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Effect of the Quiet Eye Training on Motor Learning of Pistol Shooters

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Original Article

Abstract

Introduction: A quiet eye is a key predictor in the efficient implementation of the inhibitory tasks and targeting. This study aims to investigate the effect of quiet eye training on improving the performance of pistol shooters.

Materials and Methods: This was a controlled clinical trial study in which the participants included 20 male and female shooters with an average age of 22 years and a record between 545 and 555 m. The subjects were purposively selected from among 60 male and female shooters who participated in the 10-meter pistol race and in the country's top competitions. Ater completing the consent form, the subjects were classified from the highest score to the lowest score based on the pre-test scores and were placed in two groups as one in between (ABBA method) (10 in quiet eye training and 10 in technical training). The participants performed 10 attempts at each of the pre-test, post-test, and retention tests. The training protocol of the quiet eye group was in accordance with the pattern obtained from the elite shooter pattern along with the verbal instruction for 8 sessions and in 6 blocks of 10 consecutive shoots. Data was analyzed through the independent t-test, repeated measures analysis of variance (ANOVA), and Bonferroni post-hoc test in the SPSS software (version 20, IBM Corporation, Armonk, NY, USA) at the level $P < 0.050$.

Results: The repeated measures ANOVA results of the study groups (from pre-test to retention) showed that these changes were significant for the quiet eye training group ($P \leq 0.001$). According to the results of the Bonferroni post-hoc test, the quiet eye training group had a better shooting function in the post-test ($P \leq 0.010$) and retention ($P \leq 0.020$) stages compared to the pre-test. The results of the independent t-test indicated that there was a significant difference between the quiet training and technical groups in the pos-test ($P \leq 0.007$) and retention phases ($P \leq 0.004$).

Conclusion: The findings suggested that the quiet eye training can improve the learning of pistol shooting skills through external guidance of visual attention.

Keywords: Quiet eye training; Shooting; Motor learning

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Introduction

In many sports, performers have to make quick decisions in an ever-changing environment. In such sports, players need to focus only on necessary and relevant sources of information in order to improve and enhance performance. Therefore, recognizing when and where to look at is an important factor in a skillful performance. In recent years, numerous studies have examined the movement of performers' eyes on selected areas of the play. Studies have shown that the pattern of skillful visual search is not performed randomly, but based on intentional perceptual strategies. In the field of visual behavior studies in sports, the quiet eye variable has been considered by some researchers (1). Quiet eye is defined as "fixing or tracking vision on a place or an object in the visual-motor context with a 3-degree angle of view for at least 100 milliseconds without staring." In fact, the quiet eye occurs when it is fixed in a position with 3 degrees of angle of view for at least 100 milliseconds. Thus, the quiet eye is a perception-action variable that begins with the

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beginning of a specific movement in the task (2). Some studies have suggested that with increasing quiet eye duration, accuracy and expertise improve (3,4). Additionally, the results of other studies indicate that the duration of the quiet eye in successful attempts is longer than that in unsuccessful attempts (5,6). Therefore, improving this visual skill can be one of the necessary factors for an athlete who wants to achieve a higher level of skill; So that elite players have the best visual skills.

Investigations in this area help to make predictions about the underlying structure of the task. For example, it can be determined which source of information is related to performance and how this source of information changes with skill development (7).

To properly understand the environment, it is necessary to place images in the center of vision through purposeful movements of the eyes, head, and body, which is called glare control. Glare control involves a number of different eye movements, or saccades, in which the object of interest is brought to the center of vision and keeps this information constant. Thus, details can be extracted (i.e. fixations and pursuits). Saccades are eyes' jumping movements that bring the maximum visual acuity point to the center of vision. Thus, the object can be seen clearly (8). Information processing is suppressed between saccades, but saccades connect the fixations, glare, and pursuits to each other. Therefore, a coherent view of the scene is obtained. Fixation is the maintenance of a constant glare in the range of 1 to 3 degrees from the angle of view for 80 to 150 milliseconds, which allows it to process information (2). Thus, the quiet eye is a variable that is related to skill and is the basis for research questions in the field of motor learning and practice (9,10). The quiet eye technology provides a way to discover and understand the underlying mechanisms and dynamics and real-time cognitive processing leading to skillful execution (11); so that the quiet eye has been a key predictor of efficient performance in inhibitory and targeting tasks over the years (6).

Several studies have been conducted using video-based eye tracking systems in sports with targeting components such as shooting, darts, billiards, table tennis, and football (10,12-15); Three potential concepts (attention control, attention focus, and response planning) illustrate how the quiet eye can enhance performance and accelerate learning in targeting sports (16). Sports such as shooting, archery, and darts require both excellent skills in optimal movement control and focus on the target (17).

The results of a study examining the performance of eye movements and gun movement control on 24 skilled shooters indicated that the stability of the gun movement and the longer lifespan of the quiet eye are very important for successful performance in shooting at flying targets (18).

The results of a study aimed at investigating the effect of internal and external focus on the quiet eye characteristics of elite military shooters concluded that the beginning, end, and duration of the quiet eye under external and internal focus conditions were earlier and longer, respectively (17).

Some researchers have successfully used the quiet eye as an educational tool to improve performance in various targeting sports (19-21), and recently outside the field of sports, the quiet eye has also been used as a tool; such as when its exercises are used in educational skills related to surgery (22) or the population of clinical patients (23). In some studies, quiet eye training (where to look and for how long) leads to increased performance due to a relative increase in the quiet eye (16,24).

A pairing training protocol was performed on 21 novice golfers when starting to swing backwards in full and closed vision conditions to explain the roles related to simultaneous preprogramming and control during the quiet eye period, with the results suggesting that in full vision conditions in contrast to the closed vision, the radial error was higher and the length of the quiet eye period was longer (25).

In another study, the quiet eye behavior of semi-skilled and skilled basketball players in defensive versus non-defensive situations was compared. The results were indicative of the increasing effects of the long-term performance of the quiet eye in the defensive position compared to the non-defensive game. In addition, the early start of the quiet eye was associated with successful implementation in support of previous proposals, in which not only the duration, but also timing were important. These findings not only extend the positive effects of the quiet eye on motor performance for dynamic play conditions, but also support the role of the quiet eye in responding to programming and information processing (26).

Vision skills enable champions of all levels of ability to quickly and accurately detect and process visual information. This is the first step in preparing the body for a proper response during the competition and is one of the most important elements of success in sports. Improving visual skills can be one of the factors needed for an athlete who wants to achieve a higher level of play; So that elite players with the best visual skills are at.

The relevant research literature has not addressed the effect of quiet eye interventions on the performance and retention of important variables in pistol shooting task. Therefore, the present study seeks to answer the question of whether the quiet eye training protocol designed can improve the performance of pistol shooters. An effective relationship has been proposed between eye movement and training methods in sports as the first performance improvement technique and shooting exercise is one of the skills in which visual function plays an effective role. Accordingly, the present study is accomplished with the aim to investigate the effect of performing quiet eye training on the performance of shooters. Based on the investigations in various sports, designing quiet eye exercises can improve the duration of quiet eye affecting the shooter's performance and help the elite and even semi-skilled shooters to achieve the best shooting result faster.

Materials and Methods

This was a controlled clinical trial study designed as a pretest-posttest and retention with two groups of quiet eye exercises and technical exercises. First, after arrangement with the Shooting Federation of the Islamic Republic of Iran, the quiet eye performance was examined and recorded on the eyes of five pistol shooters, members of the national team, by an eye tracking device.

The study population consisted of 60 male and female shooters in the 10-meter pistol category present in the country's major competitions (Premier League, national championship and freestyle) who, according to previous research (20). Among this population, after completing the consent form, 20 subjects were selected using the purposive and convenience sampling method, and based on the pre-test scores, they were assigned into the two groups of quiet eye exercises (n = 10) and technical exercises (n = 10) from the highest to the lowest score as every other one (ABBA method). The study inclusion criteria included a record of 545-555 m, normal vision, aligned eyes and hands: superior right, and age range of 18 to 24 years. All participants used personal equipment related to their shooting sport that they always practiced with.

The present study was approved with the ethics code IR.SSRI.REC1398.132 in the research ethics committee of the Institute of Physical Education and Sports Sciences and with the IRCT20200223046592N1 on the Iranian Registry of Clinical Trials (IRCT).

In order to record the score, a SCATT device (USB ST4-12, SCATT Company, Russia) was utilized, the optical sensor of which was mounted under the pistol barrel and its information was stored in the first computer via a cable. At the same time, to check the onset and duration of the quiet eye, a pupil eye tracking device (Pupil Eye Tracking USB model, PUPIL, Germany) was used, which was placed on the eyes and their information was stored in the second computer via a cable.

30 minutes before the start of the test, the subjects attended the special Olympics shooting hall of Sepahanshahr in Isfahan, Iran. All steps before the test were fully explained to the participants by the tester and they got familiar with the test process. Each shooter then performed 10 attempts for 10 minutes as a pre-test.

In the first training session of the quiet eye training group, while the shooters were asked not to participate in any shooting exercises other than the quiet eye training, the method of participating in the quiet eye training was explained to them on one of the participants of the quiet eye group. Each shooter performed the quiet eye exercises in accordance with the pattern obtained from the elite shooter pattern and through video screening with verbal instructions for 8 sessions in 6 blocks of 10 consecutive minutes. In this way, in each block, two participants attended the training site at the previously specified time and performed 10 attempts for 10 minutes in each block (the first and second fixation blocks with 5 glare points on the bore sighter, the third and fourth fixation blocks with 3 glare points on the bore sighter, and the fifth and sixth blocks with matching the fixation of 3 glare points on the bore sighter with the elite shooter eye movements) similar to the test conditions under the supervision of the researcher and the scores of each block were recorded in each training session (27). In total, each shooter made 480 attempts. The technical training group also learnt their technical training, including watching the training video of one of the Olympic pistol shooting champions, based on the technical points performed, dry training (without bullets) and training on training targets, and based on the amount of time and sessions similar to the quiet eye training group under the supervision of their coach and in a time different from the quiet eye training group. Immediately after training, a shooting post-test was taken as an acquisition test, and a retention test after 24 hours (28).

The obtained data were summarized and described using descriptive statistical methods including

calculation of mean and standard deviation (SD) and drawing tables. The Shapiro-Wilk test was employed to evaluate the normal distribution of the data and repeated measures analysis of variance (ANOVA), independent t, and Bonferroni post hoc tests were used to test the study hypotheses. Finally, the data were analyzed in SPSS software (version 20, IBM Corporation, Armonk, NY, USA).

Results

First, the normality of the data distribution was investigated using the Shapiro-Wilk test, with the results showing that the data was of a normal distribution
($P > 0.05$). The process of change of the study groups in the pre-test stage, acquisition sessions, and post-test and retention stages is presented in figure 1.

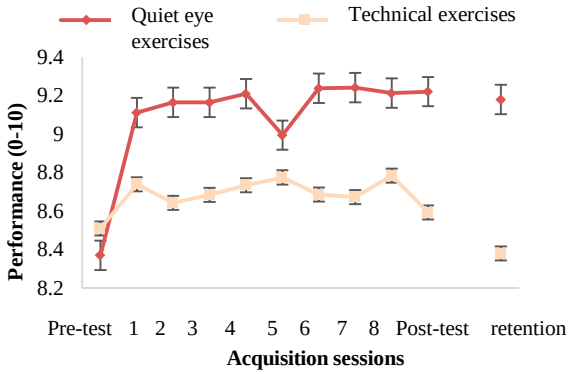

Figure 1. Changes in the shooting performance of the study groups during the acquisition sessions and study stages

The results of the repeated measures ANOVA test with the assumption of Mauchly's Test of Sphericity ($P > 0.05$) to see the changes of the study groups from the pre-test to retention indicated that these changes were significant for the quiet eye training group, but not significant for the technical training group. The results of the Bonferroni post hoc test showed that the quiet eye training group had better shooting performance in the post-test and retention stages than in the pre-test stage. No significant difference was observed between the pre-test and retention stages. Based on the results of the independent t-test, there was no significant difference between the quiet eye and technical exercise groups in the pre-test stage, but there was a significant difference between the two groups in the pre-test and retention stages; thus, the quiet eye training group showed better shooting performance compared to the technical training group (Table 1).

Table 1. Results of repeated measures analysis of variance (ANOVA) test to examine the intra-group differences in shooting performance at different stages

Group	Indicators	df	F	P	Effect size
Quiet eye exercises	Conditions	2	10.42	0.001*	0.53
	Error	18	-	-	-
Technical exercises	Conditions	2	1.15	0.330	0.11
	Error	18	-	-	-

* Significance at the level of $P \leq 0.05$
df: Degrees of freedom

The results of the Bonferroni post hoc test revealed that the quiet eye training group had better shooting performance in the post-test and retention stages than in the pre-test stage. No significant difference was observed between the pre-test and retention stages. The results of the independent t-test showed that there was no significant difference between the quiet eye and technical exercise groups in the pre-test stage, but there was a significant difference between the two groups in the pre-test and retention stages; thus, the quiet eye training group showed better shooting performance in comparison to the technical training group (Table 2).

Table 2. Results of Bonferroni post hoc test to examine the differences between the study stages of the quiet eye training group

Stage (i)	Stage (j)	Mean difference	P
Pre-test	Post-test	0.85	0.010*
	Retention	0.81	0.020*
Post-test	Retention	0.04	0.990

* Significance at the level of $P \leq 0.05$

The results of the independent t-test showed that there was no significant difference between the quiet eye and technical exercise groups in the pre-test stage, but the difference between the two groups in the pre-test and retention stages was significant; thus, the quiet eye training group showed better shooting performance than the technical training group (Table 3).

Table 3. Independent t-test results to examine the differences in shooting performance between the two quiet eye and technical exercise groups

Stage	df	Mean difference	T	P
Pre-test	18	0.14	0.79	0.440
Post-test	18	0.62	3.04	0.007*
Retention	18	0.80	3.29	0.004*

* Significance at the level of $P \leq 0.05$
df: Degrees of freedom

Discussion

The aim of this study was to investigate the effect of quiet eye exercises on improving the performance of pistol shooters. The quiet eye has beneficial effects on performance through training protocols and can be used as an educational tool to improve performance in various targeting sports, which shows a clear correlation between the quiet eye and performance (16). The findings regarding the effect of quiet eye exercises showed that the group of quiet eye exercises in the post-test and retention stages had better shooting performance compared to the pre-test stage and a significant difference was observed between the pre-test and retention stages. In other words, performing quiet eye exercises in the quiet eye group increased the shooters' record, which is in line with the findings of previous studies (12,16,24,26).

Concerning the effectiveness of the quiet eye exercises, it can be argued that the quiet eye exercises, by the number of perceptual motor workspaces, can affect the number and type of locations and targets in a visual motor space, location of vital targets, focus, and optimal timing of glare. Give. Research into the phenomenon of the quiet eye in sports shows that when a high level of skill is acquired, not only is glare directed directly to the most important places and targets in the performance space, but also vital targets and the optimal performance infrastructure are obtained and received at the right time (29). For example, Causer et al. found that quiet eye time in skilled shooters was significantly longer than in novice shooters (18), which is in agreement with the findings of the present study and the results of Miles et al. on the effectiveness of quiet eye practices on the performance and shooting and catching learning of young children (30,31). Therefore, it can indicate the effect of quiet eye exercises on proper and timely scheduling of quiet eye and performance (21). By examining the factors affecting shooting skills and especially achieving more records, staying on target (18) through the training of perceptual-cognitive skills such as the quiet eye, affected the performance of the shooter (2,16,32,33).

In the study by Moore et al., who examined the effect of quiet eye training on the performance and kinematics of novice golfers' swings, it was found that the quiet eye training group had a longer quiet eye duration and better golf swing efficiency (lower acceleration). Additionally, their further analysis indicated that only the swing acceleration could explain the difference between the performance of the control and the quiet eye training groups, which is also present in the kinematics of the weapon and the aiming. Therefore, they argued that the threshold of the quiet eye duration may explain the lack of correlation between performance and quiet eye duration (20). If the quiet eye does not have the desired threshold, it may not be able to increase the length of the quiet eye and consequently improve performance. It seems that the quiet eye in the present study has reached the desired threshold, which has been able to increase the record.

There is a strong correlation between eye movement and programming networks that may be important during quiet eye (34). The importance of understanding the mechanisms of the quiet eye provides more knowledge of the behavioral and neural mechanisms and productivity strategies by professional athletes. Moreover, the formulation of more efficient training protocols to improve the direction of movement not only in exercise, but also in other cases such as surgery and among the population of clinical patients such as children will be facilitated by coordinating the development of disorders and stroke survivors (35); As the quiet eye lasts longer, accuracy and expertise improve (4,36). Furthermore, increasing the duration of the quiet eye in successful attempts compared to the more unsuccessful attempts can be one of the factors required for an athlete who wants to achieve a higher level of skill (5,6,37).

This states that the performer fixes the information field of the image on the visual focus, and complex information processing guides his or her decision-making skills and motor control; in a way that due to the suppression of information during saccades, the visual search strategy uses fewer and longer fixations, more effectively and efficiently (38). The results of investigations have shown that paying attention to the fixation points leads to inhibition of the visual-motor system (reduction in the range and acceleration of the saccades). Thus, active fixation on points leads to the allocation of attention to that point and disregard for environmental situations (39); So that the fixation time before performing a movement as one of the quiet eye strategies, expresses the difference between specialized motor skills and execution in precise motor tasks (26); While optimal glare control in the selection of accurate targets, optimal timing, and the ability to focus attention for a long time are among the needs of shooting skills that confirm the results of the present study and can also argue that the findings of the present study are consistent with the results of previous studies (40,41).

Another argument in support of the present study is that the quiet eye may be used as part of a pre-

performance routine to help the performer focus on what he or she can control (a performance-related external sign). Thus, quiet eye training is a practical technique for guiding the external focus of visual attention and its timing in relation to important movements (motor vision control) (27). Through facilitating information processing, quiet eye affects motor performance and can lead to increased accuracy and performance in a throwing task. It seems that quiet eye exercises cause the person to focus on important stimuli that underlie optimal performance (42-44).

Improving visual skills in sports is one of the important techniques to improve performance. Through the inclusion of vision training programs or with the help of different and effective tools and methods in promoting this type of skills, the above-mentioned methods can certainly improve environmental vision, eye, hand, body coordination, proprioception, vision, and spatial awareness (45).

The quiet eye is a perceptual-motor skill and can be used as a performance-enhancing technique on beginner and professional athletes. Additionally, the positive relationship between quiet eye and external focus leads to training and performance improvement, and staring at focus areas has been used in most quiet eye training protocols. The relative contribution of quiet eye training through quiet eye manipulation and glare control to identify why, how, and when (where to look and for how long) during targeting exercises can affect performance (16,24). In examining the effect of quiet eye exercises, it is necessary to pay attention to the characteristics and skill level of athletes; So that beginner athletes are in the first stage of learning (verbal-cognitive stage) and need a lot of attention. Therefore, the use of this type of exercise is not recommended due to the imposition of high cognitive load and its adverse effects on performance and learning.

Limitations

Lack of morning sleep control for participants who attended the training session was one of the limitations. It was likely that they did not get enough sleep at night or that they had taken sleeping pills in training sessions due to illness. Nutrition, sleep, and personal issues affecting motor function were other limitations of the study.

Recommendations

Given that quiet eye is a perceptual-motor skill that has its own temporal characteristics and is also an important factor influencing performance and gaining more scores in most targeting sports, it is suggested that in future studies, given its temporal characteristics, this skill be presented in a larger number of sessions and concurrent with exercises focusing on the implementation of skill techniques. Besides, according to studies conducted in racket sports such as table tennis, badminton, and tennis, where most athletes perform hits with the dominant hand, no research has been carried out so far. It is suggested that future research examine the relationship between quiet eye exercises and how performing the hitting hand movement in which the athlete performs the hits with the dominant hand at the same time, as well as the amount of learning transfer to the non- dominant hand.

Conclusion

The results of the present study showed that quiet eye training can have a positive effect on performance and improve shooters' scores. Considering that quiet eye is an important factor influencing performance and gaining more points in most targeting sports with less dynamic conditions such as pistol shooting, it helps the shooter to perform movements more efficiently in the task of fixed aiming, and as a result, he has better control in the targeting moment.

It can be concluded that this type of visual skills can be one of the important indicators in the way of training and talent development in targeting sports according to the characteristics of sports tasks that can be applied in schools and sports talent development centers.

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Authors' Contribution

Jaleh Bahramian-Dehkordi: study design and ideation, providing study equipment and samples, data collection, analysis and interpretation of results, specialized statistics services, manuscript preparation; Saleh Rafiee: support, executive, and scientific study services, specialized evaluation of manuscript in

terms of scientific concepts, approval of the final manuscript for submission to the journal office, responsibility of maintaining the integrity of the study process from the beginning to publication, and responding to the referees' comments.

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Conflict of Interest

The authors declare no conflict of interest.

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