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THE SENSORY-MOTOR CONTROL OF SKILLED DART PLAYERS

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Abstract

This research aims to examine the quiet eye, which is a perceptual ability linked with expertise and best performance. However, there is not enough information about improving quiet eye performance. The current study aimed to investigate the quiet eye parameters of participants for both hits and misses shot. **Material & Methods**: Ten high-level (n=10, ages; 26.60 ± 3.89years; training experience=8.30 ± 2.03years) dart players (in the first top ten ranks in Turkey League) attended the study. A total of twenty-seven dart throws (9 throws x 3 sets) by each one were performed according to competition rules. During twenty-seven throws performed according to the competition rules, the participants' quiet eye behaviors were classified and compared as hits and misses. The Mann-Whitney U test determined the difference between throws. **Results**: quiet eye duration of hits (Mean±Standard deviation: 776.60±218.10ms) were found to be statistically longer than misses (Mean±Standard deviation: 457.33±109.91ms) (p=0.023). **Conclusion:** In line with the literature's information, it has been shown that hits provide a significantly longer quiet eye duration and higher throwing hits in targeting the dartboard compared to misses. Task-specific norms and standards can be applied for quiet eye training to players by determining high-level players' visual follow-up strategies during hits and misses. According to the determined QE standards, gaze strategies can be provided to the athletes by giving feedback on the paths they need to follow for accurate shots and their gaze behavior.

Keywords: Dart, Quiet Eye, Sports, Motor Control, Visual Control

USTA DART OYUNCULARININ SENSÖR-MOTOR KONTROLÜ

Özet

Araştırmanın amacı Dingin göz, uzmanlık ve üstün performans sergilemekle ilişkili algısal bir beceridir; ancak, dingin gözün performansın iyileştirmesi hakkında çok az şey bilinmektedir. Araştırmanın amacı, profesyonel sporcuların isabetli ve isabetsiz dart atış görevi sırasındaki Dingin göz (QE) parametrelerini incelemektir. **Yöntem:** Araştırmaya Türkiye sıralamasında ilk 20'ye girmiş 10 profesyonel (n=10, yaş; 26.60 ± 3.89 yıl; 173, 6 5,56 cm; 77,2 ± 6,65 kg; 8.30 ± 2.03 yıl) dart sporcusu katılmıştır. Katılımcılar müsabaka kurallarına göre 9'ar darttan 3 set olacak şekilde 27 dart atışı gerçekleştirmiştir. Katılımcıların müsabaka kurallarına göre gerçekleştirdiği 27 dart atışı sırasında sergiledikleri dingin göz davranışları başarılı ve başarısız atışlar olarak gruplandırılmış ve karşılaştırılmıştır. Atışlar arasında fark olup olmadığı Mann-Whitney U testi ile belirlenmiştir. **Bulgular**: İsabetli atışlardaki QE süresi (Ortalama±Standart Sapma: 776,60±218,10ms) isabetsiz atışlarla karşılaştırıldığında (Ortalama±Standart Sapma: 457.33±109,91ms) istatistiksel düzeyde anlmalı olarak daha uzundur (p=0.023). **Sonuç:** Literatürde yer alan bilgilerle parelel olarak, isabetli atışların isabetsiz atışlara kıyasla dart tahtası üzerine hedeflenme görevinde önemli ölçüde daha uzun dingin göz süresinin daha yüksek atış isabeti sağladığını göstermiştir. Üst düzey sporcuların başarılı ve başarısız atışlar sırasındaki görsel takip stratejilerinin belirlenmesi, sporculara uygulanacak QE eğitimi ile motor görevlere özgü normlar ve standartlar belirlenip uygulanabilir. Belirlenen QE standartlarına göre, sporculara, isabetli atışlar için izlemesi gereken yollar ve kendi bakış davranışı hakkında geri dönüt verilerek bakış stratejilerinin geliştirilmesi sağlanabilir.

Anahtar Kelimeler: Dart, Dingin Göz, Göz Hareketleri, Motor Kontrol.

INTRODUCTION

The primary purpose of darts sport is to shot towards the highest scored target (Nasu et al., 2014). A well-programmed motor control process is required for the successful performance of dart performance and all other motor tasks (Law and Wong, 2020). The processing of acquired visual information and perception are the main factors affecting this situation. Individuals should recognize what must be done and factor it within neural, perceptual, or cognitive forms. According to The necessities, chooses the best action from the various choices that may be present efficiently, and they need to execute a cognitively organized course of action so that a planned outcome happens (Vickers, 2009). Athletes need to be able to swiftly perceive and appraise (visual) knowledge from their surroundings and process associated (visual) cues to be able to react quickly by generating the suitable motor command and responding to the changing status (Vickers, 2007). Memmert et al. (2009) reported a minimal difference between athletes in general attention and visual skills. However, studies in the literature show that elite and novice athletes exposed notable differences in attentional capacities and skills (Kasper et al., 2012). Kasper et al. (2012) found that the visual attention skills of athletes were better than non-athletes. It is critical to thoroughly comprehend athletes' optical skills to help them reach their full potential in this context. When examining studies in the literature, it is seen that the quiet eye parameter presents significant findings while throwing in sports branches (basketball, throwing, darts) (Mann et al., 2007, Vickers & Williams, 2007). The quiet eye is defined as the latest fixation duration from onset to the hands' first visible progress into the throwing action (for example, fixing the ball's gaze before a golf throw). It reflects a significant cognitive processing period during which relevant visual cues are organized to optimize motor responses (Vickers, 1996; Williams et al., 2002; Wilson & Pearcy, 2009).

In this way, movement performance is higher when the onset, offset, and quiet eye period is optimal (Vickers 2009). A recent meta-analysis revealed that a long quiet eye duration is associated with successful motor performance in various sports tasks and explains both within-group and inter-group variability (Lebeau et al., 2016; Mann et al., 2011; Mann et al., 2007). While within-group differences indicate that longer quiet eye duration is associated with successful motor performances, differences between groups also indicate that high-level players' have longer quiet eye durations than novices (Mann ve ark., 2007). In studies for close targets to delimitate quiet eye duration, three motor control phases are defined: (1) a preparatory phase in which the motion is planned, (2) a stimulus phase in which motion is initiated, and (3) error prediction and editing phase in which the motion is modulated before striking the target (Abrams et al., 1990). During the preparation phase, the individual sets the action's target and pre-programs the action just as needed to get started (Tumialis, 2020). Then they initiate motion in the stimulus phase so that the joints move swiftly towards the target. During the error prediction and editing phase, they set the action that arranges final control to the target (Vickers 1996). In the dart throw, the quiet eye is characterized as the last fixation on the target before extending the arm towards the target (Vickers 2000). The movement's arrangement occurs during the alignment or flexion phases in the quiet eye fixation and removes any fixation that needs to be fixed on the target while the dart is being thrown. When the literature is examined; neural, cognitive, and perceptual systems need

optimal time to process their critical visual information before moving into action; eye movements seem to have contradictory results in their work (Vickers ve Adolphe 1997). For this reason, the current study aimed to examine the participants' quiet eye models for hits and misses during dart throws. The study hypothesizes that the quiet eye duration is longer during the hits.

METHODS

Research Model

This research was designed using a cross-sectional scanning model, which is one of the research methods (Büyüköztürk et al., 2008).

Participants

Ten high-level (n=10, ages; 26.60 ± 3.89years; training experience=8.30 ± 2.03years) dart players (in the first top ten ranks in Turkey League) attended the study. Before the tests, general information about the test protocol was given to all participants. None of the participants had any health problems, and none of them use glasses or contact lenses. Before the tests, taking caffeine and similar stimulants has been restricted for participants. All tested participants were the same league members. The local Research Ethics Committee approved the research (Board approval numbers: E-87914409-050.03.04-8947). Before the measurements, written and verbal information was given to all participants, and the voluntary participation statement was approved and signed.

Procedures

All participants performed a total of twenty-seven throws (9 throws x 3 sets). For darts, a targeting sport, it was asked to throw darts in the triple area (60 points point) of the 20 points division, which is the highest-scoring point.

The throwing technique was explained to the players by a coach. Players were informed to throw a single throw after fixing the elbow to the dartboard. The dartboard was placed according to the conditions of the competition, 2.37 m from the foot line at the height of 1.73 m as prescribed in the World Darts Federation criteria (Figure 1). A high-quality darts set, with the weight of 24 grams and steel-pinned, about 45 cm in diameter, was used.

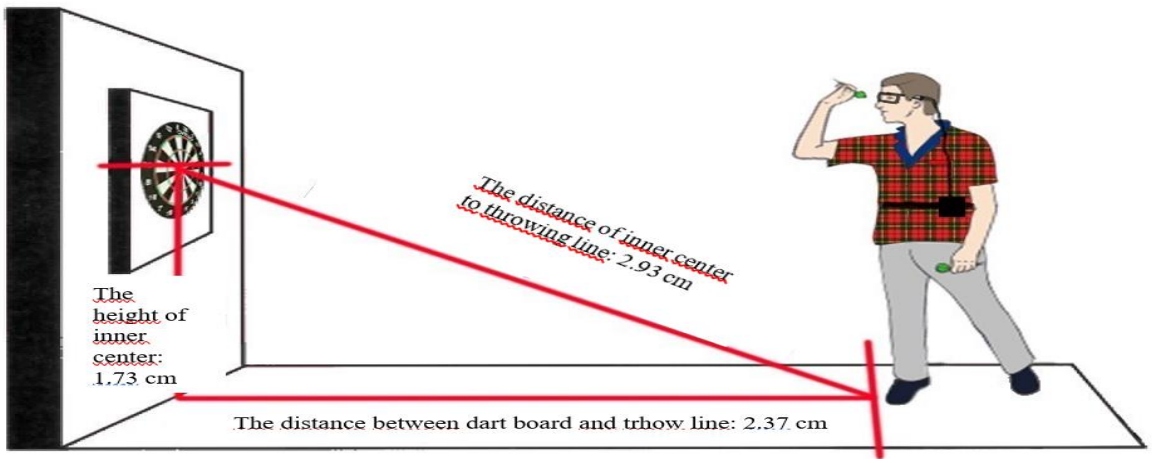


Fig. 1 Schematic view of the throwing area

The participant's visual search behavior was recorded with the Tobii Pro Glasses2 eye tracking device (Tobii Pro Glasses2, Stockholm, Sweden). The tests were conducted in daylight and at a recording rate of 100 Hz. The device was placed on the face most comfortably using special nose pads for each participant's facial structure. After placing the eye tracker on the face, the calibration process was carried out to adapt it with Tobii Glasses Controller (Glasses Controller Software, Stockholm, Sweden) software, which records the data online. A separate recording was made for each throw of the participants, and the calibration process was repeated in each recording (Figure. 2).

Fig. 2. The Moment of Fixation on the Dartboard Taken from the Eye Tracking System

For the specific dart throw task, the quiet eye was defined as the final fixation before the throwing arm's extension (Vickers 2000; Rienhoff ve ark. 2012; Khanjari, 2020). Participants were allowed to warm up for 20 minutes before all measurements according to the darts-specific warm-up protocol. Before the tests started, the coach explained how the dart technically should be thrown. Participants were given a total of 30 trial throws to get used to the research protocol. In this way, participants' adaptation to the glasses and calibration adjustments were made. Participants throw 27 darts by the protocol from the throw line (from 2.37 cm distance) determined by the international darts authorities. The tests took 60 minutes for each participant in total. The tests were conducted between 09:00 and 17:30 in the Dart Hall, except for the training days.

Analysis of Data

Ten high-level dart players participated in the study; each of the players performed 27 throws in total. For the players, 270 separate records were obtained from a total of 270 throws. The raw data recorded by the eye-tracker has been analyzed with Tobii Pro Lab (Glasses Pro Lab Software, Stockholm, Sweden) software, which is an analysis system specific to the eye tracker. After transferring the raw data to software, we determined each record according to the examined areas of interest. Areas of interest were divided into two zones: the triple portion of the 20number zone (60-points red zone) and the dartboard's remaining zone (figure 2).

Fig. 3 Determined area of interest

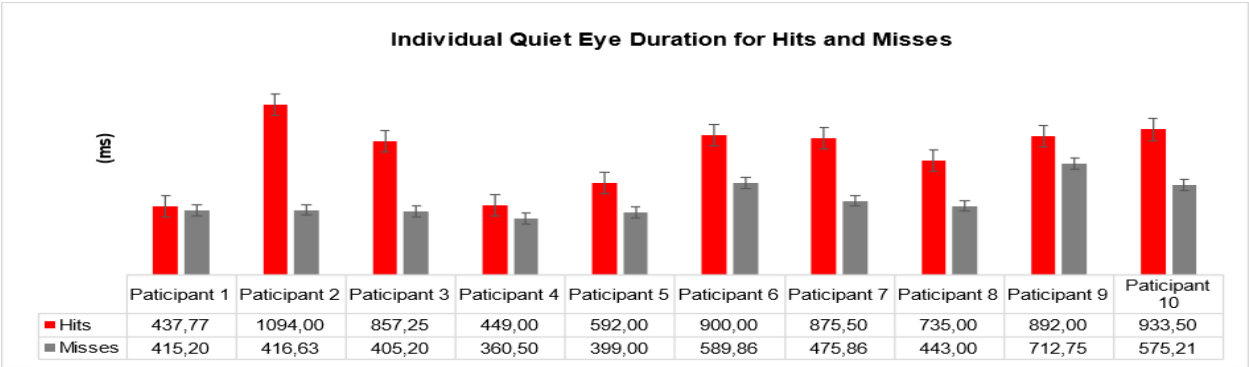
The start of the measurement was determined when the dart was placed on the throwing line, and the player's head turned to the dartboard and was terminated after it was released and touched the dartboard. From the raw data, for the specific dart-throwing task, the quiet eye time was determined as the final fixation before the extension of the throwing arm (Vickers 2000; Rienhoff et al.2012), and analyzes have been made according to this. After the throw, it was thought that the participants had no control over the result of hitting the target. However, as it is necessary for the definition of neuromotor ability to see if it was hit, the recording took until the dart hit the target. The last and the most prolonged gaze (quiet eye duration) have been analyzed before the throw. For the quiet eye, which determines the neural programming process before the throw, the participant's gaze was fixed at a position on the target for a minimum of 100 ms (3 video frames). The data were analyzed with the probability of deviation of the visual angle of 0.25°. The gaze cursor was calculated with 0.5° precision and hits.

STATISTICAL ANALYSIS

The study data's statistical analysis was conducted using SPSS 22.0 software (SPSS Inc., Chicago, IL). After testing the normality of data, quiet eye duration for hits and throws were compared with the Mann-Whitney U test. Statistical significance was set at $p<0.05$.

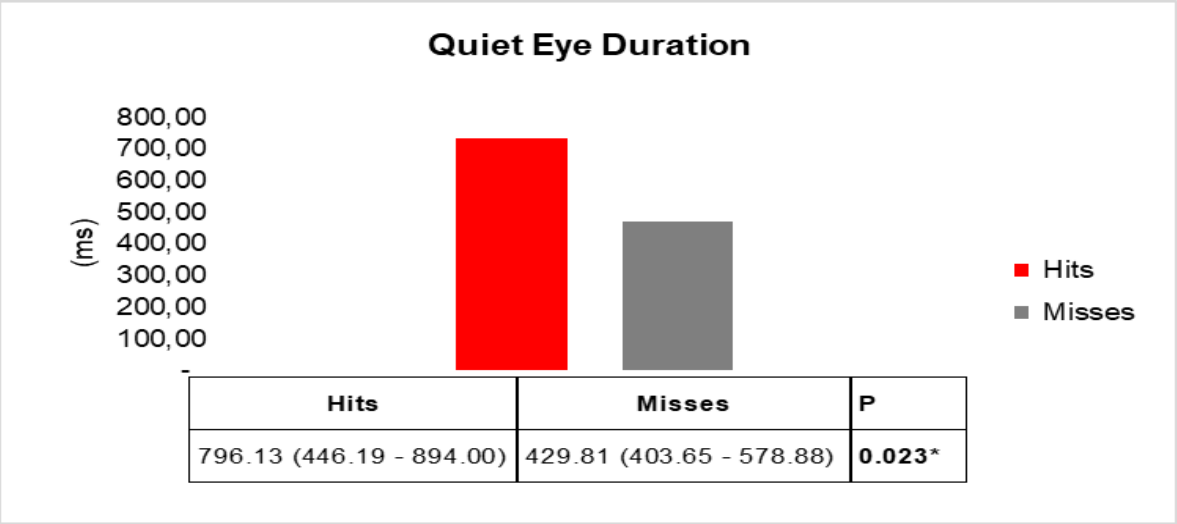
RESULTS

While calculating the quiet eye duration of participants, means and standard deviations were considered. The mean ± standard deviation values of darts players during throws were found as follows; 776.60 ± 218.10 ms for hits and 457.33 ± 109.91 ms for missed throws. According to statistical analysis, quiet eye duration for hits and missed were statistically different (Graph 1 and Graph 2).



	Paticipant 1	Paticipant 2	Paticipant 3	Paticipant 4	Paticipant 5	Paticipant 6	Paticipant 7	Paticipant 8	Paticipant 9	Paticipant 10
Hits	437,77	1094,00	857,25	449,00	592,00	900,00	875,50	735,00	892,00	933,50
Misses	415,20	416,63	405,20	360,50	399,00	589,86	475,86	443,00	712,75	575,21

Graph.1 Individual Quiet Eye Duration for Hits and Misses



Hits	Misses	P
796.13 (446.19 - 894.00)	429.81 (403.65 - 578.88)	**0.023***

Graph. 2 Quiet eye duration for hits and misses

DISCUSSION AND CONCLUSION

The quiet eye is an objective measure of the location, start, and duration of the fixation pursues gaze recorded while the participant performs a motor task. Moreover, a quiet eye is known to feature high levels of skill and accuracy in throwing sports. This study aimed to examine the quiet eye duration, one of the high-level dart players' eye strategies for hitting and missing the target point on the dartboard.

Research findings show that darts' accuracy is affected by temporal control of quiet eye fixation, alignment, flexion, and extension phases of the throw. Vickers (2009), in a study conducted with dart players, stated that hits throw occur when the quiet eye is longer and occurs in late adjustment - early flexion phases. Generally, it is stated that longer quiet eye duration is related to higher motor skills and more successful performance (Klostermann and Hossner, 2018; Kavyanı et al., 2020). Considering the long quiet eye duration found for hits in our current study, it can be said that it is in line with the research findings conducted in the literature (Vickers, 1992; Janelle et al., 2000; Panchuk & Vickers, 2006). During throws with a long quiet eye duration, it is seen that it is possible to throw accurately with a correct quiet eye behavior even if the gaze is not stabilized in the last phase of the throw (Vickers, 1996; Harle & Vickers, 2001). Savelsbergh et al., 2002; In other words, the study's findings revealed that the essential factor in the performance of dart throwing is the optimum onset, offset, and duration of the quiet eye according to the final extension phase of the throw. The studies carried out in the literature indicate that experienced (expert) athletes have a longer quiet eye duration (Vickers, 1996; Williams et al., 2002; Vickers & Williams, 2007) than novice athletes and that the final fixation starts earlier during the onset of motor response (Causer et al., 2010; Harle & Vickers, 2001; Janelle et al., 2000; Panchuk & Vickers, 2006). When viewed from an in-group perspective, the relationship between throwing performance and quiet eye duration during hits is characterized by longer quiet eye duration (Harle & Vickers, 2001; Janelle et al., 2000; Vickers, 1996; Vickers & Adolphe, 1997; Simpson et al., 2020). Therefore, the most important factor underlying a hits dart throw is that quiet eye fixation must be timed so that the onset occurs during late alignment on the target and the duration

extends to early flexion. During this time, the target should be fixed during the continuous period of quiet eye focus and concentration (Williams et al., 2002; Causer, 2010; Homanian, 2020). The quiet eye offset should occur just before arm extension during mid-flexion, which should remain off target for less than half a second (Van Der et al.,2021; Flındall et al.,2020; Horn and Marchetto, 2020). During the extension of the arm ending the throw, it is unnecessary to keep the fixation on the target.

In conclusion, high-level dart players' eye strategies between hits and miss throws were examined. It was determined that they exhibited a longer quiet eye duration in hits throws. It has been shown that the longer quiet eye behavior is more successful results about the perceptual-motor programming process, hand, and eye coordination. The result of our research coincides with the results of other studies in the literature. In addition to the studies in the literature, it can be thought that a specific study (triple ring, 60 points) for the area of interest stated in our study would be significant for dart sport. Task-specific norms and standards can be applied for the quiet eye training to be applied to the athletes by determining high-level players' visual follow-up strategies during hits and miss throws. According to the determined quiet eye standards, one can give the athlete feedback about her/his view, and the ways she/he should follow for hits throw can be determined.

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