DOI: https://doi.org/10.53350/pjmhs211572246

ORIGINAL ARTICLE

The Quiet Eye durations of air pistol shooting athletes

TONGUÇ VARDAR[1], FATIH SENDURAN[2]
[1]*Faculty of Physical Education and Sports Science, Uludag University, Turkey*
[2]*Department of Physical Education and Sports, University of National Defense, Turkey*
Correspondence to Dr. Fatih Senduran, Email. fsenduran@yahoo.com, Cell: +90 506 2888240

ABSTRACT

Background: The Focusing the attention during the preparation period undergone immediately before carrying out a motor performance is vitally important for success. Visual ability, Quiet Eye and focusing the attention on the appropriate area play a critical role in achieving successful performance in branches of sport. Quiet eye (QE) is defined as the final fixation of the pupil on a location or object for a specific motor task.

Aim: The aim of this study was to examine the durations of effective and final focusing (quiet eye) carried out during the process of taking aim at the target by air pistol shooting athletes with their eyes immediately before taking a shot.

Methods: A total of 8 right-handed male licensed pistol shooting athletes (4 novice and 4 elite) participated in the research. A total of 320 shots -160 dry (unscored) and 160 live (scored) shots were taken by the novice and elite athletes. For the purpose of recording pupil movements and quiet eye durations during the shots taken by the athletes, an eye-tracking device attached to the head was used. The recorded data were examined with iMotions computer software, which can perform biometric analysis. The athletes' quiet eye durations occurring when taking aim at the target were examined according to athletes' characteristics (novice and elite) and the type of shot carried out (scored and unscored) by means of the independent samples t-test.

Results: The findings of the study revealed that the athletes had 25.3% longer quiet eye durations when firing scored shots than when firing unscored shots ($p = .000$). Especially, novice athletes exhibited 37.8% longer periods of focusing behaviour when firing scored shots than when firing unscored shots ($p = .000$). Elite athletes displayed 21.26% longer periods of focusing behaviour when firing unscored shots compared with novice athletes ($p = .005$).

Conclusion: According to the results of the research, it can be said that in the sport of air pistol shooting, giving priority to dry shooting training and conducting special exercises for developing quiet eye (QE) duration can contribute positively to the development of novice athletes' shooting skills.

Keywords: Quiet eye, eye tracking, air pistol, shooting, motor skill, cognitive processes.

INTRODUCTION

The sport of air-pistol shooting is a branch of air weapon competitions of the International Shooting Sport Federation.[1] Athletes try to hit a 10-point circle with a diameter of 11.5mm from a distance of 10 m. The sport of shooting is a branch of sport that requires not only physical skill, but also a technical infrastructure, high mental focus and complex skills. For shooting athletes to keep all sustained repetitive movements (aiming at the target, pulling the trigger, etc.) under control, they need to be able control their whole bodies and maintain their concentration for long periods.[2] While concentrating his attention directly on the target and focusing directly on the sight picture, a good marksman must also coordinate his body's postural activity and the action of raising the arm.[3]

Focusing the attention during the preparation period undergone immediately before carrying out a motor performance is vitally important for success.[3] Vickers,[4] stated that visual ability, focus and focusing the attention on the appropriate area play a critical role in achieving successful performance in branches of sport. In a number of studies on motor performance that they carried out, Krede et al.,[5] emphasised that in order to carry out various performance tasks effectively, it is important for the athlete to be able to gather visual information in an appropriate manner.

Nowadays, the number of studies conducted with an eye monitoring system in the field of sports science is steadily increasing. In particular, studies on the "quiet eye", which is the final moment of focus carried out prior to a motor movement, is one of the current fields of study in which this technology is used. With the most common definition, quiet eye (QE) is defined as the final fixation of the pupil on a location or object for a specific motor task.[6] QE is also defined as "the final fixation or tracking gaze that is located on a specific location or object in the task environment within 3° of visual angle (or less) for a minimum of 100 milliseconds (ms)".[7] QE begins immediately before the critical final movement in a motor task (onset) and ends when the gaze deviates from the viewed object or location for a minimum of 100 milliseconds and with a visual angle of 3° (offset). QE can be regarded as a kind of visual perception ability allowing athletes, while planning their next moves, to focus on the next move by removing distracting elements.

Numerous studies have revealed that the location of focus of the gaze is generally associated with the matters under consideration. There is a relationship between a situation visualised in our mind and the point focused on by our gaze. This situation is expressed as the eye-mind hypothesis.[8,6] The athlete's ability to accurately select the correct visual clues in order to make a move is very important for successful performance. A longer QE duration assists the earlier acquisition of visual information and making the appropriate choice prior to a critical movement. By this means, more rapid motor movements can be performed.[7]

Studies conducted in the field of sports science have revealed that the case of longer QE has the effect of

significantly increasing performance in elite athletes' sensorimotor behaviours.[9] Therefore, it can be expected that shooting athletes' achievement of a sustained level of QE when taking aim at the target will contribute to optimum shooting success.

The aim of this study is to examine how pistol shooter athletes' QE durations are realised in the cognitive process immediately prior to pulling the trigger while taking shots in the sport of pistol shooting, which is a branch of sport requiring complex skills together with high mental and visual focusing. Based on the previous findings of studies made in various branches of sport related to the skill of aiming at a target, such as archery and darts, in which QE durations were investigated, it is expected that the length of QE durations of pistol shooting athletes will depend on the characteristics of the athlete.[7,4]

MATERIAL & METHODS

Sample: Eight right-handed skilled male shooters (4 elite and 4 novice) were recruited in this study. The athletes who took part in the research are licensed shooters of the Shooting and Hunting Federation of Turkey. To be defined as elite shooters, sportsmen/women were required to have at least 10 years' experience, to have taken part in national competitions, and to be currently active athletes. Elite shooters should also have participated in at least one international sports competition. Novice shooters were chosen from among shooting athletes with a maximum of 2 years' experience and athletes who had taken part in at least one national competition. They practised shooting regularly at least four times per week. The mean shooting score of the elite shooters was 575 and for the novice shooters, 545. The study was approved by an institutional review board, Uludag University, for the protection of the human subjects. All of the participants provided their informed consent.

Instrument, Measures and Apparatus

Air-pistol Shooting Task. In order to increase ecological validity, this study employed a real shooting task in accordance with normal contests rather than employing an electronic shooting training system. A 10 m range was assembled in a data collection building designed for the purpose, according to International Shooting Sport Federation regulations. The shooting task lasted for about 60 minutes per shooter.

Shooting Performance. Firstly, shooters were required to fire 20 dry (unscored) shots. After firing 20 dry shots, the shooters were asked to maintain their positions and not to leave the shooting range. Then, the athletes were asked to fire 20 live (scored) shots by squeezing the trigger. Therefore, the shooters each fired a total of 40 shots (20 dry and 20 live) during the training. No intervention was made in the athletes' shooting routines, timing, shooting techniques, experiences or shooting habits. The shooters did not see any researchers during shooting. The shooters were allowed to shoot under the same conditions as those in which they shot on a normal training day. Participants used their own pistols to carry out the shooting task so as to minimize unfamiliarity related to pistol handling. The bull's eye was awarded a score of 10. The other eight concentric rings were each marked with different diameters (an increase of 0.8 cm per ring) and awarded different scores according to proximity to the bull's eye. The shot score and position for all participants were reported following each shot.

Pupil Movement Recording. As the hardware/technical device during data collection, an eye-tracking tool that analyses pupil movements, and can record data such as what the eye looks at and how long it remains fixed on a certain point, was used. The athletes' pupil movements while firing dry (unscored) and live (scored) shots were instantly recorded with the mobile eye-tracking device that they wore. To record the pupils with the eye-tracking tool, first of all the calibration process was carried out. Since each athlete's head structure and position of the eyes in the face were different, the calibration process was conducted separately for each shooter. Then, so that the athletes could become familiar with the device, they were asked to shoot freely for 5 minutes. For the athletes to feel comfortable and shoot at ease, the recording process was begun after they had entered the shooting range. In order to determine raw data showing where shooters looked in the real world, quiet eye duration and duration of focusing, the 'iMotions (2019)' computer software,[10] which allows biometric measurements to be made, was used.

Procedures: The participants were requested not to consume drinks containing alcohol or caffeine for at least 24 hours before performing on the shooting range. Following the eye-tracking calibration procedure, the participants were requested to practise with ten warm-up shots. During the experimental recordings, all participants were requested to keep their body static and their eyes open for at least three seconds before shooting in order to minimize possible artifacts from body sway and blinking during shooting. For each shot fired by the athletes in their dry and live shot performances, their pupil sizes and changes, periods of focusing on the fore-sight, and quiet eye (QE) durations were determined with the eye-tracking device. The shooting athletes' pupil measurements began at QE onset and ended at QE offset. This process was carried out 40 times for each shooter, and so, a total of 320 times for all shooters. As a result of the analysis made, data for 160 dry shot performances and 160 live shot performances were obtained. The pupil movements carried out by the athletes while shooting were converted into digital data with the computer software algorithm. With this software, each performance realised by the shooting athletes (dry fire and live fire) was analysed one by one.

During the measurement of the athletes' performances, data that did not conform to the reliability values of the eye-tracking device and shots formed as a result of lost pupil data were not included in the study. The lights located in the shooting polygon were kept fixed throughout the research. Consequently, the amount of light had no effect on changes in the shooters' pupils.

Data Analysis: The distribution types of the obtained data were analysed with the Kolmogorov-Smirnov test of normality. The pupil sizes of the athletes who took part in the research were determined with the independent samples t-test according to whether the shot made was scored or unscored (live or dry) and also according to whether the athletes were elite or novice. The level of statistical significance was set at $p=0.05$.

RESULTS

During assessment of the athletes, data that did not conform to the reliability values of the eye monitoring device were not included in the study. Accordingly, 126 dry (unscored) shots and 143 live (scored) shots of all athletes were included in the study. Therefore, a total of 269 scored and unscored shots of novice and elite athletes were used for determining the athletes' quiet eye durations.

Shooting Score Rates: The mean values of the scored shots fired by the novice and elite athletes during the research process are shown in Table 1.

Accordingly, 74 scored shots of novice athletes and 69 scored shots of elite athletes were included in the study. A significant difference was found between the scored shots fired by novice and elite athletes during the research process. The mean shooting scores of elite athletes (X̄ =9.72, sd=0.63) were higher than the mean shooting scores of novice athletes (X̄ =9.37, sd=0.80) (t=-2.851, p = 0.005). Elite athletes' mean shooting scores were higher than those of novice athletes at a rate of 3.60%. Considering the training history and experience of national and international competitions of elite athletes, the fact that their shooting scores were higher than those of novice athletes can be regarded as an expected result.

Table 1: T-test Results Comparing Novice and Elite Athletes on *Shooting Score*

Athletes	M	SD	M.Diff	t	df	p
Novice	9.37	0.80	0.35	-2.851	141	0.00**
Elite	9.72	0.63				

** *p*<.001

Quiet Eye:

Table 2 and Figure 1 show the mean values for the number of milliseconds that the novice and elite athletes fixated their gaze on the foresight in order to take accurate and effective aim (QE), in the moment immediately prior to pulling the pistol trigger, during the dry (unscored) and live (scored) shots that they fired.

Table 2: Quiet Eye Duration (milliseconds) of Athletes According to Athletes Skills (Novice and Elite)

Athletes	*Shooting Type*	F	M (ms)	t	P
Novice	Unscored	62	4691	6.110	0.00**
	Scored	74	7547		
	Total Shoot [a]	136	6119		
Elite	Unscored	64	6016	1.541	0.126
	Scored	69	6743		
	Total Shoot [b]	133	6379	1.011 [ab]	0.477[ab]

** *p*<0.01, [a] *QE of* Novice *Athletes,* [b] *QE of* Elite *Athletes.*

A significant difference was found in the quiet eye behaviours of novice athletes' pupils according to the type of shot that they fired. While the athletes were looking at the foresight in the period immediately before firing dry (unscored) shots (X̄=4691, sd=2334) and live (scored) shots (X̄ =7547, sd=2995), the duration of fixating their gaze (QE) on the foresight was particularly longer for live (scored) shots (t=6.110, p = 0.000). The novice athletes wished to fixate their gaze on the foresight (QE) for a 37.8% longer period when firing live (scored) shots compared to the case when firing dry (unscored) shots. It can be said that this was done in order to take a clearer and more accurate aim. Moreover, it can be thought that the athletes paid less attention to dry (unscored) shots. Since there would be no loss of points in dry (unscored) shots, it was seen that the novice athletes focused on the foresight (QE) for a shorter period when firing these shots than when firing live (scored) shots. As for elite athletes, however, a significant difference was not found between the quiet eye durations of their pupils for dry (unscored) shots and live (scored) shots. While the athletes were looking at the foresight in the period immediately before firing dry (unscored) shots (X̄=6016, sd=2616) and live (scored) shots (X̄ =6743, sd=3114), the durations of fixating their gaze (QE) on the foresight were very similar (t=1.541, p = 0.126). The elite athletes wished to fixate their gaze on the foresight (QE) for similar periods when firing dry (unscored) shots and firing live (scored) shots. This indicates that elite athletes displayed similar quiet eye (effective focusing) pupil behaviours while firing both live (scored) shots and dry (unscored) shots. The elite athletes gave as much importance to dry (unscored) shooting as they did to live (scored) shooting and exhibited similar quiet eye behaviours for both types of shot. The mean values for the number of milliseconds that the athletes fixated their gaze on the foresight in order to take accurate and effective aim (QE), in the moment immediately prior to pulling the trigger, during the dry (unscored) and live (scored) shots that they fired, according to the comparison of their characteristics as athletes, are shown in Table 3 and Figure 1.

Table 3: Quiet Eye Duration (milliseconds) of Athletes According to Shooting Type (Unscored and Scored)

Shooting Type	*Athletes*	F	M (ms)	t	P
Unscored	Novice	62	4691	-2,867	0.00**
	Elit	64	6016		
	Total Shoot [a]	126	5353		
Scored	Novice	74	7547	1.572	0.119
	Elit	69	6743		
	Total Shoot [b]	143	7145	5.238[ab]	0.00** [ab]

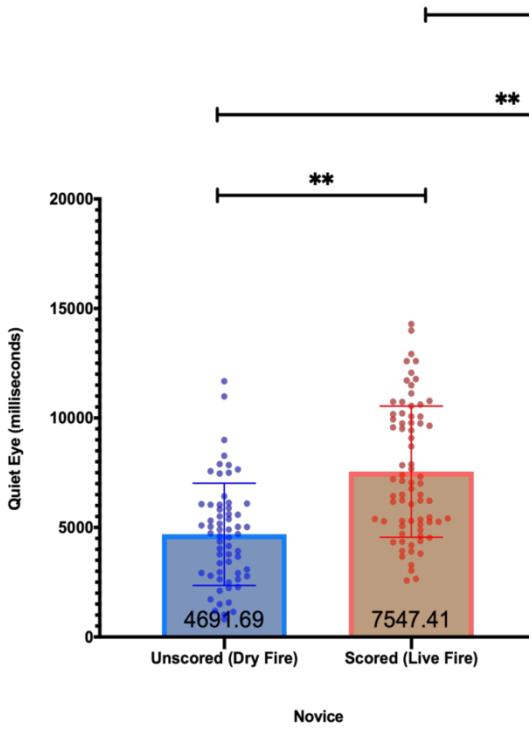
** *p*<0.01, [a] *QE of* Unscored Shoot, [b] *QE of* Scored Shoot

When firing dry (unscored) shots, a significant difference was found in the length of time that novice and elite athletes fixated their gaze on the foresight in the period immediately before the shot. Elite athletes' quiet eye durations (X̄=6016, sd=2616) were longer than novice athletes' quiet eye durations (X̄ =4691, sd=2334) (t=-2.867, p = 0.005). It was seen that when firing dry (unscored) shots, the mean quiet eye durations of elite athletes were 21.26% higher than the mean quiet eye durations of novice athletes. Practising with dry shots is an exercise technique which shooters do not really like and which requires patience. In this exercise, the aim is for athletes to learn the correct techniques and go through the stages carried out in actual shooting. According to the data obtained, it can be said that elite athletes focused more on dry shots and evaluated this process more productively. Novice athletes focused on the foresight for a shorter period in dry shooting. It can be said that this situation is due to young athletes' lack of experience and to the fact that they are more impatient.

A significant difference was not found between the period spent by novice and elite athletes in fixating the gaze on the

foresight of the pistol (QE) immediately before the shot during live (scored) shooting. The quiet eye durations of elite athletes (X =7547, sd=2995) and the quiet eye durations of novice athletes (X =6743, sd=3114) were very close to each other (t=1.572, p = 0.119). It was observed that the mean quiet eye durations of novice athletes during scored shooting were higher than those of elite athletes. Bearing in mind that this situation did not make a significant difference between novice and elite athletes, it can be stated that novice athletes were more inclined to keep their pupils fixated to take aim immediately before pulling the trigger to fire a shot than were elite athletes.

Figure 1: Quiet Eye Duration (milliseconds) of AthletesDuring Dry Fire and Live Fire



** p<0.01

DISCUSSION

In the sport of shooting, many factors have an impact on success. A number of interrelated variables, such as the correct stance, balanced adjustment of the centre of gravity, applying the principles of aiming, trigger and breath control, and the process of focusing on the target have a direct effect on shooting success. Due to the complex structure of shooting performance, a shooting athlete has to manage various factors (attention, motor control, stance balance, etc.) successfully in order to take a successful shot.

In the air-pistol branch of shooting, a shooter's process of pointing his pistol at the target, entering the line of fire with his arm, and taking aim are among the most important steps that the athlete has to perform correctly before taking the shot (pulling the trigger). During this process, the shooter must have captured the correct position and the image known as the sight picture (optimal adjustment of the back sight and foresight) as well as possible. In this process, the vision, position of the eye and focus have a direct impact on success.

Athletes are required to obtain the complex information that they need from continually changing surroundings as quickly as possible. Elite athletes discover the best way to gather this information from the environment around them. For an excellent performance, athletes need to know "where" and "when" to look, since this awareness enables them to use their time more efficiently. Todorovic,[11] stated that mostly technical flaws and psychological factors that weaken coordination skill lie at the basis of unsuccessful shooting. Tremayne and Barry,[12] reported that in the sport of pistol shooting, both the attention processes and the motor preparation stage are important for a successful performance. Therefore, it is thought that quiet eye, which is expressed as careful and effective focusing, is important for successful shots in the sport of shooting.

In our study, in which we examined the length of the period in which the pupils remain fixated on the target (quiet eye) during the cognitive process in which novice and elite pistol shooting athletes take aim at the target after forming the sight picture and immediately prior to pulling the trigger; a statistically significant difference was observed between the shooting scores achieved by the novice and elite athletes during the research. Elite athletes' mean shooting scores were 3.60% higher than novice athletes' mean shooting scores. Considering elite athletes' training history and experience of national-international contests, it can be said that this is an expected result.

According to another finding of the research, when the type of shot (unscored or scored) fired by the athletes is considered, a difference was seen in effective final focusing behaviours of the pupils (quiet eye) depending on the athletes' type of shot. The athletes' quiet eye (QE) durations were 25.3% longer when they fired scored shots than when they fired unscored shots. This situation was seen more significantly in the measurement of QE duration made among novice athletes among themselves. Novice athletes exhibited more sustained QE behaviour when taking scored shots than when taking unscored shots, at a rate of 37.8%. In other words, novice athletes among themselves focused more on scored shots than on unscored shots. However, a significant difference was not found in QE durations for scored and unscored shots fired by elite athletes among themselves. The elite athletes exhibited similar QE behaviour for both types of shot.

When both groups of athletes were compared with each other, however, the novice and elite athletes displayed similar QE behaviour to each other when taking scored shots. The QE durations of focusing the pupils on the foresight for an accurate sight image by novice and elite athletes were similar to each other for scored shots. However, this situation changed when they were taking unscored shots. When the elite athletes fired unscored shots, they exhibited a longer period of QE behaviour than the novice athletes, at a rate of 21.26%. In other words, elite athletes focused more on unscored shots than novice athletes did.

In a study conducted to determine QE durations of darts players, a significant difference in QE durations was not

observed between skilled and less skilled players.[13] In another study made with darts players, however, while QE durations were considerably reduced in novice players in situations where they were under pressure or stress, such a case was not observed in elite players. In a study made with biathlon athletes, it was seen that athletes who felt under pressure during performance and whose QE duration was shorter than under training conditions displayed poorer performance. In another study carried out in this field, it was seen that athletes who were able to cope with pressure during performance had a longer QE duration.

In a study conducted with rifle shooters, Janelle et al.,[14] observed elite athletes' mean QE durations to be 11.5 seconds, and mean QE durations of novice athletes to be 7.6 seconds. In our study, which was conducted with pistol shooters, however, elite athletes' QE durations were determined as 6.3 seconds, while novice athletes' QE durations were determined to be 6.2 seconds, and therefore, a significant difference was not observed between the QE durations of elite and novice athletes.

On the other hand, when athletes felt under pressure in our study, in other words, when they received a score in return for the shots that they fired, they tended to sustain their QE duration for longer than when they fired shots that were not rewarded with a score. This case was more significant especially for novice athletes. When novice athletes fired scored shots for which they felt under pressure, they held their QE duration for longer than they did for unscored shots. However, this situation was different for elite athletes, whose QE durations for both types of shot, that is, whether they received a score or not following the shot, were almost the same. In our research, it was observed that a pressure environment that elite athletes were in did not have an effect in changing QE durations occurring in the shots that they fired. The elite athletes did not compromise on QE discipline whatever the type of shot. They gave the same amount of attention to both types of shot (scored-unscored). However, novice athletes maintained the QE duration they used in scored shots for much longer than in unscored shots, for which there was less anxiety about making mistakes. Causer et al.,[15] reported that elite shotgun athletes not only had significantly longer QE durations than their sub-elite counterparts, but that they also had more efficient gun barrel kinematics. It is generally reported that stable gun motion and longer QE duration are critical for successful performance in the discipline of rifle shooting.[15]In studies that include elite and non-elite athletes conducted in the sports of rifle shooting and volleyball,[14,16] it is mostly reported that elite athletes display longer QE duration behaviour than novice athletes at a rate of 62%.[17] When the literature related to QE duration is examined, it is seen that the duration of QE in elite athletes is significantly longer than in sub-elite or novice athletes. In other words, athletes who display high-level performance are able to focus on objects or locations earlier and maintain their periods of focus for longer, irrespective of the conditions they face. Since elite athletes begin their final focusing time (QE onset) earlier, they are able to find a way to see critical visual information earlier. In this way, they are able to relay better quality instructions to the motor system.

According to the findings of studies made in previous years, researchers recommend that the period of final focusing made by athletes should be long enough not only to aim correctly at the target, but also to ensure the accuracy of the aim. A similar result was also revealed in our research, especially for dry (unscored) shots. Elite athletes were inclined to sustain their QE durations for longer than novice athletes when taking dry (unscored) shots. The dry shot is the most basic exercise and perfection method used in pistol shooting. However, for some athletes it is a tedious, unappealing exercise, the result of which is not immediately obtained. Dry shot training is not an exercise that is performed enthusiastically among shooting athletes. However, it is not possible to become an elite shooting athlete without continually doing dry shot training, that is, without regularly repeating through dry training the steps applied when shooting with live rounds. According to the shooting athletes who took part in our study, novice pistol shooters exhibited QE behaviours in dry (unscored) shooting for shorter periods than they did for live (scored) shooting.

It can be stated that this difference between QE durations in scored and unscored shooting among novice athletes may affect the performances that novice athletes display in the competitions they take part in in the future. Studies conducted in a number of branches of sport in which a target is focused on or followed, such as ice hockey, golf and darts, have revealed that earlier and longer-lasting focusing made before performing a motor movement increases success rates.[16,14,7,17,4] In similar research carried out in previous years, it was shown that special training aimed at developing quiet eye (QE) duration was effective in different branches of sport that include target-related factors (golf, basketball, penalty shots in soccer, etc.).[18] Special QE exercises applied in training enabled significant increases in athletes' QE durations and in their performances. Moreover, these studies revealed that under conditions of high anxiety, athletes trained with specific QE protocols were able to remain in a state of QE for longer periods than other athletes. Longer QE durations enable visually obtained knowledge of the target position to be relayed (transferred) efficiently to the motor control systems. In this way, more effective movement kinematics and muscle activation can be realised for successful performance of skills.

CONCLUSION

The fact that the QE durations of the novice pistol shooter athletes who participated in our study were shorter in dry shooting exercises that in live shooting can be interpreted to indicate that dry shooting exercises were not performed properly and did not serve their purpose. Moreover, on pistol shooting athletes' journey to becoming elite athletes, they should bring the duration of focusing on the target for taking aim immediately before pulling the trigger (QE) when firing unscored shots close to the same level as the duration of focusing (QE) that is realised when firing scored shots.

According to the findings obtained in our study and to studies made in the literature, one can say that conducting special exercises aimed at developing quiet eye (QE) duration in the sport of pistol shooting, especially during dry shooting training, will make a positive contribution to developing novice

athletes' performance and shooting skill in the process of becoming elite athletes. Moreover, it is envisaged that the use of the eye-tracking system used in this study and similar ones in shooting training will contribute to revealing how qualified elite athletes' pupil-focusing behaviours are performed during dry (unscored) and live (scored) shooting, and thereby, to learning the strong and weak aspects that athletes possess during the process of focusing.

Recommendations: This study was carried out only on pistol shooting athletes. It is considered that inclusion of rifle shooting athletes would be appropriate in future studies.

In future studies to be made with shooting athletes, it is considered that the use of an eye-tracking system and other research instruments (e.g., EEG, EMG, HRV, etc.) together in order to analyse different processes (mental perception, visual perception, coordination, etc.) in athletes' performance will contribute to obtaining more comprehensive and sensitive results.

Disclaimer: None.

Conflict of interest: None.

Source of funding: None

REFERENCES

1. ISSF. International Shooting Federation. *Rules*. München Germany, 2019.
2. Barth K, Dreilich B. *Training Shooting Sports*. Meyer & Meyer Sport, 2011.
3. Hillman C. H, Apparies R. J, Janelle C. M, Hatfield B. D. An electrocortical comparison of executed and rejected shots in skilled marksmen. *Biological Psychology* 2000: 52, 71.
4. Vickers J. N. Origins and current issues in Quiet Eye research. *Current Issues in Sport*, 2016.
5. Krede, R., Vater, C., Klostermann, A., Hossner, E. J. Eye-tracking technology and the dynamics of natural gaze behavior in sports: A systematic review of 40 years of research. *Frontiers in Psychology 2017:* 12-18.
6. Bojko A. *Eye Tracking the User Experience. A Practical Guide to Research*. Rosenfeld Media, LLC, 2013.
7. Vickers J. N. *Perception, cognition & decision training: The Quiet Eye in action*. Champaign, IL: Human Kinetics, 2007.
8. Hoffman J. E. *Visual attention and eye movements*. Hove, UK: Psychology Press, 1998.
9. Hossner E.-J. (Ed.) Quiet Eye research – Joan Vickers on target. *Current Issues in Sport Science* 2016;1:100.
10. iMotions. *iMotions Biometric Research Platform, 2019*
11. Todorovic Z. *ISSF Training Academy C Coaching Course*.Finland, 2019
12. Tremayne P, Barry R. J. Elite pistol shooters: physiological patterning of best vs. worst shots. *International Journal of Psychophysiology* 2001; 41(1): 19–29.
13. Rienhoff R, Baker J, Fischer L, Strauss B, Schorer J. 'Field of vision influences sensory-motor control of skilled and less-skilled dart players'. *Journal of Sports Science & Medicine* 2012; 11: 542–50.
14. Janelle C. M, Hillman C. H., Apparies R. J, Murray N. P, Meili L, Fallon E. A, Hatfield B. D.'Expertise differences in cortical activation and gaze behavior during rifle shooting', *Journal of Sport & Exercise Psychology* 2000; 22: 167–82.
15. Causer J, Bennett S. J., Holmes P. S., Janelle C. M, Williams A. M. 'Quiet eye duration and gun motion in elite shotgun shooting'. *Medicine & Science In Sports & Exercise* 2010; 42: 1599–1608.
16. Vickers J. N., Adolphe R. 'Gaze behaviour while tracking an object and aiming at a far target. *International Journal of Sports Vision* 1997; 4: 17–25.
17. Wilson M.R, Cuser J, Vickers J.N. "Aiming for Excellence" , in *Routledge Handbook of Sport Expertise* ed. Joseph Baker and Damian Farrow, Routledge, 2015.
18. Vickers J. N, Williams A. M. 'Performing under pressure: The interactive effects of physiological arousal, cognitive anxiety and gaze control in elite biathlon shooters'. *Journal of Motor Behavior* 2007; 39: 381–94.