The Effects of Caffeine Intake on AC/A Ratio, Near Point of Convergence, and Reading Speed

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ABSTRACT

Background and Objectives: Accommodation refers to an increase in the convexity of the crystalline lens allowing the eye to change its focus from distance to near objects. It is measured in Diopters. Accommodation can sometimes be excessive, causing the eye to exert more power than needed, which can result in symptoms like eye strain, blurred vision, and headaches. In this study, the effects of caffeine intake on the AC/A ratio, Near Point of Convergence (NPC), and reading speed are evaluated. Caffeine (1,3,7-trimethylxanthine) is the most widely consumed psychoactive stimulant worldwide, commonly found in coffee, tea, energy drinks, carbonated beverages, gums, and cocoa. Its physiological effects are well-documented, including pupil dilation, increased intraocular pressure (IOP), and enhanced accommodation.

METHODOLOGY: A descriptive cross-sectional study was conducted at The University of Faisalabad (TUF) using a convenient sampling technique. The study included 80 emmetropic female, caffeine consumers and aged 18–26 years. Data collection took place between September 2021 and May 2022. The AC/A ratio, NPC, and reading speed were initially assessed in a caffeine-free state. Subsequently, each participant consumed 100 mg of Nestlé black coffee, and these parameters were measured again at intervals of 30, 60, and 90 minutes post-caffeine intake. The AC/A ratio and NPC were quantified by the heterophoric method and the RAF ruler respectively, whereas reading speed was assessed with N10 print. Data analysis was carried out with repeated measures analysis of variance using SPSS version 20.

RESULTS: Among postmenopausal female patients with type 1 osteoporosis, the incidence of sarcopenia was relatively high (90.35%), affecting quality of life in 39.82% of patients, postural instability in 92.21% of patients, and balance in 39.92% of patients.

CONCLUSION: It is concluded that excessive Caffeine consumption has adverse effect on near vision and reading speed. Moreover, it also decreased the amount of AC/A ratio.

KEYWORDS: AC/A ratio, Caffeine, Near Point of Convergence (NPC), Reading Speed

INTRODUCTION

The human eye is a remarkable organ that enables us to see. It is about 2.5 cm in diameter and has three main layers: the fibrous, vascular, and neural layers. These layers surround important components like the crystalline lens, aqueous humor, and vitreous body. (1) The crystalline lens is a clear, biconvex structure that lacks blood vessels and is vital for focusing light onto the retina. Made mostly of water and protein, it accounts for about one-third of the eye's ability to refract light. (2) The lens is held in place by zonular fibers connect ed to the ciliary body, which allows for accommodation. This ability to adjust is crucial for clear vision, and it is aided by the ciliary muscle, which contracts to lessen the tension on the zonules, making the lens more rounded. (3)

Accommodation refers to increase in the convexity of the crystalline lens allowing the eye to change its focus from distance to near objects. It is measured in Diopters. Accommodation can sometimes be excessive, causing the eye to exert more power than needed,

which can result in symptoms like eye strain, blurred vision, and headaches. (4) Conversely, accommodation insufficiency occurs when the eye struggles to produce enough accommodative power, often due to aging or health issues such as glaucoma, diabetes, or anemia, leading to challenges with near vision. A key measure of ocular function is the accommodation-convergence/accommodation (AC/A) ratio, which indicates how much convergence is triggered by each diopter of accommodation. Typically, a normal AC/A ratio falls between 3-5 prism diopters for each diopter of accommodation, with variations suggesting potential ocular issues like esophoria or exophoria, depending on whether the ratio is too high or too low. (5) The AC/A ratio can be evaluated using methods such as the heterophoric method, gradient method, and fixation disparity method, and is affected by factors like interpupillary distance and the distance of objects AC/A ratio is calculated by heterophoric method by using the formula in which Δn stands for deviation at near and Δd stand for the deviation at distance, d is fixation distance in diopters:

$$AC/A = IPD + \Delta n - \Delta d/d.$$

Convergence, which is the inward movement of the eyes to focus on nearby objects, is another crucial element of visual function. (6) The Near Point of Convergence (NPC) refers to the closest distance at which an object can be seen without experiencing double vision, with a normal NPC range being 7-10 mm. Disorders related to convergence, such as convergence insufficiency and convergence excess, can hinder near vision, resulting in symptoms like blurred vision or double vision when looking at close objects. (7) The NPC can be measured using the Royal Air Force (RAF) ruler, which is specifically designed to evaluate both convergence and accommodation capabilities. Additionally, reading speed is an important factor in visual performance, especially for those who engage in extensive reading tasks, such as students or office workers. (8)

Reading speed is usually measured in words per minute, with a standard rate being around 168 words per minute. The subjects are asked to read Times New Roman print of font size 10. . It can be assessed with stop watch by two methods. We can calculate it by counting the words an individual can read in one minute. It can also be calculated by using the formula. Reading Speed Calculation= (word on page/ second to read) ×60. (9) Several ocular and systemic conditions can impact this speed, such as refractive errors, eye diseases, and health issues like diabetes or hyperten

sion. Additionally, environmental factors, including light intensity and glare, can affect how efficiently one reads. (10)

Caffeine, also known as 1,3,7-trimethylxanthine, is a widely consumed psychoactive stimulant recognized for its ability to boost mental alertness, decrease fatigue, and enhance focus. (11) It is commonly found in coffee, tea, energy drinks, and other beverages, with peak levels in the bloodstream occurring 30 to 60 minutes after consumption. The half-life of caffeine in the body typically ranges from 3 to 6 hours. Caffeine works by blocking adenosine receptors in the brain, stimulating the sympathetic nervous system, and raising blood pressure and heart rate. Furthermore, it influences the visual system by altering intraocular pressure, causing pupil dilation, and increasing the effort needed for accommodation, which may lead to changes in visual performance, including effects on the AC/A ratio, near point of convergence, and reading speed. (12), (13)

Numerous studies have indicated that caffeine consumption might have a negative impact on near vision, reducing the ability to focus on close objects and potentially slowing down reading speed. These effects are especially pronounced for those who depend on high levels of accommodation for tasks that require close attention, such as students or office workers. While caffeine is known to enhance cognitive function and alertness, its effects on visual performance, particularly for near vision tasks, continue to be an area of active research. Gaining insights into how caffeine affects these visual aspects could be beneficial for individuals engaged in near work, particularly those with existing visual issues or those who regularly consume large amounts of caffeine.

This study intends to evaluate the influence of caffeine on the AC/A ratio, near point of convergence (NPC), and reading speed in healthy emmetropic females. By assessing these parameters before and after caffeine consumption, the research aims to shed light on how caffeine intake affects visual function and performance during near tasks. The hypothesis posits that caffeine consumption will result in significant alterations in the AC/A ratio, NPC, and reading speed when compared to baseline measurements.

METHODOLOGY

Study Design: Descriptive cross-sectional study design was used to conduct study.

Study Setting: This study was conducted at The University of Faisalabad, Faisalabad.

Study Duration: The duration of study was 8 months

from September 2021 to May 2022.

Population of Study: Female subjects aged between 18-26 years old were included in this study.

Sample Size: 80 healthy female subjects were included.

Sampling Technique: Convenient sampling technique was used in this study.

Inclusion Criteria:
• Only females.
• Age between 18-26 years.
• Healthy emmetropes.
• Caffeine consumers.

Exclusion Criteria:
• All types of refractive errors.
• Ocular diseases.
• Systematic diseases.
• Extra Ocular Muscles (EOM) instability.
• Past ocular surgery.

Data Collection Instruments:
• RAF Ruler (CLEMENT CLARKE OPH-THALMIC)
• Prism Bar
• Millimeter Ruler
• Pen torch (Camelion)
• Log MAR Chart (ASF Universal)
• Trial Box
• Times New Roman N10 Print
• Stop watch

Data Collection Tool: Self-designed examination based Proforma was used.

Data Collection Procedure: Descriptive cross-sectional study design was used to conduct this study including sample size of 80 healthy female subjects selected through convenient sampling technique. Age of subjects was between 18-26 years old. Participants' AC/A ratio, Near Point of Convergence (NPC), and reading speed were assessed in a baseline condition before consumption of 100 mg of Nestle black coffee (containing caffeine). Measurements were then repeated at intervals of 30, 60, and 90 minutes after caffeine consumption. The data was compared before and after 30, 60 and 90 minutes.

Figure-1: Measuring reading speed, NPC, AC/A ratio and IPD

Data Analysis: Data was analyzed through SPSS software version 21 using paired sample T-test and repeated measure ANOVA test respectively. 95% confidence interval was used as standard measure.

Ethical Consideration: Both oral and written consent was taken from subjects prior to study. Subjects were ensured that information provided by them was kept confidential and was used for research purpose only. This information could not be disclosed except in the case where researcher was obliged legally to disclose it. Proforma attached

RESULTS

A descriptive cross-sectional study was conducted at The University of Faisalabad (TUF). 80 healthy emmetrope female subjects aged between 18 to 26 years old were included in this study. Data was collected using convenient sampling technique. AC/A ratio, NPC and reading speed were assessed in decaffeinated subjects. After that, 100 mg of nestle black coffee (containing caffeine) was consumed by each subject and again these parameters were measured at time interval of 30, 60 and 90 minutes of caffeine intake.

Age Distribution: 80 female emmetrope subjects were collected through convenient sampling technique at The University of Faisalabad. The mean age and standard deviation of females were M=20.75 and SD=±1.634. Age distribution of age group of subjects was respectively.

Descriptive statistics of NPC: Descriptive cross-sectional study was conducted at The University of Faisalabad (TUF). 80 healthy emmetrope female subjects aged between 18 to 26 years old were included in this study. Mean value of NPC 7.44 mm with the standard deviation of ±3.434 was recorded in decaffeinated subjects. After caffeine intake the mean value and standard deviation of NPC at 30 minutes, 60 minutes and 90 minutes was (M=8.96, SD=± 3.563), (M=9.11, SD=±3.703), (M=10.27, SD=±4.784) respectively. NPC showed a significant decrease in mean value after successive time intervals.
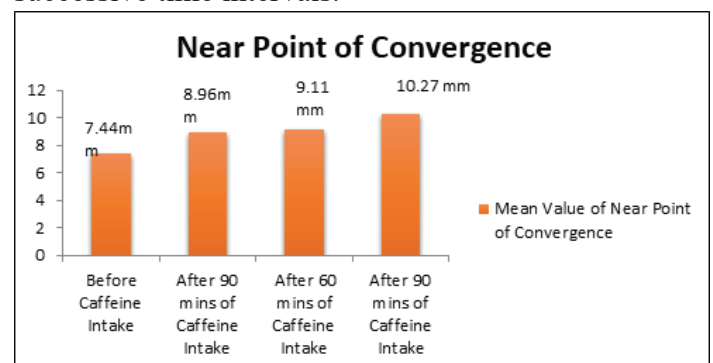

Figure-2: Mean values of NPC before and after caffeine intake

Repeated Measure Analysis of Variance (ANOVA) of NPC: 80 female emmetrope subjects aged between 18-16 years old were taken in this study. Descriptive cross-sectional study design was used and through convenient sampling technique data was collected. Repeated measure ANOVA result showed mean square of sphericity assumed as 108.474 and that of Greenhouse-Geisser was 145.031. The value of significance level was found to be P=0.000.

Table-1: Repeated Measure (ANOVA) of Near Point Convergence

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	325.421	3	108.474	22.330	.000
	Greenhouse-Geisser	325.421	2.244	145.031	22.330	.000

Descriptive statistics of AC/A ratio: In decaffeinated subjects mean and standard deviation value of AC/A ratio was 4.4445 and ±1.055 respectively. After caffeine intake the mean value and standard deviation of AC/A ratio at 30, 60 and 90 minutes was (M=4.369, SD=±1.117), (M=4.150, SD=±1.117) and (M=4.270, SD=±1.165) respectively. A significant decrease in mean value of AC/A ratio was observed from the mean baseline value respectively.
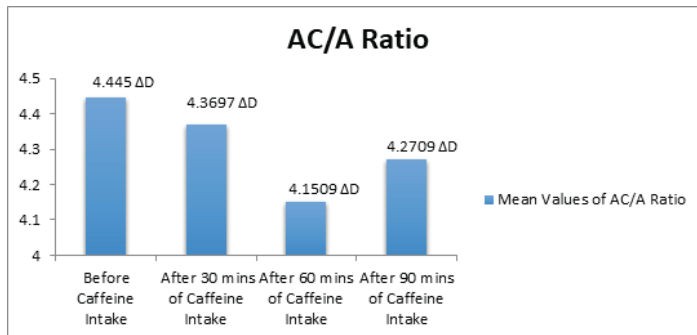

Figure-3: Mean values of AC/A ratio before and after caffeine intake

Repeated Measure Analysis of Variance (ANOVA) of AC/A Ratio: Effect of caffeine over AC/A ratio was assessed on 80 female emmetrope subjects aged between 18-16 years old. Repeated measure ANOVA test was applied on the values of AC/A ratio. The result showed mean square of sphericity assumed as 1.294, and that of Greenhouse-Geisser was 1.630. The value of significance level was found to be P=0.046 respectively.

Table-2: Repeated Measure (ANOVA) of AC/A Ratio

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Time	Sphericity Assumed	3.881	3	1.294	2.948	.034
	Greenhouse-Geisser	3.881	2.381	1.630	2.948	.046

Descriptive Statistics of Reading Speed: Mean value of reading speed 165.50 wpm with the standard deviation ±29.908 of was recorded in decaffeinated subjects. After caffeine intake, the mean value and standard deviation of reading speed at 30 minutes, 60 minutes and 90 minutes was (M=154.40, SD=±23.477), (M=163.04, SD=±25.530) and (M=159.71, SD=±21.772) respectively. Reading speed showed a significant decrease from the mean baseline respectively.
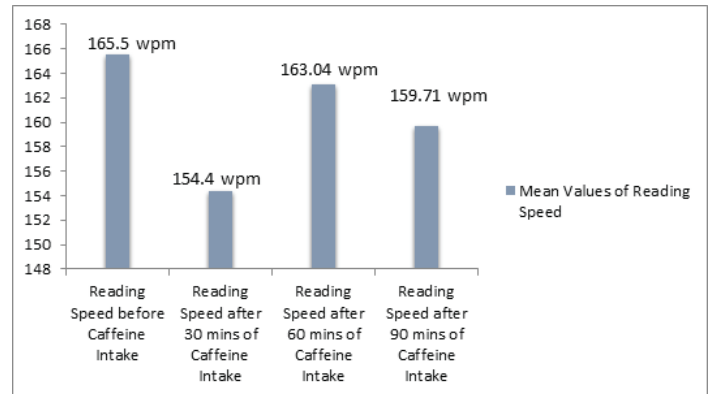

Figure-4: Mean values of Reading Speed before and after caffeine intake

Repeated Measure Analysis of Variance (ANOVA) of Reading Speed: This descriptive cross-sectional study was performed on 80 female emmetrope subjects aged between 18-16 years old. Convenient sampling technique was applied for collecting the sample size. Repeated measure ANOVA test was applied on the values of reading speed. The result showed mean square of sphericity assumed as 1844.358, and that of Greenhouse-Geisser was 2126.312. The value of significance level was found to be P=0.001 respectively.

Table-3: Repeated Measure ANOVA of Reading Speed before and after caffeine Intake

Source		Type III Sum of Square	df	Mean Square	F	Sig.
Time	Sphericity Assumed	5533.075	3	1844.358	6.224	.000
	Greenhouse-Geisser	5533.075	2.602	2126.312	6.224	.001

This descriptive cross-sectional study was carried out at The University of Faisalabad and involved 80 healthy female emmetropes aged 18-26 years, who were selected through convenient sampling. The objective of the study was to evaluate the impact of caffeine on the AC/A ratio, near point of convergence (NPC), and reading speed before and after consuming 100 mg of Nestle black coffee. The results showed significant decreases in the mean values of NPC (P=0.000), AC/A ratio (P=0.046), and reading speed (P=0.001) after caffeine intake at intervals of 30, 60, and 90 minutes.

DISCUSSION

Descriptive cross-sectional study design was used to conduct this study. 80 healthy female subjects were selected through convenient sampling technique. Age of subjects was between 18-26 years old. This study was conducted in The University of Faisalabad (TUF), Faisalabad in the time duration of September 2023 to May 2024. Only females, emmetropes and caffeine consumers were taken in this study. Subjects with refractive errors, ocular pathologies and systemic diseases were excluded from the study. Informed verbal and written consent were taken from the subjects regarding this study. AC/A ratio, NPC and Reading speed were assessed in decaffeinated subjects. After that 100 mg of nestle black coffee (containing caffeine) was consumed by each subject and again AC/A ratio, NPC and reading speed were measured with a time interval of 30, 60 and 90 minutes. AC/A ratio and NPC were assessed by heterophoric method and using Royal Air Force ruler (RAF) respectively. Reading speed was also assessed by Times New Roman N10 print. Result showed decrease in the mean value of NPC after caffeine intake in successive time intervals (P=0.000). A significant decrease in the value of AC/A ratio was observed after caffeine intake as compared to baseline value (P=0.046). Similarly, reading speed was also decrease from the baseline value (P=0.001) after caffeine intake.

A randomized control trial study was conducted by Odjhimogho in 2019 included 30 emmetropes and non-habitual caffeine users consisting of 15 males and 15 females aged between 19-30 years. The basic purpose of study was near vision assessment by measuring amplitude of accommodation and near point of convergence (NPC) post caffeine consumption. The participants were subdivided into two other groups A and B. 100 mg of caffeine concentration was given to group A and 200 mg of caffeine was given to group B. The value of mean NPC decreased significantly (P<0.05). (14) Current descriptive cross-sectional

study consisted of 80 healthy female emmetropes aged between 18-26 years old. Effect of AC/A ratio, NPC and reading speed was assessed before and after 100 mg of caffeine intake. Repeated Measure ANOVA test was applied. The mean value of NPC, AC/A ratio and reading speed showed significant decrease (P=0.000), (P=0.046) and (0.001) from the mean baseline values respectively.

Murari conducted a randomized control, crossover study in 2018 which included 49 normal healthy individuals age above 18 years old. The purpose of assessment was measurement of reading performance, accommodative power, pupil size, choroidal thickness and Tear Break up Time after caffeine consumption. These subjects were given placebo capsules and 200 mg of caffeine and were assessed after 1 hour and 2 hours respectively. The data was statistically analyzed by repeated measure ANOVA. This study showed that reading rate increased significantly after caffeine intake (P<0.05). (15) Current study was conducted by using convenient sampling technique in which 80 female subjects aged between 18 to 26 years old were included. Caffeine consumer subjects were taken to find out the effect of caffeine over NPC, AC/A ratio and reading speed after consumption of 100 mg nestle coffee with time interval of 30, 60 and 90 minutes. The study conducted in 2018 showed an increase in reading performance. Conversely, current study showed a decrease in mean baseline value of reading speed (P=0.001) after caffeine intake. NPC (P=0.000) and AC/A ratio (P=0.046) were also decreased from mean baseline value after caffeine intake.

CONCLUSION

This descriptive cross-sectional study involved 80 healthy female participants and examined how caffeine affects near vision parameters such as the AC/A ratio, NPC, and reading speed. After establishing baseline values for these parameters in subjects who had not consumed caffeine, each participant ingested 100 mg of Nestlé black coffee, and measurements were taken again at 30, 60, and 90 minutes after consumption. The results showed a significant decrease in NPC (10.27±4.784, P=0.000), AC/A ratio (4.2709±1.16512, P=0.046), and reading speed (159.71±21.772, P=0.001) following caffeine intake. These findings indicate that caffeine consumption has a negative impact on near vision and reading performance, leading to reductions in NPC, AC/A ratio, and reading speed. This study concluded that excessive caffeine consumption had adverse effect on near vision and reading speed. Moreover, it also decreased the amount of AC/A ratio.

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Authors Contributions:

Hadia Nisar and Nida Amin: Substantial contribution to the conception, design of the work and implementation

Rabbia Tariq: Survey and design of the work

Nashrah Khaliq: Materials and data collection

Shahan Yamin Siddiqui: SPSS computing tool and drafting for approval of the final version to be published