stimulation.[8]

Caffeine consumption shows inconsistent effects on pupil size.[9] When caffeine was topically applied on anesthetized rats, significant miosis was observed, whereas recent studies show that pupil dilation is induced by caffeine consumption. These responses also seem to be related to habitual consumption of caffeine as more pupil dilation was observed in non-habitual consumers of caffeine. Accommodative vergence response also influenced by caffeine consumption as magnitude of accommodation is enhanced and AC/A ratio is reduced after consumption of caffeine.[9]

Visual acuity is defined as the spatial detail resolution ability of the visual system and measures the angular size of detail that observer can just resolve. It is limited by neural and optical factors.[10] Pupil is defined as the opening of iris, which controls the amount of light entering into the eye. Pupil size is optical system's essential component as it affects various optical processes.[11] Pupil size influences light spread in image on retina. When pupil becomes smaller light spread increases due to diffraction but chromatic optical aberrations reduce, so optimal pupil size to compensate these problems is 2.5 mm.[10] Pupil size not only controls amount of light but also optimizes visual perception by affecting chromatic and spherical aberrations.[12]

Pupil size is likely affected by caffeine intake, as caffeine is an autonomic nervous system stimulant and pupil size also controlled by autonomic stimulation. However , sympathetic-parasympathetic balance modification caused by caffeine is still ambiguous and greatly variable results are available in studies.[2]

Pupil size and accommodation are regulated by iris and ciliary muscles respectively, and both of these receive autonomic innervations. Sympathetic innervation is responsible for pupil dilation and accommodation relaxation while parasympathetic innervation plays role for pupil constriction and accommodation stimulation.[8] In some recent studies it is dictated that, caffeine intake is found to be linked with variation in vision related tasks.[13,14]

So, it is thought that caffeine can alter visual performance by changing pupil size or accommodation.[8]

MATERIAL AND METHOD

Caffeine consumers who drank coffee at-least 3 times per week or tea at-least 2 times per day were included in this comparative cross-sectional study. After taking their general history, pupil size was

measured both in dim illumination and bright light conditions with the help of mm ruler and pen torch. Visual acuity for distance (dVA) and near (nVA) was assessed using logMAR (E-chart) and near acuity chart respectively.

Mean values of dVA, nVA, PS(dim) and PS(illuminated) of caffeine consumers were compared to standard values of dVA(0.00) in logMAR , nVA(N=6.00), mean pupil size under dim light (6.00mm) and mean pupil size under bright light (3.00mm) respectively using One-Sample t Test.

RESULTS

Two hundred forty-six (246) individuals participated with age group 20-60 years and mean age of 29.83 (±9.72) years, out of which 145 were females and 101 were males. Out of 246 participants 147 were residents of Lahore and 99 were outsiders, nine (9) participants were diabetic and 237 were non-diabetic , out of 246 participants 28 were hypertensive while 218 were normal.

Table - 1: Distance visual acuity comparison

One-Sample Test

	Test Value = 0.00						95% confidence interval of the difference	
	mean	Standard deviation	T	df	Significance (2-tailed)	Mean difference	lower	upper
Mean_dVA	0.1075	0.13338	12.644	245	0.000	0.10752	0.0908	0.1243

When mean distance VA of caffeine consuming population was compared with standard distance visual acuity (0.00) in logMAR, One Sample-T Test showed that result is significant as p-value is .000(<0.05) and distance visual acuity of caffeine consumers was reduced compared to testing value.

Table - 2: Near visual acuity comparison

One Sample T- Test

	Test Value = 6.00						95% confidence interval of the difference	
	mean	Standard deviation	T	df	Significance (2-tailed)	Mean difference	lower	upper
Mean_nVA	6.5203	1.54	5.271	245	0.000	0.52033	0.3259	0.7148

To compare mean near visual acuity of caffeine consumers to standard value (6.00) One Sample- T Test was applied and it showed that result is significant as p value is .000 and near visual acuity of caffeine consumers was reduced compared to testing value.

Table - 3: Pupil size (dim) comparison

One-Sample T Test

	Test Value = 6.00mm						95% confidence interval of the difference	
	mean	Standard deviation	T	df	Significance (2-tailed)	Mean difference	lower	upper
Mean PS (dim)	5.8435	0.7534	-3.258	245	0.001	-0.15650	-0.2511	-0.619

Mean pupil size in dim condition (PS_Dim) of caffeine consumers was compared with mean of pupil size in dim light by using One-Sample T Test and it showed that result is significant as p-value is .001 and pupil size of caffeine consumers under dim light conditions was small compared to testing value.

Table - 4: Pupil size (illuminated) comparison

One Sample T- Test

	Test Value = 3.00						95% confidence interval of the difference	
	mean	Standard deviation	T	df	Significance (2-tailed)	Mean difference	lower	upper
Mean PS (illuminated)	3.4929	1.1096	6.967	245	0.000	0.49289	0.3535	0.6322

Mean pupil size in illuminated condition (PS) of caffeine consumers were compared to mean of standard value (3.00mm) by using One-Sample T Test and it showed that result is significantas p-value is .000 (<0.05) and pupil size of caffeine consumers in illuminated conditions was larger compared to testing value.

DISCUSSION

Caffeine is a psychostimulant drug that belongs to the xanthine group and it is a competitive inhibitor of adenosine so in this way it increases the level of acetylcholine, adrenalin and dopamine by increasing cAMP level in the body. According to some studies caffeine influence physiological processes by stimulating sympathetic nervous system but some studies say caffeine acts by activating the parasympathetic nervous system[8]

In eye different structures such as muscles of iris control pupil size and are innervated by autonomic

nervous system and ciliary muscles which control accommodation response are also innervated by autonomic nervous system, so caffeine intake can alter pupil size[2] and accommodation response.[8]

Mean value of distance visual acuity of caffeine consumers (1.075±1.3338) was compared with standard visual acuity (0.00) in LogMAR by using One-Sample T Test and p value was 0.000 (<0.05) so resultwas significant . Visual acuity of caffeine users was reduced than the standard value this difference could be due to alteration in pupil and accommodation response caused due to caffeine.[8] This difference can be occurred due to difference in illumination or minor refractive errors.

Similarly, when mean near value acuity (nVA) of caffeine consumers (6.5203 ±1.54) , measured using a near visual acuity chart, was compared to standard near visual acuity value N=6.00 by using One - Sample T Test then p value was 0.000(<0.05), so result is significant and this shows that caffeine consumption can reduce near visual acuity by altering accommodation response.[8] This result could occur due to presbyopic condition as many people do not use glasses in very early stage of presbyopia and many people do not carry their near add glasses with them all the time.

Pupil size in dim light condition (PS-dim) in caffeine consumers was measured under same conditions and then its mean value (5.8435±0.7534) was compared to the mean of normal pupil size range in dim light condition present in literature (6.00mm), using One -Sample T Test and p value was .001(<0.05), so data is significant and caffeine intake can alter the pupil size in dim light condition by reducing its size.9 In a previous study when topical caffeine was applied on anesthetized rats then miosis was observed and according to that study caffeine show inconsistent effect on pupil size.[9]

When mean value of pupil size measured, in illuminated conditions under same situations for all participants in caffeine consumers (3.4929mm±1.1096), with a pen-torch and mm ruler was compared with mean value of normal pupil size in bright light conditions (3.00mm) using One-Sample T Test then p value was 0.000 (<0.05) and result was significant. This data analysis shows that pupil diameter of caffeine consumers is a bit larger than mean standard value under illuminated conditions. Which means caffeine can cause pupil dilatation as presented in previous study.[8]

CONCLUSION

This comparative cross sectional (analytical) study on concluded that in regular caffeine consumers near and distance visual acuity and pupil size for both dim and bright light conditions were different from the standard value of visual acuity and pupil size present in literature.

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REFERENCES

1. Ammon H. Biochemical mechanism of caffeine tolerance. Arch Pharm (Weinheim). 1991;324(5):261-7.
2. Yoon JJ, Danesh-Meyer HV. Caffeine and the eye. Surv Ophthalmol. 2019;64(3):334-44.
3. Redondo B, Jiménez R, Molina R, Dalton K, Vera J. Effects of caffeine ingestion on dynamic visual acuity: a placebo-controlled, double-blind, balanced-crossover study in low caffeine consumers. Psychopharmacology (Berl). 2021;238(12):3391-8.
4. Ashraf Z, Waheed N, Iftikhar G. Caffeine: a cross-sectional analysis of caffeine intake in Karachi, Pakistan. FUUAST Journal of Biology. 2018;8(2):359-62.
5. Cappelletti S, Daria P, Sani G, Aromatario M. Caffeine: cognitive and physical performance enhancer or psychoactive drug? CurrNeuropharmacol. 2015;13(1):71-88.
6. Mclellan TM, Caldwell JA, Lieberman HR. A review of caffeine's effects on cognitive, physical and occupational performance. NeurosciBiobehav Rev. 2016;71:294-312.
7. Doepker C, Lieberman HR, Smith AP, Peck JD, El-Sohemy A, Welsh BT. Caffeine: friend or foe. Annu Rev Food Sci Technol. 2016;7:117-37.
8. Abokyi S, Owusu-Mensah J, Osei K. Caffeine intake is associated with pupil dilation and enhanced accommodation. Eye (Lond). 2017;31(4):615-9.
9. Redondo B, Vera J, Molina R, Luque-Casado A, Jimenez R. Caffeine alters the dynamics of ocular accommodation depending on the habitual caffeine intake. Exp Eye Res. 2019;185:107663.
10. Jackson A, Bailey I. Visual acuity. Optometry in Practice. 2004;5:53-68.
11. Atchison DA, Smith G, Smith G. Optics of the human eye: Butterworth-Heinemann Oxford; 2000.
12. Park JW, Kang BH, Kwon JW, Cho KJ. Analysis of various factors affecting pupil size in patients with glaucoma. BMC Ophthalmol. 2017;17(1):1-8.
13. Coren S. The effect of caffeine ingestion on the perceived instability of visual patterns. Int J Psychophysiol. 2002;43(2):185-9.
14. Kirshner A, Schmid R. The effects of caffeine on near point plus acceptance. J Am Optom Assoc.. 1984;55(2):97-102.