European Journal of Physical Education and Sport Science
ISSN: 2501 - 1235
ISSN-L: 2501 - 1235
Available on-line at: www.oapub.org/edu

DOI: 10.46827/ejpe.v11i8.5730 Volume 11 | Issue 8 | 2024

COMPARISON OF QUIET EYE DURATION OF THREE DIFFERENT PERFORMANCE LEVEL ATHLETES IN AIR PISTOL SHOOTING: A PRELIMINARY RESEARCH REPORT

İsmail Bayram[1,2,3i]
Ece Ayaz Kanat[4]
Deniz Şimşek[5]
[1]Dresden Technical University,
Faculty of Psychology,
Psychology of Learning and Instruction,
Dresden, Germany
[2]Dresden Technical University,
Centre for Tactile Internet with Human-in-the-Loop (CeTI),
Dresden, Germany
[3]Istanbul Rumeli University,
Faculty of Sport Sciences,
Department of Coaching Training,
Istanbul, Türkiye
[4]Marmara University,
Graduate School of Health Sciences,
Exercise and Training Science,
Istanbul, Türkiye
[5]Eskişehir Technical University,
Faculty of Sport Sciences,
Department of Physical Education and Sports Teaching,
Eskişehir, Türkiye

Abstract:
Prior research has suggested that the duration of the quiet eye, a period of stabilized gaze on a critical target before executing a motor skill, may serve as a reliable marker of expertise. This study aimed to investigate the role of quiet eye durations in shooting performance across various skill levels classified as novice, experienced, and expert, particularly in young populations. A novice, an experienced, and an expert shooter performed four shooting sessions from a 10 meters distance while an advanced eye-tracking system recorded gaze behaviour at a sampling frequency of 100 Hz. Mean and standard deviation values of quiet eye times were computed for each skill level determined as novice (332 ± 144.14 ms), experienced (817.75 ± 5.31 ms), and expert (925.5 ± 103.70 ms). The results revealed a congruent pattern in the relationship between quiet eye duration and skill levels. Expert athlete exhibited significantly longer quiet eye

[i] Correspondence: email ismail.bayram@tu-dresden.de

durations compared to other levels, confirming our initial hypothesis. These results emphasize that, as athletes progress in experience, there is a corresponding enhancement in their ability to sustain focus on critical targets during specific motor skills, a crucial aspect of shooting performance. Moreover, this enhancement seems to occur even at young ages. These findings underscore the significance of quiet eye duration in evaluating skill development and expertise in shooting sports. Increasing participant numbers will pave the way for further research to refine our understanding of these dynamics in diverse sporting contexts.

Keywords: eye-tracking, pistol shooting, quiet eye duration, skill level, athlete expertise

1. Introduction

Pistol shooting recently gathered much attention all around the world after the phenomenal pose of Yusuf Dikeç in the 2024 Paris Olympic Games. Although he maintains a calm stance, this discipline demands a high level of mental focus and multifactorial complex skills (4). As an aiming sport, the performance is closely linked to gaze behaviour and naturally, continuous rehearsal over a long period of time transforms an athlete from being a novice performer to being an expert (1).

In the context of sports science, it is important for athletes to gather visual information to perform various sport-specific tasks effectively (15, 30). Gaze behaviour described as ''*boosting the processing of visual input to enable the best possible coupling of perception and action*'' is a crucial part of gathering visual information (13). The quiet eye stands for the final fixation of the gaze that is located on the target with a minimum of 100 ms duration and a maximum of 3^0 visual angle (26). There is a phenomenon in the related literature called ''Efficiency Paradox'' which means the increase of quiet eye duration with the increase of expertise level in order to optimise fine-tuning of the motor task (19).

The use of eye-tracking devices has considerably increased, especially within the past two decades (23). Since the collection of visually relevant information is vital to performing a variety of tasks effectively, analysing gaze behaviour has the potential to increase our understanding of motor performance (18). Different protocols have been offered for static and dynamic conditions. Despite some methodological data collection difficulties during dynamic conditions, eye-tracking systems are capable of conducting high-frequency data acquisition during static conditions in a better way (17).

The proficiency level in rapid-action sports like tennis and football is contingent upon the management of precise and adept physical motions within strict spatial and temporal boundaries but in precision-oriented sports such as archery and shooting, the ability to aim at the target is the primary determining factor (11). Due to the importance of the effect of visual information process speed and gaze behaviour on motor performance, a plethora of studies compared gaze behaviour in different performance levels of athletes (15). Expertise level plays a critical role in quiet eye duration, and in most cases, quiet eye duration is longer when the performance level increases (12, 16, 21, 27). This is reported by various studies such as in racket sports (2), soccer (16, 28, 32), basketball (12, 27, 6, 14, 20), volleyball (21), tennis (22) and shooting (4, 8, 9,10, 24, 31) indicating expert athletes are exhibiting longer quite eye durations.

Much of this research has, however, examined visual research strategies in riffle or gun shooting, and studies comparing gaze behaviour in pistol shooting are rare, particularly in younger age groups. Typically, these studies are carried out with eye-tracking devices where players view and respond to photographs or video films positioned in front of them in a laboratory setting, creating a lack of study focus under real competition conditions. Scholars have, in fact, identified sensory and mental adaptations that distinguish expert performers from their less proficient counterparts, as well as exceptional performances from substandard ones, as documented in recent reviews by Kredel et al. (15) and Lebeau et al. (17) also in meta-analyses by Mann et al. (18) and Williams and Jackson (29). A possible explanation for that adaptation process might be because muscular adaptation as a response to physical load occurs within ~4 weeks (3), while changes in observable motor performances might take years of practice (5).

Nevertheless, quiet eye components combined with performance outputs are not investigated deeply, especially in young populations. In this regard, the purpose of this pilot study was to compare quiet eye durations and shooting performance of three different performance levels in air pistol shooters. We hypothesized that the proficiency level of athletes and quiet eye durations would increase parallelly.

2. Material and Methods

2.1. Research Model

This research is a cross-sectional preliminary study in the observational model, which aims to identify patterns and differences in quiet eye durations among novice, experienced and expert athletes, with a particular emphasis on young populations.

2.2. Participants

Three male shooters, classified as novice (age: 18 years; weight: 59kg; height: 169cm; training age: 3 years), experienced (age: 19 years; weight: 61 kg; height: 171 cm; training age: 5 years), and expert (age: 19 years; weight: 74 kg; height: 173 cm; training age: 7 years), participated in the study voluntarily. The level grouping of the athletes was determined according to the threshold scores determined by the Turkish Shooting and Hunting Federation. In addition, the expert-level athlete passed the Olympic threshold, and he has the qualification to participate in the Olympics. They were devoid of any injuries related to shooting or any form of chronic disease at the time of assessment. Participants were instructed to abstain from consuming alcohol or caffeinated beverages for a minimum of 24 hours prior to the experiment.

2.3. Data Collection Tools

Each shooter performed four shootings at a 10 meters distance (Figure 1) based on the International Shooting Sports Federation (ISSF) rules and regulations. Eye movement data was collected (100 Hz) using an eye-tracking system (Tobii Pro Glasses 2, Glasses controller Software, Stockholm, Sweden). The eye-tracking system (Figure 2) acts as an infrared projection system, which accurately captures cornea movements. Additionally, the system consisted of four cameras, with two located on each side (right and left), positioned in the inside corners of the glasses. These cameras not only record eye movements but also facilitate audio recording.

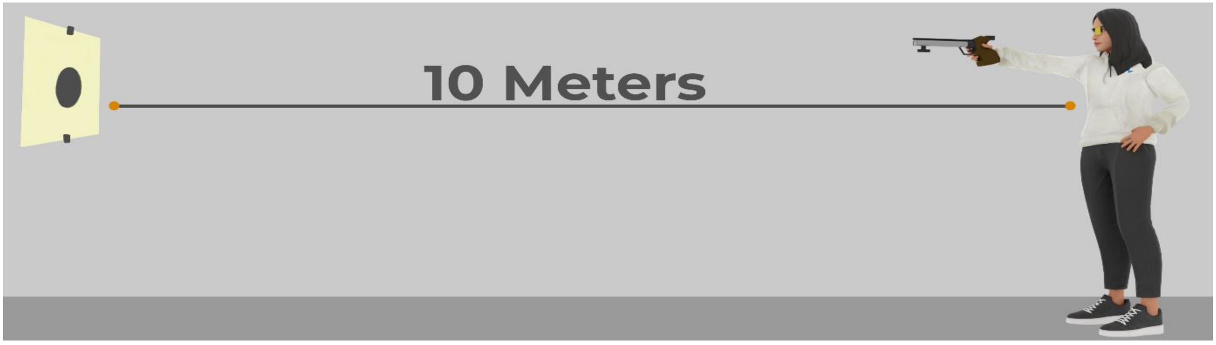

Figure 1: Experimental setup

Throughout the shooting sessions, the eye-tracking system recorded cornea movements by projecting infrared light onto the participants` corneas. Simultaneously, a vector-based algorithm calculated the distance between the pupil and cornea, visually representing the focal point on a computer screen. The detailed working principle and general features of the system are explained by Senduran (23) broadly. The eye-tracking system wirelessly transmitted this information using its built-in Wi-Fi feature, converting the data into numerical format.

Figure 2: Tobii Pro Glasses 2 Eye-Tracking System

During four shooting sessions, an electronic target system (Scatt Shooter Training Systems, Moscow, Russia) was employed to measure and determine each shooting performance (Figure 3).

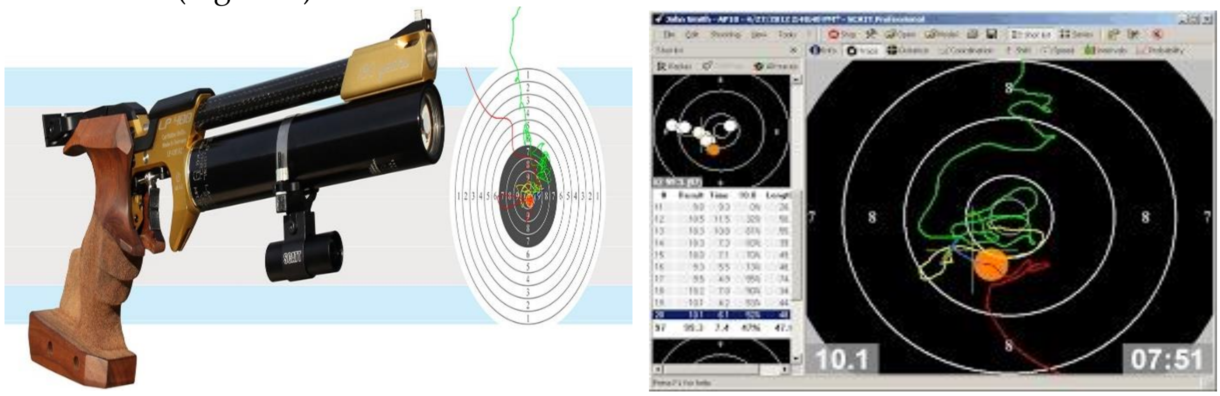

Figure 3: Scatt Shooter Training Systems

2.4. Data Acquisition

Prior to the shooting tests, all participants participated in a comprehensive 10-minute shooting-specific warm-up to prepare for the upcoming task in their regular routine. Following the warm-up, a 15-minute familiarization period was conducted where participants engaged with the Scatt System. At the same time, the eye-tracking system was securely attached to each participant to ensure they were comfortable with the equipment and ready for the measurements.

The Olympic rules for the 10m Air Pistol event consist of 60 competition shots for solo categories, where shooters have one hour and 15 minutes to complete their shots, with the top eight moving on to the medal round. In the mixed team (one male and one female) event, each team member fires 40 shots, and the top five teams compete for overall honours. We employed a mixed-team approach so that each athlete performed 10 shots within four blocks, making a total of 40 shots. The score of these 10 shots and quiet eye time during shots were then averaged, and the mean value of each block was presented as a single data point.

2.5. Data Analysis

The mean value of the 10 shots in each block was calculated and presented as a single data point. This method provided a clear and concise representation of performance, facilitating the monitorization of quiet eye duration and shooting accuracy across different skill levels. We were unable to perform statistical analysis since we had only one participant for each group.

The shooting process comprised four phases: positioning, preparation, aiming, and shooting. Quiet eye duration was measured when the participants' gaze remained within the Area of Interest (AOI), defined as the target and bead. The quiet eye time indicated the longest focus on the target before triggering the shot. Quiet eye duration was calculated by using the manufacturer-provided analysis software, Tobii Pro Lab (version 1.76). Mean and standard deviation values were calculated in an Excel sheet after exporting the raw data from the eye-tracking system. This is a pilot study comparing quiet eye duration of three different performance levels in pistol shooting so that all the raw data is presented in the results section.

3. Results

Our findings provided support for the notion that expert athletes exhibit longer quiet eye duration during specific motor skills. In contrast, novice athletes tend to execute shorter and more frequent saccades to maintain focus on a target. Specifically, experts demonstrate the ability to sustain a single saccade for a longer duration. The mean and standard deviation values of quiet eye duration for the shooters were as follows: beginner, 332 ± 144.14 ms; intermediate, 817.75 ± 5.31 ms; and expert, 925.5 ± 103.70 ms (Figure 4).

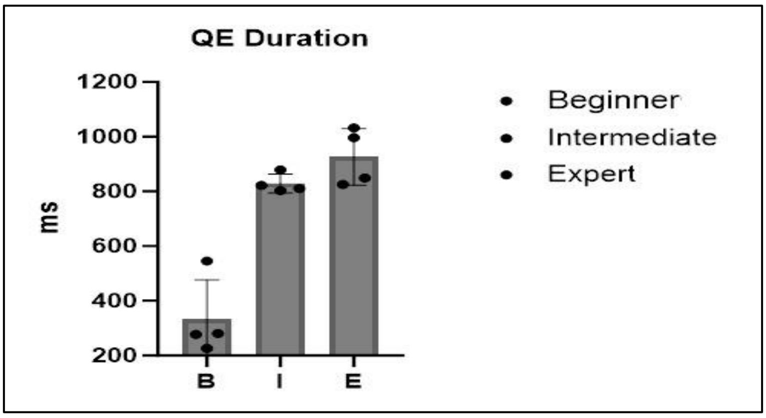

Figure 4: Quiet Eye duration according to expertise levels shoots

Additionally, we analysed the mean shooting scores for each skill level. The beginner shooter achieved a mean score of 8.1, the intermediate shooter scored 8.9, and the expert shooter obtained a score of 10.3, reflecting their respective shooting abilities (Figures 5 and 6).

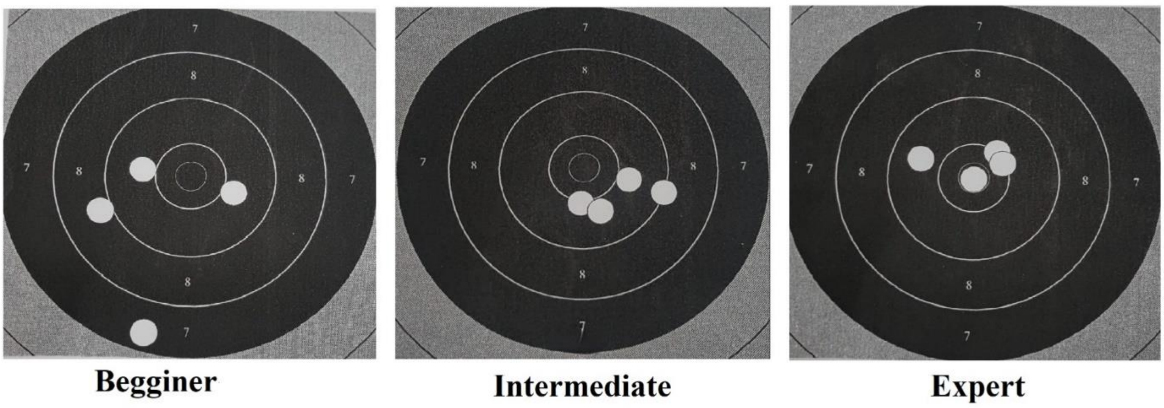

Figure 5: Shooting scores from Scatt Shooter Training Systems according to expertise levels shoots

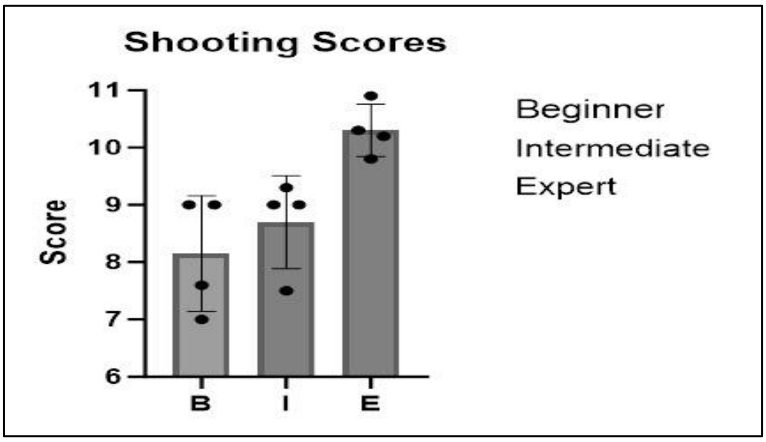

Figure 6: Graphical view of shooting scores according to expertise levels

Figures 5 and 6 illustrate the shooting scores elicited from the Scatt Shooter Training Systems, categorized according to the expertise levels of the athletes. The data clearly indicate a progression in performance aligned with the expertise levels as: expert shooters consistently achieve the highest scores, followed by intermediate shooters, while beginner shooters display the lowest scores. This trend highlights the correlation between increased proficiency and shooting accuracy, emphasizing the impact of training and experience on shooting performance. The graphical representation in Figure 6 visually reinforces this hierarchy, offering a clear comparison of the scores across different expertise levels.

4. Discussion

This preliminary study aimed to investigate the role of quiet eye duration and shooting performance in young athletes of different skill levels. By utilizing an eye-tracking system, we were able to capture and analyse the eye movements of a novice, an experienced, and an expert shooter during four shooting blocks at a distance of 10 meters. Our results provided a better understanding of the quiet eye and its association with shooting expertise, especially within young populations (late adolescence, early adulthood). The presented raw data revealed clear distinctions in quiet eye behaviour between different skill levels, with expert and intermediate shooters exhibiting significantly longer quiet eye duration compared to novice (expert > intermediate > beginner).

Our results support previous studies reporting a longer quiet eye duration of expert shooters (4, 10, 7). We assumed that the proficiency level of athletes and quiet eye durations would increase parallelly. Based on the raw data, his assumption is true since we observed a mutual increase in expertise level and quiet eye durations. A recent study (7) reported a clear distinction of mean quiet eye durations between novice and intermediate shooters (novice: 897 ms and intermediate: 3423 ms), which aligns with our results. Various other sports, such as basketball (12, 27, 6, 14, 20), tennis (22), soccer (16) and volleyball (21), repeatedly report longer quite eye durations for experts. However, Vardar and Senduran (25) reported that there is a 37.8% increase in the duration of quiet eye when firing scored shots compared to firing unscored shots.

There are some conflicting results in the studies where successful and unsuccessful performances are compared. For instance, in Vickers′ study (27), it was reported that the quiet eye duration did not vary significantly during missed shots among near-expert basketball players. On the other hand, Ayaz Kanat and Simsek (12) found that when comparing successful and unsuccessful free throws in basketball, there was a shorter quiet eye duration exhibited by amateurs during unsuccessful attempts, as opposed to experts. Recently, Güler et al. (7) reported that there were no significant differences in quiet eye durations, even when shooting performance was superior in shots that scored a perfect 10.

In our findings, we observed that the quiet eye duration of the expert shooter was three times longer than that of the novice shooter (332 vs. 925). We attribute this difference to motion economy and the motor programming process of the shooting (26, 19, 17). The values for experienced shooters were quite similar to those of expert players, as in experienced players, too, longer quiet eye durations are expected to be positively correlated with performance. Novices, characterized by shorter quiet eye durations, appear to undergo a transformation in their gaze behaviour as they gain experience (18). Our findings support the idea that skill development is linked to the ability to sustain longer quiet eye durations. This transformation from novice to expert appears to be marked by an extension of the quiet eye duration, a phenomenon that suggests skill acquisition and expertise progression (1).

Moreover, there are many other parameters that directly affect the shooting performance. For instance, stability of hold, cleanness of triggering, aiming accuracy, and timing of triggering were identified through multiple regression analysis as the foremost predictors, collectively accounting for 81% of the variance in shooting scores (9). In this regard, future studies should focus on the shooting performance assessment in a holistic manner.

Our preliminary investigation into the relationship between quiet eye durations and shooting performance was not limited to quiet eye duration analysis alone. We also delved into the quantitative aspects of shooting expertise, as reflected in the Total Scores achieved by our participants. These findings emphasize that not only do experts sustain longer quiet eye durations, but they also consistently outperform their less experienced counterparts.

This preliminary study possesses certain limitations, notably the small number of shots analysed. Furthermore, the participants were confined to a narrow range of only one participant from each group, certainly limiting the generalizability of the findings. To enhance the external validity and generalizability of our findings, future research should aim to include a larger sample size within each skill level category. This would provide a more comprehensive understanding of the relationship between visual strategies and shooting performance. Coaches can gain valuable insights into the role of the quiet eye and its connection to shooting scores, offering opportunities for performance optimization. Moreover, coaches may find it beneficial to implement strategies aimed at enhancing athletes´ gaze behaviour based on the outcomes of such studies.

5. Conclusion

In conclusion, our study provides more evidence supporting the hypothesis that quiet eye duration increases as the experience level of an athlete progresses, also in young populations. These findings align with existing literature on the subject and underscore the significance of quiet eye durations in skill acquisition and expertise development. By expanding the participant pool, researchers can obtain a more comprehensive understanding of the relationship between quiet eye behaviours and shooting expertise. Furthermore, incorporating a diverse range of athletes from various competitive levels and different shooting disciplines would provide a more robust examination of the phenomenon. And this could potentially inform training protocols and interventions aimed at enhancing skill acquisition and performance outcomes.

Acknowledgements
This study has been orally presented at the 9th International Biomechanics Congress held by Anadolu University in Eskişehir, TÜRKİYE. The authors would like to express their sincere appreciation to the participants who volunteered for the study. We are grateful for their invaluable contribution and commitment. Special thanks are also due to the coaches, Veli Can Çalhan and Mübeccel Çalhan, for their support, expertise and assistance throughout the research process. This study is partly funded by the German Research Foundation (DFG, Deutsche Forschungsgemeinschaft) as part of Germany's Excellence Strategy – EXC 2050/1 – Project ID 390696704 – Cluster of Excellence "Centre for Tactile Internet with Human-in-the-Loop" (CeTI) of Technische Universität Dresden.

Conflict of Interest Statement
The authors declare no conflicts of interest.

About the Author(s)
İsmail Bayram has completed his PhD in sports biomechanics and is currently working at the Technische Universität Dresden and its Cluster of Excellence, CeTI - (Centre for Tactile Internet with Human-in-the-Loop) as a Postdoctoral Research Associate. He also holds an Assistant Professor position at Istanbul Rumeli University. His research focuses on multisensory experiments using technologies like motion capture, electromyography, and eye tracking to enhance sensory-motor skill acquisition, particularly in high-level sports.
Ece Ayaz Kanat is a PhD student at Marmara University, Graduate School of Health Sciences, Movement and Training Science Program. Ece does research on eye movements

and the psychophysiology of basketball players and other athletes. She is currently working at a research center in Mississippi, USA.
Deniz Şimşek is a Professor Dr. at Eskisehir Technical University, Faculty of Sport Sciences, Department of Physical Education and Sports Teaching. Her main research areas are talent identification and guidance in sports, exercise and sports physiology, athletic performance in archery, game and performance analyses and biomechanical analyses of sport-related technical skills.

References

1. Abernethy B, (2013). *Biophysical foundations of human movement*. 3rd ed. Champaign, IL: Human Kinetics; 394 p. Retrieved from https://books.google.gg/books?id=w-FlXA8p7vQC&printsec=frontcover&source=gbs_atb#v=onepage&q&f=false

2. Abernethy, B., & Russell, D. G. (1987). The relationship between expertise and visual search strategy in a racquet sport. *Human Movement Science*, 6(4), 283-319. https://doi.org/10.1016/0167-9457(87)90001-7

3. Altan, E., Seide, S., Bayram, I., Gizzi, L., Ertan, H., & Röhrle, O. (2020). A systematic review and meta-analysis on the longitudinal effects of unilateral knee extension exercise on muscle strength. *Frontiers in Sports and Active Living*, 2, 518148. https://doi.org/10.3389/fspor.2020.518148

4. Causer, J., Bennett, S. J., Holmes, P. S., Janelle, C. M., & Williams, A. M. (2010). Quiet eye duration and gun motion in elite shotgun shooting. *Medicine and Science in Sports and Exercise*, 42(8), 1599-1608. https://doi.org/10.1249/MSS.0B013E3181D1B059

5. Ertan, H., & Bayram, I. (2020). *Fundamentals of human movement, its control and energetics*. In Comparative Kinesiology of the Human Body (pp. 29-45). Academic Press. https://doi.org/10.1016/B978-0-12-812162-7.00003-5

6. Fischer, L., Rienhoff, R., Tirp, J., Baker, J., Strauss, B., & Schorer, J. (2015). Retention of quiet eye in older skilled basketball players. *Journal of Motor Behavior*, 47(5), 407-414. https://doi.org/10.1080/00222895.2014.1003780

7. Güler, G., Şimşek, D., Tuncer, S., & Mon-López, D. (2023). Evaluation of physiological parameters and gaze behaviour of air pistol shooters related to performance outcomes. *International Journal of Performance Analysis in Sport*, 1-12. https://doi.org/10.1080/24748668.2023.2280348

8. Heusler, B., & Sutter, C. (2020). Gaze control in law enforcement: Comparing a tactical police unit to patrol officers. *Journal of Police and Criminal Psychology*, 1-17. https://doi.org/10.1007/s11896-020-09412-z

9. Ihalainen, S., Kuitunen, S., Mononen, K., & Linnamo, V. (2016). Determinants of elite-level air rifle shooting performance. *Scandinavian Journal of Medicine & Science in Sports*, 26(3), 266-274. https://doi.org/10.1111/sms.12440

10. Janelle, C. M., Hillman, C. H., Apparies, R. J., Murray, N. P., Meili, L., Fallon, E. A., & Hatfield, B. D. (2000). Expertise differences in cortical activation and gaze behavior during rifle shooting. *Journal of Sport and Exercise Psychology*, 22(2), 167-182. https://doi.org/10.1123/jsep.22.2.167

11. Jordet, G., Aksum, K. M., Pedersen, D. N., Walvekar, A., Trivedi, A., McCall, A., ... & Priestley, D. (2020). Scanning, contextual factors, and association with performance in English Premier League footballers: An investigation across a season. *Frontiers in Psychology*, 11, 553813. https://doi.org/10.3389/fpsyg.2020.553813

12. Kanat, E. A., & Şimşek, D. (2021). The 'Quiet Eye' and motor performance in basketball free throw shooting. *Physical Education of Students*, 25(2), 103-109. https://doi.org/10.15561/20755279.2021.0205

13. Klostermann, A., & Moeinirad, S. (2020). Fewer fixations of longer duration? Expert gaze behavior revisited. *German Journal of Exercise and Sport Research*, 50(1), 146-161. https://doi.org/10.1007/s12662-019-00616-y

14. Klostermann, A., Panchuk, D., & Farrow, D. (2018). Perception-action coupling in complex game play: Exploring the quiet eye in contested basketball jump shots. *Journal of Sports Sciences*, 36(9), 1054-1060. https://doi.org/10.1080/02640414.2017.1355063

15. Kredel, R., Vater, C., Klostermann, A., & Hossner, E. J. (2017). Eye-tracking technology and the dynamics of natural gaze behavior in sports: A systematic review of 40 years of research. *Frontiers in Psychology*, 8, 1845. https://doi:10.3389/fpsyg.2017.01845

16. Krzepota, J., Stępiński, M., & Zwierko, T. (2016). Gaze control in one versus one defensive situations in soccer players with various levels of expertise. *Perceptual and Motor Skills*, 123(3), 769-783. https://doi.org/10.1177/0031512516664903

17. Lebeau, J. C., Liu, S., Sáenz-Moncaleano, C., Sanduvete-Chaves, S., Chacón-Moscoso, S., Becker, B. J., & Tenenbaum, G. (2016). Quiet eye and performance in

sport: A meta-analysis. *Journal of Sport and Exercise Psychology*, 38(5), 441-457. https://doi.org/10.1123/jsep.2015-0123

18. Mann, D. T., Williams, A. M., Ward, P., & Janelle, C. M. (2007). Perceptual-cognitive expertise in sport: A meta-analysis. *Journal of Sport and Exercise Psychology*, 29(4), 457-478. https://doi.org/10.1123/jsep.29.4.457

19. Mann, D. T., Wright, A., & Janelle, C. M. (2016). Quiet Eye: The efficiency paradox–comment on Vickers. *Current Issues in Sport Science* (CISS), 1, 111-111. https://doi.org/10.15203/CISS_2016.100

20. Oudejans, R. R., Karamat, R. S., & Stolk, M. H. (2012). Effects of actions preceding the jump shot on gaze behavior and shooting performance in elite female basketball players. *International Journal of Sports Science & Coaching*, 7(2), 255-267. https://doi.org/10.1260/1747-9541.7.2.255

21. Piras, A., Lobietti, R., & Squatrito, S. (2014). Response time, visual search strategy, and anticipatory skills in volleyball players. *Journal of Ophthalmology*, 2014. http://dx.doi.org/10.1155/2014/189268

22. Sáenz-Moncaleano, C., Basevitch, I., & Tenenbaum, G. (2018). Gaze behaviors during serve returns in tennis: a comparison between intermediate-and high-skill players. *Journal of Sport and Exercise Psychology*, 40(2), 49-59. https://doi.org/10.1123/jsep.2017-0253

23. Senduran, F. (2019). Use of Eye-Tracking System in Sport Science: A Guide to Novice Researchers. *Spormetre the Journal of Physical Education and Sport Sciences*, 17(4), 1-13. https://doi.org/10.33689/spormetre.528980

24. Shao, M., Lai, Y., Gong, A., Yang, Y., Chen, T., & Jiang, C. (2020). Effect of shooting experience on executive function: Differences between experts and novices. *PeerJ*, 8, e9802. http://doi.org/10.7717/peerj.9802

25. Vardar, T., & Senduran, F. (2021). The Quiet Eye durations of air pistol shooting athletes. *Pakistan Journal of Medical & Health Sciences*, 15(7). https://doi.org/10.53350/pjmhs211572246

26. Vickers, J. N. (1996a). Visual control when aiming at a far target. *Journal of Experimental Psychology: Human Perception and Performance*, 22(2), 342. https://doi.org/10.1037/0096-1523.22.2.342

27. Vickers, J. N. (1996b). Control of visual attention during the basketball free throw. *The American Journal of Sports Medicine*, 24(6_suppl), S93-S97. http://doi.org/0363-5465/96/2424-893$02.00/0

28. Ward, P., & Williams, A. M. (2003). Perceptual and cognitive skill development in soccer: The multidimensional nature of expert performance. *Journal of Sport and Exercise Psychology*, 25(1), 93-111. https://doi.org/10.1123/jsep.25.1.93

29. Williams, A. M., & Jackson, R. C. (2019). Anticipation in sport: Fifty years on, what have we learned and what research still needs to be undertaken? *Psychology of Sport and Exercise*, 42, 16-24. https://doi.org/10.1016/j.psychsport.2018.11.014

30. Williams, A. M., Janelle, C. M., & Davids, K. (2004). Constraints on the search for visual information in sport. *International Journal of Sport and Exercise Psychology*, 2(3), 301-318. https://doi.org/10.1080/1612197X.2004.9671747

31. Williams, A. M., Singer, R. N., & Frehlich, S. G. (2002). Quiet eye duration, expertise, and task complexity in near and far aiming tasks. *Journal of Motor Behavior*, 34(2), 197-207. https://doi.org/10.1080/00222890209601941

32. Williams, M., Davids, K., Burwitz, L., & Williams, J. (1993). Cognitive knowledge and soccer performance. *Perceptual and Motor Skills*, 76(2), 579-593. https://doi.org/10.2466/pms.1993.76.2.579