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Research Article

Effect of Bike Riding Activity on the Tear Film Parameters in Dry Eye Subjects: An Observational Nonrandomized Comparative Study

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Abstract

Background: Bike riding is beneficial to health and leads to a significant decrease in the rate of mortality and morbidity. However, bike riding could disrupt the balance of moisture in the tear film, leading to dry eye symptoms.

Aim: To test the effect of bike riding, for the first time, on the tear meniscus height (TMH), noninvasive breakup time (NITBUT), and lipid layer patterns (LLP) in dry eye subjects using a single device.

Methods: Forty dry-eye males aged 18 to 35 years (29.3 ± 6.7 years) were recruited. A control group of 40 males with dry eyes (18 - 36 years; 28.5 ± 4.3 years) participated in the study for comparison. The measurements were carried out before bike riding, and the cyclists were allowed to cycle for 50 minutes. The measurements were repeated after bike riding. The subjects in the control group were allowed to stay in the open air for 50 minutes, and the measurements were performed at 0 and 50 minutes.

Results: For the study group, a significant (Wilcoxon signed-ranks test, $P < 0.001$) difference was found between the median NITBUT scores before and after bike riding. On the other hand, no significant differences were found between the TMH ($P = 0.321$) and LLP grades ($P = 0.552$) before and after bike riding. For the control group, no significant differences were found between the two measurements of the NITBUT ($P = 0.914$), TMH ($P = 0.113$), and LLP ($P = 0.480$) at 0 and 50 minutes.

Conclusion: The EASYTEAR view+ was used for the first time to assess the effect of bike riding on some tear film parameters in dry eye subjects. The TBUT time was significantly shorter after bike riding compared with pre-riding. No significant differences were found in the TMH measurements and LLP before and after bike riding.

***Keywords:** Tear Film; Lipid Layer Patterns; Noninvasive Tear Breakup Time; Bike Riding; Dry Eye*

Introduction

Tear film lubricates the ocular surface, protects the eye against outside pathogens invasion, and supplies oxygen and nutrients to the cornea. In addition, it is responsible for smoothing the cornea's surface and facilitating eyelid movement [1]. The tear film contains an outer lipid layer (e.g. polar and non-polar lipid) and a mucoaqueous inner phase (e.g. mucins, electrolytes, enzymes, and large molecules) in a biphasic structure [2,3]. The lacrimal glands secrete the aqueous contents. The Meibomian glands produce the lipid phase [4]. Lipids play an essential role in stabilizing the tear film stability and reducing tear evaporation [5]. Disrupting lacrimal and meibomian glands functions causes disorders and diseases in the tear film (e.g. dry eye) [6].

Dry eye is an ocular disease that affects a large proportion of the world's population. It is associated with smoking, contact lens wearing, weather, chronic illnesses, and digital screen use [7]. The loss of tear film homeostasis causes dry eyes. It leads to tear film instability and ocular discomfort (e.g. excessive tear evaporation, hyperosmolarity, irradiation, ocular inflammation, pain, and redness [1]. Tear evaporation, volume, stability, osmolarity, and quality should be assessed to avoid any ocular complications due to dry eye. The most common tests to detect eye dryness are noninvasive tear breakup time (NITBUT) [8], tears evaporation rate [9,10], phenol red thread (PRT) [11], Schirmer [12], tear meniscus height (TMH) [13], and osmolarity of tear film [14]. Recently, several tear film parameters, NITBUT, TMH, and lipid layer patterns (LLP), among smokers and subjects with a high body mass index have been assessed using a single device (EASYTEAR view+), and the measurements agreed with those reported using different instruments [15].

Physical activity protects against age-related disorders such as macular degeneration [16]. It reduces the risk of age-related cataracts [17-20] and oxidative stress. It increases the activity of antioxidants and improves general health [21]. In addition, it modulates inflammation by increasing the concentration of high-density lipoproteins and, therefore, inhibits lipid peroxidation [22,23]. Moreover, physical activity improves insulin resistance and lipid profile [24-26]. However, exposure to sunlight (ultraviolet radiation) could increase the risk of cataracts and oxidative stress [27]. Oxidative stress is associated with age-related disorders and leads to damage in the lens protein to cause cataracts. As a successful approach to managing certain persistent diseases, aerobic exercise can be utilized [28]. For example, tear secretion can be increased in diabetic mice after 8 weeks of aerobic activity [29]. Exercise has a beneficial effect on releasing some of the symptoms of discomfort in dry eye subjects [30]. For example, the pain experienced by dry eye subjects can be improved following 10 weeks of exercise [31].

The current research investigates for the first time the effect of bike riding for a short duration (50 minutes) on the NITBUT, TML, and LLP in dry eye subjects using a single device.

Methods

Subjects

Forty dry-eye males aged 18 to 35 years (29.3 ± 6.7 years) were recruited. A control group of 40 males with dry eyes (18-36 years; 28.5 ± 4.3 years) participated in the study for comparison. The subjects were recruited from Riyadh City, Saudi Arabia. Subjects with a history of ocular surgery or diseases were excluded. The TMH was performed first, followed by the NITBUT and LLP using EASYTEAR view+. Each subject's right eye was tested with five-minute intervals between tests. The measurements were carried out before bike riding, and the cyclists were allowed to cycle for 50 minutes. The measurements were repeated after bike riding. The subjects in the control group were allowed to stay in the open air for 50 minutes, and the measurements were performed at 0 and 50 minutes. The subjects were recruited from Riyadh City, Saudi Arabia. Subjects with a history of ocular surgery or diseases were excluded. The subjects in both groups were not allowed to wear glasses or a face shield. Written consent has been provided by participants prior to the research. The IRB committee at King Saud University (E-21-6474) approved the study. The participants were treated according to the tenets of the Helsinki Declaration.

The ocular surface disease index (OSDI)

The OSDI was used for the inclusion of dry eye subjects. All participants completed the OSDI, and subjects with a score ≥ 13 were allowed to participate in the study [32].

EASYTEAR view+

The NITBUT, TMH, and LLP were assessed using a single device, EASYTEAR view+ (EASYTEAR SRL, Via Maioliche, Trento, Italy). The instrument is easy to use, portable, and *in vivo* visualizes the lipid phase interference of the tear film. It requires a short sitting time compared with the classic test lacrimal. It has three intuitive buttons to select the type of illumination easily. In addition, it can be regulated across five levels, and a timer allows the calculation of average NIBUT. The measurements were carried out three times by two independent masked researchers. The measurements were carried out in January 2023 between 16:00 and 18:00. The temperature was between 19 and 24°C and the humidity was between 15 and 22%.

The NITBUT test

The NITBUT was measured as the time elapsed until the blur of the lines could be seen. It was recorded as the number of seconds between the appearance of the first dry spot in the tear film and the last blink. The cut-off of the NITUBT for dry eye is less than 10 seconds [33].

The TMH test

The TMH was measured as the height of the triangular-shaped cross-section between the margin of the lower lid and cornea. The cut-off of the TMH for dry eye is lower than 0.2 mm [34].

The LLP

The interference pattern formed by the lipid layer was visualized, and the LLP was assessed. The images of the LLP were graded based on the five-point scale (grades A, B, C, D, and E) [35]. Grade A (open meshwork or a gray appearance lipid layer) has a lipid layer thickness of 13-15 nm. Grade B (more closed meshwork or more compact lipid layer) has a lipid layer thickness of 30-50 nm. Grade C (grey wave) has a lipid layer thickness of 50-80 nm. Grades D (~80 nm) and E (90-140 nm) refer to amorphous or color fringe appearance, respectively. The A-E grades were replaced by 1-5, respectively, to be able to analyze the data statistically, as previously reported [15].

Statistical analysis

The SPSS software (version 23) has been utilized for the statistical analysis of the data. The Wilcoxon signed-rank test has been used to analyze differences in measurements within a single group. At the same time, the Mann-Whitney test was used to analyze the data in both groups [36].

Results

The data were found to be abnormally distributed (Kolmogorov-Smirnov test; $P < 0.05$) for the NITBUT, TMH, and LLP in the study and control groups. Thus, non-parametric tests were subsequently performed. No significant difference was found in age between the study and control groups (Wilcoxon Signed-Ranks test, $P = 0.870$). The median scores for the NITBUT, TMH, and LLP in the study and control groups are shown in table 1 and 2, respectively.

Parameter	Pre-bike riding (0 minutes)	Post-bike riding (50 minutes)	P-value
NITBUT (s)*	6.0 (2.7)	4.6 (1.7)	< 0.001
TMH (mm)	0.18 (0.08)	0.17 (0.07)	0.321
LLP	1.5 (2)	2 (2)	0.552

Table 1: *Median (IQR) scores for the NITBUT, TMH, and LLP in the study group (N = 40) before (0 minutes) and after bike riding (50 minutes).*

**Significant difference (Wilcoxon signed-ranks test; P < 0.001).*

Parameter	0 minutes	50 minutes	P-value
NITBUT (s)	6.3 (2.2)	6.6 (2.3)	0.914
TMH (mm)	0.21 (0.08)	0.20 (0.08)	0.113
LLP	2 (1)	2 (1)	0.480

Table 2: *Median (IQR) scores for the NITBUT, TMH, and LLP in the control group (N = 40) with a 50-minute gap.*

A significant (Wilcoxon signed-ranks test, P < 0.001) difference was found in the median NITBUT scores between the two measurements (before and after bike riding) in the study group. The side-by-side boxplots for the NITBUT scores in the study group pre- and post-bike riding are shown in figure 1. On the other hand, no significant differences in the TMH (P = 0.321) and LLP grades (P = 0.552) were found between pre- and post-bike riding. For the control group, no significant differences were found between pre- and post-bike riding in the NITBUT (P = 0.914), TMH (P = 0.113), and LLP (P = 0.480).

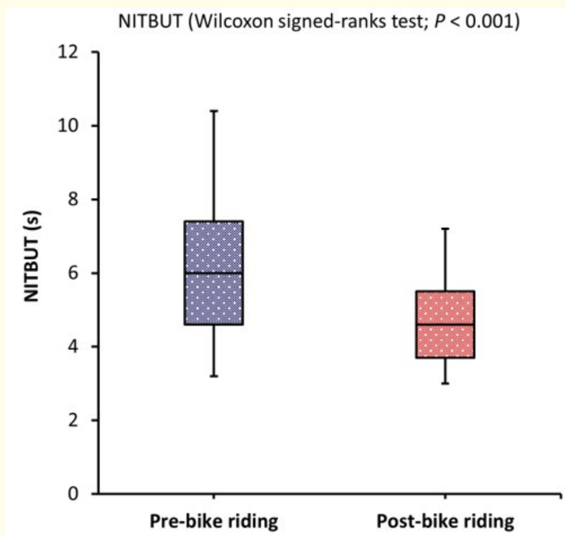

Figure 1: *Side-by-side boxplots of the NITBUT scores in the study group pre- and post-bike riding.*

The graphical presentation of lipid layer grades for the cyclists before and after bike riding is shown in figure 2. The grading of the LLP images was based on previous reports [15,35]. The LLP assessment showed that grade A (open meshwork, a gray appearance, or a thin white-blue layer with a thickness of 13 - 15 nm) was predominant before and after bike riding. At the same time, grade D (amorphous with a lipid layer thickness of ~80 nm) was the least common before and after bike riding.

Discussion

The current research is the first report to assess the effect of bike riding on the tear film parameters in dry eye subjects. The duration of NITBUT was significantly (P < 0.001) shorter after bike riding for 50 minutes (median = 4.6 seconds) compared to the time before

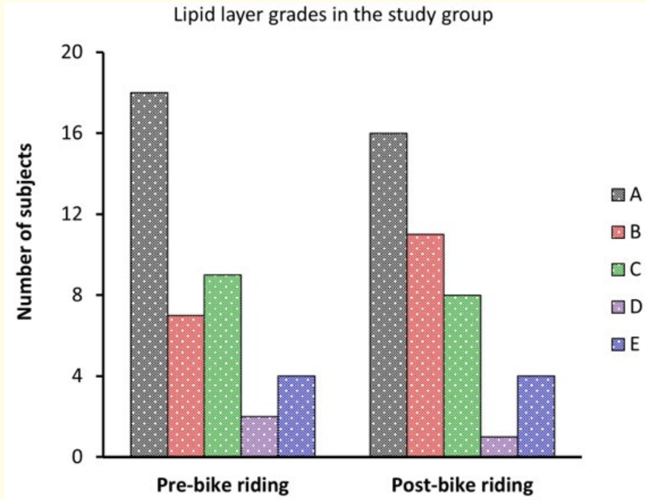

Figure 2: *LLP representation in the study group pre- and post-bike riding.*

riding (median = 6.0 seconds). However, no significant differences in TMH and LLP were noticed before and after bike riding. As far as we are aware, this is the first report that aims to investigate the effect of bike riding on the tear film parameters. No data are available in the literature to directly compare with the current results.

It is believed that wind, air pollution, and dehydration have a role to play. For example, dehydration could lead to an increase in tear evaporation. In addition, the blinking rate during bike riding is much less since riders are more focused on the road. The blinking rate affects the tear film stability. Blinking helps lipids spread over the ocular surface, reducing tear evaporation. Incomplete blinking disturbs the spreading of the lipid phase and leads to instability in the tear film [37,38]. There is an inverse relationship between the number of incomplete blinking and tear breakup time [39].

Treadmill exercise significantly improves tear film stability and secretion in athletes compared to non-athletes [40]. For example, athletes' basal tear secretion increased from 22.3 ± 2.5 to 25.8 ± 1.7 mm (P = 0.001) following exercise. The TBUT increased from 14.6 ± 2.9 to 17.7 ± 2.7s among athletes, and the change was more significant than in non-athletes (P = 0.004) [40]. Aerobic exercise for 30 minutes improves tear secretion in dry eye subjects [41]. For example, tear volume measured using the Schirmer I test and tear film stability measured by the NITBUT test has increased in dry eye subjects after aerobic exercise [41]. In addition, the study showed that aerobic exercise leads to a decrease in the concentration of 8-hydroxy-2'-deoxyguanosine, an oxidative stress marker, and the rate of blinks after aerobic exercise [41].

It should be noted that temperature, humidity, and level of carbon dioxide in the air are risk factors for dry eyes [1]. Wind blasts the face and the eyes during bike riding at high speed. The wind could disrupt the moisture level within the tear film. In addition, the dust, exhaust fumes, and pollens within the air could lead to dry eye symptoms such as pain, irritation, redness, sandy sensation, and light sensitivity. Wearing a face shield or sunglasses can reduce the effect of wind. Sunglasses can prevent the wind from going to the eye to some degree. However, the gaps at both sides, bottom, and top of lenses can still allow air into the eyes. Therefore, the airflow can hit the eye, causing discomfort feeling. Dehydration plays a role in inducing dry eye symptoms due to shortages of aqueous contents within the tear film. Therefore, wearing a face shield or sunglasses during bike riding is essential to reduce tear evaporation and the risk of inducing dry eye. The use of eye lubricants and omega-3 fatty acid supplements can eliminate the risk of eye dryness. In addition, drinking water during bike riding reduces dry eye symptoms.

Limitations of the Study

The current study has several limitations. First, only male subjects with dry eyes were included in the study. Second, the subjects were recruited only from Riyadh City. Third, only 40 subjects participated in each group. Fourth, only EASYTEAR view+ was used to assess the tear film parameters. Therefore, a future study is needed to understand better the role bike riding plays and its effect on the tear film.

Conclusion

The EASYTEAR view+ was used for the first time to assess the effect of bike riding on some tear film parameters in dry eye subjects. The tear breakup time was significantly shorter after bike riding compared with pre-riding. No significant differences were found in the tear meniscus height measurements and lipid layer patterns before and after bike riding.

Disclosure

The authors report no conflicts of interest in this work.

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