

Effect of Coffee on Pupil Size & Ocular Wavefront Aberration Measurements in Healthy Subjects

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Abstract:

Background: Caffeine has been demonstrated to be associated with increased blood pressure, decreased heart rate, and reduced cerebral blood flow. The caffeine has shown to be related to changes in intraocular pressure (IOP), retinal and choroidal thickness, and pupil size. Ocular wavefront aberrations (OWA) have reported having an impact on the retinal image quality of the human eye.¹ Purpose: Assess the influence of coffee drinking on Ocular Wavefront Aberration (OWA) measurements & pupil size.

Materials and Methods: This prospective cross-sectional study included an entire of fifty young, healthy, and non-regular coffee drinker female students from King Saud University recruited for the study. None of the participants have any history of drug or ocular and systemic disease, previous ocular surgery, or trauma. Informed consent obtained from all participants before including them in the study. Each participant accomplished the baseline ophthalmic examinations, including best-corrected visual acuity (BCVA) assessment, refractive measurements, and then asked for OWA. Participants obtained one cup of Turkish coffee. Pupil size and Ocular Wave front Aberration (OWA) measurements assessed before coffee drinking and at 5 minutes, 30 minutes, and 4 hours after coffee drinking by using a wavefrontaberrometer device (WASCA Analyzer). All measurements carried out under the same room illumination. Subjects with spherical refractive power between $-4.00D$ and $+4.00D$ and cylindrical refractivepowerless than $-1.00D$ included for the study.

Results: The study included fifty healthy participants (100 eyes). All subjects were female with no ocular pathology. The mean age was 21.28 ± 2.72 , while the age range was (19-32), Although pupil size appeared a slight increase following coffee drinking, but not significantly alteration during the measurements ($p = 0.1$). The caffeine resulted in no significant difference between total high order aberration (HOA), total spherical aberration (TSA), total coma (TC) and total trefoil (TTF) before caffeine intake, after 5 minutes, 30 minutes and after 4 hours. ($P=0.9$, $P=0.9$, $P=0.5$ & $P=0.4$) respectively.

Conclusion: The main conclusion of this work presented in this section that a single administration of coffee results in no significant variation found between pupil size diameter in healthy individuals and the optical aberration measurements.

Key Word: Pupil size, caffeine intake, high order aberration, total spherical aberration, total coma & optical aberration measurements

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I. Introduction

Caffeine and Pupil

Caffeine has been demonstrated to be related to increased blood pressure, reduced heart rate, and downgraded cerebral blood flow. The caffeine has shown to be related to alterations in intraocular pressure (IOP), retinal, choroidal thickness, and pupil size. Ocular Wavefront Aberrations (OWA) influencing the retinal image quality of the human eye.¹ The pupil is one of the main essential parts of the visual of the system as its primary purpose is to control the amount of light incoming the eye. It located at the center of the iris, which placed anterior to the lens and ciliary body. The pupil constricts after the parasympathetic stimulation of the sphincter papillae muscle and dilates after the sympathetic stimulation of the dilator muscle. Light conditions, biological factors, diseases, medications, can influence the pupil movement.

Anatomy of the Pupil

According to Finger, 1996, mentioned the anatomy of the pupil. The Iris is 12 mm in diameter, with a circumference of 37 mm. The pupil margin rests on the lens, without whose support, for example, in aphakic patients; it becomes tremulous (iridonesis). The size of the pupil controls the amount of light entering the eye and is dependent on the state of contraction of the intrinsic pupillary muscles, the dilator and sphincter pupillae. The pupil may vary from 1 to 8 mm in diameter, and there may be a slight degree of asymmetry between right and left eyes in healthy individuals.³

Optical Aberration

Each ray of light from a point in the object plane would converge to the same end in the image plane, forming a clear image. This way occurs in an ideal optical system. But in aberrations, the influences of different rays converge to various points. This aberration may be one of these types: spherical aberration, coma, astigmatism, a curvature of field, and distortion. The spherical aberration is the difference between the focal points for rays that are close to the axis and the focal points for rays that strike the lens near its border. The focal point is the point that the beam was bypassing through the lens. Spherical aberration raises with the diameter of the lens and decreases by controlling the opening of the lens so that only rays in the paraxial area can pass through it. Coma is an optical aberration because off-axis rays not quite converge at the focal plane. When coma is positive, the image of an object produced by off-axis rays is somewhat larger than the image produced by paraxial rays, but when coma is negative, the image produced by the off-axis rays is slightly smaller. Coma named because a point image blurred into a comet shape.^{4,5}

Astigmatism occurred when the effective radius of curvature of the lens in one way is not similar as in a perpendicular direction and when an object point is quite far off of the central axis of the lens two image points, one for the rays that hit the lens in the plane of the object and the central axis of the lens and another for rays that strike the lens perpendicular to this plane. The curvature of field happened because the focal plane is not planar, but spherical. Although the previous aberrations eliminated, this one remains. One likely condition to precise this aberration by using a combination of a positive and a negative lens that is very close together. Distortion happened because the transverse magnification may be a function of the off-axis image distance. Distortion may be positive Distortion or negative Distortion. Finally, the last aberration chromatic aberration occurs when a lens is bringing different colors of light to a center at various points because of a variation in the index of refraction of a lens with the wavelength of the event light.^{4,5}

II. Material And Methods

This observational, cross-sectional prospective study comprised an entire of fifty young, healthy, and non-usual coffee drinker female students enrolled in the study from the College of Applied Medical Science. An age between (19-32 years) with a mean age of (mean \pm SD=28 \pm 2.27 years). Subjects with spherical refractive power between $-4.00D$ and $+4.00D$ and cylindrical refractive power less than $-1.00D$ included for the study. Informed written permission obtained from each member before running the examinations. The study accepted by the ethics group of the College of Applied Medical Science, and the participants were treated based on the Helsinki Declaration.

Study Duration: September 2018 to December 2018.

Sample size: 50 patients.

Sample size calculation: The sample size estimated based on a single proportion design. We assumed that the confidence interval of 10% and a confidence level of 95%. We planned to include 50 patients.

Subjects & selection method: The study population drew from females students at the College of Applied Medical Science from September 2018 to December 2018. Participants received one cup of Turkish coffee. The Pupil size and Ocular Wavefront Aberrations (OWA) measurements assessed before coffee drinking and at 5 minutes, 30 minutes, and 4 hours after coffee drinking by using a wavefront aberrometer device (WASCA Analyzer).

Inclusion criteria:

1. Females sex
2. Aged ≥ 19 years < 40 years
3. spherical refractive power between $-4.00D$ and $+4.00D$ and cylindrical refractive power less than $-1.00D$

Exclusion criteria:

1. Pregnant women
2. Any history of drug or ocular and systemic disease
3. Previous ocular surgery, or trauma

Procedure methodology

After written informed consent obtained, comprehensive baseline ophthalmic investigations presented in all subjects, including best corrected visual acuity (BCVA) assessment, refractive measurements. Subjects advised stopping head movements of the subjects to a minimum during the measurements. The pupil diameter automatically recorded by the device. All measurements performed under natural pupil size. While the subject concentrates on a target inside the device named WASCA Analyzer (figure no.2), a beam of infrared light with a wavelength of 780 nm directed towards the fundus, the ray backscattered by the retina and travels in return across the eye and pupil. The exit ray directed to a Hartmann-Shack wavefront sensor that examines the dimension of the optical wave.

The Irx3 machine makes an OWA map and Zernike graph. Zernike polynomial series up to and counting the 10th order computed for each measurement. The Root means-square (RMS) wavefront error of each Zernike mode was detected, and the amounts of total coma (TC), total trefoil (TF), total spherical aberration (TSA), and total higher-order aberrations (HOAs) determined.^{1,6}



Figure no.1 WASCA Analyzer

Statistical analysis

The analysis carried out using a statistical package performed GraphPadInStat version3.The Repeated - ANOVA test used to evaluate the significance of the difference in pupil size changes & optical aberration in all the four sessions (before coffee intake, after 5 minutes, after 30 minutes & after 4 hours). Pearson’s correlation and linear regression used to examine the relationship between pupil size change & optical aberrations

III. Result

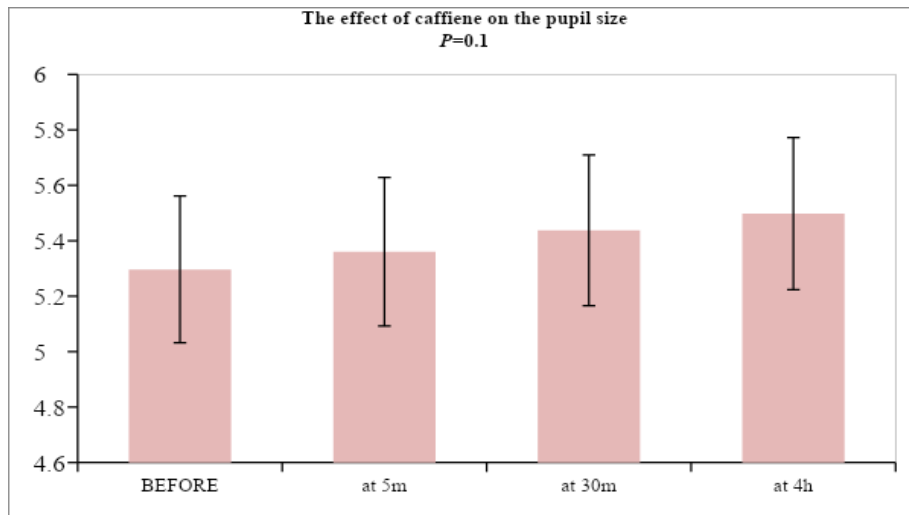
The study included 50 patients, a total of 100 eyes. All patients were female students- age between (19-32 years) with a mean age of (28±2.27 years).Descriptive statistics computed for all study variables shown in table no 1.

		Subjects			
Number of Subjects		50			
Age (yrs) mean ± SD		21.28±2.72			
Age range (min/max)		19-32			
Spherical equivalent (Diopter) mean ± SD		-0.71±1.13			
VA		0.9±0.01			
Period	Before drinking	After 5 minutes	After 30 minutes	After 4 hours	P-value
Pupil size mean ± SD	5.2±0.74	5.3±0.72	5.4±0.73	5.4±0.69	0.1

HOA mean ± SD	0.252±0.12	0.258±0.11	0.254±0.11	0.254±0.11	0.9
TSA mean ± SD	1.34±1.10	1.37±1.15	1.30±0.99	1.39±1.14	0.9
TC mean ± SD	-0.34±0.62	-0.32±0.61	-0.31±0.59	-0.28±0.59	0.5
TTF mean ± SD	-0.17±0.50	-0.23±0.47	-0.19±0.48	-0.18±0.46	0.4

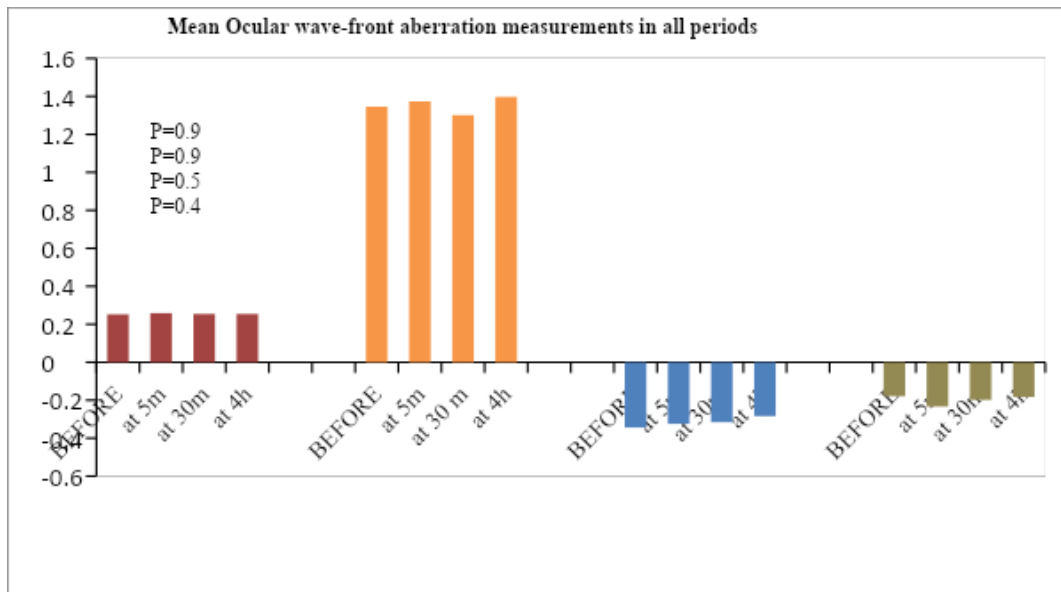
Effect of caffeine on pupil size

Pupil size appeared a small increase following coffee drinking that indicates no statistical difference, and the values are nearly the same during the measurements ($P= 0.1$), as presented below in figure no.1



Ocular wavefront aberration measurements

No significant variation found in the mean ocular wavefront aberration ($P<0.05$) for total high order aberration (HOA), total spherical aberration (TSA), total coma (TC) and total trefoil (TTF) before caffeine taken, after 5 minutes, 30 minutes and after 4 hours, as shown in figure no.2 below.



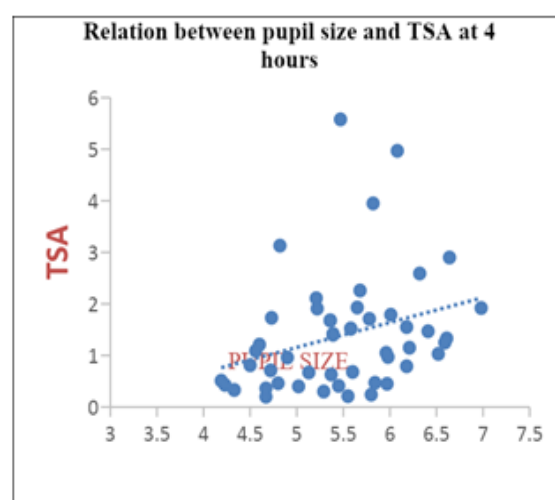
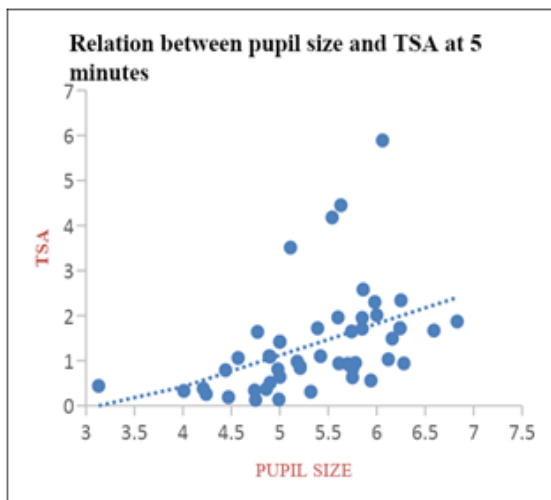
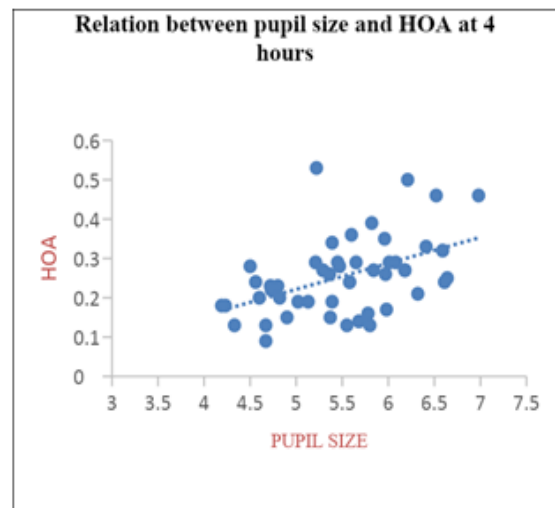
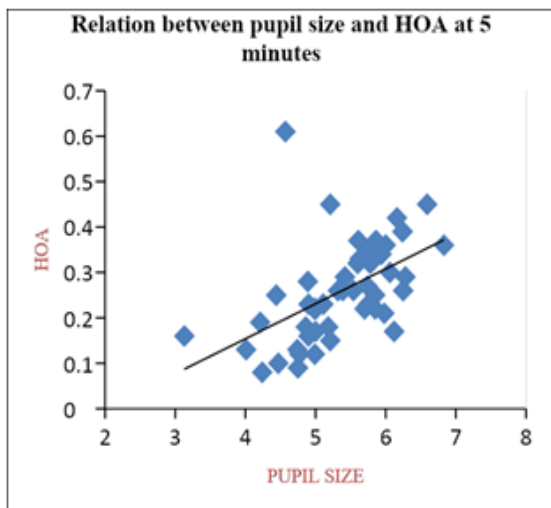
Correlation between pupil size and optical aberration

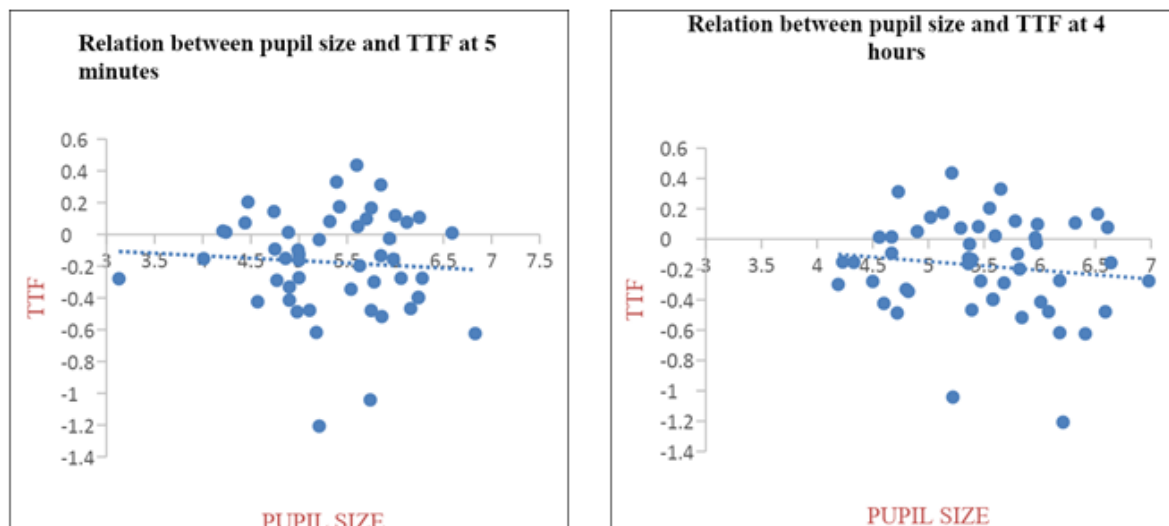
No association found between these subgroups. Other variables highlighted below in table no.2, such as total high order aberration (HOA) and total spherical aberration (TSA), are presented significant positive association between pupil size change and optical aberration.

	HOA	TSA	TC	TTF
Pupil size 5 minutes (<i>r</i> ; <i>p</i>)	<i>r</i> =0.5 <i>p</i> < 0.05	<i>r</i> =0.4 <i>p</i> < 0.05	<i>r</i> = -0.1 <i>p</i> =0.3	<i>r</i> =-0.1 <i>p</i> = 0.4
Pupil size 30 minutes (<i>r</i> ; <i>p</i>)	<i>r</i> =0.5 <i>p</i> < 0.05	<i>r</i> =-0.1 <i>p</i> = 0.4	<i>r</i> = 0.2 <i>p</i> =0.1	<i>r</i> =-0.1 <i>p</i> =0.7
Pupil size 4 hours (<i>r</i> ; <i>p</i>)	<i>r</i> =0.5 <i>p</i> < 0.05	<i>r</i> =0.3 <i>p</i> < 0.05	<i>r</i> = -0.1 <i>p</i> =0.6	<i>r</i> =-0.1 <i>p</i> =0.4

r: correlation coefficient, *P* < 0.05

HOA: total higher-order aberration; TSA: total spherical aberration; TC: total coma; TTF: total trefoil.





IV. Discussion

This study aims to assess the influence of coffee drinking on Ocular Wavefront Aberration (OWA) measurements & pupil size.

This clinic-based study proved that the caffeine doesn't have a significant effect on pupil size and the optical aberration measurements. On the contrary, we obtained a positive association between pupil size alteration and HOA and TSA after 5 minutes and 4 hours of coffee drinking. These findings are in contrast to the data reported by Bardak, Gunay, Mumcu&Bardak, that found a significant increase in HOA and TF following coffee intake ($p = 0.029$ and $p = 0.009$) respectively.¹

A study by Abokyi, Owusu-Mensah&Osei, assessed the influence of caffeine on pupil size and accommodation, the research conducted in 50 healthy subjects of age range 19 to 25 years, they used 250 mg caffeine drink on separate days, they found that amplitude of accommodation increased and pupil diameter enlarged after the ingestion of caffeine, $P < 0.001$. They took at baseline and 30, 60, and 90 min time points post-treatment.⁷

Some studies supported that, caffeine improves both parasympathetic and sympathetic nerve activity(SNS), as Corti et al., reported similar observations in their experiments ,coffee and caffeine increase muscle sympathetic nerve activity (MSA) and blood pressure (BP) in non-habitual coffee drinkers, and that the caffeine activates the SNS, increases systolic/diastolic blood pressure, and reduce heart rate.⁸ Another study by Monda et al., examined the effect of caffeine on young, healthy subjects in two positions; they found that a cup of espresso coffee (75 mg of caffeine) enlarge parasympathetic activity in young, healthy people in a supine position.⁹

Coffee also can affect the intraocular pressure, Jiwani et al., studied the intraocular pressure (IOP), ocular perfusion pressure (OPP), and ocular pulse amplitude (OPA) after caffeinated coffee consumption in those with or at danger for primary open-angle glaucoma (POAG). They ended that one cup of caffeinated coffee (182mg caffeine) statistically increases IOP, OPP, and OPA as compared with decaffeinated (4mg caffeine).¹⁰

However, in summary, this work offers minimal aspects, such as the small sample size. Furthermore, this works also limited by its consideration of no ability to gather Male participants inside the Females Collage.

Further prospective studies could perform considering the possible effect of coffee on Refractive error, subjective and objective visual acuity.

VII. Conclusion

The main conclusion of this work presented in this section that a single administration of coffee results in no significant variation found between pupil size diameter in healthy individuals and the optical aberration measurements.

References

- [1]. Bardak, H., Gunay, M., Mumcu, U., & Bardak, Y. (2016). Effect of Single Administration of Coffee on Pupil Size and Ocular Wavefront Aberration Measurements in Healthy Subjects. *Biomed Research International*, 2016, 1-5. doi: 10.1155/2016/9578308
- [2]. McDougal, David H, and Paul D Gamlin. "Autonomic control of the eye." *Comprehensive Physiology* vol. 5,1 (2015): 439-73. doi:10.1002/cphy.c140014
- [3]. Finger, P. (1996). Book Review *The Eye: Basic sciences in practice* By John V. Forrester, Andrew D. Dick, Paul McMenemy, and William R. Lee. 409 pp., illustrated. Philadelphia, W.B. Saunders, 1996. \$45. 0-7020-1790-6. *New England Journal Of Medicine*, 334(23), 1550-1550. doi: 10.1056/nejm199606063342320
- [4]. Thurman, S. (2009). Impact of aberrations on image quality. *SPIE Newsroom*. doi: 10.1117/2.1200901.1463
- [5]. Liang, J., & Williams, D. (1997). Aberrations and retinal image quality of the normal human eye. *Journal Of The Optical Society Of America A*, 14(11), 2873. doi: 10.1364/josaa.14.002873
- [6]. Mirzajani, A., Aghataheri, S., Ghoreishi, M., Jafarzadepour, E., & Mohammadinia, M. (2016). Evaluation of corneal higher order aberrations in normal topographic patterns. *Journal Of Current Ophthalmology*, 28(2), 75-80. doi: 10.1016/j.joco.2016.03.001
- [7]. Abokyi, S., Owusu-Mensah, J., & Osei, K. (2016). Caffeine intake is associated with pupil dilation and enhanced accommodation. *Eye*, 31(4), 615-619. doi: 10.1038/eye.2016.288
- [8]. Corti, R., Binggeli, C., Sudano, I., Spieker, L., Hänseler, E., & Ruschitzka, F. et al. (2002). Coffee Acutely Increases Sympathetic Nerve Activity and Blood Pressure Independently of Caffeine Content. *Circulation*, 106(23), 2935-2940. doi: 10.1161/01.cir.0000046228.97025.3a
- [9]. Monda, M., Viggiano, A., Vicidomini, C., Viggiano, A., Iannaccone, T., Tafuri, D., & De Luca, B. (2009). Espresso coffee increases parasympathetic activity in young, healthy people. *Nutritional Neuroscience*, 12(1), 43-48. doi: 10.1179/147683009x388841
- [10]. Jiwani, A., Rhee, D., Brauner, S., Gardiner, M., Chen, T., & Shen, L. et al. (2012). Effects of caffeinated coffee consumption on intraocular pressure, ocular perfusion pressure, and ocular pulse amplitude: a randomized controlled trial. *Eye*, 26(8), 1122-1130. doi: 10.1038/eye.2012.113

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