Visual search and anticipation of jumping serve in men's volleyball player

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Abstract: This study adopts a series of research, from the laboratory environment to the real sports environment to explore visual search characteristics at different levels of men 's volleyball players about the jump serve. In experiment 1, There was no significant difference in the participants ' visual search characteristics of the total fixation duration, the fixation account, the average fixation duration, the reaction time and the correct rate among the master, first-class and non-ranking athletes. The gaze position of the master and the first-class athletes is more concentrated, and their attention is mainly paid to the athletes ' limb movements, including the body orientation of the upper limbs, arm and wrist movements, which is also consistent with the basis for judging the landing point in their oral reports. The gaze position of the non-level athletes is more dispersed, and their fixations and time of the ball are more than the other two groups. In experiment 2, the number of fixations of the master athletes on the ball and upper limbs is significantly higher than that of non-level athletes, but there is no significant difference in the total fixation duration. Meanwhile with the improvement of sports level, the reaction time does not show significant difference, but the master and first level athletes are obviously better and faster at receive than the non-level athletes. From the results, it generally found the high-level volleyball athletes visual search mode in real receiving environment.

Key words: visual search, volleyball players, jumping serve

1 Introduction

For sports events, visual information processing is closely related to sports performance. Athletes rely on vision for 80-90 % of the information in the competition. High-level athletes have better visual search characteristics than undergrade athletes that they find more relevant and beneficial stimulation information in the competition and training environment, so as to make more accurate and efficient decisions and show better competitive ability.

In the volleyball game, the prediction and positioning of the receiving service play a very important role. Firstly, athletes must judge the position of the server to determine a reasonable position ; according to the serve 's motor, the type of the ball and the flight trajectory, find the ball 's landing point and move in time[1][2]. In this process, the visual search plays an important role in the early.

With the world development of volleyball games, serve and receive has become two important counterbalance technology and promote the sustained development of volleyball. In the men 's volleyball competition, the world 's top teams in the game mostly use strong jump serve in common, so that its superiority of speed and strength has become the important factor for the team to win. Not only can jump serve break the rhythm of the competition, but also lead to direct scoring, damage an attack. The world-class teams also have a good pass and defense technology, can make the first attack direct scoring, defending-attack perform wonderful.

Laboratory studies have shown that high-level volleyball players are better than undergrade volleyball players in visual search and pre-judgment of receiving service. The eye movement experiment of Fortin et al. [3] shows that professional and non-volleyball players have more fixation points and shorter fixation time, but professional volleyball players are more accurate in judgment. From the perspective of visual search features, the upper body of the opponent 's player becomes the most concerned visual cue at the moment of the opponent 's touching the ball in all scenarios. The study also discusses that professional volleyball players distinguish key information from general information when making decisions, which points to the fact that professional volleyball players have more cognitive decision-making ability than ordinary players, but at the same time, the author also points out that volleyball players have good cognitive decision-making ability does not mean that they perform better in competitions. The research of Korean scholar[4]shows that professional volleyball players are more accurate than novice volleyball players in prediction, but there is no difference in the response time of judgment between the two. From the eye movement data, the average fixation time of professional volleyball players in the serve-first pass and first pass-set stages is long, and the fixation duration at the fixation point is short; in the first pass-set stage, professional volleyball players have longer fixation time and shorter judgment time of the attack area than novice players.

Jafarzadehpur et al. [5] compared the visual search characteristics of volleyball players and non-volleyball players. Research shows that volleyball players have better visual strategy and attention selection ability than non-players. Statistically speaking, there are significant differences between middle-level, excellent volleyball players and non-athletes, novice volleyball players. At the same time, the author points out that there is a correlation between the visual system and the perception-motion coordination that the visual system guides the procedural changes of motion as the most important perception regulator. The visual system of excellent volleyball players can quickly and clearly change the fixation point, which is the reason why volleyball players perform better in the visual search than other subjects. Piras A [6] and others used eye movement experiments to compare and analyze the visual dynamics of volleyball players and non-volleyball players when watching volleyball scene videos. The research shows that volleyball players watch the video with fewer fixation points but longer fixation time. They pay more attention to the trajectory of the coach 's passing ball and then to the hand of the passing player, rather than the volleyball player 's whole eye is focusing on the ball. This study supports the explanation that professional volleyball players obtain more information from fewer key fixation points and that volleyball players at different levels reflect different visual information processing decisions.

Afonso José[7][8][9] conducted a series of studies on volleyball players ' cognitive decision-making. Athletes with more experience in oral report have more comprehensive and perfect situational cognition. Although eye movement data and oral reports are not compared together, studies have confirmed that exercise decision-making in a complex exercise environment depends

largely on the specialization of perception-cognition, and the specialization of cognition is influenced by instinct and acquired specific sport training. He suggested using representative complex tasks to design experiments in a real sports environment.

In the experimental environment, the above studies have shown that high-level athletes have more efficient and distinctive visual search features, but few studies have researched the differences in visual search features between high-level volleyball players and undergrade athletes under real conditions. Whether the results of laboratory research and real scene research are consistent needs further verification. In this study, it explores the visual search characteristics of male volleyball players at different levels in screen and the real receiving scene experiments, which has more theoretical value and practical significance and is beneficial for further special visual training.

2 Experiment 1

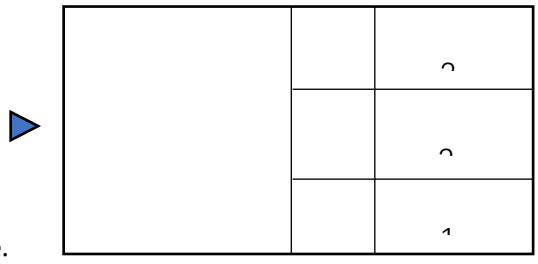
2.1 Methods and apparatus

2.1.1 Anticipants

A total of 48 men's volleyball players from Beijing Sport University were divided into three groups , ten players from the master level group(mean age , training experience 6.20±1.75 years), sixteen players from the first level group(mean age, training experience 6.88±1.36 years) and 22 players from the non-level group(mean age , training experience 2.53±2.48 years)according to the sports level to participate in the experiment. Among them, the master level group and the non-level group each has one left-handed person, and the remaining athletes are right-handed. In accordance with the Declaration of Helsinki, the study was approved by the Ethics Committee of Beijing Sport University.

2.1.2 Visual instruments

The eye tracking system used in this study is Tobii F250 telemetry eye tracker, combined with ErogoLAB man-machine-environment synchronization system to complete the visual data acquisition and processing of the experiment 1, which is supported by Beijing Jinfa Technology Co., Ltd. The eye tracking system is a wireless observation eye tracker, which is suitable for a variety of screen stimuli. The sampling rate is 250 Hz, and the installation is simple.



2.1.3 Experimental stimulus

The experimental video materials were recorded in the comprehensive hall of Beijing Sport University. Fifteen male volleyball players (nine from first level and six from master level (mean age , training experience 7.67±2.72 years)) who were accustomed to applying jump serve in competitions were invited to serve vigorously on the opposite side of the court. The average service speed was measured by a velocimeter, and the serve data of overspeed and low speed were eliminated.

Due to the strong jump serve drop area mainly concentrated in backcourt area [10], the experimental receiving placement area is equally divided into 1, 2, 3 area of the backcourt. The video recorder is set up at a distance of 5 meters from the end line of the venue and 2 meters high. Finally, 135 serving videos with a length of 3s are collected and edited. Experts are invited to screen out the 20 videos that best meet the requirements in each region, a total of 60 video stimulation materials.

2.1.4 Experimental procedure

First, subjects sat quietly in front of the computer screen and completed the calibration by the Tobii F250 eye movement instrument; Guided the subjects to read the experimental introduction and fully understand the content and purpose of the experiment before it began; Start the experiment with the subjects' permission.

The subjects were asked to sit in front of the computer screen and watch 60 randomly played serving videos. After each video was played, there was a 1500 ms interval between each video to allow the subjects to have a break and prepare for the next video. In the process of watching each video, the subjects need to judge the placement of the drop points by pressing the key, and set the ' J ' key to represent the left area 1, the ' K ' key to represent the middle area 2 , and the ' L ' key to represent the right area 3. Erogolab records the keystrokes and reaction times, as shown in Figure 1.

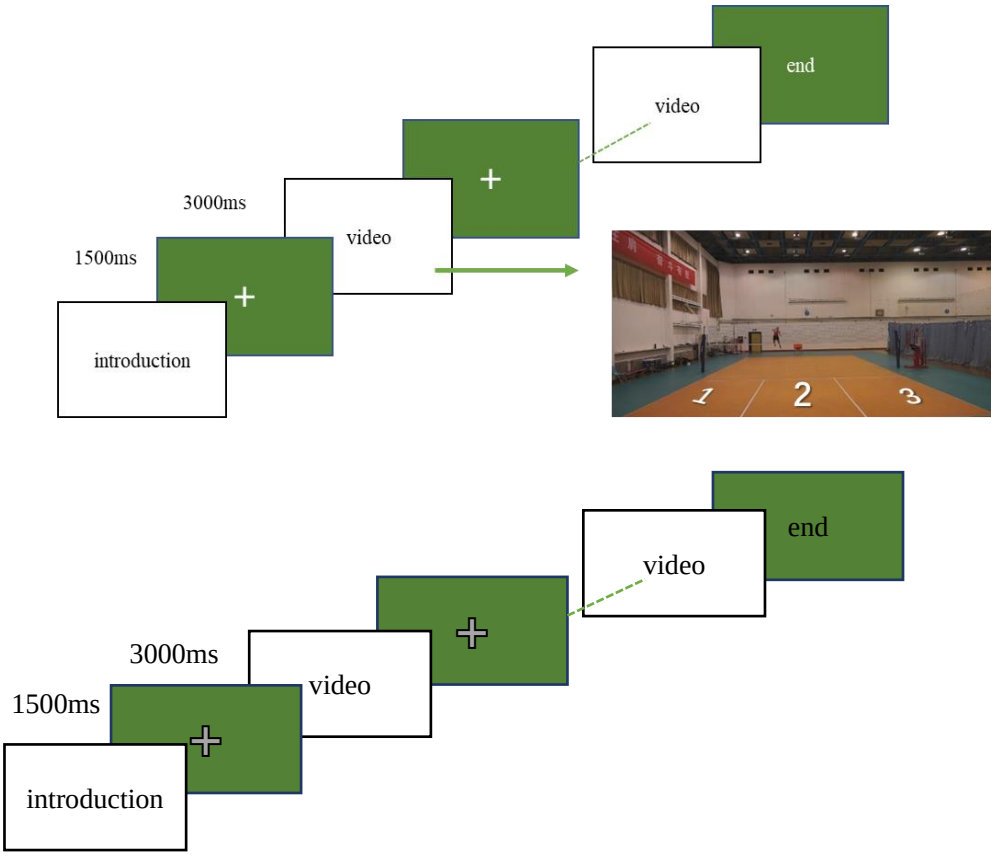


Fig 1 Diagram of experimental steps

2.1.5 AOI division and data processing

The visual search data of the athletes are recorded by the Tobii F250 eye tracker, and then the area of interest is edited by the Ergolab platform. Finally, the original data form is exported, and the SPSS 22.0 is used to analyze the visual search data, reaction time and accuracy of different levels of male volleyball players by variance analysis.

The area of interest (AOI) is divided into each frame on the Ergolab platform according to the technical movements changes of the volleyball players during the service. The division area is divided into head, upper limb, lower limb, right arm (serving arm), left arm, and ball.

The visual search data included AOI total fixation time, AOI total fixation count, AOI average fixation time, fixation position, etc. Reaction time refers to the time required to watch each serving video in the laboratory environment for keyboard judgment. Response accuracy refers to whether the key-button presented the drop area that pressed by the subjects matched the correct serving placement.

2.2 Results

2.2.1 Comparison of visual search data

There was no significant difference in the total fixation time of head($F(2,45)=0.887, P=0.419$), right arm($F(2.45)=1.705, P=0.193$), left arm($F(2.45)=0.455, P=0.637$), upper limb($F(2.45)=1.654, P=0.203$), lower limb($F(2.45)=0.795, P=0.458$) and ball($F(2.45)=1.635, P=0.206$) among different levels of male volleyball players. Master level athletes AOI total fixation time is slightly higher than the other two groups. From Figure 2(A), the master level athletes have more allocation time for upper limbs, lower limbs than other two groups. However the non-level athletes have more allocation time for ball than the master level and the first level.

There was no significant difference in the total fixation account of head($F(2,45)=0.248, P=0.781$), right arm($F(2.45)=0.194, P=0.824$), left arm($F(2.45)=2.027, P=0.144$), upper limb($F(2.45)=2.168, P=0.126$), lower limb($F(2.45)=0.856, P=0.432$) and ball($F(2.45)=2.080, P=0.137$) among different levels of male volleyball players. From figure 2(B), non-level athletes had higher fixation account in the head, left arm, upper limbs and the ball than the other two groups, while the master, first-level athletes had more fixations in the right arm and lower limbs.

There was no significant difference in the average fixation duration of head($F(2,45)=0.883, P=0.4200$), right arm($F(2.45)=1.174 P=0.318$), left arm($F(2.45)=0.581, P=0.563$), upper limb($F(2.45)=1.933, P=0.157$), lower limb($F(2.45)=0.974, P=0.385$) and ball($F(2.45)=1.465, P=0.242$) among different levels of male volleyball players. From the figure 2(C),the non-level players had more average fixation duration on the ball than the other two levels.

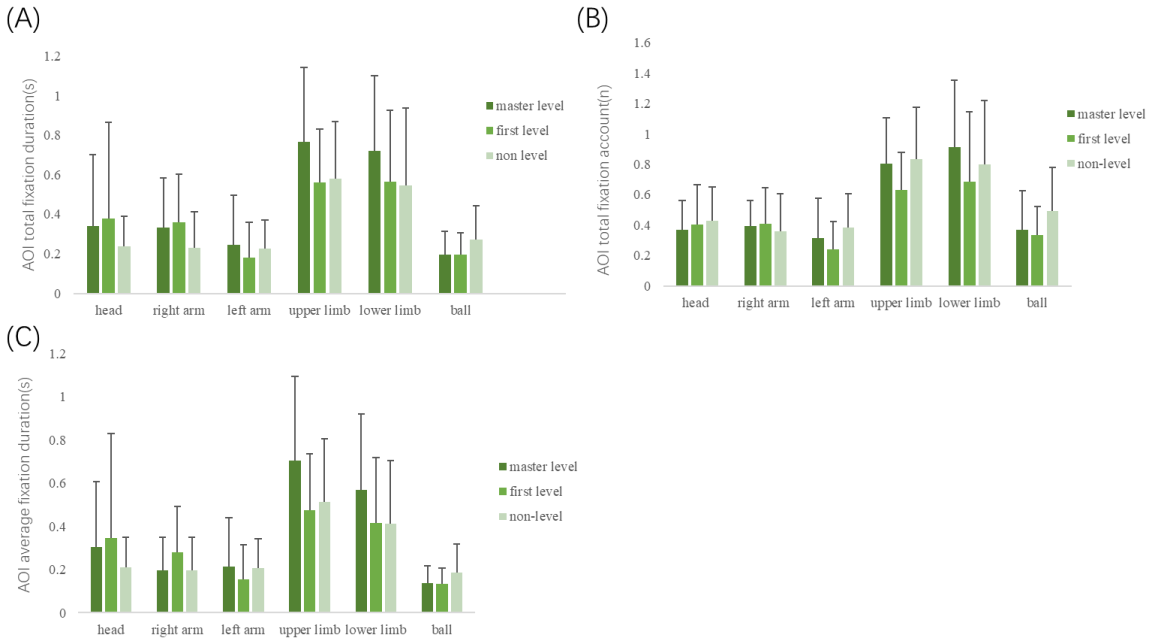


Fig2 Visual search data from different levels volleyball male players in EXP 1.

(A) AOI total fixation duration(s) shows that there is no significant difference between groups.

(B) AOI total fixation account(n) shows that there is no significant difference between groups.

(C) AOI average fixation duration(s) shows that there is no significant difference between groups.

2.2.2 Comparison of AOI fixation position

Edit the video frame of the player and divide them into three procedures. The first procedure is ball-throwing procedure from before throwing the ball, the moment of throwing the ball, the ball being thrown in the air; the second procedure is hitting-ball procedure from the back swing of the upper arm, the moment of taking off, the pulling arm, the moment of hitting the ball; the third procedure is after hitting-ball procedure from the moment before the ball passing the net, the moment of the ball passing the net, the moment of the ball already passed the net, and the moment of the ball landing. The Ergolab platform exports the data of the coordinate gaze points of the corresponding frame, and draws the scatter diagram of the gaze points of those frames. As shown in figure 3, the orange circle in the diagram represents the position of the player 's gaze points.

As can be seen from the figure 3, non-level athlete’s fixation point is more dispersed, and they more concerned about the ball trajectory; the first level athletes and master athletes paid more attention to the movement of the server, while less attention to the ball. In the ball-throwing procedure, with the improvement of the athlete’s level, the subjects paid more attention to the hand throwing movement of the server, while with the decrease of the athlete’s level, the subjects ' fixation point also changed with the trajectory of the ball ; in the hitting-ball procedure, with the improvement of sports level, the athletes paid more attention to the body orientation, arm swing and hitting arm movement of the server while the non-level athletes’ gaze points were dispersed ; in the procedure after hitting the ball, the subjects ' fixation points are basically changing with the trajectory of the ball.

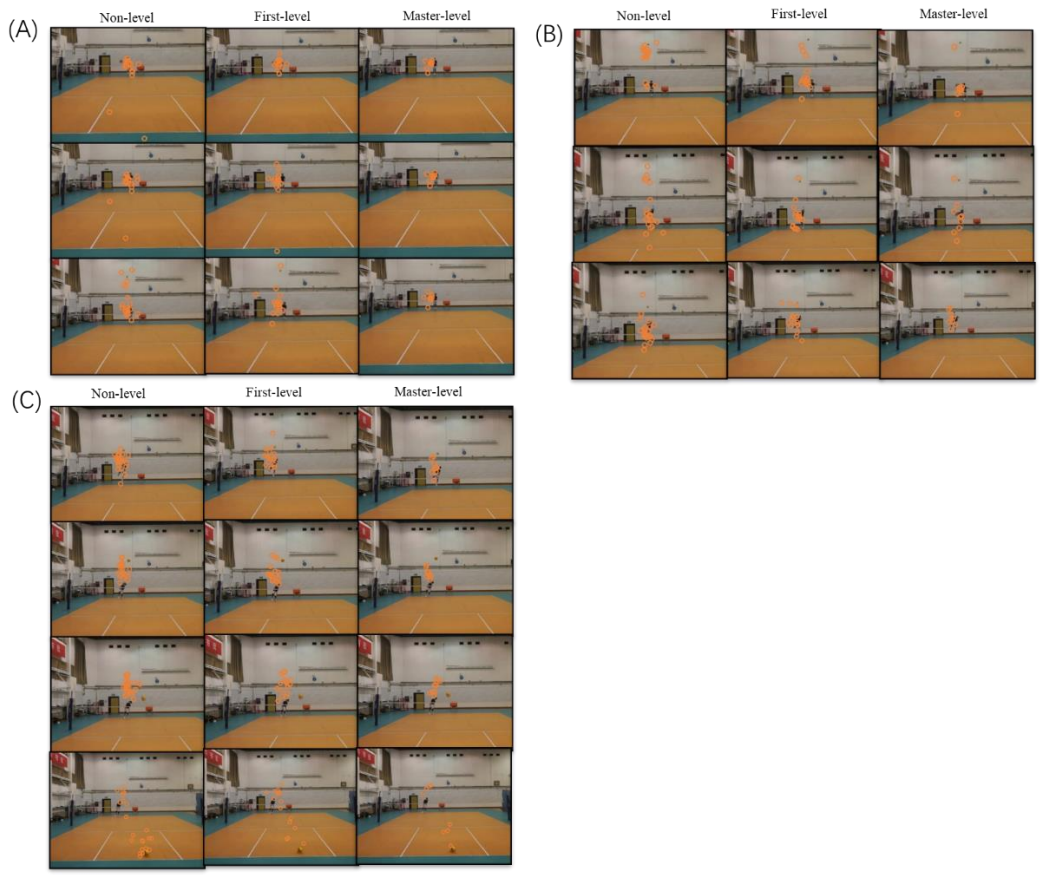


Figure 3 AOI fixation position

(A) In the ball - throwing procedure, the subjects paid more attention to the body movement of the sever and less attention to the ball with the improvement of the athletes level;(B) In the hitting-ball procedure, the subjects paid more attention to the body orientation, swing arm and the hitting arm; (C) After hitting ball, the subjects fixation changed follow the ball trajectory.

2.2.3 Comparison of reaction time and accuracy

There was no significant difference in the reaction time($F(2,45)=1.164, P=0.322$) and the correct account($F(2,45)=0.102, P=0.903$) of different levels of male volleyball players(Fig 4). With the improvement of sports level, the reaction time of athletes showed a decreasing trend that the reaction time of master level athletes was faster than that of first level and non-level athletes. Through the size of the standard difference, it can be seen that although there is no significant difference in the correct number of different groups, the high-level athletes' judgment is relatively stable and concentrated ($SD=4.296, 6.260$), while the judgment of non-level athletes is polarized ($SD=8.999$).

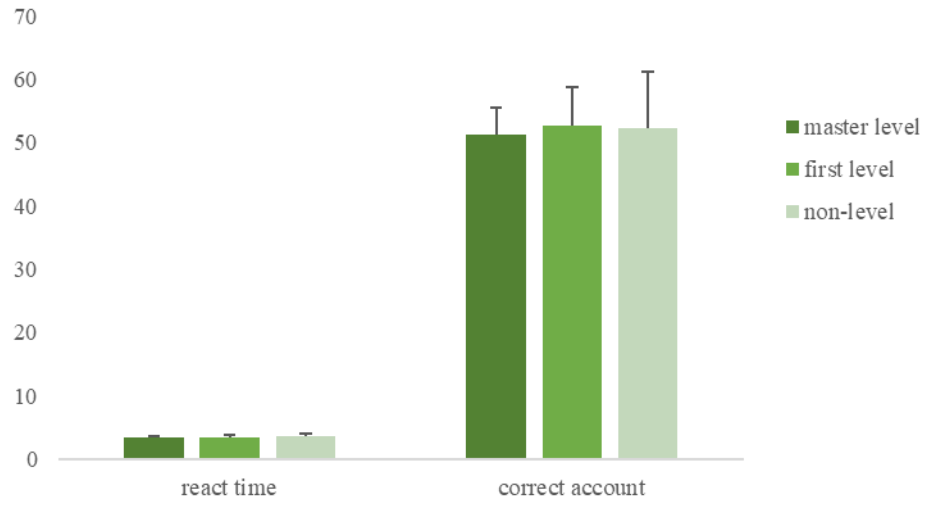


Fig 4 Reaction time and correct account of male volleyball player at different levels

2.2.4 Comparison of oral report

After completing the video test, the subjects were asked to answer a question immediately in the form of an oral report: ' During the observing of the video, what is the basis for you to judge the service placement area?' Table 4 sorted out the oral statements of different levels of men 's volleyball players on the issue. It can be found that the statements of high-level athletes on the pre-judgment, positioning and placement of strong jump serve are more complete, detailed and logical.

In the judgment of the falling placement of the strong jump serve, the master-level athlete believed that they can roughly judge the drop area of the serve according to the opponent 's standing position and the direction of the taking off step, and then accurately diagnose the location by the wrist direction of the batting and the flight trajectory of the ball. Some athletes put forward that there are certain limitations in video viewing. If it is a live catch, it can be roughly judged one or two meters after the athlete 's shot. First-level athletes thought that one is to see ' body orientation when hitting the ball ', and the other is to see ' the flight track of the ball '. Non-level athletes' judgment is mainly based on ' the flight track of the ball ' and ' the area where the ball falls ', meanwhile they put forward that it is difficult to determine the placement until the ball exactly land on the area.

Table 1 Verbal report comparison of male volleyball players at different levels

Group	Basis for judging falling point
Master group	1. Position of the server
	2. The height and position of throwing ball
	3. Taking off action and body orientation
	4. Wrist orientation when hit the ball
	5. Arm swing direction
	6. Ball's position when pass the net
	7. The trajectory of the ball after hit it
First group	1. Action of the server
	2. Body orientation and diversion
	3. Trajectory of the ball
	4. Track of the ball after pass the net
Non-group	1. Trajectory of the ball

2.3 Discussion

There was no significant difference in the participants ' visual search characteristics of the total fixation duration, the fixation account, the average fixation duration, the reaction time and the correct rate among the master, first-class and non-ranking athletes. However, it is worth mentioning that the gaze position of the master and the first-class athletes is more concentrated, and their attention is mainly paid to the athletes ' limb movements, including the body orientation of the upper limbs, arm and wrist movements, which is also consistent with the basis for judging the landing point in their oral reports. The gaze position of the non-level athletes is more dispersed, and their fixations and time of the ball are more than the other two groups, which also confirms the previous research hypothesis.

Although there is no significant difference in reaction time and accuracy between athletes of different levels, which may be caused by the short duration of video stimulation and the simple tasks, it may also indicate that though athletes at different levels have different processing methods of visual search, the final cognitive decision-making effect in the laboratory environment is the same. At the same time, it is also questioned whether the visual search processing methods of athletes at different levels in real scenes can also achieve the same sports performance, that needs further study, so there comes the experiment 2.

3 Experiment 2

3.1 Methods and apparatus

3.1.1 Anticipants

39 volleyball players from BAIC men 's volleyball team (N= 7), men 's volleyball player of Beijing Sport University (n=36) were divided into three groups to participate in the real jump serve experiment, which were 12 players from the master level group (mean age , training experience 7.83±3.01 years), 12 players from the first level group (mean age , training experience 7.08±1.51 years) and the 15 players from non-level group (mean age , training experience 2.30± 2.53 years). Among them, the master level group and the non-level group each have one left-handed person, and the other athletes are right-handed.

3.1.2 Visual instruments

A eye tracker system Tobii Glasses2, combined with ErogoLAB man-machine environment synchronization system was provided by Beijing Jinfa Technology Company. The eye tracking system is a wearable eye tracker with wireless real-time observation, light weight and comfortable wearing. The sampling rate is 100 Hz, which supports the test of complex experimental environment and frequent activities of subjects. Therefore, it can meet the experimental requirements of volleyball players in simulating competition and training environment.

3.1.3 Experimental procedure

The experiment was carried out in the comprehensive hall of Beijing Sport University and Beiqi Volleyball Training Hall.

After wearing the Tobii eye tracker, the subjects completed the visual calibration. Before the

experiment, the participants were informed of the experimental content and precautions. Before the test, the participants were familiar with the experimental environment and experimental instruments, adjusted the comfort level of the eye movement instrument, and began the experiment voluntarily and allowed.

As show from the figure 5, the subjects were prepared to stand in the No.2 area of the volleyball court to receive the strong jump serve. The subjects needed to judge the serve whether fell in the No.2 area and receive the ball. The ball in other areas could not be connected until the subjects completed 10 effective catches in the No.2 area. The eye tracker worn by the subjects recorded the subjective visual interface data, and the camera 5 meters away from the side line and the end line of the venue recorded the action video of the subjects receiving the ball. After completing the receiving experiment, the subjects need to complete an oral report on the receiving task immediately.

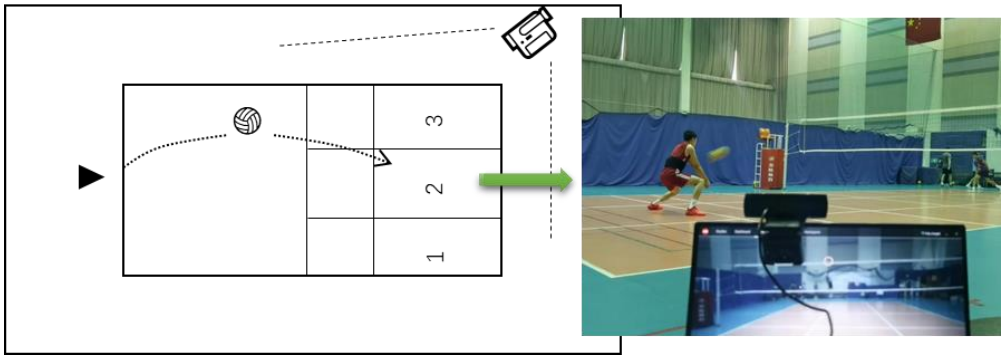


Fig 5 Diagram of experimental steps

3.1.4 AOI division and data processing

AOI division and visual data were collect by the same way from Experiment 1, but the reaction time and receiving accuracy were different.

The visual search data included saccades, visual distance, AOI total fixation time, AOI total fixation count, AOI average fixation time, fixation position and route, etc. Reaction time refers to the time from the time when the server throws the ball to the time when the participant anticipate the ball and the body moved. Receiving accuracy refers to the study[11], combined with Datavolley technical statistical standards, 5 points for the placement of the ball which is located in a rectangle of 2.3 meters long and 1.6 meters wide, 2 meters away from the right-side line; 4 points for the placement of the ball which is located in a rectangle of 4.1 meters long and 3 meters wide, 2 meters away from the right-side line; 3 points for the placement of the ball which is located in the front field area except 5 points' and 4 points' area; 2 points for receiving the ball in the backcourt area.;1 point for receiving the ball outside the venue.

3.2 Results

3.2.1 Comparison of visual search data

There was no significant difference in the AOI total fixation duration of

head(F(2,36)=1.415,P=0.256), right arm(F(2,36)=0.434,P=0.651), left arm(F(2,36)=0.715,P=0.496), upper limb(F(2,36)=1.265,P=0.294), lower limb(F(2,36)=0.936,P=0.402) and ball(F(2,36)=1.904,P=0.164) among different levels of male volleyball players. Master level athletes' total fixation duration is slightly higher than the other two groups. From Figure 15, the master level athletes had more allocation time for the ball and upper limbs than other two groups, while non-level athletes had more allocation time for the arm and lower limbs but less allocation time for the ball.

Although there was no significant difference in head(F(2,36)=0.181,P=0.836), right arm(F(2,36)=1.274,P=0.292), left arm(F(2,36)=0.403,P=0.671), upper limb(F(2,36)=2.976,P=0.064), lower limb(F(2,36)=0.093,P=0.911), there was a significant difference in the total fixations account on the ball between different levels of male volleyball players ($P < 0.05$). Through the post-test (LSD), it was found that there was a significant difference in fixation account on the upper limbs between the master group and the non-level group ($P = 0.020$), and also on the ball ($P = 0.010$). The fixation account on the ball and upper limbs of master level was higher than that of the other two groups. As can be seen from Figure 16, high-level athletes have more fixations on the ball and upper limbs, first-level athletes have more fixations on the upper limbs, lower limbs and the ball, and non-level athletes have more fixations on the right arm and lower limbs.

There was no significant difference in the average fixation duration of different level male volleyball players in head(F(2,36)=1.415,P=0.256), right arm(F(2,36)=0.434,P=0.655), left arm(F(2,36)=0.715,P=0.496), upper limb(F(2,36)=1.265,P=0.294), lower limb(F(2,36)=0.936,P=0.402) and ball(F(2,36)=1.904,P=0.164). From the average point of view (Fig 17), the average fixation duration of the master level players in the interest area and the average fixation duration on the ball are higher than other two levels of athletes.

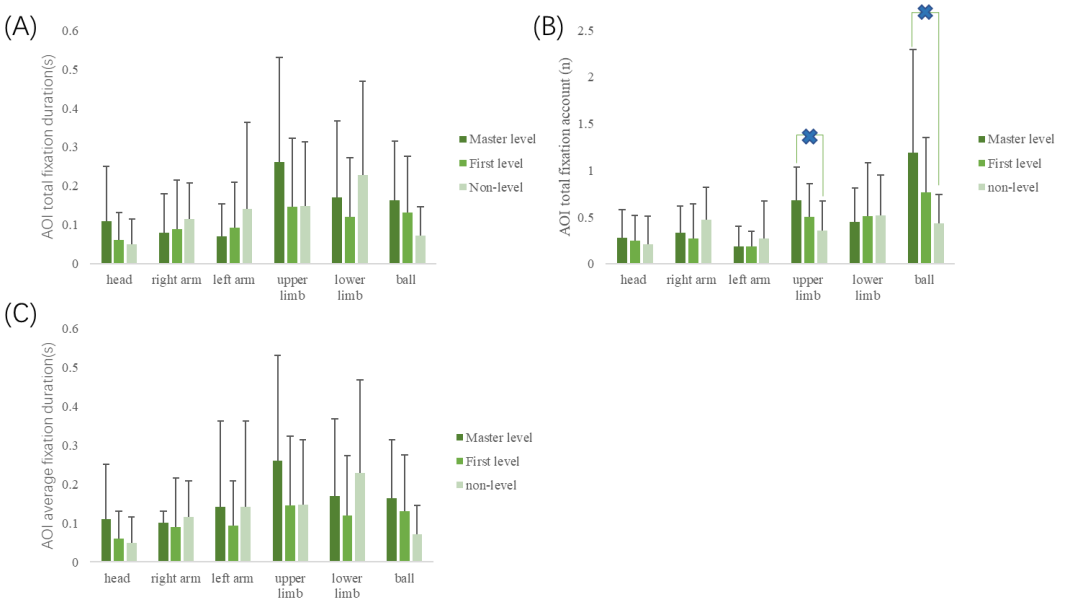


Fig 6 Visual search data from different volleyball male players in EXP 2

(A) AOI total fixation duration(s) shows that there is no significant difference among three groups.

(B) AOI total fixation account (n) shows that there is significant difference between the master level group and the non-level group in upper limb and ball, the master level group paid more attention to opponent’s upper limb motor and the volleyball.

(C) AOI average fixation duration(s) shows that there is no significant difference among three groups

3.2.2 Comparison of fixation position and route

The subjective visual videos are exported through the Ergolab platform, and are clipped into frames of the players into three procedures which is same to experiment 1, from ball-throwing procedure to receiving the ball. The fixation points and fixation routes of the men 's volleyball players at different levels in the process of receiving the strong jump serve are compared, as shown in Figure 7. The red dots in the figure represent the position of the athletes ' fixation, and the size of the dots represents the duration of the athletes ' fixation at this position. The connection between red dots and red dots represents the route of athletes ' gaze.

It can be found that the master athletes have the cleanest fixation points and short fixation time, while the non-level athletes have more complicated fixation points and longer fixation time. Non-level athletes’ focusing locations were more scattered, and the focusing route was more cluttered which moves frequently between horizontal and vertical site, often pay attention to the surrounding environment information out of the serving action; the first-class athletes were more concentrated in the ball and body parts and their vision moved with the action of the server, and the fixation route is simple and regular. Master athletes focused mainly surround the ball and the opponent‘s motor and their visual route moved vertically with the ball’s trajectory.

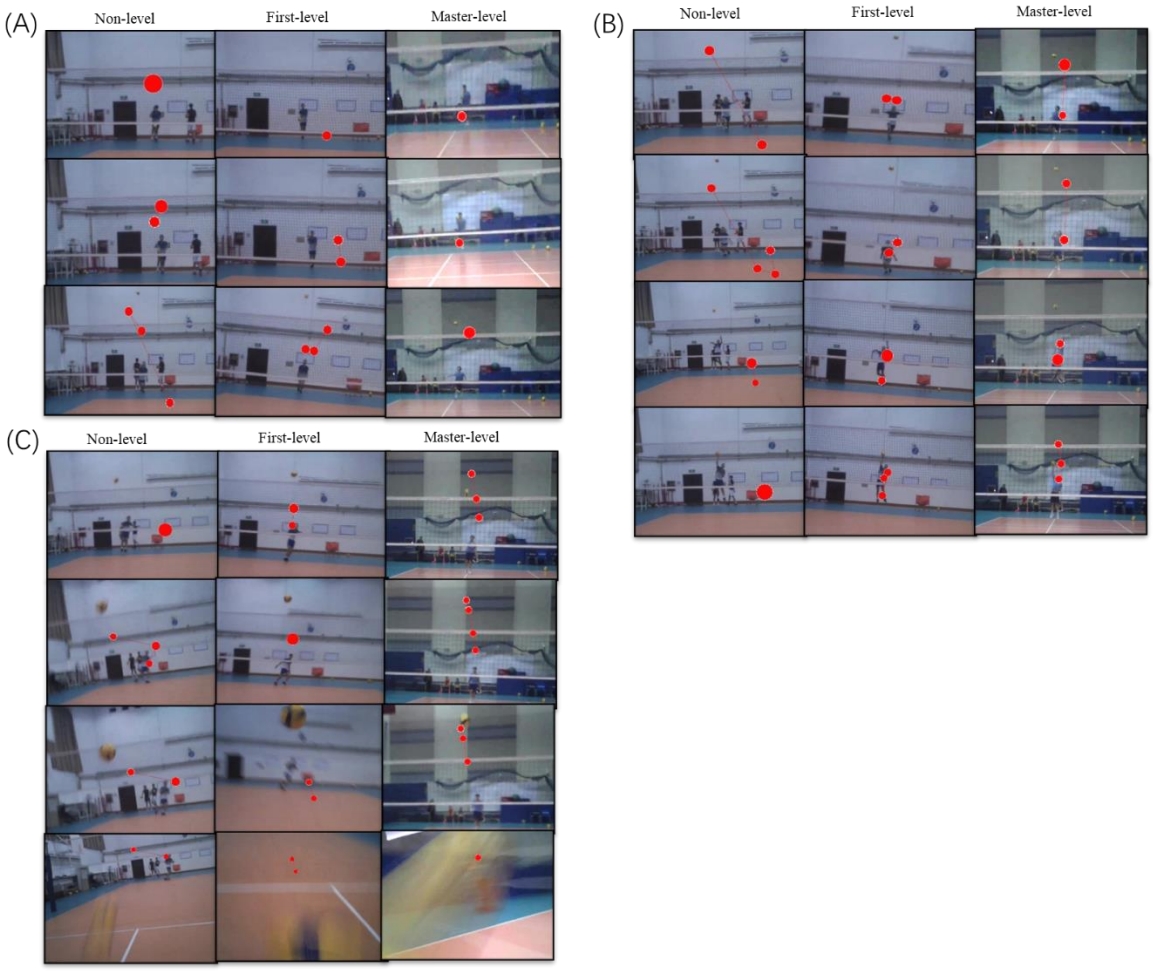


Figure 7 Fixation position and route of male volleyball players at different levels

(A) In the ball-throwing procedure, the master level players paid more attention to the ball while the lower level players fixed on more information from environment.

(B) In the hitting-ball procedure, the master level players focused on the position relation between the ball and server's motor while the first level paid more attention to the server's body movement, and the non-level players paid more useless information from surroundings.

(C) After hitting the ball, the players focused on the ball with the improvement of the levels, the master level players can predict the ball trajectory in advance.

3.2.3 Comparison of reaction time and receiving accuracy

There is a very significant difference ($P < 0.01$) in the average receiving score of men 's volleyball players at different levels (Fig 8). Through the post-test (LSD), there is a very significant difference ($P = 0.000$) in the average receiving score between the non-level athletes and the master-level athletes, and there is a very significant difference ($P = 0.000$) between the non-level athletes the first-level athletes but no significance between the master level and the first level .

There may be differences in the reaction time of different levels of men 's volleyball players (P < 0.10). Through the post-test (LSD), it is found that there is a significant difference in the reaction time between the first-level athletes and the non-level athletes (P = 0.030). First level athletes have shorter reaction time than non-level athletes.

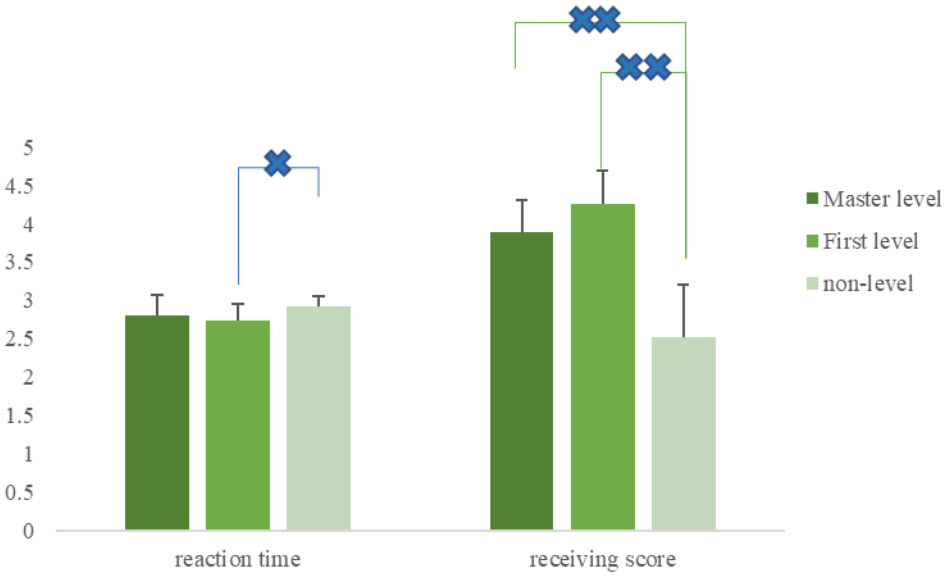


Fig 8 Average reaction time and score of receiving of male volleyball player at different levels

3.2.4 Comparison of oral report

After completing the receiving test, the subjects were asked to answer questions in the form of an oral report: 'When receiving a strong jump serve, what is the basis for you to judge the service placement area? 'and ' Do you think it is important to predict and take position when catching a strong jump serve? Why? ', Table 2 organizes the oral statements of men 's volleyball players at different levels on the two questions. It can be found that high-level athletes, especially experienced athletes, have more complete, rich and comprehensive statements on the prediction and positioning of the jump serve, and the description is closely combined with the competition scene.

In the judgment of the strong jump service, the master athletes believe that in addition need to understand the opponent 's service habits and routes before the game, but also need to be based on the real game of the various actions of the server and stare at the ball, not be cheated by the serve ' deceptive action ' ; the three groups of athletes all mentioned the ' flight track of the ball ' and the ' body orientation ' of the service player, but the master athletes described in more detail the ' flight track before crossing the net and the position of the ball when crossing the net area ' and the ' body orientation of the service player when taking off '.

Basically, all athletes believe that pre-judgment and positioning are ' very important ' in the catch jump serve. Athletes at the master level have a clearer understanding of the important reasons for pre-judgment and positioning. They believe that accurate pre-judgment can guide them to take positions in advance, and then they can take a more relaxed body posture to pass the ball. They also answered from the fast and powerful characteristics of the strong jump service that they think a good serve can cause a direct score. If there is no pre-judgment, it will not respond in the

process of catching the ball.

Table 2 Oral report comparison of male volleyball players at different levels

group	Basis for judging falling point	The importance of anticipation and positioning
Master level	8. Knowledge of opponents in the event 9. Taking off action、body orientation 10. Wrist action when hitting the ball 11. Arm swing 12. Ball trajectory before passing the net 13. The position of the ball when it passes the net 14. The height and position of throwing ball 15. Stare at ball	1. Prediction is very important, basically pre-judgment of the ball can know the approximate falling placement of the ball, and then carry out the correct positioning, so that you can control the body rather than off the body and take the unnormal form to catch the ball; 2. Strong jump serve is very fast in large-scale events, especially in international events, some balls can drop on the hairline. If there is no pre-judgment that cannot react when receiving the ball, the team may lose score directly; 3. Jump serve has fast speed, power strength, unlike the floating ball can be set, most of them are supposed to use the service way to catch. Pre-judgment can take the position in advance and use the correct position to catch the ball, in order to achieve good service effect.
First level	5. Serve action of opponents 6. Body orientation 7. Trajectory of the ball 8. Arm swing	1. Prediction and position are important, jump serve is fast, not to take position in advance may not respond to catch the ball ; 2. Prediction is more important than taking position because you can move your feet in advance to catch the ball
Non-level	3. Trajectory of the ball 4. Flying radian of the ball 5. Serving position and direction of the ball	1. Correct prediction and position can receive the ball greatly.

3.3 Discussion

The fixation duration and fixation count of each region of interest can reflect the efficiency of visual information processing. The longer fixation duration, the cognitive processing rate of information is slower with lower efficiency[12][13]. Studies have shown that in an open competition environment, excellent football players take more times and shorter fixation for attention position than novice players[14][15]. In this experiment, the number of fixations of the master athletes on the ball and upper limbs is significantly higher than that of the ungraded athletes, but there is no significant difference in the total fixation time, which further verifies the previous research. When the high-level athletes perform visual search, they take a short and frequent attention to the location of attention, and the efficiency of information processing is higher.

From the results of this study, with the improvement of sports level, the reaction time does not show significant difference, but the master and first level athletes are obviously better at receive than the non-level athletes. ' Fast and good ' seems to be a rule that professional level volleyball players when they receive strong jumps. This may be because the fast speed of the strong jump service itself leads to a limited time for the athletes to take a move, and the high level

athletes seem to move faster and take more correct position than lower athletes. Due to the long training period and rich experience in participating in the competition, the high-level athletes have a deeper understanding of the judgment of the receiving placement, which also coincides with the results of their oral report. At the same time, their motor skills and ‘the sense of ball’ are significantly stronger than those of non-level athletes, so there was a significant difference only in the receiving effect.

Therefore, to a certain extent, it also shows that the information processing efficiency of visual search plays an important role in the prediction and positioning of athletes when receiving serve.

4 General discussion

4.1 The visual search characteristic of male volleyball players at different levels

Combined with the characteristics of strong jump serve, its heavy, fast and rotary features makes it be difficult to receive . High-level athletes receive the ball much better because they pay more attention to the relation between the crucial movement of the serve and the route of the ball when receiving strong jump serve, avoiding other irrelevant information. From the screenshots of each action in the gaze route of experiment 1 and experiment 2, it is verified that the master and first-level athletes‘ gaze points are more centralized, while the gaze points of non-level athletes are more dispersed and the information sources searched are more complex. This is also the same as the relevant research results of baseball[16] tennis[17]and volleyball[18][19]. The gaze trajectory of high-level professional athletes is simpler and clearer, the attention points are more concentrated, and the visual information search is more efficient.

The visual allocation of experiment 1 and experiment 2 is different. In Experiment 1, high-level athletes pay more attention to the trunk and arm movements of athletes, while non-level athletes pay more attention to the ball. In Experiment 2, the master athletes’ attention was paid mainly to the ball, the upper limb and the right arm, while the non-level athletes paid more attention to the other area and paid less attention to the ball. In experiment 1 and experiment 2, the high-level athletes mainly allocated their gaze to the upper limbs and arms when receiving the service, which is mutually verified with some domestic and foreign research[20][21]. It shows that when receiving the strong jump service, the main service movements of the server include arm movements and upper limb movements such as body orientation rotation, sideways, shoulder lifting, arm pulling and other details become an important source of information for high-level athletes to make prediction. However, in the real experimental scene, the high-level athletes pay more attention to the ball with short duration and more fixation, which is different from the screen experiment results. This may be because the experimental task became different and more complex, the athletes ' visual search and cognitive processing methods changed. In the screen experimental environment, only simple key reactions are involved, and the subjects only can judge through limited and efficient information, while the tasks in the real scene require the subjects to receive the ball as much as possible, so that the subjects need to pay more attention to the effect of receiving the ball.

4.2 The visual search mode of male volleyball players at different levels

Athletes ' visual search patterns can be reflected by their fixation allocation and fixation trajectory[22]. High-level male volleyball players visual search mode is better than non-level athletes.

In the information retrieval and extraction stage of visual search, master and first-level

athletes can quickly notice the effective information, so as to process the next information more smoothly and efficiently. Treisman [23] believes that if the individual 's visual attention is scattered or overloaded, the information will not be able to perform correct brain cognitive processing, resulting in illusory binding. Therefore, the scattered and complex gaze of ungraded athletes becomes the reason why they cannot effectively extract information.

In the information extraction and processing stage, the master and first-level athletes adopt multiple fixation times and short fixation duration to cognitively process effective information. Through the bottom-up processing method, the information is integrated with their own memories, cognition and environment. Finally, the ball is connected from top to bottom through rapid response and correct positioning.

Therefore, high-level athletes visual search mode is simple, short duration and more fixations focused on the right arm, upper limb and ball path.

4.3 The visual-cognitive-performance analysis of male volleyball players at different levels

Although there was no significant difference in reaction time and decision-making accuracy among athletes at different levels in Experiment 1, high-level athletes performed significantly better than non-level athletes in Experiment 2. Undoubtedly, visual search plays an important role in the information input stage of cognitive decision-making[24]. Elite athletes have more flexible attention and sports cognitive ability[25]. According to the research results, high-level male volleyball players do have more efficient visual search and cognitive processing ability than low-level male volleyball players, but many studies have questioned whether the improvement of visual search and cognitive decision-making ability can be converted to the improvement of sports performance to a certain extent [26]. At present, many sports visual training used sports video, pictures and two-dimensional computer vision tasks as experimental stimuli and training methods to test the effect of sport performance improvement [27][28][29], but the results showed that the subjects only improved the response and accuracy of visual training tasks, but not the improvement of sports skills[30][31][32][33]. Therefore, this needs further research and investigation, maybe combine with visual specific-training can confirm the performance improvement hypothesis.

5 Conclusion

From the results, it generally confirmed the previous hypothesis that high-level volleyball athletes have more efficient visual search strategy than the non-level volleyball players. However, different level volleyball players' visual search characteristics are different during various situation. High level players visual track is more simple and clearer than non-level players. In screen experiment environment, high-level players make decision mainly from the upper limb and server's motor while in real sport scene, they pay more attention to the ball and upper limb of the server. Whether the change of visual strategy can extensively improve the receiving skill performance, it is supposed to take a further intervention study.

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