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EFFECT OF ACTIVE AND PASSIVE SMOKING ON AMPLITUDE OF ACCOMMODATION, NEAR POINT OF CONVERGENCE AND PUPIL SIZE

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Abstract

Background:
Smoking is a major risk factor for numerous ocular and systemic diseases. Nicotine exerts significant physiological effects on multiple organ systems, including the eye.

Aim:
This study aimed to evaluate and compare the acute effects of active and passive smoking on pupil size, amplitude of accommodation, and near point of convergence.

Methodology:
A comparative cross-sectional study was conducted at the University of Faisalabad. Thirty participants aged 18–25 years were enrolled after obtaining informed consent. Participants were instructed to abstain from caffeine-containing products and tobacco smoking for 12 hours prior to baseline measurements. Active smokers then smoked a cigarette containing 1.0 mg of nicotine, while passive smokers were exposed to the same cigarette smoke. Pupil size was measured using a pupillary distance ruler, and amplitude of accommodation and near point of convergence were assessed with a Royal Air Force rule five minutes after exposure. Data were recorded on a self-designed proforma and analyzed using paired-sample and independent-sample t-tests in SPSS software.

Results:
Mean ± standard deviation values before and after smoking were as follows:
Pupil size: 6.0 ± 0.5252 mm vs. 5.017 ± 0.3592 mm
Amplitude of accommodation: 11.10 ± 0.803 D vs. 9.23 ± 1.194 D
Near point of convergence: 7.03 ± 0.964 cm vs. 8.63 ± 1.066 cm
All changes were statistically significant ($p < 0.05$; $p = 0.00$). Pupil size and amplitude of accommodation were similarly affected in active and passive smokers ($p = 0.075$ and $p = 0.093$, respectively), whereas near point of convergence was less affected in passive smokers compared with active smokers ($p = 0.023$).

Conclusion:
Both active and passive smoking produce acute, transient effects on pupil size, amplitude of accommodation, and near point of convergence.

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INTRODUCTION

Smoking is one of the leading preventable causes of morbidity and mortality worldwide. Cigarette smoke contains thousands of harmful chemicals, including nicotine, tar, carbon monoxide, and other toxic substances that can adversely affect different organs of the body (1,2). Both active and passive smoking have been associated with several health complications. Smoking is also an important risk factor for various ocular disorders, including dry eye disease, cataract, glaucoma, age-related macular degeneration, and thyroid eye disease (3,4,5). These harmful effects are primarily associated with oxidative stress, vascular changes, and damage to ocular tissues caused by toxic substances present in tobacco smoke (6,4).

Nicotine is the major addictive component of tobacco and is responsible for many of the immediate physiological effects of smoking. It acts on nicotinic acetylcholine receptors in the nervous system, stimulating the release of neurotransmitters such as dopamine and influencing autonomic activity (7,8). Nicotine also causes vasoconstriction and increases heart rate and blood pressure, which may affect blood circulation throughout the body, including the ocular structures (9,10). Previous studies have demonstrated that nicotine exposure can produce changes in pupil size and other visual functions, suggesting its potential influence on ocular physiology (11,12).

The visual system involves several coordinated mechanisms that allow the eyes to maintain clear vision at different viewing distances. Accommodation and convergence are two essential components of binocular vision, particularly during near activities. Accommodation refers to the ability of the eye to change its optical power to maintain a clear retinal image of objects at varying distances (13). This process primarily involves contraction of the ciliary muscle, relaxation of zonular fibres, and an increase in the curvature and thickness of the crystalline lens, resulting in increased refractive power for near vision (14).

The accommodative response is accompanied by pupillary constriction and convergence, collectively known as the near triad. These responses occur simultaneously when shifting fixation from a distant object to a near target. The near reflex involves the coordinated activity of the visual cortex, midbrain centres, Edinger–Westphal nucleus, and oculomotor nerve (15). Any alteration in these mechanisms may influence near visual performance and binocular coordination.

Previous research has investigated the effects of cigarette smoking on accommodative function and pupillary responses. Exposure to cigarette smoke has been reported to reduce the amplitude of accommodation by approximately 0.50 dioptres in some studies (6). However, other investigations have reported an increase in accommodative response following smoking, possibly due to transient pupillary constriction and an increase in depth of focus (16). Nicotine administration has also been associated with significant changes in pupil diameter, with an initial constriction followed by subsequent changes in pupillary size (11,12). These findings suggest that smoking may influence different components of the visual system through its effects on autonomic and ocular mechanisms.

Convergence is the simultaneous inward movement of both eyes to maintain binocular fixation on a near object. The convergence system consists of four components: tonic, accommodative, fusional, and proximal convergence. Their coordinated functioning is necessary to maintain single binocular vision during near activities (15). The near point of convergence (NPC) is an important clinical measurement used to evaluate the maximum convergence ability of both eyes. It represents the closest point at which an individual can maintain binocular fixation on a target without experiencing diplopia or losing ocular alignment (17).

NPC is commonly assessed by moving a fixation target slowly towards the patient's eyes while observing the point at which one eye deviates outward or the patient reports double vision. This distance is recorded as the break point, while the distance at which single vision is regained is recorded as the recovery point. In young adults, a break point of less than 5 cm and a recovery point of less than 7 cm are generally

considered expected findings (18). An abnormal NPC is frequently associated with convergence insufficiency, which may cause symptoms such as eyestrain, headaches, blurred vision, and difficulty performing near tasks (19).

Several factors, including age and accommodative function, may influence NPC measurements. Age-related changes in accommodation can affect accommodative convergence and consequently alter convergence performance (17). Therefore, NPC assessment is an important part of routine binocular vision evaluation.

Although previous studies have explored the effects of smoking on ocular health, accommodation, and pupillary responses, limited evidence is available regarding its association with convergence function. Considering the potential influence of nicotine on ocular physiology and the mechanisms involved in near vision, it is important to investigate whether smoking is associated with changes in convergence ability. Therefore, the present study aims to evaluate and compare the near point of convergence among smokers and non-smokers.

Materials and Methods

A comparative cross-sectional study was conducted at The University of Faisalabad, Faisalabad, from February to June 2023. A total of 30 male participants aged 18–25 years were recruited through purposive sampling and divided into two groups: 15 active smokers and 15 passive smokers. Active smokers who consumed at least one cigarette per day (containing 1 mg nicotine) and passive smokers exposed to cigarette smoke for at least one hour daily were included. Participants with emmetropic refraction, normal amplitude of accommodation, normal NPC, and mesopic pupil size ranging from 5.5–7.3 mm were selected. Individuals with refractive errors, accommodative or convergence anomalies, systemic diseases, ocular abnormalities, previous ocular surgery or trauma, medication use for ocular disorders, drug addiction, stress conditions, or poor cooperation were excluded. Data were collected using a self-designed proforma. The Royal Air Force (RAF) rule was used to measure near point of convergence (NPC) and amplitude of accommodation, while a pupillary distance ruler was used to measure pupil diameter under mesopic conditions (0.01–3.0 cd/m²). Written informed consent was obtained from all participants. Before baseline measurements, participants were instructed to avoid caffeine-containing products and tobacco smoking for 12 hours. Subsequently, active smokers smoked a cigarette containing 1 mg of nicotine, while passive smokers were exposed to cigarette smoke. After five minutes of exposure, pupil diameter, NPC, and amplitude of accommodation were measured using the respective instruments. Participants with an amplitude of accommodation of 10–12 dioptres and NPC of 6–9 cm were considered within the study's specified normal ranges.

RESULTS

Demographic Characteristics

A total of 30 participants aged between 18 and 25 years were evaluated in this study. The sample consisted of two equal cohorts: active smokers (n = 15) and passive smokers (n = 15). The overall mean age of the participants was 21.87 ± 1.995 years.

Table 1: Baseline Demographic Characteristics of Participants

Parameter	N	Minimum	Maximum	Mean	Std. Deviation (SD)
Age (Years)	30	18	25	21.87	1.995

Intra-Group Comparisons (Pre- vs. Post-Exposure)

1. Pupil Size

The baseline mean pupil size before smoking exposure was 6.000 ± 0.5252 mm. Five minutes post-exposure, the mean pupil size decreased significantly to 5.017 ± 0.3592 mm. A paired samples t-test revealed a mean reduction of 0.9833 ± 0.4251 mm, which was statistically significant ($p < 0.001$).

2. Amplitude of Accommodation (AoA)

Before exposure, the baseline mean amplitude of accommodation across all participants was 11.10 ± 0.803 D. Following 5 minutes of smoking exposure, the mean amplitude of accommodation significantly decreased to 9.23 ± 1.194 D. Paired t-test analysis demonstrated a statistically significant mean reduction of 1.867 ± 1.106 D ($p < 0.001$).

3. Near Point of Convergence (NPC)

The mean baseline near point of convergence was 7.03 ± 0.964 cm. Five minutes post-exposure, the mean NPC receded significantly to 8.63 ± 1.066 cm. Paired t-test comparison indicated a significant mean change of -1.600 ± 0.675 cm ($p < 0.001$), demonstrating a substantial reduction in convergence performance.

Table 2: Paired Pre- and Post-Exposure Ocular Parameters (N = 30)

Ocular Parameter	Pre-Exposure (Mean ± SD)	Post-Exposure (Mean ± SD)	Paired Mean Difference	Std. Error Mean	p-value
Pupil Size (mm)	6.000 ± 0.5252	5.017 ± 0.3592	0.9833 ± 0.4251	0.0776	< 0.001
Amplitude of Accommodation (D)	11.10 ± 0.803	9.23 ± 1.194	1.867 ± 1.106	0.202	< 0.001
Near Point of Convergence (cm)	7.03 ± 0.964	8.63 ± 1.066	-1.600 ± 0.675	0.123	< 0.001

Inter-Group Comparisons (Active vs. Passive Smokers)

An independent sample t-test was conducted to evaluate baseline and post-exposure differences between active (n = 15) and passive (n = 15) smokers.

• Pupil Size: No statistically significant difference was observed between active and passive smokers before exposure ($p = 0.735$) or after exposure ($p = 0.075$).

• Amplitude of Accommodation: No statistically significant difference was found between active and passive smokers before exposure ($p = 0.263$) or after exposure ($p = 0.093$).

• Near Point of Convergence: A statistically significant difference in NPC was observed between groups both before exposure (7.40 cm vs. 6.67 cm, $p = 0.035$) and after exposure (9.07 cm vs. 8.20 cm, $t = 2.402$, $p = 0.023$).

Table 3: Comparison of Active vs. Passive Smokers Across Parameters

Parameter	Group	N	Pre-Exposure Mean ± SD	Post-Exposure Mean ± SD	Post-Exposure t-value	Post-Exposure p-value
Pupil Size (mm)	Active Smoker	15	5.967 ± 0.5164	4.900 ± 0.2803	-1.852	0.075
	Passive Smoker	15	6.033 ± 0.5499	5.133 ± 0.3994		
Amplitude of Accommodation (D)	Active Smoker	15	10.93 ± 0.884	8.87 ± 1.187	-1.739	0.093
	Passive Smoker	15	11.27 ± 0.704	9.60 ± 1.121		
Near Point of Convergence (cm)	Active Smoker	15	7.40 ± 0.986	9.07 ± 0.961	2.402	0.023*
	Passive Smoker	15	6.67 ± 0.816	8.20 ± 1.014		

DISCUSSION

Effect of active and passive smoking on different parameters of eye (pupil size, amplitude of accommodation and near point of convergence) was evaluated in this study. The purpose of this study was to compare smoking effect on ocular parameters between active and passive smokers. Patients of age 18 to 25 years were included in this study. Total 30 people were selected out of which 15 were active smokers and 15 were passive smokers.

In a research done in 2022 by Latif. N et al, short term effects of smoking were carried out in smokers who smoke regularly. This test was carried out to see the effect of smoking on pupil size and accommodation. Forty five participants were chosen for this test and their ages were between 18-50 years. They were told not to smoke at least 1 hour before the test. These smokers were tested within five minutes after smoking a cigarette. They concluded that smoking exposure decreases the amount of amplitude of accommodation as determined by the subjective royal air force rule.

They discovered that exposure to cigarette smoke reduced the amplitude of accommodation by roughly 0.50D on average (6). In our research, we measured amplitude of accommodation before and after smoking. We chose 30 participants out of which 15 were active smokers and 15 were passive smokers. Their ages were 18-25 years. People with normally having 10-12 diopters amplitude of accommodation were considered. All participants were instructed to stop using any caffeine-containing products or smoking tobacco 12 hours before baseline readings. We discovered that in both active and passive smokers, amplitude of accomodation was decreased having 9.23 diopter mean value after consumption of cigarette and also their pupil sizes decreased.

A research was conducted by Bardak. H et al in 2017 found that smoking causes a decrease in pupil size and they also studied that smoking cigarettes increases the amplitude of accommodation. Thirty four cigarette smokers were involved and all of these participants were asked to smoke a cigarette that contains 1.0mg of nicotine.

Participants were asked to abstain from smoking 12 hours prior to the test. Participant with any systemic or ocular abnormality were excluded. None of the participants had ever undergone trauma or eye surgery. There was not a single study participant who had ever taken medication for eye diseases. Their inclusion criteria were to use same 24room lighting for all of the measurements. All measurements were taken with the normal pupil size (16). In present study, all participants were emmetropes with normal amplitude of accommodation included. Participants with mesopic pupil size 5.5 to 7.3mm and room luminance of 0.01 to 3.0 cd/m2 were included. Participants with any refractive error, accommodative anomalies and convergence anomalies were excluded and people with any systemic disease, mentally retarded and non-cooperative patients were also eliminated. Stress conditions and drug addicted persons and subject with

any history of ocular surgery or trauma, any history of medication for ocular disorders and any ocular abnormality were excluded. Results were decreased pupil size, decreased amplitude of accomodation and near point of convergence. Hashemi H et al. carried out a population-based cross-sectional study in Iran in 2019. In their study, the near point of convergence was determined by displaying the near Snellen chart to the patient and target at a suggested constant speed of around 1 cm/s, one line above the highest corrected visual acuity. The target was moved to within 50 centimetres of the person. By taking a brief smoking history, they compare older people who have smoked and those who have not. They came to the conclusion that there was no discernible link between smoking and the near point of convergence (17). We measured near point of convergence by the help of Royal Air Force rule or convergence rule after 5 minutes of smoking. In our research, we found out that there is a noticeable change in the near point of convergence after consuming a cigarette, for both smoking actively and passively. We included participants of age 18-25 years and their normal near point of convergence was 6 cm to 10 cm. Near point of convergence. We asked them not to consume any caffeinated products or smoke for 12 hours prior to the test. Then we noted a reading before

starting test and after 5 minutes of smoking. Their near point of convergence also decreased with mean value of 8.63 cm after they consumed 1.0 mg of nicotine in smoke. Same happened with person who smoked passively, their near point of convergence decreased.

A research that was published in 2012 by Sobac. G. et al, conducted in Military Medical Academy and Medical School, Etlik, Turkey. They investigated how long- term smoking affected pupil and people ability to recover from photostress. Forty individuals who had been heavy smokers for at least five years, along with forty same age and same gender non smokers, were enrolled. They were chosen among adults between the ages of 20 and 39 who did not have any other ocular issues aside from refractive defects. The patient right eyes were only examined during the investigation. 25The pupillometer built into the Nidek OPD Scan (Nidek by Gamagori, Japan) was used to measure pupil diameters. The Nidek OPD scan automatically takes three measurements and outputs the mean of those three measurements. They concluded that long-term smoking can cause pupil dilation and raise the macular foveal threshold value right after photostress (20). In our current study we used pupillary distance ruler to assess pupil size and royal air force rule for amplitude of accommodation and near point of convergence after 5 minutes of smoking.We investigated short term effects of active and passive smoking on ocular parameters. Then, active smokers were allowed to consume cigarette containing 1.0 mg of nicotine and passive smokers were allowed to expose that cigarette smoke. Only male patients between 18 to 25 years of age were our subjects. Erdem U. et al. conducted a study in 2015 on the impact of cigarette smoking on pupil size in photopic and mesopic circumstances. Every participant was told to inhale one cigarette with 1.0 mg of nicotine. Three measurements in both mesopic and photopic conditions were made. The mean photopic pupil size decreased with smoking, from 3.52 0.73 mm to 3.29 0.58 mm with p value 0.001. Furthermore, smoking was associated with a p-value of 0.001 drop in the mean mesopic pupil size, which went from 6.42 0.75 mm to 6.14 0.75 mm. Their investigation thus came to the conclusion that smoking causes the pupil's size to decrease (12). In current study SPSS statistical software was used to analyze all of the statistical data. The mean value of pupil size decreased from 6 mm to 5.017 mm with $p<0.05$. The mean value of amplitude of accomodation was 11.10 diopter before smoking and 9.23 diopters after smoking with $p<0.05$. Mean value of near point of convergence changed from 7.03 cm before smoking to 8.63 cm after smoking with $p<0.05$. Thus it showed that for all three parameters values decreased from its initial values.

CONCLUSION

- This study concluded that active and passive smoking constricted the pupil, amplitude of accomodation and near point of convergence immediately after smoking. A short term effect of smoking was noted after 5 minutes of smoking a cigarette.
- There is same effect of active and passive smoking on amplitude of accomodation and pupil size, both showed a decrease in its value. For near point of convergence active smoking showed notable result than passive smoking.

Limitations and Recommendations

This study has several methodological constraints that limit the generalizability of its findings. The sample was restricted to a small cohort of 30 male participants aged 18 to 25, which excludes females and older age groups. Additionally,measurement techniques relied on simpler or subjective tools: pupil size was measured using a pupillary distance ruler rather than specialized digital equipment, and the amplitude of accommodation was evaluated subjectively using an RAF rule rather than objective methods. Finally, the scope of exposure was limited to an acute dose of only 1 mg of nicotine. To build upon these findings, public education campaigns should emphasize quitting smoking to preserve eye health and protect against the risks of secondhand smoke. Scientifically, future research should assess higher daily dosages of nicotine and examine the chronic, long-term impacts of smoking. Further studies should also investigate the specific ocular effects of other harmful chemical components present in

cigarette smoke, such as carbon monoxide,ammonia, and tar.

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