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Original Article

THE INFLUENCE OF THE FIRST PASS ON THE VOLLEYBALL BLOCKERS' DECISION-MAKING

A INFLUÊNCIA DO PRIMEIRO PASSE NA TOMADA DE DECISÃO DOS BLOQUEADORES DO VOLEIBOL

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ABSTRACT
This study examined the information constraining volleyball blockers' decision-making as they attempted to anticipate an opponent's shot. The role of the ball flight information emerging from the interaction between the digger and the setter was investigated. In the first experiment a kinematic analysis of the ball trajectory was run in order to determine its influence on setter's action. In the second experiment players were asked to predict the block location by watching a video involving (i) the complete ball flight or (ii) only the final ball flight. It was verified that the setting occurred more frequently to the outside hitter when setter was far from the net (experiment 1). In addition, it was found that the ball flight information and the setter position guided the blockers anticipation (experiment 2). These findings suggest that the passing information can provide support for blocking anticipation in specific situations in which the ball flight was characterised by high altitudes.
Keywords: Anticipation. Decision-making. Volleyball.

RESUMO
O presente estudo examinou a informação que constrange a tomada de decisão dos bloqueadores no jogo de voleibol, referente à antecipação da jogada adversária. Foi investigado o papel da informação do voo da bola, que emerge da interação entre o passador e o levantador. No primeiro experimento foi feita análise cinemática da trajetória da bola para determinar sua influência na ação do levantador. No segundo experimento jogadores tinham que prever o local em que ocorreria o bloqueio, após assistir a dois tipos de vídeo que continham: (i) o voo completo da bola ou (ii) apenas o voo final da bola. Verificou-se que o levantamento ocorreu mais frequentemente para o jogador da posição 2, quando o levantador estava mais distante da rede (experimento 1). Adicionalmente, verificou-se que a informação de voo da bola e a posição do levantador guiaram a antecipação dos bloqueadores em algumas situações (experimento 2). Os achados sugerem que a informação do passe pode fornecer suporte para a antecipação de bloqueadores em situações específicas, nas quais o voo da bola seja caracterizado por grandes alturas.
Palavras-chave: Antecipação. Tomada de decisões. Voleibol.

Introduction

The ability to make decisions is a critical component of successful performances in fast ball sports such as volleyball. Studies have pointed out that anticipation is an important process underlying the successful decision-making in time-stressed situations (e.g.[1-4]). In this sense, performers make decisions as a process of prospectively select the most adequate option from a number of alternatives in a specific game situation[5]. To put this in another way, in fast ball sports the decision-making could be thought as a kind of anticipatory process, as it precedes the execution of the action. When a performer acts, the related decision was made previously based on prospective perception of the game dynamic.

The investigation of anticipatory processes has traditionally been examined by using temporal occlusion[1]. While the typical de-coupling of performer's perception and action processes when using such an approach has been criticised (see van der Kamp et al.[6]), useful

findings have emerged. For instance, the expert performer when compared to lesser skilled performers typically demonstrates their attunement to the pre-contact kinematic information[2].

Both decision-making and anticipation have been demonstrated to differentiate between expert and non-expert performers[7]. In a non-invasive team sport such as volleyball it has been shown that skilled players may also use the ball displacement as a critical information source to assist with their anticipatory performance[8]. Further experts have been shown to recall the inherent features within patterns (opponent's positions) with greater accuracy[9]. Moreover, according to Macquet[10] the information perceived in the course of action by volleyball players can be connected to a recognition process of the contextual situation, which configures a possible pre-arrangement of the decisions. In this sense, regarding volleyball defensive actions, performance may vary according to the age group and/or competition level, as a consequence of changes such as players' maturity and progress in the training process[11].

Notwithstanding the knowledge about which information volleyball players are able to pick up, the following question arises: on what information do the players base their decisions? In the current study how the defending team deals with a range of emergent attacking options is of interest.

Besides court defence, the block is a defensive action whose aim is to intercept, stop, or restrain the opponent's offensive actions. The block is a team's first line of defence, considered an important aspect of defensive success of winning teams[4,11,12]. This refers to a volleyball motor skill performed by one or more front-row players, who contact the ball higher than the net. In order to block successfully a number of information sources including ball flight information and relative court position guides blockers' decision making[13,14].

The aim of this study was to investigate the influence of the pass information provided by the interaction between the digger and the setter on the blockers' decision-making. It was hypothesised that the information provided by ball trajectory emerging from the digger-setter interaction would be critical for the blockers' anticipation. For this purpose, a first experiment was designed to identify the passing kinematic characteristics most frequently performed in different setter court positions when responding to a serve. From the identified passes, a second experiment then presented participants with two temporally manipulated video-based scenarios of digging-setting actions and required them to decide where to move to block the ball.

Experiment 1: Characterisation of the pass

Methods

Participants

Four female amateur players (one setter and three diggers) from a specialist sports school volleyball squad, aged between 16-17 years and average of 4.75 (*SD* = 0.5) years of experience were recruited. The study was approved by the Victoria University Research Ethics Committee (number 002485) and all participants gave informed consent.

Procedures

Data from digger-setter actions were collected in a standard indoor volleyball court, where the players were asked to perform typical dig to set actions. The video record was used for kinematic analysis of the ball trajectory by considering different patterns of ball flight in two main situations: when the setter was near the net (to 1.20 m) and far from the net (more than 1.20 m). The distance was considered based on previous findings that the distance is a

factor capable of constraining decisions[15], including volleyball decisions[16]. The video frame in which the ball touched the setter's hands was used to categorise each situation.

The setter was asked to attempt to deliver the ball to four attack/block possibilities according to how the ball arrived to her: (1) outside hitter (blockers' zone 2), (2) right side hitter (blockers' zone 4), (3) middle hitter (blockers' zone 3), or (4) over the net (tip), instead of setting the ball to a hitter (Figure 1).

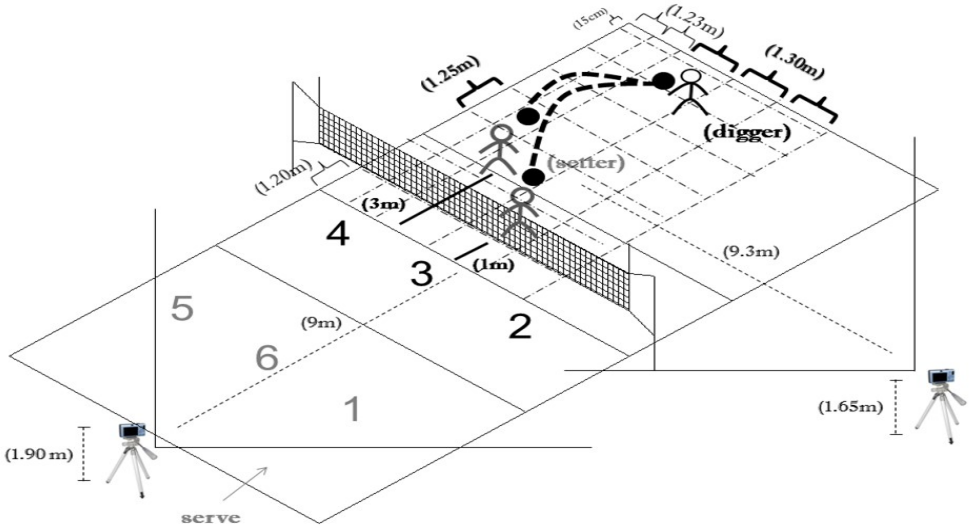

Figure 1. Illustration of the experimental situation
Source: Own source

A total of 115 sequences of dig-set passing interactions were recorded using two digital video cameras to capture bi-dimensional motion of the ball flight. One camera (Panasonic HC-V520M Full HD – 50 HZ) was positioned perpendicular to the sagittal plane of the participants (4.8 m from the volleyball court – 9.3 m from the centre of the court, 1.65 m wide). The other camera (Sony NXCAM Exmor R – 50 HZ) was placed near the endline of the serving team (9 m from the centre of the court, 1.90 m wide). The side-on images were used for the kinematic analysis, with the other camera footage used to determine the exact position of the players on the court. Each sequence of play involved an attack performed by two players (without the spike) in responding to a serve from behind the endline camera. A perspective grid was constructed of masking tape on the floor, and was used to calibrate the images (*x* and *y* axis) according to the displacement of the players in each sequence of play (Figure 1).

Data Analysis

Analyses focused on the ball flight characteristics and on the attack/block possibilities. Analysis considered data from the first frame of the video in which the ball touched the digger's arms to the frame in which the ball touched the setter's hands. The following dependent variables were obtained by using Siliconcoach Live software:

(a) *Relative angle of the ball flight trajectory (θ)* was defined by the initial trajectory of the ball (two frames) relative to its horizontal and vertical displacement from the ball contact (digger);

(b) *Relative ball velocity at release (m/s)* was defined by the average of the horizontal and vertical velocities in the first two frames from the ball contact (digger);

(c) *Ball height (m)* was defined by the maximum height reached by the ball during its trajectory;

(d) *Ball flight time (s)* referred to the time between the digger's action and setter's action by considering their ball contact.

The Welch's *t*-test for unequal variances was used to compare each of these dependent variables in each attack/block possibilities (blockers' zones 2, 3, 4 and tip) by considering the situations near and far from the net. This t-test with Welch correction was designed to provide a valid t-test in the presence of unequal population variances. Instead of a pooled variance estimate, this test uses sample variances and sample sizes from each sample to compute the t statistic. As such, it can also be used to evaluate differences between samples with unequal numbers of observations, due to it being conservative in this situation[17].

Results

Descriptive analysis showed that the setter delivered the ball most often to blockers' zone 2 (53%). This was followed by blockers' zone 4 (29.6%), blockers' zone 3 (10.4%), and the tip (7%). The analysis also showed that to deliver the ball to blockers' zones 2 and 4, the setter was positioned more frequently far from the net (69% and 56% respectively). The average distances in these zones were 1.88 m and 1.62 m respectively. To deliver the ball to the zone 3, the setter was positioned more frequently (75%) near the net (1.03 m). And, to tip the ball the setter was positioned exclusively (100%) near the net (0.46 m).

Regarding the inferential analyses, the Welch's *t*-test revealed differences only regarding the sets to blockers' zone 2: passing angle ($t = 45.97$, $p < .001$), relative maximum ball height ($t = 9.08$, $p = .005$), and passing time ($t = 13.79$, $p = .001$) (Figure 2).

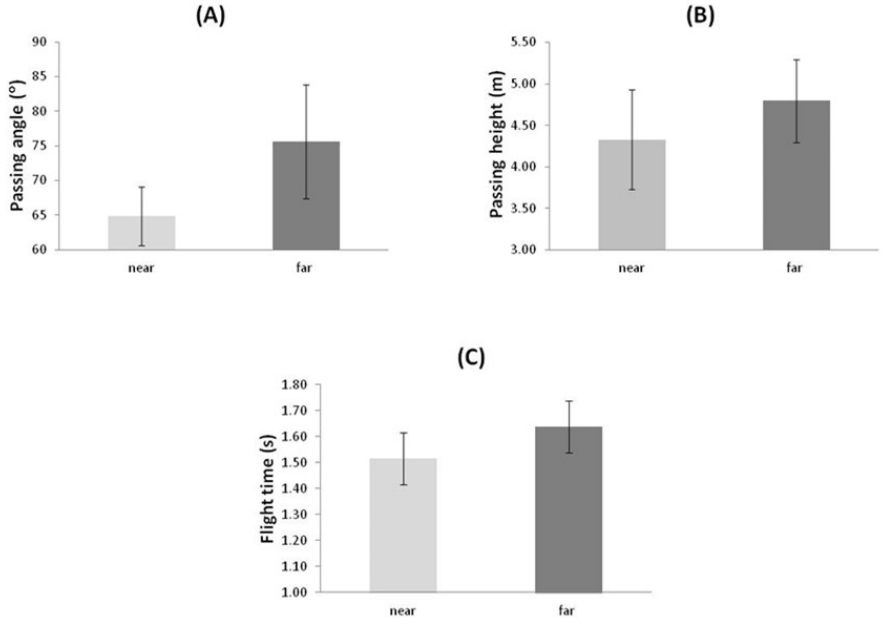

Figure 2. Structure of ball flight in passes resulting in sets to blockers' zone 2 according the two situational conditions, near and far: (A) passing angle, (B) passing height and (C) flight time

Source: Own source

Discussion

This experiment sought to identify the kinematic characteristics of the ball flight emerging from digging-setting interactions in two different court positions. Firstly, results corroborate the ball distribution in elite volleyball matches by showing that the setter delivered the ball more frequently to the outside hitter (blockers' zone 2)[18-20]. The sets to the middle and right side hitter were those second options[20.]

According to Ridgway and Hamilton[21], the setter is constrained to send the ball to outside (blockers' zone 2) when the pass is not perfect. This is the easiest and safest choice when the pass is off the net and/or other options are not available, which explains why most of the sets far from the net situation were to blockers' zone 2 (65.6 %). Ridgway and Hamilton[21] also suggested that the goal of the attack is to isolate hitters against only one blocker, and the outside hitter zone is one where a double block frequently occurs.

In other words, low-performance passes constraint the setter's action, which increase the probability of plays with slow attack times[11,20]. This increase in time limits the options for attacking and determines the setting zone, facilitating players' anticipation and decision-making, when blocking and defending. Then, this kind of play promotes the set-up of a block with a larger number of players[22].

Moreover, results showed that the tip action was the only one characterized by sets completed significantly closer to the net (M= 0.46 m), whereas the zones 2 and 4 options were characterized by similar distances (far from the net). The tip finding allows us to infer that this specific action was executed as a function of the distance. Although the number of tips occurred had been low, is reasonable to think that the small distance afforded the tip, as well as a specific boxer-target distance afforded a single punching action in the study of Hristovski et al.[15]. This is supported to volleyball as tips were different from sets considering the setter-net distance, with similar mean value of 0.61 m in the study of Denardi[23].

Secondly, results of the ball flight characteristics showed that the angles, heights, and times of passing for the sets to blockers' zone 2 performed far from the net situation were larger than those in the near the net situation. In line with Barsingerhorn et al.[16], ball flight times also differed according to net distance.

Based on these two key findings, occlusion conditions were derived for experiment 2. Specifically, the relative preference of sets to blockers' zone 2, and the kinematic differences in the near and far from the net situations were used to verify the apparent predictability for blockers.

Experiment 2: Block decision-making test

Methods

Participants

Twenty-two volleyball players in school and higher level tournaments such as state league were recruited. They differed in terms of experience: less experience (n = 10) with a mean age of 14.5 years (*SD* = 1.1 years) and 2.7 years of playing experience (*SD* = .7), and more experience (n = 12) with a mean age of 16.5 years (*SD* = 1.2) and 4.5 years of playing experience (*SD* = .9). The study was approved by the Victoria University Research Ethics Committee (number 002485) and all participants gave informed consent.

Procedures

The end line video footage collected in the experiment 1 was randomly selected and edited into test clips. There were two different conditions: (1) Digger-setter condition - in which all information about complete flight of the dig was presented. The occlusion occurred from the moment the setter contacted the ball; and (2) Setter condition - in which the only information presented was the ball flight from 320 ms before the setter contacted the ball. Hence, a significant amount of the dig ball flight information was removed in the Setter condition. Both scenarios were edited using Adobe Premiere Pro CS 5 software version 5.0.0.

Each participant watched 48 clips (24 clips of each experimental condition) of 2 s duration with an inter-trial interval of 5 s presented in a randomised manner. Prior to the testing trials, six practice trials, three per experimental condition were administered to allow the participants to familiarise themselves with task requirements. The proportion of the trials to each zone was as follows: 18 trials to blockers' zone 2, 14 trials to blockers' zone 3, 10 trials to blockers' zone 4, and six tips. This was consistent with the relative occurrence of the actions among the four block options found in the experiment 1. In order to approximate the experimental conditions of temporal constrain of response to those real situations, the participants were asked to identify by marking a response sheet as soon as possible where they would block the ball (i.e., zones 2, 3, 4 or tip) based on the information available.

Data Analysis

The main dependent measure was the percentage of correct decisions. A 2 x 2 x 4 ANOVA (experience level x condition x block) was employed with Greenhouse-Geisser correction applied for violations of sphericity. A α was set at .05, and the partial eta squared was used to refer the effect size by Cohen's d standard.

An additional set of analyses involved only the 18 trials related to blockers' zone 2. A series of ANOVAS with percentage of correct decisions as dependent variable were used to explore the key dependent measures considered in the experiment 1 as following:

(i) Situation - 2 x 2 x 2 ANOVA (experience level x condition x net distance), considering 8 trials for near situation *vs* 10 trials for far situation, from the 18 trials presented;

(ii) *Relative angle of the ball flight trajectory* - 2 x 2 x 2 ANOVA (experience level x condition x angle), considering 10 trials for low passing angles *vs* 8 trials for high passing angles, from the 18 trials presented;

(iii) B*all height* - 2 x 2 ANOVA (experience level x condition), considering 12 trials for high altitudes, from the 18 trials presented;

(iv) *Relative ball velocity at release* - 2 x 2 ANOVA (experience level x condition), considering 14 trials for mean values of velocity, from the 18 trials presented.

Results

Results revealed a significant effect for block possibilities [$F(3, 60) = 7.39$, $p < .05$, $\eta p^2 = .27$], showing that all participants were more accurate in predicting the tip than in the other decisions. A two-way interaction between block possibilities x experience level [$F(3, 60) = 7.18$, $p < .05$, $\eta p^2 = .26$] demonstrated that the less experienced players had poorer accuracy compared to the more experienced players in the decisions related to blockers' zone 2 and 4. There were no other significant effects: condition [$F(1, 20) = 0.34$, $p > .05$, $\eta p^2 = .02$], condition x experience level interaction [$F(1, 20) = 0.03$, $p > .05$, $\eta p^2 = .001$], condition x block possibilities interaction [$F(3, 60) = 1.28$, $p > .05$, $\eta p^2 = .06$], condition x block possibilities x experience level interaction [$F(3, 60) = 2.26$, $p > .05$, $\eta p^2 = .10$]. All findings are collectively represented in Figure 3.

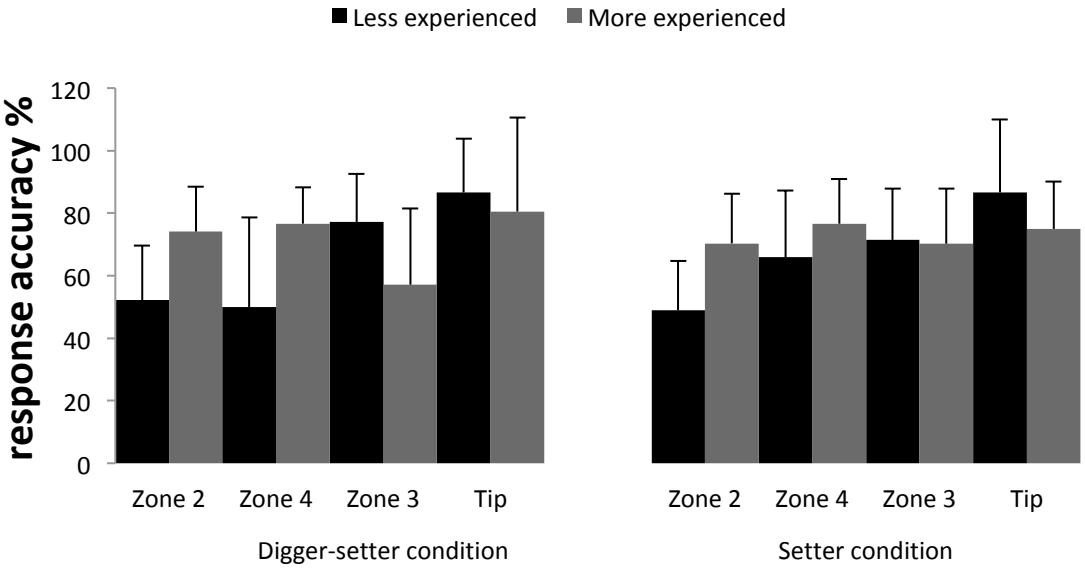

Figure 3. Mean accuracy percentages for both conditions (Digger-setter and Setter) in each block option (Zones 2, 3, 4 and Tip) and across experience levels. Errors bars show standard deviation

Source: Own source

Concerning the additional blockers' zone 2 analyses, ANOVA revealed a significant effect of situation [$F(1, 20) = 18.78$, $p < .05$, $\eta p^2 = .48$], showing that all participants were more accurate in the decisions made in the far from the net situation. Analysis also revealed a significant effect for angle [$F(1, 20) = 7.39$, $p < .05$, $\eta p^2 = .27$], showing that participants made more accurate decisions in trials characterised by high passing angles compared to low passing angles. The *ball height* analysis revealed a significant effect of condition [$F(1, 20) = 4.56$, $p < .05$, $\eta p^2 = .19$], showing that participants were more accurate in the decisions made for the trials in the Digger-setter condition compared to the Setter condition. There were no significant differences for the *relative ball velocity at release* analysis.

Discussion

This study examined the decision-making of two groups of volleyball players as they attempted to anticipate where to move in order to block an opponent's shot. In particular, the pass information provided by the interaction between digger and setter was manipulated. While the perception of passing characteristics seemed to be similar for both experience groups in both informational conditions, notably less experienced players made poorer decisions than more experienced players in sets to zones 2 and 4. Independent of experience level, the tip was the easiest situation to anticipate.

The information available in the Setter condition was essentially the setter-net distance and the setter's body configuration (kinematics) in relation to the ball. This information was also available in the Digger-setter condition, but it was connected to the ball flight information, characterising the interaction between the digger and the setter. The information provided by the setter's kinematics, which was included in both experimental conditions, seems to be the source of information most likely to have influenced the perception of the players, as there were no significant effects for condition.

The pass information prior to set might not be a typical source of information in which the less/more experienced volleyball players are attuned. However, examination of a higher

experienced group may reveal a different pattern of results and warrants further exploration. It is important to highlight that in the present study our interest was to assess the importance of the pass characteristics as an informational variable for the anticipatory process. However, consideration of more fine-grained moments of occlusion could provide a more complete and deeper understanding of the nature and sources of information used by blockers; for instance, using the progressive temporal occlusion approach[1]. This could clarify the assumption that the setter's kinematics was the main cue used by blockers to anticipate their action.

Independent of the two informational conditions manipulated (Digger-setter/Setter), the current findings revealed that all participants were more accurate at anticipating tips compared to any of the other sets. This is consistent with the results from experiment 1, where tips showed the greatest predictability of structure, as they were the only ones characterized by sets completed significantly closer to the net.

Less experienced players were significantly less accurate than more experienced players specifically in the decisions related to zones 2 and 4. Considering that these decisions involved both, near and far from the net situations, the decisions in the near situation may have been more difficult for less experienced players due to the equivalence between ball flights of the other block options. That is, the situations characterised by accurate passes allow the setter to be positioned near the net, affording him/her more tactical flexibility. According to Barsingerhorn et al.[16], when the setter receives the pass close to an ideal setting zone (near the net and between the zone 2 and 3), he/she would be successful in giving the set-up for an attack.

Particularly in the far situation, uncertainty in the zones 2 and 4 decisions was likely caused by the similar structure of their ball flights, which also resulted in a similar setter position. This could explain the poorer accuracy of the less experienced players to both options compared to more experienced players.

Additional analysis of the blockers' zone 2 revealed that all participants' decisions were less accurate in the near situation and for low passing angles. This demonstrates greater unpredictability when the setter was near the net. In terms of ball flight patterns, in this situation the passing angles were low, which may have contributed to reduced altitude of the ball. However, the reason for the unpredictability seems not to be associated with the ball flight parameters, as the players responded similarly in the two conditions. Rather, it is more likely related to the individual setter's characteristics who delivered the ball to different court locations.

Regardless the situation (near/far net distance), in the zone 2 trials in which the ball reached high altitudes the participants exhibited superior accuracy in the Digger-setter condition compared to the Setter condition. Interestingly, for this specific parameter (ball height) participants seemed to need the ball information to make better decisions. The ball flight information also seemed to be critical in correctly anticipating the decision to block the ball in zone 2. According to Ridgway and Hamilton[21], experts suggest that a good pass should not go extremely high. It should make a gentle arc landing softly to the setter, as one of the problems associated with passing the ball too high is it will be accelerating on descent, which makes it more difficult to set. A more difficult ball to set can represent an easier prediction for the blockers, assuming that high passes take a longer time to initiate the offensive play, slowing fast paced offensive attacks[21]. This circumstance provides a different perception of the environment to the defence (blockers and receivers), giving it more time to position[20-22]. Therefore, for these high ball actions, the ball flight information related to the pass seems to constrain the blockers' anticipation.

General discussion

Results of the experiment 1 indicated some structure of ball flight in situations involving sets to blocker's zone 2, namely passes differently characterised in the near and far from the net situations. It was also inferred out that the distance between the setter and the net was important for the emergence of set location, i.e., the option to set more frequently to blockers' zone 2 when the setter was far from the net. Interestingly, the additional zone 2 analyses of the experiment 2 revealed that these decisions (setter far from the net) of the less and more experienced players were easier as compared to those in which the setter was near the net. This reinforces the cited apparent predictability of the setter's option to set to blockers' zone 2 in the far situation.

There was similarity of the occlusion results about the perception of the pass, regardless of the presence of ball trajectory, supporting the assumption that the setter's kinematics was a likely cue used by blockers, as well as the setter-net distance, as both sources of information were provided in both conditions. Hence, the present study suggests that pass information can provide anticipatory information useful to blockers' decision-making in specific circumstances. Most notably in blockers' zone 2 situations in which the ball flight was characterised by high altitudes. For these situations, the ball flight information appears to be a potential candidate to represent an informational constraint for blockers' decision-making (see Hristovski et al.[15]). Likewise, the distance between the setter and the net could be thought of as a potential candidate to represent an informational constraint for the setter's decision to tip the ball, as all the tips occurred when the setter was near the net (experiment 1). Moreover, this predictability of structure associated with the experience level of the intermediate setter of the present study may have guided all the participants when anticipating the tips.

It could be suggested that these findings provide useful information about the significance of the blockers' anticipation based on the first pass characteristics for applying into volleyball teaching/training contexts. However, it is important to be clear that our inferences are bounded to our manipulations. Therefore, we assume that those important aspects that were not covered by our method need to be considered in future investigations. For example: (i) considering that this referred to a descriptive study, how its findings could be translated into instructions needs to be investigated; (ii) the displacement of the setter to reach the ball also seems a next logical step when trying to understand emergence of set location, which would improve the inferences about blocker's decision-making; (iii) further research could also verify if there is a critical distance constraining the setter's action to tip the ball, as well as a critical height influencing the blockers' anticipation to rely on the pass information (ball flight) more than on the set information; (iv) these environmental constraints could be also examined in association with the individual constraints of different setters, characterising the set of constraints in the perception-action cycle[24] (v) although we have asked players to respond as soon as possible, this was not analysed as a dependent variable, including in consideration to the players' positional specialties; finally, (vi) further study could also verify if the players' age did not imply different cognitive ability to decision-making in a multiple choice environment[25].

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