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The Role of Visual Search Behavior and the Verbal Report in Anticipation Skill of Skilled and None-Skilled Badminton Players in Smash Hits

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Original Article

Abstract

Introduction: The importance and prerequisite of anticipation in success is not overlooked in many sports skills. The purpose of this study was to investigate the role of anticipation skills, visual search behavior, and verbal reports of skilled and non-skilled badminton's players in smash hits.

Materials and Methods: The participants in this study were 22 women aged 20-30 years divided into two groups of skilled (n = 10) and non-skilled (n = 12). Participants viewed 18 video clips from smash hits in different positions and anticipated the landing in less than 3 seconds. Visual Search Behavior (number, duration, and position of fixation) of skilled and non-skilled players was surveyed using the Pupil Model Vision Detector that recorded a spot of gaze at 60 HZ (60 frames per second). After completing the test, using the questionnaire, they recorded the verbal reports of the participants in order to compare them with the visual search results. To compare the data, independent t and Friedman's tests were used.

Results: There was not a significant difference in anticipation accuracy between the two groups. In the study of visual search behavior, there was a significant difference between the two groups in the number (P = 0.010) and duration (P = 0.005) of fixations in the position of rackets. However, there was no significant difference regarding the number and duration of fixations on the position of the wrists, balls, and legs, as well as the other positions. The results of the verbal report indicated that the focus of the attention of skilled players on anticipation skills was the position of the racket.

Conclusion: Generally, in the case of anticipation skills, it can be said that skilled players spent more time looking for racket position. Using these results in the trial of non-skilled individuals can be useful in promotion of correct anticipation, and facilitating the process of learning skills.

Keywords: Anticipation skill, Visual fixation, Verbal report, Badminton

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Introduction

A successful performance in sports requires the ability to understand and apply efficient and accurate principles of motion patterns (1). Understanding that skillful perception is superior to proper performance made the researchers to examine its role in sports performances. One of the key components on which the performance of the skilled individuals is based, is the ability to make perceptual judgments based on basic information and to select accurate responses based on the detailed information obtained during the initial preparation stage using the anticipation and control process (2). As a perceptual-cognitive skill, anticipation is defined as the ability to identify and process environmental information, so that it interacts with existing knowledge structures and practical capabilities for an appropriate selection and execution (3). One of the constant questions regarding the performances of the skilled individuals is how they have increased their ability to use anticipation to deal with intrinsic time constraints (2).

In the field of human performances in sport, the

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performance of skilled people is of great value because these high quality performances have been obtained over a very long time or millions of times of trial. The improved ability of the skilled individuals to anticipate future events from basic detailed information enables them to find out the opponent's game strategy, while the less skilled people lack this ability (2). The findings of investigations suggest that the skilled players can identify the relevant information very quickly, which reflects their ability to use specific knowledge that shows their superiority in anticipation over the novice players (4). The results of studies by Alder et al. in badminton (5), Muller et al. in cricket (6), and Jin et al. in badminton (7) suggested that the anticipation accuracy is much higher in the skilled participants in comparison to the beginners. Conclusions regarding motor and cognitive skills may stem mainly from the two main indicators of visual patterns and duration of visual focus in the preparation, anticipation, and execution stages (8).

Skilled players use different visual strategies and more useful clues compared to the beginner players. Available evidence considers the difference between the skilled players and beginners not only at the behavioral level but also at the psychological level (9). The visual search behavior of skilled players is undeniably correlated with the opponent's motor performance, which is regarded as an essential part in the success of anticipation (5). Limited time conditions in many sport fields require athletes to extract the most valuable sources of visual information and use this information to anticipate the opponent's performance (10). Studies on visual search involves alternation between fixations and saccades. Fixations are time periods in which the visual image is held constant on the eye cavity to obtain the information required, however saccades are the rapid and ballistic eye movements that move visual attention among different positions in less than 100 ms (11). Researchers mainly focus on the eye fixation, which may take place several times during visual search. The features of these fixations, such as their number, position, and duration, are used more often to understand how and to what information the performer is paying attention. The field of vision refers to the environment ahead of the player, which changes with his movements, forming a new field of vision. The location of each gaze indicates the areas of interest of the athlete, while the number and time of fixation of each gaze is an indicator of the level of information processed by the athlete (12). The duration of fixations is an estimate of the distribution of attention in specific areas that is crucial to the strategy of the game (8).

Contradictory results have been reported in recording eye movements in relation to the accuracy of anticipation skills in different sports. For instance, Alder et al. in badminton (5), Savelsbergh et al in soccer (1), and Williams et al. in tennis (13) found that skilled individuals had longer visual fixations compared to beginners; Whereas in other studies, such as Roca et al. in soccer (14), Mcrobert et al. in cricket (15), and Afonso et al. in volleyball (16), reported inconsistent results and found that skilled players had more visual fixations with shorter durations in comparison to the beginners. The scientists concluded that the gaze-related visual search strategies may vary in relation to each task and given the specific context and requirements of that task. Therefore, different tasks may benefit from different visual strategies. Another method used by researchers to discover the perceptual-cognitive differences between skilled and novice players is to record verbal reports. There is a clear link between visual search behaviors and the complex knowledge of verbal reporting, meaning that skilled individuals pay more attention to functional spaces and such spaces enable them to obtain more robust information on game issues (16). Among the studies using verbal reports to discover the differences between the skilled and beginner individuals in the anticipation skills in sports, the studies conducted by Williams and Davids in soccer (17) and Jackson and Mogan in tennis (18) can be mentioned; however, little investigations have been carried out on badminton athletes.

Badminton is a fast-paced sport that requires a great agility and high reaction speed. Therefore, effective anticipation of the opponent's movement can help improve the speed and process of success in the game. In addition, there may be cues from the performance of the skilled players that can be used to acquire skills rapidly and effectively. Therefore, given the limited studies in this area, the present study was accomplished with the aim to examine whether there was a difference between anticipation skills, visual search behaviors, and verbal reporting in skilled and non-skilled badminton players in smash hits.

Materials and Methods

This was a causal-comparative study in which the anticipation skills, visual search behaviors, and verbal reporting of the skilled and non-skilled badminton players in smash hits were compared to each other. The subjects included 10 skilled female players (with a mean age 25.20 ± 4.04 years) from badminton team of Zahedan City, Iran, and 12 non-skilled badminton

players (with a mean age 22.25 ± 2.80 years) from among female physical education students of Zahedan Branch, Islamic Azad University, who had passed Badminton 1 course and had no history of participation in previous badminton competitions. The participants were selected using the purposeful convenience sampling method. The skilled participants in the present study had at least 5 years of experience in the field of badminton and had a provincial championship experience. They also performed regular weekly exercises (three sessions per week). All subjects participated in the study as informed and with complete consent.

Prior to the test, 36 video clips of badminton smash hits performed by two elite players (members of national youth badminton team) in the Sistan and Baluchestan Province team in the presence of three badminton coaches in the Olympic Village Badminton Hall of Zahedan (with standard conditions), were prepared. The clips were filmed using three cameras (NX3, Sony, Japan) embedded in different locations and mixed and montaged using Adobe Premiere Pro cc2017 software.

1. The main camera, which was used to play the videos to the subjects, was positioned in the opposite field where the subjects had to actually be, so that they could imagine themselves as a real receiver and be able to anticipate more accurately.

2. The second camera, which was utilized by the tester to accurately determine where the ball landed, was located outside the field on the left side.

3. The third camera, which was used by the tester to accurately determine where the ball landed, was placed at the end part of the field.

The clips started 2-3 s before the ball and racket contact and stopped at the point of contact of the ball and the racket. This was performed using EDIUS software (Grass Valley Co., USA). After producing the 36 clips of the smash hits, 18 expert clips were selected from among them based on the opinions of a few expert coaches. The clips were selected quite randomly with different landing sites. Moreover, three clips were selected separately to familiarize the subjects with how to perform the test. All clips were played back on a 2.5 × 1.5 m screen using a projector (CP-EX251N, Hitachi, Japan). To investigate the subjects' visual search behavior, an eye tracking device (Pupil, Pupil Company, Germany) that recorded the gaze point at every moment at 60 Hz (60 frames per second), was employed. The data obtained in the form of a video tape were transferred to a computer (MacBook Pro, Apple, USA) via a cable. The Pupil Capture software was utilized to record eye movements and changes and the Pupil Player software was used to analyze the recorded data. The eye tracking device used in this study was capable of recording data such as number, location, and duration of fixations.

The test site was performed in the Mountaineering Hall of the Olympic Village of Zahedan. Prior to conducting the study, a briefing was held to familiarize the subjects with how to perform and assess the subjects' vision based on the Snellen chart. The subjects were then asked to complete a demographic information form including age, badminton history, and the consent form for voluntary participation in the study. On the day of the test, each subject was first explained how to perform the test using the relevant clips. The subject was placed on a comfortable chair 2 m away from the screen. The tracking device was then placed on the subject's eyes and the device cameras were adjusted to each eye of the subject. Before showing each of the clips, a five-point calibration method was adopted to calibrate the device for the smash hits. After each calibration, the calibration was carefully monitored. Before each clip was played, the subject was given a warning signal, such as an alert, to make them pay more attention. Each of the clips was shown as at the moment that the ball and racket hit, the film was stopped and the answer sheet image was displayed on the screen, and the subject was asked to anticipate the ball landing position (Figure 1).

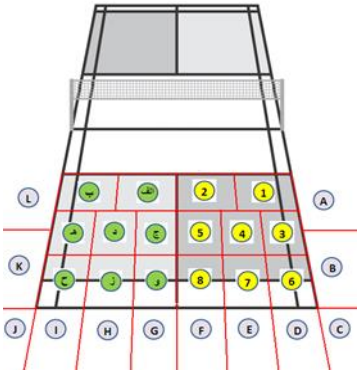

Figure 1. How to respond to the question on the ball's landing position anticipation

At the same time, the subjects' verbal reports on the position of the ball landing site were recorded by one of the testers to compare the anticipation skills between the two groups of skilled and non-skilled players on the answer sheet. The subject was required to respond immediately after the clip was completed, in a maximum of three seconds. The responses

beyond the specified time range were not recorded (5). There was a 1-minute rest between each trial. After the clips were displayed, each subject was asked to answer a questionnaire developed on the important visual preferences according to the badminton experts' opinions, so that each subject had to mention the order of preference of the important positions of his gaze for the anticipation skill on the answer sheet. A computer system connected to the projector was used to display the clips, and another computer system with Pupil software installed was employed to record the data of the eye tracking device. After completing the test and collecting data, the scores obtained by the players were compared to examine the anticipation skill level. Furthermore, in order to compare the visual behavior strategies of the subjects, the films recorded by the tracking device were examined in terms of number, duration, and locations of interest of visual fixations of the skilled and non-skilled players (racket, wrist, ball, and other areas).

Descriptive statistics were exploited to categorize raw data, determine mean and standard deviation (SD) values, and prepare tables, in addition, the Excel software (version 2013) was used to prepare the graphs. Besides, the Shapiro-Wilk test was utilized to identify the homogeneity and normality of the participant information. The independent t-test and Friedman test were used to test the study hypotheses. Finally, the data were analyzed in SPSS software (version 16.0, SPSS Inc., Chicago, IL, USA), with $P < 0.05$ considered as the significance level.

Results

At first, the normal distribution of the data on the anticipation skills and visual search behavior was evaluated using the Shapiro-Wilk test, with the results indicating a normal distribution for the data obtained in both parts ($P < 0.050$). The results of the independent t-test are presented in table 1 to examine the signs of gaze in the smash hits of the skilled and non-skilled players.

The independent t-test results indicated that there was a significant difference between the number of fixations on the racket position ($P = 0.010$) and the duration of fixation on the racket position ($P = 0.005$) for the skilled and non-skilled players in badminton smash skill (Table 1); This means that the skilled players had a higher number and duration of fixation in the racket position compared to the non-skilled players. There were no significant differences between the skilled and non-skilled players on other signs of gaze (number and duration of fixation in the wrist, ball, and foot positions). Based on the results of the independent t-test, there was no significant difference between the anticipation behavior [$t = -1.20$, $P = 0.240$, Degree of freedom (df) = 20] and the accuracy percentage of the anticipation behavior ($t = -1.20$, $P = 0.240$, $df = 20$) between the skilled and non-skilled players in badminton smash skills.

Table 1. Independent t-test results to examine the signs of gaze of skilled and non-skilled players in smash hits

Variable	df	t	P value
Number of fixations on racket	20	-2.84	0.010*
Number of fixations on ball	20	-0.25	0.800
Number of fixations on wrist	20	0.13	0.890
Number of fixations on feet	20	-1.48	0.150
Duration of fixations on racket	20	-3.18	0.005*
Duration of fixations on ball	20	0.83	0.630
Duration of fixations on wrist	20	0.03	0.970
Duration of fixations on feet	20	-1.09	0.280

* The difference was significant at the 0.05 level ($P < 0.050$).

The Friedman test results revealed that there was a significant difference between the rank priorities of visual signs of the badminton smash skill in the skilled group ($df = 4$, $P = 0.001$, $\chi^2 = 27.44$), however the difference between these signs was not significant in the non-skilled group ($df = 4$, $P = 0.280$, $\chi^2 = 5.06$).

Comparison of the rank priorities of the skilled group showed that the racket position with a mean of 1.30 was ranked first and the wrist, ball, foot, and other positions with mean values of respectively 2.00, 3.30, 4.20, and 4.20 ranked next.

Discussion

The present study was accomplished aiming to investigate the anticipation skills, visual search behaviors, and verbal reports of the skilled and non-skilled badminton players in smash hits. The findings on the anticipation skill in badminton smash hits showed that there was no significant difference in the anticipation accuracy of the skilled and non-skilled individuals. Since no study was found regarding the badminton smash hits, the results were compared with those of other sports. The results of the present study were consistent with the findings of the studies by Ward et al. on the skilled and beginner tennis athletes (19), Bard et al. on skilled and non-skilled gymnastics referees (20), and Bard and Fleury on skilled and non-skilled basketball attackers (21). The findings were also in line with the findings of the studies carried out by Rafiee et al. on skilled and novice basketball referees (22), Jackson and Mogan on tennis skill (18), Jin et al. on skilled and non-skilled badminton players (7), and Brenton et al. on highly skilled and less skilled young cricket batsmen (23). One of the

reasons for the lack of significant differences between the two groups in the present study can be attributed to the low difference in the participants' (skilled and non-skilled) skill levels. Other reasons include the high complexity of the smash skill, as the anticipation capability seems to decrease as the skill becomes more complex.

In general, there are two basic questions on using the video skill show: First, does the video skill show provide exactly the information available in the real world? In the meantime, in the present study all efforts were made to bring the display of the clips closer to the actual conditions. For example, the clips were displayed 2 to 3 seconds before the ball and racket contact so that the subjects had enough time to focus. In addition, the clips were played on a large screen of 2×1.5 m^2 so that the clips be closer to reality. In the real world, however, the spectator pressure, competition levels, and also familiarity with how the opponent plays, the quality of the game field, and the like can affect the decision-making and visual search behavior. The second question was whether the participants' verbal or written perceptual responses accurately reflected the responses produced in the environmental performances (2). The perceptual judgments that are made in response to the video presentation may not be sufficient to anticipate the skill. Moreover, the relationship between perception and practice in laboratory environments is generally ignored. In the tests, the participants often respond to visual scenes by pressing buttons, controlling a joystick, or verbal reports, which are not identical to what is happening in the real world.

Limited time conditions in many sport fields require athletes to derive the most valuable sources of visual information and use this information to anticipate the opponent's performance. The highly skilled athletes believe that it is important to be able to perceive the visual information in order to anticipate the opponent's movement pattern and use it to anticipate the subsequent events (10). The findings of the present study regarding the visual behavior search (number, duration, and position of fixations) in badminton smash hits indicated that skilled players had more number and duration of fixations on the racket position, while no significant difference was found between the skilled and non-skilled players in the number and duration of fixations on the wrist, ball, foot, and other positions.

Regarding the visual fixation time, the findings of the studies by Alder et al. on badminton players in response to the opponent's performance (5) and Savelsbergh et al. on successful and unsuccessful soccer goalkeepers during a simulated penalty shootout (1,24), were in agreement with those of the present study. However, the present study findings contradicted the results of the studies by Abdoli et al. on skilled and novice basketball players (25), Singer et al. on skilled and beginner tennis players (26), and Rafiee et al. on skilled and novice basketball referees (22).

The duration of visual focus is an estimate of the distribution of attention in specific areas that is crucial to game strategy (8). In terms of the number of visual fixations, the results of the present study were consistent with the results of the studies by Roca et al. in soccer (14), Afonso et al. in a complex and dynamic volleyball show that involved on-site data information (16), and McRobert et al. in cricket, and were in disagreement with the results of the studies by Abdoli et al. (25) in basketball, Savelsbergh et al. in football (1,24) and Rafiee et al. in basketball. The findings of investigations suggest that skilled players apply different visual strategies and more useful clues in comparison to the novice players. Additionally, skilled players are able to identify relevant information very quickly, indicating their ability to use specific knowledge showing their superiority in anticipation over the novice players (4).

In their study, Vaeyens et al. reported that skilled players had superiority over beginners in the method, knowledge, and strategy (27). It is likely that long-term focusing will allow the skilled group to have more time to extract information from the motor cues resulting from the opponent's physical movements (5). In complex situations, the superiority of the skilled individuals over beginners emerges, meaning that as the conditions become more complex, the need for more sophisticated designs increases (10,28). According to the results of the studies by Dicks et al. (29) and Mann et al. (30), even the simulated environments may not accurately represent a clear understanding of the differences between the skilled and less skilled individuals. However, most of the studies published are based on the laboratory simulations. Alder et al. stated that there was evidence that the opponent's motion performance and the athlete's visual search behavior are inextricably linked, suggesting that they cannot be examined separately (5).

In some studies, the approach of the effective use of visual axis methods by skilled players has been mentioned, and in fact, it refers to the fact that skilled people keep their eyes on an area and control the environment using the peripheral vision. This method is along with some advantages; first, there is evidence to suggest that information may be processed by

peripheral vision much faster than central vision, and this has many advantages in time constraints. Second, when peripheral vision is used, the use of eye movements, which are considered as passive information processing periods, is reduced to control all parts of the screen. Third, it is possible to quickly shift the focus from one area of the display to another when using peripheral vision rather than the central vision. Therefore, under time constraints, a search pattern with less focal fixations may be considered as an efficient search pattern, however players change their search strategies in different situations depending on the constraints ahead in the visual system. In fact, task constraints may lead the performer to use central vision over peripheral vision to extract the task-specific information. Hence, an extensive search strategy, which involves more fixations in a shorter period of time, is intended to assure the defenders that they are aware of all the information sources including the ball position, the individual position, the movements of the key attackers, and the position of the teammates (31).

The results of the present study, using the retrospective verbal reports, indicated that the points of interest of the skilled players were different compared to the non-skilled players for the anticipation skill, so that the priority of the visual focus of the skilled players were respectively on the position of the racket, wrist, ball, foot, and other areas, while the visual focus priority of the non-skilled players were on the other positions, wrist, racket, foot, and ball, respectively. These findings are in line with the results of recording the eye movements of the skilled and non-skilled players through the eye tracking device. The results of the verbal report and its concordance with the results of the visual search behavior of the present study were consistent with the findings of the studies accomplished by Jin et al. in badminton, Roca et al. in football (14), and Afonso et al. in volleyball (16). As all of these studies showed a positive relationship between verbal reports and visual search behavior.

Limitations

The limitations of the present study included the lack of control over fatigue among the participants during the test due to the high sensitivity of the eye tracking device, the need to calibrate the device before playing each video clip for each subject, and lack of control over the subjects' rest and sleep levels the night before the test. This physical and psychological fatigue could affect their focus and attention.

Recommendations

In the present study, only the visual skills and anticipation skill levels of the skilled and non-skilled players were compared and no training intervention was performed on the subjects. Therefore, it is suggested that by designing an exercise protocol based on the findings of the present study, their role on the individuals' anticipation and decision making skills be investigated. There is also little empirical works in evaluating the underlying execution processes (when the obtained information is of real world) compared to when the information collected is based on film simulation. Therefore, more extensive studies are needed to be conducted in this area and in real sports environments, including badminton.

Conclusion

In general, it can be claimed that skilled players spend more time looking at the racket position compared to the non-skilled players in the anticipation skill. Using these findings can greatly help coaches in training badminton skills to novice players and thus facilitate the training and learning process.

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The present study was extracted from a Ph.D. thesis with code of ethics IR.SSRC.REC.1398.044, approved by Physical Education and Sports Sciences Research Institute, Tehran, Iran. The authors would like to appreciate all the participants and others who contributed to this study.

Authors' Contribution

Fatemeh Shirmehenji: Study design and ideation, study support and executional services, analysis and interpretation of data and specialized statistics services, manuscript preparation and review, Responsibility for the integration of the study from the beginning to the end, and responding to reviewers' questions on all sections and aspects of the manuscript; Mehdi Namazizadeh: Study design and ideation, analysis and interpretation of data, manuscript review for scientific concepts, confirmation of final manuscript content before submission to the journal, and responding to reviewers' questions on all sections and aspects of the manuscript; Mahmoud Sheikh: Study design and ideation, analysis and interpretation of data, manuscript review for scientific concepts, confirmation of final manuscript content before submission to the journal, and responding to reviewers' questions on all sections and aspects of the manuscript; Saleh Rafiee: Study design and ideation,

analysis and interpretation of data, manuscript review for scientific concepts, confirmation of final manuscript content before submission to the journal, responding to reviewers' questions on all sections and aspects of the manuscript, and providing the equipment needed.

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Conflict of Interests

The authors declare no conflict of interest. Fatemeh Shirmehenji was a Ph.D. student in Movement Behavior at Kish International Campus, University of Tehran, Mehdi Namazizadeh was the supervisor professos, and Mahmoud Sheikh and Saleh Rafiee were respectively the first and second advisors of the thesis.

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