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Impact of Aerobic Exercise on Tear Volume in Healthy Young Adults

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ABSTRACT

***Background**:* This study evaluates the impact of a 5-minute aerobic exercise session on tear volume in healthy young adults, with comparisons across sex.

Methods: Sixty-four healthy adults (33 females, 31 males; ages 18–28) were recruited from the University of Ilorin. Inclusion criteria included normal ocular health and the ability to cycle moderately for 5 minutes. Exclusion criteria were any conditions affecting tear production, medications altering it, contact lens use, recent ocular surgeries, or exercise contraindications. Informed consent was obtained. Data were analysed using SPSS (Version 25.0) with descriptive demographics and tear volume statistics. The Shapiro-Wilk test assessed normality, paired-samples t-tests compared tear volume under different conditions, and independent-samples t-tests compared sexes, with significance at $p < 0.05$.

Result: Paired t-tests showed a significant decrease in tear volume during exercise compared to before ($t(63) = 3.36$, $p < .001$) and a significant increase after exercise compared to during ($t(63) = -3.02$, $p = .004$). No significant difference was found between before and after exercise ($t(63) = -0.50$, $p = .617$). These findings indicate that exercise temporarily lowers tear volume, with a subsequent recovery post-exercise.
Conclusion: This study demonstrates that short durations of aerobic exercise can increase tear secretion in healthy individuals.

***Keywords**:* Aerobic exercise, Dry eye, Tear volume, Schirmer I test, Sex differences, Ocular health.

1. INTRODUCTION

Tear production is essential for maintaining ocular surface health, providing lubrication, nutrition, and protection against environmental irritants [1]. Disruptions in tear quantity or quality can lead to dry eye disease, which impacts the quality of life [2]. Age, hormonal changes, and systemic diseases influence tear production [3]. Modern lifestyles, characterised by prolonged digital device use and reduced physical activity, have been associated with increased dry eye symptoms across age groups [4]. Aerobic exercise affects ocular parameters, including intraocular pressure, ocular blood flow, and visual function [5; 6]. It also enhances systemic circulation and autonomic nervous system activity, potentially influencing lacrimal gland function through neural or hormonal pathways [7; 8;9]. However, the specific effects of aerobic exercise on tear volume in healthy populations remain underexplored. This study investigates whether a short-duration aerobic exercise session alters tear volume in healthy young adults and examines potential sex differences. The findings may inform strategies to promote ocular surface health through physical activity.

2. MATERIALS AND METHODS.

2.1: Materials

2.1.1 Study Design

This within-subjects experimental study assessed changes in tear volume before, during, and after a 5-minute cycling session, with a between-subjects comparison of female and male participants. The study was conducted at

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the University of Ilorin Optometry Clinic, Nigeria, under controlled conditions (temperature 22–24°C, humidity 40–50%) to minimise external effects on tear production.

2.1.2 Participants
Sixty-four healthy adults (33 females, 51.6%; 31 males, 48.4%; 18–28 years, mean 21.34 ± 2.20 years) were recruited from the University of Ilorin community. Inclusion criteria included normal ocular health (assessed via slit-lamp examination) and the ability to cycle moderately for 5 minutes. Exclusion criteria included ocular or systemic conditions affecting tear production (e.g., dry eye, diabetes), medications altering tear production, contact lens use, recent ocular surgery (within 6 months), or exercise contraindications (e.g., cardiovascular issues). Written informed consent was obtained.

2.2: Method:
Tear volume was measured using the Schirmer I test in three phases: pre-exercise (baseline), during exercise, and post-exercise. Measurements were conducted in the right eye to standardise and minimise inter-eye variability.
2.2.1 Pre-Exercise Measurement
Participants underwent ocular health screening, and demographic data (age, sex) were recorded. Baseline tear volume was measured using the Schirmer I test (without anaesthesia).
Sterile 35-mm Schirmer strips were placed in the lower conjunctival sac for 5 minutes, and wetting length (mm) was recorded.

2.2.2 Exercise Protocol
Participants cycled for 5 minutes on a stationary ergometer at moderate intensity (50–70% of age-predicted maximum heart rate, calculated as 220 – age). This duration was chosen to elicit a physiological response (e.g., autonomic activation) without causing significant fatigue, based on prior studies of short-duration exercise effects (Sun et al., 2022). Heart rate was monitored to ensure compliance.

2.2.3 During-Exercise Measurement
Tear volume was measured during the final minute of cycling using the Schirmer I test. Participants briefly reduced cycling speed to allow safe strip placement, minimizing movement artifacts. Strips were placed under controlled conditions to reduce evaporation effects.

2.2.4 Post-Exercise Measurement
After cycling, participants rested for exactly 2 minutes to standardize recovery time, and tear volume was measured using the Schirmer I test, following the same protocol.

2.2.5 Tear Volume Measurement
The primary outcome, tear volume, was quantified in mm using the Schirmer I test. Wetting length was recorded and categorized into clinically relevant ranges (<10 mm, 10–20 mm, >20 mm) based on dry eye thresholds (Stapleton et al., 2017). A single trained examiner performed measurements under sterile conditions to ensure consistency.

2.2.6 Ethical Considerations
The University of Ilorin Ethics Committee approved the study. Participants provided informed consent, and data confidentiality was ensured. Heart rate monitoring ensured participant safety during exercise, and no adverse events occurred.

2.3: Statistical Analysis:
Data were analysed using SPSS (Version 25.0). Descriptive statistics (frequencies, means, standard deviations, 95% CI's) summarized demographics and tear volume. Shapiro-Will tests assessed normality. Paired-samples t-tests compared tear volume across conditions (pre-, during, post-exercise), and independent-samples t-tests compared sexes. Significance was set at $p < 0.05$.

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3. RESULTS

3.1 Demographic Characteristics:

Sixty-four participants (33 females, 31 males; mean age 21.34 ± 2.20 years, 95% CI: 20.79–21.89 years) were included. Most participants (62.5%) were aged 18–21 years, followed by 22–25 years (31.3%) and 26–28 years (6.2%), as shown in Figure 1 and Figure 2.

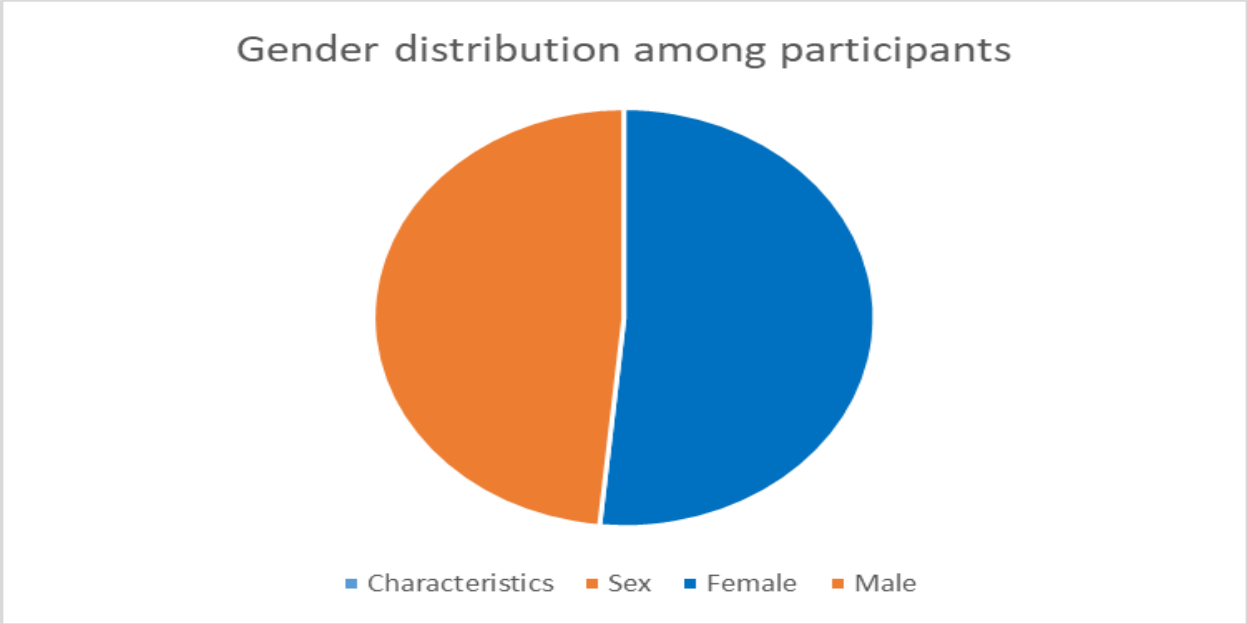

Figure 1: Gender distribution among participants

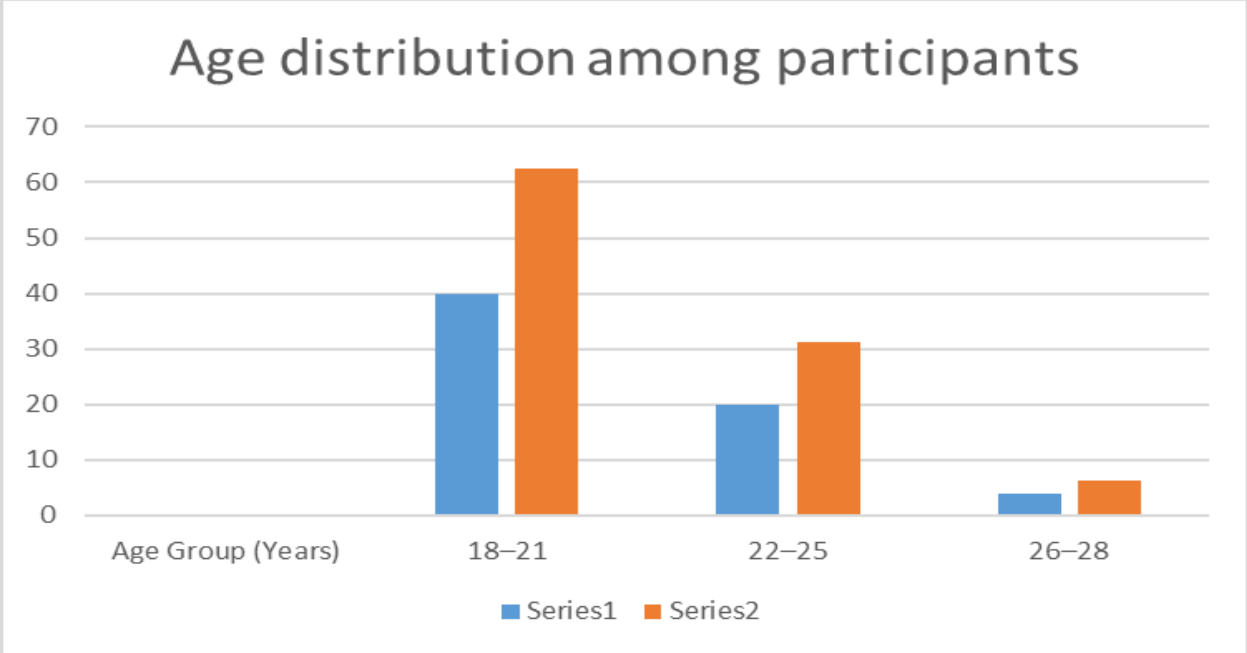

Figure 2: Age distribution among participants

3.2 Tear Volume Distribution:
Table 1 shows tear volume distributions. Before exercise, 28.1% of participants had tear volumes <10 mm, 45.3% had 10–20 mm, and 26.6% had >20 mm. During exercise, 37.5% had <10 mm, 48.4% had 10–20 mm, and 14.1% had >20 mm. Post-exercise, 21.9% had <10 mm, 39.1% had 10–20 mm, and 39.0% had >20 mm.

Table 1: Tear Volume Distribution Across Conditions

Tear Volume	Before Exercise	During Exercise	After Exercise
	n (%)	n (%)	n (%)
<10 mm	18 (28.1)	24 (37.5)	14 (21.9)
10–20 mm	29 (45.3)	31 (48.4)	25 (39.1)
>20 mm	17 (26.6)	9 (14.1)	25 (39.0)
Total	64 (100)	64 (100)	64 (100)

3.3 Differences in Tear Volume Across Conditions:
Mean tear volumes were 20.91 ± 11.12 mm (95% CI: 18.13–23.68 mm) before exercise, 15.88 ± 11.08 mm (95% CI: 13.11–18.64 mm) during exercise, and 21.77 ± 12.15 mm (95% CI: 18.73–24.80 mm) after exercise. Shapiro-Wilk tests confirmed normality for tear volume differences (pre- vs. during: $W = .97$, $p = .133$; pre- vs. post: $W = .98$, $p = .330$). Paired t-tests showed a significant decrease in tear volume during exercise compared to baseline ($t(63) = 3.36$, $p < .001$) and a significant increase post-exercise compared to during exercise ($t(63) = -3.02$, $p = .004$). No significant difference was found between pre- and post-exercise ($t(63) = -0.50$, $p = .617$), as shown in Table 2.

Table 2: Paired Comparisons of Tear Volume Across Conditions

Paired Differences	Mean (mm)	SD (mm)	t	df	p
Before – During Exercise	5.03	11.99	3.36	63	< .001
Before – After Exercise	-0.86	13.68	-0.50	63	.617

3.4 Sex Differences in Tear Volume:
Independent t-tests showed no significant differences in tear volume between females (M = 21.64 ± 10.76 mm) and males (M = 20.13 ± 11.62 mm) before exercise ($t(62) = .539$, $p = .592$) or after exercise (females: M = 23.18 ± 12.16 mm; males: M = 20.26 ± 12.16 mm; $t(62) = .961$, $p = .340$). During exercise, males had significantly lower tear volumes (M = 12.55 ± 10.21 mm) than females (M = 19.00 ± 11.11 mm; $t(62) = 2.415$, $p = .019$), as shown in Table 3.
Table 3: Sex Differences in Tear Volume Across Conditions

Condition	Group	M (mm)	SD (mm)	t	df	p
Before Exercise	Female	21.64	10.76	.539	62	.592
	Male	20.13	11.62			
During Exercise	Female	19.00	11.11	2.415	62	.019
	Male	12.55	10.21			
After Exercise	Female	23.18	12.16	.961	62	.340
	Male	20.26	12.16			

4. DISCUSSION

This study found a significant reduction in tear volume during a 5-minute aerobic exercise session (M = 15.88 ± 11.08 mm) compared to baseline (M = 20.91 ± 11.12 mm; t(63) = 3.36, p < .001), with recovery to baseline levels post-exercise (M = 21.77 ± 12.15 mm; p = .617). These findings suggest that short-duration exercise temporarily suppresses tear production or increases tear evaporation, consistent with [10], who reported exercise-induced disruptions in tear film dynamics. Potential mechanisms include increased blink rates, air movement during cycling enhancing evaporation [11] or autonomic nervous system shifts reducing lacrimal gland secretion during exercise (9Dartt, 2009). The post-exercise recovery likely reflects restored hydration or autonomic balance, as the lacrimal gland resumes normal function [12]. The shift in tear volume distribution supports these findings. During exercise, 37.5% of participants had tear volumes <10 mm (indicative of low tear production; [2], compared to 28.1% pre-exercise. Post-exercise, 39.0% had tear volumes >20 mm, suggesting a compensatory response. Unlike [13], who reported a significant post-exercise tear volume increase (24.77 ± 2.46 mm; p < .001) in athletes, this study found no significant increase post-exercise, possibly due to differences in participant fitness levels or exercise protocols.

No sex differences were observed before (p = .592) or after (p = .340) exercise, indicating comparable baseline and recovery tear production. However, during exercise, males had significantly lower tear volumes than females (p = .019). This may reflect higher male sweat rates increasing tear evaporation or sex-specific hormonal influences on lacrimal gland function [14]. For example, androgens may suppress tear production under stress, while estrogens may stabilise it [8]. This finding suggests males may experience greater ocular surface stress during exercise, warranting further investigation. The transient reduction in tear volume during exercise could temporarily compromise ocular surface protection, though no participants reported discomfort. Athletes or individuals engaging in prolonged exercise may benefit from protective measures, such as eyewear to reduce evaporation or artificial tears to maintain tear film stability [10].The sample size (n = 64) and focus on young adults (18–28 years) limit generalizability to older or clinical populations. The 5-minute exercise duration may not reflect typical aerobic activities, and tear film composition or quality was not assessed, limiting insights into overall tear film dynamics. Despite controls, environmental factors (e.g., air movement during cycling) may have influenced measurements during exercise. The sex difference during exercise warrants further exploration, including the influence of hormones and fitness levels.

5. CONCLUSION

This study demonstrates that a 5-minute aerobic exercise session significantly reduces tear volume in healthy young adults during exercise (p < .001), with recovery to baseline levels post-exercise (p = .617). Males exhibit lower tear volumes than females during exercise (p = .019), suggesting sex-specific responses. These findings highlight the transient impact of short-duration exercise on tear production and the potential need for protective measures during physical activity to maintain ocular surface health. Further research is needed to elucidate underlying mechanisms and explore long-term or clinical implications.

DECLARATIONS:

Acknowledgment: None.

Conflict of Interest: The authors declare no conflict of interest.

Authors Contributions:

Ayodeji E. Ige: Contributed to methodology, proofreading, editing, and supervision. Oluwasola M. Ojo: Contributed to supervision and proofreading. Ayoola G. Grace: Contributed to data collection, data analysis, and methodology.

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