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Comparison of Anticipation Accuracy and Visual Search Behavior of Handball Players in Simulated Triple Handball Defense Situation

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Original Article

Abstract

Introduction: The purpose of this study is to compare the anticipation accuracy and visual search behavior of handball players in three different defensive positions of 1 × 1, 2 × 2, and 3 × 3.

Materials and Methods: In this study, 20 handball players aged 16-19 from among national youth team and Pishgaman team of Isfahan, Iran, and were selected via purposive sampling method. At first, videos of different game situations were recorded by the researcher in three situations (1 × 1, 2 × 2, and 3 × 3). Then, handball players observed the three attack-defense positions by eye-tracking device. Then, the players' anticipation of the outcome of the ball position (Fint, Shot, Pass) that was told verbally, was recorded by the researcher and the players' visual search behavior was recorded by the eye-tracker.

Results: The result of repeated measures analysis of variance (ANOVA) and Bonferroni post hoc test illustrated that there was a significant different in the anticipation, number, and total duration of visual fixation of the skilled players in the three situations. The anticipation, number, and duration of fixation in the 3 × 3 position were better than the two other positions (P = 0.05). The players looked at the opponent's head, trunk, and hands for position recognition.

Conclusion: In the present study, defensive handball players focused on the background information on the player's head, trunk, and hand in order to anticipate and identify the attacking player's pattern in position three versus three relative to position two versus two in position two and position one in front of one. In addition, the visual search behavior in position three versus three was better for the player than the other two positions.

Keywords: Anticipation; Visual search behavior; Athlete; Handball; Defense situation

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Introduction

One of the important perceptual skills is anticipating future events based on the previous events (1). In fact, anticipating the opponent's intentions and setting an appropriate response based on the existing provisions and tactical and strategic considerations of key functions based on past information and experience are applied in many sports, especially ball sports (2), team sports, and racket sports (3,4). When one is going to make an anticipation during a match, it is important to make a correct anticipation. For this purpose, the person must be able to use the background information of the environment and the task, and if he identifies this information correctly and accurately, he can accurately anticipate the outcome of the performance (for example, shots or passes, etc.) and during various exercises, he can even improve his anticipation and reduce the error rate in his anticipations. In fact, the player will not be able to anticipate until he obtains this background information from the execution environment and the person performing the task. Accordingly, anticipation can be practiced in open and closed skills with players so that they can acquire the necessary skills for it. In closed skills, due to the stability in the skill, it is very easy to practice and improve the anticipation, however in the open skills, due to the change of the three components of "environment, person, and task", training should be performed in different ways so that the person's doubt is gradually

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reduced in the response selection and the number of possible wrong responses. During this process, the player learns to reduce uncertainty in practice about the type of event or time of the event. For example, when a coach is going to train the forearm pass in volleyball, he first passes the ball directly to the person's hands and informs him. As the person progresses, the coach sends the pass to the left, right, front, and back, and again informs him to get the necessary information from the type and manner of the pass and the type of hand and body movement of the performer, and finally, the coach does not announce anymore which direction he is passing and the performer makes the anticipation based on the information obtained from the previous exercises and the type and manner of sending the ball and the type and manner of movement of the person's body, and based on which receives the ball. As a result, if the background information to focus on is chosen correctly by the player, his anticipation will be satisfactory and he will be able to design the right reaction to what is going to happen. Therefore, the player's performance in the match will be better, but if the person does not correctly identify the background information, he will make a wrong anticipation and thus, his performance will fail. Softball and rugby players face time uncertainty. In other words, the player sees the approaching object as continuous and the time uncertainty decreases and the spatial uncertainty contributes to creating the need for anticipation (5,6). Relying on this knowledge, they can anticipate the opponent's behaviors (4). Perceptual anticipation refers to the performer's ability to anticipate current events based on detailed information (1). This information is usually present in the form of cues in the field of performance (1). The ability to anticipate the opponent's performance is essential to allow the athlete to have maximum time to select and perform appropriately (7). Skilled athletes are able to anticipate the opponent's movements using visual information of their movements before performing movements such as ball-racket contact, ball-foot contact, or sword-body contact (8-10). Despite the importance of anticipation in a successful performance, it is still one of the less researched areas of visual-perceptual motor behavior (7). The visual search process involves the use of sight to obtain information from the environment (11). Visual search selects important cues that affect the three parts of the action control process. These three sections include "action selection, restriction of the selected action, and timing of the action initiation" (4). By influencing these processes, the visual system enables the individual to be prepared and start the action in accordance with the requirements of the performance (1). Saccades are rapid, leaping movements of the eye that shift visual attention between different positions in less than 100,000ths of a second (12). These movements move the eye towards the stimulus with a short delay relative to the stimulus, and during these movements, information processing is suppressed (5). Skilled subjects have a better perception of the information resources available to perform the function (9). Fixations are periods of time in which the visual image is kept fixed on the eye socket for the necessary information (3).

In examining the visual search behavior, respectively, fixations, position, duration, and number are important to understand how and what information the performer is paying attention to (13). In sports skills, fixations are recognized as a criterion for athletes' proficiency (13). The duration of the fixation period indicates the relative importance and complexity of the display area for the observer (13). The fixation position is a reflection of the important signs used in decision making and areas of interest to the athlete (14); while the number of fixations reflects the information processing needs of the performer (15). Some researchers have suggested that the visual search behavior of skilled individuals, leading to more accurate anticipations or decisions, results from more fixations with shorter periods on the player owning the ball in football (16) or fewer fixations with longer periods on the individual or ball in cricket and football (9,17). Few investigations have been conducted on the accuracy of anticipation and visual search behavior of handball goalkeepers during performing the penalty shots (18,19). In open sports conditions, such as when participants watch the attack-defense position pattern of the game, defenders are exposed to a large number of relevant and irrelevant signs in movement to defend against the attacking player, and they must identify the type of movement and intent of the attacking player in a timely and correctly manner. Based on the studies conducted, it seems that few studies have been conducted in relation to visual search in these conditions; however, no research has been performed on handball in defensive situations. Accordingly, the present study is carried out aiming to determine whether the accuracy of anticipation and visual search behavior of handball players vary in different situations, and if there is a difference, in which position is the difference greater?

Materials and Methods

In this quasi-experimental and cross-sectional study, the anticipations of handball players in three positions of 1 × 1, 2 × 2, and 3 × 3 were compared. The study was conducted during the competition season in 2019 by the Isfahan Province Handball Board, Iran. The matter was reported to the national team coach, and after calling him, among the skilled handball players who were members of the Isfahan National Youth and Pioneers Team in the age range of 16 to 19, the players were selected using the purposive sampling method.

The total number of participating volunteers was 20 men at the youth league and national team level. Given the call, since the number of youth players at the league and national level was limited to the same number in Isfahan, the convenience sampling was performed. This number was a combination of the three teams of Youth, Pioneers and National Youth Team, and Isfahan Zobahan, and the players of the Sepahan team did not participate in the study due to not being allowed by the club to cooperate in the study. Due to the skill and limited sample size in Isfahan province, all players were examined for physical health and vision and approved by an optometrist. The participants had at least 8 years of experience playing handball and participating in league and national handball team competitions. The players had regular weekly training (three sessions per week). The players were endorsed by three handball coaches who had more successful assists and shots in the league compared to other players. All subjects participated in the study consciously and with full satisfaction. Before starting the study, the code of ethics was obtained from the Iran National Committee for Ethics in Biomedical Research of the Institute of Physical Education and Sports Sciences. In order to investigate the visual search behavior of the subjects in the present study, a pair of vision tracking glasses (Pupil Core Eye Tracking, Pupil Lab, Berlin, Germany) was used that recorded the glare point at any time at a frequency of 60 Hz (60 frames per second). The data was transferred via cable to a computer. The software (Pupil Capture X64- V1.15- 65-ga7c4fdb, Pupil Lab, Berlin, Germany) was used in order to record eye movements and changes and the software (Pupil Player X64- V1.15- 65-ga7c4fdb, Pupil Lab, Berlin, Germany) to analyze the recorded data and display them. The visual tracker used in the present study had the ability to record data such as number, location (areas on the player's body or ball that the participant looked at and anticipated the outcome according to that area. The more experienced the player, the more accurate the location he selected. In order to identify the players' favorite position in the present study, 8 areas of head, torso, hands, waist, thighs to knees, knees to ankles, balls, and kickbacks were considered), and the duration of fixations.

In the present study, out of the 200 clips recorded, 15 clips were selected in three simulated defensive positions of (1 × 1), (2 × 2), and (3 × 3). The clips were prepared by the researcher during six filming sessions, each session lasting one hour, using a camera (Sony, Exmor R 18.2 MEGA PIXELS Optical SteadyShot DSC-WX100 3.6v, Kōnan, Minato, Tokyo, Japan) with a resolution of 20 megapixels from the opposite angle (camera in the role of the central defender). Three handball coaches (the coachs of the Iranian national youth team, the national beach handball team of Iran, and the national team of Iran) watched the clips separately, and if the clip was duplicated or far from the study goal, it was removed and replaced by another clip and 15 clips were prepared with their opinion on whether the clips evoked real conditions. When recording the clips, the camera was mounted by the researcher on the four-meter handball line so that the image obtained from the six-meter line and the six-meter defense range could be fully visible. All of these clips were cut by the temporal occlusion paradigm at the critical point, for example at the start of a pass, shot, or at the start or during a feint. For this purpose, VidtrimPro software (Video Editor v2.6.1, Goseet, Steinhausen, Switzerland) was employed to cut videos and equalize the time of the clips. The techniques were performed in three shooting positions by the players of the Iranian national handball team (players who were not present in the test). Then, using a Sharp video projector and a 3 m × 3 m screen placed in front of the participants, the clips were displayed to each participant attended the conference room of Isfahan Handball Board individually and with prior appointment and he watched the clips randomly. The individual's seat could be adjusted three meters from the screen according to the player's height. The individual had reclined his head completely to the chair back and he was asked to keep his head still (Figure 1). The vision tracking glasses were placed on the player's face. In the one-on-one situation, the attacking player would came to the camera (defender) who was in the center-back position, and the attack would end with one of the types of feints (opposite foot, with rotation, two-way, agreeing foot) or shot. In the two-on-two position, the camera was in the central defender position with a defender on the left, and the two attackers were in front of the camera and the other defender.

The movement ended in front of the camera. In the three-on-three position, the camera was in the

central defender position, with two players on the left and right of the camera as defenders and the attackers in front of each person and the camera.

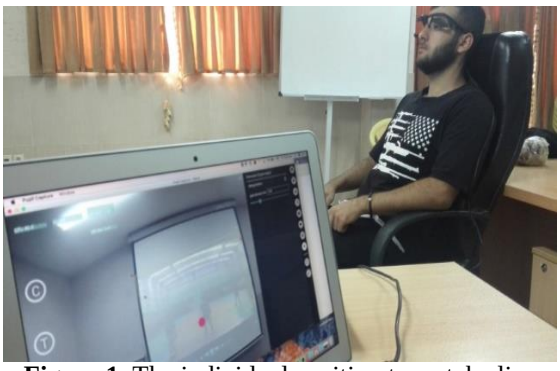

Figure 1. The individual position to watch clips

In this case, in the two positions (2 × 2 and 3 × 3), the attack ended in one of the positions of feint (types of feint), shooting, and passing or combinations of feint-shot and feint-pass. Initially, the experiment was fully explained to the participants theoretically and practically, and three attempts were made as pre-test familiarization attempts. The time of the 15 clips was very short and about 4 to 10 seconds depending on the type of position (10, 6-8, and 4 seconds in 3-on-3, 2-on-2, and 1-on-1 positions, respectively). At the end of each clip, the player verbally expressed his anticipation, which was recorded by the researcher. The clips were randomly played to the players. The player was given a 10-second break between the attempts. The participants' anticipations were scored as 0, 1, and 2 respectively for wrong decision, anticipation with 50/50 chance of success as conservative choice of position, and correct anticipation.

Descriptive statistics were employed to categorize information, mean values, standard deviation (SD), and table setting. Then, the repeated measures analysis of variance (ANOVA) and Bonferroni post hoc tests were used for pairwise comparison of different defense conditions, 3 × 3 condition versus 2 × 2 and 1 × 1, and also, 2 × 2 condition versus 1 × 1. Data distribution was also examined using the Shapiro-Wilk test. Finally, the data were analyzed in SPSS software (version 20, IBM Corporation, Armonk, NY, USA). Additionally, $P < 0.05$ was considered as the data significance level.

Results

The results of the Shapiro-Wilk test showed that the studied data followed the normal distribution ($P > 0.05$). 20 male handball players with a mean age of 17.50 ± 3.32 years, mean height of 185.00 ± 2.63 cm, and mean weight of 73.05 ± 3.20 kg participated in the study. The subjects had 9.20 ± 4.20 years of experience of sports. The body mass index (BMI) of the participants was 23.20 ± 10.24 kg/m^2.

The number of correct, 50-50, and false anticipations and the number and duration of visual fixations for the three defense positions are separately presented in table 1.

The number and duration of visual fixations on different areas of the player's body and the ball for each of the three positions are reported in table 2.

The results of the repeated measures ANOVA test for the anticipations and the number and duration of total visual fixations in different defense conditions indicated that these three positions were significantly different in all variables studied. Accordingly, based on the Mauchly's test of sphericity ($P > 0.05$), the defense conditions were significantly effective on the anticipations and the number and duration of total visual fixations (Table 3).

The findings of the Bonferroni test for the pairwise comparisons of different defense conditions revealed that the anticipation performance was significantly better at the 3 × 3 condition versus 2 × 2 and 1 × 1, and also, 2 × 2 condition versus 1 × 1, respectively ($P \leq 0.001$) and the total number and duration of visual fixation were significantly higher ($P = 0.030$ for number and $P = 0.040$ for fixation period, respectively) (Table 4).

Discussion

The aim of this study was to compare the accuracy of anticipation and visual search behavior of handball players in three defense positions 1 × 1, 2 × 2, and 3 × 3. There was a significant difference in the anticipation accuracy of handball players in comparing the three positions and it was better in the 3 × 3 position compared to the 2 × 2 and 1 × 1 positions.

Table 1. Correct, 50-50, and false anticipations and the number and duration of visual fixations by the three defense positions

Position	Types of anticipations			Visual fixation (%)	Duration of visual fixation (seconds) (Mean ± SD)
	True (%)	50-50 (%)	False (%)		
1 × 1	18	5	61	26	7987.71 ±66.65
2 × 2	31	51	28	24	9421.71 ± 77.27
3 × 3	56	44	11	40	11585.00 ± 80.33
Total	100	100	100	100	28994.67 ± 22.26

SD: Standard deviation

Table 2. Number and duration of visual fixations on different areas of the player's body and the ball for each of the three positions

Area	Parameter	Position			
		1 × 1	2 × 2	3 × 3	Total
Ball	Fixation (%)	20	49	31	100
	Fixation time (seconds)	408.23 ± 64.54	622.01 ± 62.83	454.85 ± 55.52	1485.10 ± 18.90
Knee to ankle	Fixation (%)	58	33	9	100
	Fixation time (seconds)	297.75 ± 50.20	238.55 ± 47.69	81.47 ± 25.32	617.79 ± 12.22
Thigh to knee	Fixation (%)	55	35	10	100
	Fixation time (seconds)	475.47 ± 62.11	439.32 ± 68.44	128.51 ± 41.93	1043.31 ± 17.50
Waist	Fixation (%)	41	35	24	100
	Fixation time (seconds)	1185.08 ± 90.61	997.90 ± 13.07	791.71 ±14.22	2974.70 ± 36.22
Hands	Fixation (%)	18	38	44	100
	Fixation time (seconds)	682.84 ± 71.07	1472.68 ±12.80	1772.38 ± 16.22	3927.91 ± 35.10
Trunk	Fixation (%)	33	33	34	100
	Fixation time (seconds)	2055.25 ± 14.00	1931.37 ± 14.62	1625.38 ± 14.04	5612.01 ±42.67
Head	Fixation (%)	20	30	50	100
	Fixation time (seconds)	2883.05 ± 19.10	3719.85 ± 30.77	6730.91 ±24.05	13333.82 ± 63.94

Skilled players are likely to make more accurate anticipations in the 3× 3 position, given their level of news knowledge and practice, as well as their high level of experience participating in matches and being in various attack-defense situations and performing group attack-defense tactics (19).

The findings of the present study were in line with those of the studies performed on the anticipation and visual search behavior of football players in different situations 3 × 3 and 1 × 1 (19) and also, in the study of visual perception and selection of visual cues in five skills (10), spatial and temporal anticipation of cricket players (20,21), visual search strategy in baseball players (22), skills difference in visual anticipation of different types of penalty kicks in handball goalkeepers in two positions (18), visual search and skill level and anticipation in handball players (4), and the anticipation and players search behavior of badminton players (23). In all of these studies, skilled individuals made more accurate anticipations. The results of a study that examined the anticipation skills and visual search behavior of basketball players in the 3 × 3 and 1 × 1 positions (24) did not agree with the findings of the present study. Perhaps the reason for this difference is the difference in the level of experience and professionalism of the subjects of the two studies.

In a study of basketball players, the subjects did not have the ability to recognize the movement pattern of a running event due to lack of experience and lack of sufficient skills, and were unable to encode the pattern in their long-term memory and their anticipation in the 1 × 1 position was better than the 3 × 3 position (25). Given the information processing theory, perceptual anticipation depends heavily on past experiences stored in long-term memory (15). The key issue in the area of anticipation is selective attention and pattern recognition by the player (23). Selective attention allows the individual to search for specific parts of the context to achieve related visual cues (9). However, before performing an action or tactic, by identifying detailed information obtained from the environment and people, it is possible to identify the movement pattern of the opposing player and anticipate that event. The more experienced a person is, the more accurate this pattern recognition is and the more accurate the anticipation will be (1).

According to Ericsson and Kintsch's theory of long-term memory, skilled players have the ability to encode and retrieve task-specific information based on a set of communications (26).

Table 3. Results of repeated measures analysis of variance (ANOVA) test for anticipations and the number and duration of total visual fixations in different defense conditions

Variable	Factors	Degree of freedom	Statistic F	P	Partial eta2
Anticipation (score)	Position	2	49.28	0.001*	0.72
	Error	38	-	-	-
Total number of visual fixations (frequency)	Position	2	20.60	0.001*	0.52
	Error	38	-	-	-
Total duration of visual fixations (milliseconds)	Position	2	21.15	0.001*	0.52
	Error	38	-	-	-

* Significance at the level of P < 0.050

Table 4. Findings of the Bonferroni test for the pairwise comparisons of different defense conditions

Variable	Defense (i)	Defense (j)	Mean difference	P
Anticipation (score)	1 × 1	2 × 2	-2.10	0.001*
		3 × 3	-4.75	0.001*
	2 × 2	3 × 3	-2.65	0.001*
Total number of visual fixations (frequency)	1 × 1	2 × 2	-2.70	0.005*
		3 × 3	5.20	0.001*
	2 × 2	3 × 3	-2.50	0.030*
Total duration of visual fixations (milliseconds)	1 × 1	2 × 2	-1434.03	0.040*
		3 × 3	-3597.54	0.001*
	2 × 2	3 × 3	-2163.53	0.005*

* Significance at the level of P < 0.050

Although proponents of dynamic systems ignore the role of memory, they have acknowledged that experience is an important factor (27) and without it one cannot choose the right target and identify providers (26). Experience helps us to know which part of the environment gives us the most opportunity to achieve the goal so that we search for these parts (26).

There was a significant difference between positions in the visual search behavior of handball players (number, duration, and location). The total number of fixations and the duration of fixations in the 3 × 3 position were greater than the other two positions. One of the issues in anticipating a performance is recognizing and using specific signs of interest (Aui) in different situations as well as the skill level of the players (4). The results of the present study regarding the basis of correct anticipation on the search for environmental signs (clips) were consistent with the findings of other studies (2,3,8,20,22,26,27). In pattern recognition, skilled individuals act faster and make more accurate anticipations (8). In the current study, the individuals skilled in visual search behavior focused their attention on areas with more information, enabling them to make more effective anticipations. Perhaps when playing video clips, skilled people scrutinized the screen more effectively and efficiently to find performance cues. Awareness of anticipation as the ability of a skilled player to extract meaningful background information is one of the results of an event (8).

Skilled baseball players pay attention to the wrist, forearm, and ball thrown by the thrower and have the ability to move their gaze in different stages of throwing the ball (22); because skilled players, with every look (focus), extract information that is more relevant to the task (27). It was found in a study that only skilled players had a more accurate anticipation when the hand and arm of the thrower in cricket were not removed by the occlusion technique (20). Of course, various restrictions imposed by the thrower (adjustment in the type or range of the ball) can also affect the anticipation of individuals, and to anticipate the opponent's intention in sufficient time, both the skill level and the recognition of specific signs of performance are required (20,21). Skilled defenders take information from the player who owns the ball; at the same time, they monitor changes in the position of the game in the environment (3). To anticipate the opponent's intentions and identify his initial movement, an expert uses kinematic information, which is repeated over and over. In fact, there is a direct relationship between the kinematics of the opponent's movement and the visual anticipation of the skilled player (3), and the skillful anticipation is established using kinematic and background information (28). According to Runswick, et al. in position anticipation, anticipation is facilitated when the background information is consistent with the final result (29); in contrast, when the background information is not consistent with the outcome, the kinematic information is affected and hence, the accuracy of anticipation is reduced (2,27).

In the present study, the defending handball players focused on the background information of the players head, torso, and hands, respectively, in order to anticipate and identify the attacking player's pattern. Additionally, in the 3 × 3 position, the number and duration of fixation on the player's head were greater than in the other two positions. It seems that recognizing the pattern of team and individual movement in skilled handball players is due to focusing on the player's head, torso, and hands.

Limitations

One of the limitations of the present study was its coincidence with the competition season, which could not be changed due to the time constraints of the researchers and caused limitations on access to all skilled players and the presence of players coming from other cities. Lack of control over personal and family relationships, emotional and psychological states, and anxiety of the subjects during the test were

among the other limitations of the study. Simultaneous daily events such as job, educational, social, economic, winning and losing in previous competitions, etc., which could have affected the accuracy of the subjects and their opinions were not controlled. On the other hand, different physical and physiological characteristics and nutrition of individuals could affect their overall accuracy and thus, the results.

Recommendations

Given the findings of the present study on recording visual search behavior and anticipation of handball players in defensive situations, the coaches of sports teams are suggested to use the results of visual search behavior in different positions of the game according to temporal and spatial situations as well as defensive and offensive situations. Considering that most of the studies in the field of visual search behavior in different sports have been conducted after discovering the visual behavior of players, it is suggested that in future studies the relationship between visual search behavior and electromyographic and electroencephalographic patterns be investigated.

Conclusion

In general, it seems that the anticipation and visual search behavior (number, duration, and location of fixations) in the 3 × 3 position is better than the other two positions. To determine the result in the 3 × 3 position, for example, the type of feint, shot, and pass, the number of fixations in the head, trunk, and hand areas was more than the other two positions. Moreover, the duration of fixations in the 3 × 3 position to detect the result in the head, hand, and trunk areas was longer than the other two positions.

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Authors' Contribution

Zahra Nezakat-Alhosseini: Study design and ideation, study support, executive, and scientific services, providing study equipment and samples, data collection, analysis and interpretation of results, manuscript preparation, specialized evaluation of manuscript in terms of scientific concepts, approval of the final manuscript to send to the journal office, responsibility for maintaining the integrity of the study process from the beginning to publication, and responding to the referees' comments; Saleh Rafiee: study support, executive, and scientific services, manuscript preparation, specialized evaluation of manuscript in terms of scientific concepts, approval of the final manuscript to send to the journal office, responsibility for maintaining the integrity of the study process from the beginning to publication, and responding to the referees' comments; Sadeghe Nasri: manuscript preparation, specialized evaluation of manuscript in terms of scientific concepts, approval of the final manuscript to send to the journal office, responsibility for maintaining the integrity of the study process from the beginning to publication, and responding to the referees' comments.

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Conflict of Interest

The authors declare no conflict of interest. Zahra Nezakat-Alhosseini has personally funded the basic studies related to this article and has been studying as a PhD student in motor behavior at the Central Tehran Branch, Islamic Azad University since 2016 (movement control branch).

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