COMPARATIVE STUDY OF THE CHARACTERISTICS OF THE TEAR FILM

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ABSTRACT

A study was designed in order to evaluate the tear film characteristics of a group of elite athletes and compare them with those of the sedentary population. Also to determine the effects of training on the tear film. Methods: Quantitative (red phenol and meniscus height) and qualitative (TTT and BUT) tests were conducted in a group of students and another of elite athletes, before and after a training sesion. Results: Both groups presented similar tear film characteristics. Training was found to lead to an alteration of tear film characteristics. Especially relevant were the differences encountered in BUT and tear meniscus height measurements. Discussion: The results of four different sport categories are analysed and conclusions are drawn concerning the type of contact lens most appropriate for each particular sport.

INTRODUCTION

Nowadays, it is generally accepted that, elite athletes display a superior visual performance as compared with that of a sedentary population[1,2,3,4].

Numerous studies give evidence to the existence of important differences in physiology when comparing athletes and sedentary. Thus, a higher blood plasma concentration was encountered in samples of athletes, as well as an increase in the oxygen intake and a lower heart frequency[5,6].

The quality and volume of the tear film is not only one of the major factors contributing to the optimum behaviour of a contact lens *in situ* but also must be considered to be of key relevance for the maintenance of the ocular health and even for the quality of the retinal image[7]. When an irregular corneal surface is not compensated with the tear film, a larger image (closer to the eye) is required to perceive the nature of the object. This means not only loss of detail but also loss of time, a very critical factor in athletic events[8].

The quantity and quality of the tear film can be affected by numerous factors, mainly physiological (menstrual cycle, time of the day, lacrimal composition, blink frequency), personal (nutrition, hydration, vitamin ingestion)[9] and environmental (temperature, relative air humidity, air pollution, etc)[10,11]. Particularly, in sport, it is well known that, when an athlete undertakes a hard training schedule, several mechanisms of immediate adaptation become active, driving to various biological and functional changes, such as a sharp increase in heart rate, an accumulation of lactate and an increase in blood pressure and in body temperature among others[12]. This last factor eventualy drives to a loss of water via sweating which depends on the type of activity that is under way and on environmental conditions. In certain situations an athlete may loose up to 1 or 2 litters of water per hour of exercice[13]. It is therefore surmisable from all the alterations which may occur to the equilibrium of the biological mechanisms that the eye and, in particular, the tear film, may also be affected.

The objectives of this study are to investigate the possible existence of any statistically significant difference in the quality and quantity of the tear film between a group of elite athletes from different sports before and after a training session and a group of students of Optometry, with a totally sedentary activity.

Furthermore, it will be of interest to evaluate the alterations in the characteristics of the tear film amongst the various types of sports and their specific training requirements. It is understendable that the knowledge of the changes occuring to the tear film during sport practice will allow sport vision especialists to better choose the type of contact lens which is the most appropriate for each particular sport as well as to gain an objective basis of the maximum time that a contact lens can be worn depending on the type of effort and on the environmental conditions where this effort takes place.

OBJECTIVES

1.To evalute whether any statistically significant differences in the quality and quantity of the tear film may be found between a group of elite athletes and a group of university students.

2.To determine whether any statistically significant differences in the quality and quantity of the tear film occur in the group of athletes when comparing the results from before and after the training session, taking into account the physical requirements of each sport and the environmental conditions.

3.To compare the Tear Thinning Time (TTT) and the Break Up Time (BUT) as methods of evaluating the stability of the tear film.

4.To compare the meniscus height test and the red phenol test as methods of evaluating the volume of the tear film.

METHODS

1.Subject selection

1.1.A total of 34 elite athletes from the C.A.R. of Sant Cugat del Vallés were selected, comprising the following sports:

- Tennis (n=8), because of the physical extenuation and the exposure to UVA.
- Swimming (n=11), because of the physical effort and the acuatic environment, even when using protective hermetic swimming goggles.

- Athletism, long distance (n=6), because of the physical extenuation and the factor of speed.
- Pentathlon, precision rifle shooting (n=9), because of the concentration and visual fatigue.

All the athletes had a minimum of 3 years of experience in their sport and trained daily. The age ranged from 17 to 24 years (Mean=18.63, SD=3.07).

1.2.A total of 30 students of Optometry from the E.U.O.O of Terrassa were recruited, with a similar proportion of males and females than the group of athletes (23.3% of females in the students group as compared with 29.7% in the athletes group).

None of the students practiced any sport in a regular basis. The age ranged from 19 to 25 years (Mean=22.31, SD=1.78).

2.Material

The following material was utilised: A biomicroscope with a calibrated ocular, a Helmholtz keratometer, sodic fluorescein strips, red phenol test thread strips, a hand held digital chronometer and a millimetric rule.

3.Installations

Vision Center of the C.A.R., Sant Cugat del Vallés and Center of Contact Lens Research, E.U.O.O. Terrassa.

4.Procedure

4.1.Athletes group: The following tests were conducted prior and after the training session:

- TTT14. The chronometer was stopped at the first sign of keratometric ring distortion.
- Mesurement of the height of the lacrimal meniscus15.
- Red phenol thread test16.
- BUT17.

4.2.Students group: The same tests were conducted after a minimum of 3 hours of class. The temperature of the room was 20ºC, with a humidity of 65%.

In both groups, appart from the pentathletes (the eye used for shooting was always evaluated), the eye was choosen in a random way as it is believed that, in abscence of patology, both eyes have the same tear production[18].

Both groups were asked to fill in a questionnaire. This questionnaire is a modified McMonnies[19].

All the tests were conducted by the same optometrist in order to avoid intersubject variations in the interpretation of the results.

RESULTS

The statistical techniques used to verify the hypotheses formulated in this study are shown below. The software provided with Microsoft Excel 97 was utilized. The significance level was fixed at $p<0.05$.

1.The first question was answered using a Student's t-test which did not highlight any statistically significant difference in the quality and quantity of the tear film between the group of athletes, before and after training, and that of the sedentary group (see table 1).

2.Nevertheless, the Student's t-test showed a statistically significant difference in the results of the four tests when comparing the group of athletes as a whole before and after training. These differences were specially relevant in the BUT ($p<0.0001$)and meniscus height ($p<0.001$) tests (see table 2).

3 and 4. Using the Pearson correlation test, no statistically significant relationship was found between the tests of quality (TTT and BUT), neither between the tests of volume (meniscus and red phenol) in any of the groups (see table 3).

DISCUSSION

1.<u>Comparison of the tear film characteristics of the athletes group before and after training and the students group</u>:

From the results it can be ascertained that there are no statistically significant differences in the tests of quality and quantity between the group of students and the group of athletes taken before training. Therefore it must be concluded that the better physical fittness, the various physiological and morphological adaptations which occur with training, the intake of numerous vitaminic complexes (no correlation exists between the intake of vitamines and the lacrimal parameters) and, especially, the ingestion of larger amounts of water and other liquids (1.73 daily liters for the students *versus* 2.57 the athletes), are not reason enough to assume an increased tear quality or quantity in the athletes.

On the other hand, when comparing the lacrimal parameters of the athletes immediately after training with those of the students, only the height of the meniscus presented a statistically significant difference ($p<0.01$). This might have arisen from the action of environmental conditions and from the various factors involved in training (particularly body dehydration) affecting more drastically tear volume. However, in general, the results from both groups can be considered to be very much comparable, (Student's t-test).

2.<u>Comparison of the tear film characteristics before and after training</u>:

Taking the group of athletes as a whole, statistically significant differences were found in all conducted tests between the results before and after training, especially in the BUT and meniscus tests. Thus, it must be concluded that either training or environmental conditions or both affected quality and quantity of the tear film in a negative way (all results decreased).

In order to draw more practical conclusions it is interesting to separately evaluate each sport:

a.Swimming:

The results indicate that all tests, apart from the red phenol, display a statistically significant decrease in tear film volume and stability after an aerobic training (prolongued physical effort) in roofed swimming pool, being the quality characteristics of the tear film the most affected (BUT, $p=0.02$; TTT, $p=0.01$). It is important to bear in mind that swimmers were constantly wearing hermetic goggles which prevented tear evaporation, creating a saturated air reservoir between the goggles and the eyes. Thus, it is to expect that, if no protective goggles had been worn, the evaporation would have had its effect, further reducing the tear volume (without taking in consideration the effects of chloride water in this case). Actually, the decrease in tear volume may be explained as a result of the body dehydration and loss of such chemicals as Na^+ which normally occur during aerobic sport practice.

Tear stability was probably compromised by the precipitation of polar lipids from the adjoining palpebral epithelium giving rise to the encountered values of BUT and TTT.

On another line of argument, it is well understood that physical exercice stimulates the sympathetic nervous system and that parasympathetic antagonists drive to a reduction in tear flow (which is parasympathetically mediated[20]). Training may therefore give rise to a simpathetically driven reduction in tear flow. On the other hand, the sympathetic nervous system is the main responsible for the constriction of the blood vessels, which, in turn, regulate temperature[21]. A overactive sympathetic nervous system would result in a decrease in corneal temperature, thus further limiting tear evaporation from the eye[22]. Therefore, the results obtained in this study could be underestimated.

b.Modern pentathlon (training in precision rifle shooting):

In this sport, the results display a statistically significant difference before/after training in all four tests (TTT, p=0.01; BUT, p=0.02; red phenol, p=0.009; tear meniscus, p=0.02). It must be stated that all the tests were performed on the eye used for shooting. Precision shooting involves an important visual effort, comprising blinking rate, fixation, saccadic movements at an intermediate-long distance and accommodative facility. It is well established that a reduction in blinking rate causes a significant increase in tear evaporation, resulting in an alteration in tear volume and quality[23,24]. The increased evaporation due to insuficient blinking was probably the determinant factor to explain the obtained values as training took place in a controled environment with a temperature of 20 degrees Celsius and a humidity of 60% which, according to some authors[25,26], will not interfere in any way with tear quality or quantity.

From our results, it must be concluded that, in this particular sport, visual effort contributed more to the alteration of tear film characteristics than physical effort and physiological requirements or environmental factors.

c.Athletism:

No statistically significant differences were encountered between the results before/after training. This is quite surprising bearing in mind that athletes had to train in extreme environmental conditions (temperature of 5 degrees Celsius, humidity 70%) and would lead to the conclusion stated above that visual effort affects the tear film in a more drastic way than physical requirements or environmental conditions. However, the number of athletes taking part in this study was too reduced (n=5) to allow for any proper statistical analysis or for the statment of definitive arguments.

d.Tennis:

This sport, likewise pentathlon, requires an important visual effort (including ocular movements to monitor the ball and dynamic visual accuity to determine its spin). The training took place at noon, under full sunshine, with a temperature of 9 degrees Celsius and a humidity of 70%. The physical effort consisted of a mixed training with aerobic and anaerobic stages which leads less dehydration but more acidity than a purely aerobic task. The results show a statistically significant difference in the meniscus test (p=0.02) and *almost* statistically significant in the BUT (p=0.055) and red phenol (p=0.066).

In this case, it seems reasonable to assume that environmental conditions played a major role with visual effort, general body dehydration and sympathetically activated reduction in tear flow also contributing to the results.

3.<u>Comparison of the results obtained with the different test of quality and quantity</u>:

Within the limitations of the present study it was determined that no statistically significant correlation was encountered between the TTT and BUT tests or between the red phenol and meniscus tests. It may therefore be surmised that not only the tests are independent but also that they are not even equivalent and that they problably measure different tear parameters.

Concerning BUT and TTT, although it is widely accepted that non-invasive techniques offer a better trustworthiness and therefore are better regarded[27], other authors claim that all techniques, either invasive or non-invasive, are highly variable[28,29]. Thus, in clinical practice it is recommended to perform both set of tests and interpret the results accordingly.

On the other hand, the lower correlations encountered for the quantitative test (students group, r=0.33; athletes group before, r=0.099; athletes group after, r=0.23) may be explained by the above mentioned fact that they are not really measuring the same thing because the red phenol test elicits a higher amount of reflex blinking and tearing than the meniscus test. Other authors consider this test to be totally reliable and repetitive[30]. Besides, the red phenol thread was located at the temporal margin whereas the meniscus was measured at the inferior position.

CONCLUSIONS

1.The tear film characteristics of a group of elite athletes do not differ in neither a qualitative nor a quantitative manner from those of a group of students.

2.The quality and quantity of the tear film of the group of athletes decreases after training, being the differences statistically significant.

3.The athletes of pentathlon suffer the most dramatic changes in their tear film parameters after a training consisting of presicion shooting. These results are believed to have arisen from the reduction in blinking rate. Therefore, the type of contact lenses that should be avoided are high-water content thin lenses followed by low-water content thin lenses because of their highest dehydration and resultant dimensional changes in these cases[31]. The use of artificial tear subtitutes would be advisable.

4.Swimmers also present a statistically significative reduction in their tear film quality and quantity. However, aknowledging the fact that the protective goggles prevent water evaporation and thus lens dehydration from taking place, it would be logical to adapt high water content lenses with a reduced central thickness, contrary to common practice[32].

5.The tear film of tennis players also suffers a significative alteration, problably due to evaporation. Thus, high water content contact lenses should be avoided. Furthermore, given the fact that this sport is mainly practiced in the sun and the reticence of this group of athletes to wear sunglasses, it would be advisable to use lenses with UV protective filters[33].

6.The results from the TTT and BUT tests are independent and therefore both tests should be conducted in order to gain a full understanding of the quality of the tear film.

7.The same may be affirmed of the tests of quantity: meniscus height and red phenol. Both tests should be undertaken to properly assess tear volume.

FURTHER INVESTIGATION

On the one hand, given the low reproducibility of the measurements and the low trustworthiness of the tests (especially qualitative) it is believed that the study should be repeated using a teascope which is thought to be the most appropriate technique[29].

On the other hand, it would certainly be of interest to design a study to evaluate the time which is required from the training session to fully restore the original tear film parameters.

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<u>Table 1</u>: Tear film qualitative and quantitative characteristics of a group of students and a group of athletes before and after training. Results are displayed as mean and (standard deviation). The group of athletes is taken as a whole, without differentiating any particular sport.

	Meniscus height (mm)	**Red phenol test (mm)**	**TTT (s)**	**BUT (s)**
Students	0.21 (0.16)	18.33 (6.24)	5.13 (2.42)	9 (4.28)
Athletes (before training)	0.17 (0.07)	21.08 (5.94)	5.76 (2.53)	8.91 (5.46)
Athletes (after training)	0.13 (0.06)	19.16 (5.97)	5.28 (1.46)	7.09 (3.88)

Table 2: Tear film qualitative and quantitative characteristics of a group of athletes before and after training. Results are displayed as mean and (standard deviation). Four sport modalities are preseneted: Tennis, athletism, swimming and pentathlon.

		Meniscus height (mm)	**Red phenol test (mm)**	**TTT (s)**	**BUT (s)**
Tennis (n=8)	**Before**	0.22 (0.08)	23 (5.12)	4.5 (1.8)	8.62 (2.87)
	After	0.16 (0.07)	19.86 (5.12)	6 (1.19)	7 (2.39)
Swimming (n=11)	**Before**	0.16 (0.04)	20.45 (4.33)	6.27 (2.34)	8.54 (4.63)
	After	0.11 (0.06)	19.81 (4.87)	5 (1.28)	6.64 (2.67)
Athletism (n=6)	**Before**	0.2 (0.06)	21.83 (8.95)	5.17 (1.07)	7.2 (4.4)
	After	0.2 (0.00)	23.6 (5.08)	5.2 (0.75)	6.8 (3.12)
Pentathlon (n=9)	**Before**	0.12 (0.05)	18.78 (5.75)	7.11 (3.38)	10.78 (7.91)
	After	0.09 (0.03)	15.33 (5.92)	5.11 (1.91)	7.89 (5.82)

<u>Table 3</u>: Pearson correlation test comparing TTT and BUT and also meniscus height and red phenol test in both groups (the values for the group of athletes were those taken before training). r values range from –1 and 1, where 1 and –1 are indicative of full correlation and 0 means absolute lack of correlation.

	TTT and BUT	**Meniscus height and red phenol test**
Students (n=30)	0.11	0.33
Athletes (n=34)	0.22	0.099