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ORIGINAL

OBSERVATIONAL TOOL FOR ANALYZING ATTACK COVERAGE IN VOLLEYBALL

HERRAMIENTA OBSERVACIONAL PARA ANALIZAR LA COBERTURA DEL ATAQUE EN VOLEIBOL

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ABSTRACT

This study presents a methodological proposal that uses a competitive model to analyze a game action in volleyball known as the attack coverage. An *ad hoc* observation tool was designed to carry out synchronic and diachronic analyses of the action under study whilst taking into account the different levels of behavioural interaction that can occur between players on the same team. Once the quality of the data had been verified, we carried out an exploratory study of the libero player and found 19 coverage patterns in different game situations. The results reinforced the idea that each player should take responsibility for a specific area of coverage in each particular attack zone.

KEY WORDS: observational methodology, competitive analysis, volleyball, attack coverage

RESUMEN

En este trabajo se presenta una propuesta metodológica para analizar una acción de juego del voleibol, la cobertura del ataque, desde la perspectiva del modelo competitivo. Atendiendo a los distintos niveles de interacción conductual que pueden desarrollar los jugadores de un mismo equipo, se diseñó un instrumento de observación *ad hoc* que permite realizar análisis sincrónicos y diacrónicos de la acción objeto de estudio. Una vez verificada la calidad del dato, se efectuó un estudio exploratorio de la jugadora líbero en el que se detectaron 19 patrones de cobertura en distintas situaciones de juego. Los resultados obtenidos reforzaron la idea de que cada jugador debe asumir un área de responsabilidad de cobertura determinada para cada zona de ataque en particular.

PALABRAS CLAVE: metodología observacional, análisis competitivo, voleibol, cobertura del ataque

INTRODUCTION

The aim of using an observational methodology is to study a decisive action in modern high-level volleyball known as the attack coverage. This methodology is particularly useful given the nature of sporting competition, the multiple opportunities for sociomotor interaction and the difficulties faced when trying to control for all the variables that influence the dynamics of the game (Gorospe, Hernández Mendo, Anguera, & Martínez de Santos, 2005).

In volleyball, the various actions are sequenced and related both positively and negatively so as to generate five game complexes that can mainly be distinguished by the way a team makes its first contact (Palao, 2001; Salas, 2006). As figure 1 shows, the coverage is a defensive action present in all the complexes carried out by the team in possession of the ball. It is a transition made by those players who are not completing the attack and takes place from when the ball is set to when it is spiked (Banachowsky, 1992; Meier, 1994). During the set, these players change their location on the court and form a system to cover the attacking teammate against the possibility of being neutralized by an offensive block from the opposing team (Meier, 1989; Velasco, 1997). If the attack is blocked, the coverage aims to ensure that the offensive block is defended and, therefore, that the fourth game complex begins. In addition to allowing a limited number of balls to be saved per match, this new defensive action can be decisive at certain points during the contest (Drauchke, 1998; Selinger & Ackermann-Blount, 1992). Furthermore, in high-level matches, a certain tactic can be observed that emphasizes the importance of this defensive action. In unfavourable situations, some attackers hit the ball in a controlled manner against the block to enable a counterattack to be mounted from the coverage system (Salas, 2006).

To analyze specific phases of the game such as the serve-reception relation, some studies propose the use of a competitive or contextualized analytical model (Álvaro, et al., 1995; Molina, Barriopedro, Santos, & Delgado, 2004). This model is based on an observational methodology and is characterized by the fact that it refers to competition units as observation units and that it regards contextual interference as the active principle in the behaviour and performance of the players. Consequently, the model tries to establish associations between contextual, behavioural and evaluative factors. Furthermore, given that pass tempo in volleyball can influence the formation of defensive actions such as the block, some studies have decided to include the time factor in the competitive model. In their study on the recognition of movement patterns in different attack and defence situations, Jäger and Schöllhorn (2007) took advantage of the precision offered by high-speed photography to analyze this factor.

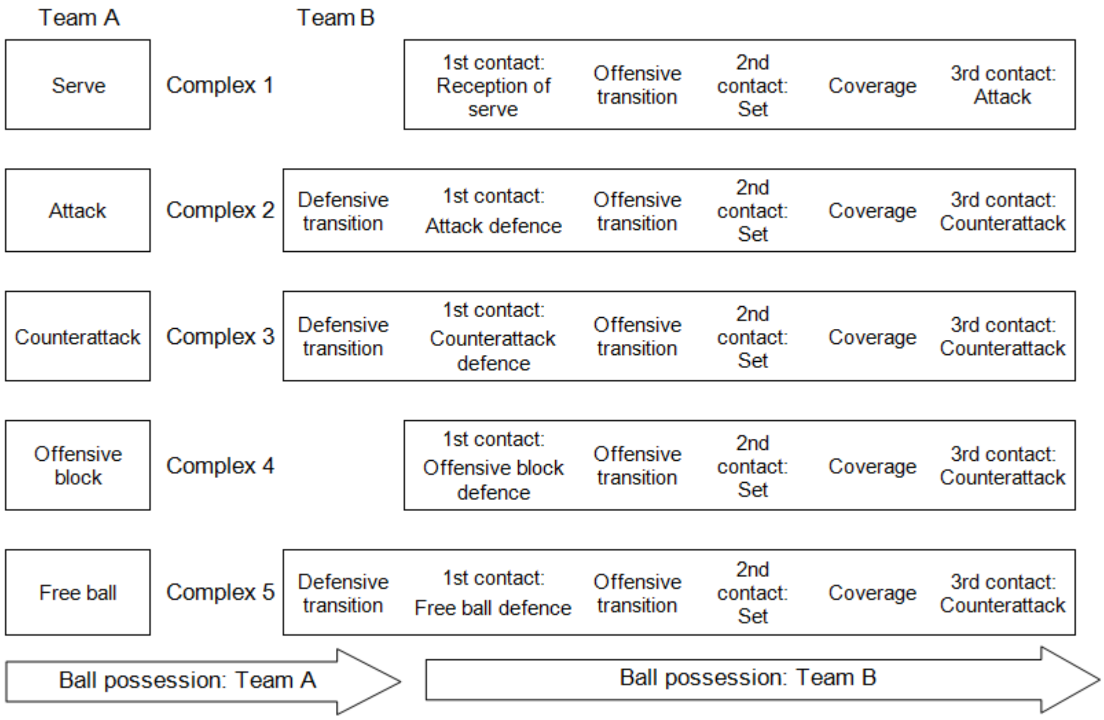

Figure 1. Flow of actions in the game complexes.

In the light of all this, the aim of the present study was to develop an instrument for analyzing the influence of different situational variables on the behaviour and performance of players taking part in an attack coverage, according to their functional specialization and in relation to other immediate actions such as the set, the attack-counterattack and the offensive block defence. Furthermore, in order to identify possible research lines for the future, we carried out an exploratory study of the attack coverage relation between liberos and attackers. The aim of this was to identify coverage patterns in different game situations.

METHODS

Design

We configured a *lag-log* observational design situated in the monitoring, nomothetic and multidimensional quadrant, which allowed us to make diachronic and synchronic analyses of the action under study (Artamendi, 2000; Blanco, Losada, & Anguera, 2003). On the basis of this design, we made external and indirect observations of official women's volleyball matches and created a systematic, intensive and continuous record of multi-event data (Anguera, 1979; Bakeman & Dabbs, 1976; Bakeman & Gottman, 1997).

Participants

We observed seven matches from the 35th Copa de la Reina (Queen's Cup). The competition was held from 5 to 8 February at the Municipal Sports Centre at Ciutadella in Menorca between 8 teams of Women's Superleague Volleyball. In total we recorded 344 units of observation, 190 in the quarter finals, 89 in the semi-finals and 65 in the final. We included a unit in the sample each time there was an attack on the third contact that was blocked by the opposing team. Consequently, we used an event sampling technique throughout the matches (Anguera, 1990). For technical reasons, we only included units that occurred in Complex 1 and the court nearest to the observer. Because they affected the structure of the game systems, we excluded those units in which the team under observation used a diagonally balanced alignment with the centre players preceding the outside players (Selinger & Ackermann-Blount, 1992). For the same reason, we ruled out units in which the libero did not replace the middle back court player.

Observational instrument

We constructed a combined ad hoc observation instrument. The first version of the Volleyball Attack Coverage Observation System (VACOS-1) is made up of 39 axes with mixed codification and a molecular structure of field formats and systems of categories (Anguera, Blanco, Losada, & Hernández Mendo, 2000). The systems of categories were presumed to be exhaustive on the basis of a preliminary test carried out on the systematized record (Anguera & Blanco, 2003). Furthermore, during the construction process we also defined the categorial nucleus and the degree of opening of each of the categories (Anguera, 1991).

Given the steps involved in the defensive transition and the attack defence, the tool is divided into three successive phases with a total of 36 behavioural and evaluative criteria. At the same, in order to obtain the most easily understood taxonomic system, most of the criteria are grouped by affinity into macro-criteria (Table 1). Thus, the first phase, which involves the preparation of the attack coverage, is made up of 14 behavioural criteria, 6 of which may be present at the moment when the set is completed. These criteria refer to the location of setter and to the starting locations of the five non-setting players in one of the 12 zones of the court (Figure 2). The second phase, when the attack coverage is completed, is made up of 13 behavioural criteria, 7 of which may be present at the moment when the attack hit starts. These criteria are the location of the player who is attacking in one of the eleven attack zones, the final location of the five players who are not attacking in one of the 12 court zones and the three-line attack coverage system. Finally, the third phase involving the offensive block defence has 8 behavioural and 1 evaluative criteria, 3 of which may be present when the defence contact begins or the ball touches the ground. These being the relocation of the defending player, the location of the blocked ball in one of the 12 court zones and the quality of the offensive block defence. This defensive action is evaluated using the reception evaluation system proposed by the game analysis programme Data Volley (Data Project, Bologna, Italy, release 2.0.4), a statistical system that is recognized by the International Federation of Volleyball and has been used in various leading studies. It should also be added that the third phase is not recorded when there is no offensive block.

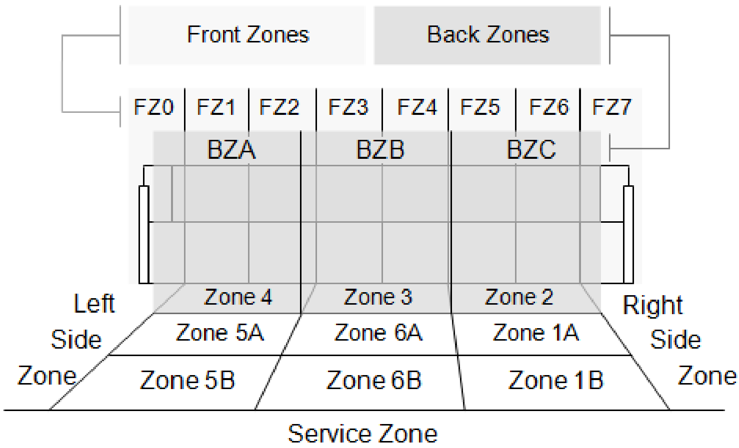

Figure 2. Zone system adapted from Beal (1992) and Callejón (2006).

From the perspective of the competitive model, the instrument is complemented with three context and time variables: the point of the team rotation, the game complex in which the coverage occurs and the set pass tempo in seconds. In line with Salas (2006), we think that these volleyball-specific situational variables can affect the behaviour and performance of the players.

Table 1. Volleyball Attack Coverage Observation System (VACOS-1).

Phase 1. Preparation of the attack coverage (14 criteria)	
Macro-criteria A. Setting Player Location (SPL, 7 criteria, 12 categories per criterion)	Macro-criteria B. Non-Setting Players Starting Location (NSPSL, 7 criteria, 12 categories per criterion)
Setter Set (SS) Opposite Set (OS) Middle 1 Set (M1S) Middle 2 Set (M2S) Outside 1 Set (O1S) Outside 2 Set (O2S) Libero Set (LS) *Example:* System of 12 categories SS = (SSZ4 SSZ3 SSZ2 SSZ5A SSZ6A SSZ1A SSZ5B SSZ6B SSZ1B SSLSZ SSRSZ SSSZ)	Setter Starting Location (SSL) Opposite Starting Location (OSL) Middle 1 Starting Location (M1SL) Middle 2 Starting Location (M2SL) Outside 1 Starting Location (O1SL) Outside 2 Starting Location (O2SL) Libero Starting Location (LSL) *Example:* System of 12 categories LSL = (LSLZ4 LSLZ3 LSLZ2 LSLZ5A LSLZ6A LSLZ1A LSLZ5B LSLZ6B LSLZ1B LSLLSZ LSLRSZ LSLSZ)
Phase 2. Completion of the attack coverage (13 criteria)	
Macro-criteria C. Attacking Player Location (APL, 5 criteria, 11 categories per criterion)	Macro-criteria D. Non-Attacking Players End Location (NAPEL, 7 criteria, 12 categories per criterion)
Opposite Attack (OA) Middle 1 Attack (M1A) Middle 2 Attack (M2A) Outside 1 Attack (O1A) Outside 2 Attack (O2A) *Example:* System of 11 categories OA = (OAFZ0 OAFZ1 OAFZ2 OAFZ3 OAFZ4 OAFZ5 OAFZ6 OAFZ7 OABZA OABZB OABZC) Attack Coverage System (ACS) Field format ACS = (023 032 131 221 212…)	Setter End Location (SEL) Opposite End Location (OEL) Middle 1 End Location (M1EL) Middle 2 End Location (M2EL) Outside 1 End Location (O1EL) Outside 2 End Location (O2EL) Libero End Location (LEL) *Example:* System of 12 categories LEL = (LELZ4 LELZ3 LELZ2 LELZ5A LELZ6A LELZ1A LELZ5B LELZ6B LELZ1B LELLSZ LELRSZ LELSZ)
Phase 3. Offensive block defence (9 criteria)	
Macro-criteria E. Defending Player Relocation (DPR, 7 criteria, 12 categories per criterion) Setter Relocation (SR) Opposite Relocation (OR) Middle 1 Relocation (M1R) Middle 2 Relocation (M2R) Outside 1 Relocation (O1R) Outside 2 Relocation (O2R) Libero Relocation (LR) Example: System of 12 categories LR = (LRZ4 LRZ3 LRZ2 LRZ5A LRZ6A LRZ1A LRZ5B LRZ6B LRZ1B LRLSZ LRRSZ LRSZ)	Blocked Ball Location (BBL) System of 12 categories BBL = (BBLZ4 BBLZ3 BBLZ2 BBLZ5A BBLZ6A BBLZ1A BBLZ5B BBLZ6B BBLZ1B BBLLSZ BBLRSZ BBLSZ) Offensive Block Defence Quality (OBDQ) System of 5 categories OBDQ = (OBDQ# OBDQ+ OBDQ/ OBDQ- OBDQ=)
Situational variables (3 variables)	
Team Rotation (TR) System of 6 conditions TR = (TR1 TR6 TR5 TR4 TR3 TR2) Game Complex (GC) System of 5 conditions GC = (GC1 GC2 GC3 GC4 GC5)	Set Pass Tempo (SPT) Field format SPT = (0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9…)

Procedures and material

The matches were recorded on high-speed digital cameras situated on the back tier of the sports hall at a height of 6 m above the court. The video files were recorded with the same focal length and zoom setting, without sound, in MOV format, with a resolution of 512x384 pixels and a frequency of 300 Hz. They were watched frame-by-frame using the Kinovea programme (Charmant &

Contrib., Bordeaux, France, release 0.8.7). This sports video analyser allowed us to fix markers on the timeline and to superimpose the matches onto a pre-recorded spatial reference system (Figure 3). We put the recorded data into an MS Excel spreadsheet (Microsoft Corporation, Redmond, WA, USA, release 2007) and exported them to the SPSS (SPSS Inc., Chicago, IL, USA, release 15.0), EduG (Educan Inc., Quebec, Canada, release 5.0.E) and SDIS-GSEQ (Bakeman & Quera, Atlanta, GA, USA, release 5.1.13) programmes for subsequent statistical analysis.

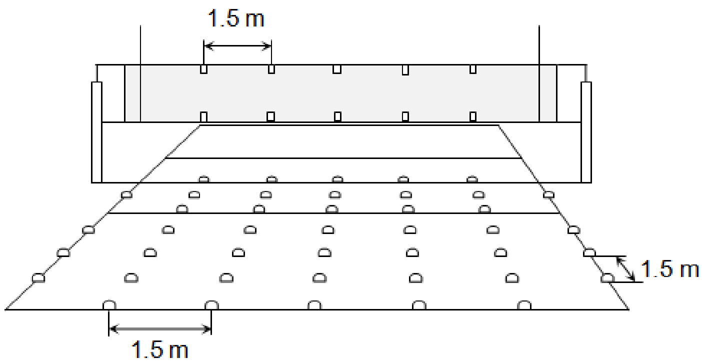

Figure 3. Spatial references on the net and on the court nearest to the observer.

The instrument was subject to a quality control process involving two expert observers with national training qualifications in volleyball. The process consisted of two recording phases prior to the systematic observation of all the matches in the Queen's Cup. The first phase was qualitative and based on consensual agreement. It consisted of making a joint and guided record of one of the matches so that the observers could come to an agreement. The second phase was quantitative and based on making an individual record of two other matches under the same conditions and then using Cohen's kappa coefficient (1968) in the SPSS programme to determine the degree of intra- and inter-observer agreement for each of the instrument's axes. In order to estimate the sources of variation that are implicit in the observation process, this quantitative phase was complemented with a generalizability study of the recorded data (Blanco & Hernández Mendo, 1998). The EduG program was used to design two facets for making random infinite calculations in order to determine the reliability between the observers, the homogeneity of the categories and the minimum number of matches required to make accurate generalizations (Castellano, Hernández Mendo, Gómez, Fontetxa, & Bueno, 2000; Gorospe et al., 2005). This statistical program is based on ANOVA and generalizability theory and enabled us to calculate the components of variance and the generalizability coefficients of each of the designs (Brennan, Jarjoura, & Deaton, 1980; Martínez Arias, 1995).

Statistical analysis

Two analysis phases were included during the exploratory study of the coverage-attack relation between the libero and attacking players. These phases gathered data from the seven matches. The first phase was macroanalytical and based on the quantitative description of the different criteria used in the phase that culminated in the attack coverage. This phase used the SPSS programme with the dual aim of re-categorizing the low-frequency behavioural categories and obtaining a more manageable taxonomic system for the subsequent analysis phase (Quera, 1986). For example, the criteria referring to the location of the attacking player (OA, M1A, M2A, O1A and O2A) had a low frequency and so were grouped with the APL macro-criteria. After this the second phase used the SDIS-GSEQ programme to carry out a synchronic or concurrent analysis. This kind of micro-analysis examines the likelihood of certain behaviours occurring at the same time as others and was applied in the present study to identify stable patterns of interactive behaviour beyond those that occur by chance (Sackett, 1979). To do this, it is essential to determine by hypothesis which behaviours act as initiators of behavioural patterns (Anguera, 1992). In our case, we regarded the eleven categories of APL macro-criteria as given behaviours and the twelve categories of the LEL criteria as conditioned behaviours. Given that the chosen categories are both present when the attack hit begins, we carried out two concurrent analyses in the lag 0. The first analysis was carried out with the contextual conditions of the TR variable and the second was carried out with the time conditions of the SPT variable. In the tables of bidimensional contingencies that we obtained, we accepted Z scores of above 1.96 and significant values when $P < 0.05$.

RESULTS

In terms of the quantitative perspective of data quality control and, in particular, Cohen's kappa coefficient (1968), we obtained values above 0.81 for all the axes of the instrument that we evaluated. Consequently, we obtained an intra- and inter-observer strength of agreement that, according to Landis and Koch's guidelines (1977), was almost perfect.

Table 2 shows the results of the generalizability study. When we analyzed the sources of variance, we found that most of the variability in the calculations of both the intra-observer reliability and inter-observer reliability (99.6 and 99.7%, respectively) corresponded to the categories, and was zero for the observers and very low in the categories-observers interaction (0.4 and 0.3%, respectively). Furthermore, a global analysis of the generalizability coefficients for both estimations gave a reliability of 0.99 regarding the accuracy of the results generalization. Moreover, both the category homogeneity calculation and the calculation regarding the minimum number of matches needed to make accurate generalizations revealed that most of the variability was associated with the categories (90.8%) because it was very low for the number of matches and reduced in the matches-categories interaction (9.2%). Regarding the overall calculation of the generalizability coefficients, the first estimate obtained a value of 0.04, which showed that the categories had a significant goodness of fit, and the second estimate obtained a coefficient of 0.99 for an estimated sample of 10 matches, which meant that the generalization of the results would be accurate.

Table 2. Generalizability study: design estimate.

	Sources of variation	Estimated component of variance	% Total variability
Intra-observer reliability	Observers (O)	-0.01	0.0
	Categories (C)	118.91	99.6
	CO	0.46	0.4
Inter-observer reliability	Observers (O)	0.00	0.0
	Categories (C)	120.83	99.7
	CO	0.34	0.3
Homogeneity of the categories	Matches (P)	0.02	0.1
	Categories (C)	28.39	90.8
	PC	2.87	9.2
Minimum number of matches	Matches (P)	0.02	0.1
	Categories (C)	28.39	90.8
	PC	2.87	9.2

Finally, table 3 presents the 19 patterns of coverage identified by means of the concurrent analyses in the lag 0. Next to each pattern is the specific game situation in which that pattern is activated. The results in the table are interpreted in the following way: in four rotations (TR6, TR5, TR3 and TR2) and in set tempos greater than 1 second (1.1, 1.3 and 1.4 s), the excitatory behavioural pattern derived from the given behaviour for the location of the attacking player in the front zone 0 (APLFZ0) is formed by the target behaviour end location of the libero in zone 4 (LELZ4).

Table 3. Patterns of attack coverage activated by the liberos in different game situations.

Macro-criteria APL: Given behaviours	LEL criterion: Target behaviours	Variable TR: Contextual conditions	Variable SPT: Time conditions (s)
APLFZ0	LELZ4	TR6 TR5 TR3 TR2	1.1 1.3 1.4
	LELZ6A	TR1	
	LELZ5A	TR4	
APLFZ1	LELZ4	TR1 TR6 TR5 TR4 TR3	1.1
	LELZ6A	TR2	
APLFZ2	LELZ5A	TR1	
APLFZ3	LELZ1A	TR1	
APLFZ4	LELZ5A	TR6	0.3
	LELZ1A	TR5	0.5
APLFZ5	LELZ5A	TR6	
APLFZ6	LELZ3	TR3	
	LELZ2	TR1 TR5 TR4 TR2	1.0 1.1 1.3 1.4
	LELZ5A	TR3	
APLFZ7	LELZ3	TR6 TR3	1.0
	LELZ2	TR4	
	LELZ6A	TR1	1.1
APLBZB	LELZ6A	TR5 TR4	
	LELZ1A	TR2	1.4 1.6

DISCUSSION

The high speed at which volleyball is played meant that we used a high speed video camera and frame-by-frame analysis in order to determine as accurately as possible the time 0 for each phase and thus ensure the quality of the data. The pass tempos are separated by a few thousandths of a second and the players' locations in relation to the pre-recorded spatial references can change notably in a very short time. The data quality has been considerably improved by determining the real marks of the points that delimit the zones of the play area and by superimposing the observation units over these images. In this regard, the results obtained have provided the reliability and generalizability values that are required in an observational tool such as this (Blanco & Hernández Mendo, 1998). Similar results were found by Castellano et al. (2000) and Gorospe et al. (2005) who created tools for analysing behaviours in football and tennis respectively.

The results of the exploratory study of the libero showed coverage patterns in all the attack zones except for back zone A (APLBZA), which had zero frequency in the descriptive analysis phase. For the same reason, no patterns were detected that were made up of the LELLSZ, LELRSZ and LELSZ categories. From this we interpret that the liberos always cover within the limits of the court. We also found no patterns made up of LELZ5B, LELZ6B and

LELZ1B target behaviours. This means that the players in this role do not usually cover the zones near the end line of the court; instead they usually cover the areas near to the attacking player because, according to the rules of the game, their defensive role does not allow them to spike, although it does allow them to take part in defensive actions right from the start. In terms of the situational variables, table 3 shows that the liberos only cover forward zones of the court (LELZ4, LELZ3 and LELZ2) in situations where set tempos are equal to or greater than one second (1.0, 1.1, 1.3 and 1.4 s) and where there are attackers in the lateral zones (APLFZ0, APLFZ1, APLFZ6, APLFZ7 and APLBZC). In the remaining situations, particularly those with very quick sets (0.3 and 0.5 s) and central zone attacks (APLFZ2, APLFZ3, APLFZ4, APLFZ5 and APLBZB), coverage patterns occur in the back zones of the court (LELZ5A, LELZ6A and LELZ1A). Greater behavioural complexity can be seen in the team rotation contextual variable and this is difficult to interpret. We think it would be easier to understand if we had information about other aspects of the game such as in which court zones the liberos have received the serve in cases where they have made their teams' first ball contact. This could justify the possible inclusion of other variables in future experiments using our observational tool. In any case, the results of the study are close to others put forward by internationally recognized authors such as Selinger and Ackermann-Blount (1992). Those authors state that each player should have a clearly assigned coverage responsibility area for each attack zone in particular. In our study, the libero shows specific coverage attack patterns for each specific game situation.

Finally, certain studies have looked at other types of contextual variables that refer to the location of the match, the level of the opponent and the score (Lago, 2009). The behaviours that we have observed in our study are collaborative and correspond to highly regular behavioural patterns, which means that the previously mentioned situational variables may have a lower impact on the activation pattern. Other opposing behaviours such as the attack or block may be much more subject to the influence of these variables and could therefore be included in future studies of the attack coverage.

CONCLUSIONS

The structure of our observation tool has allowed us to carry out a synchronic, or concurrent, analysis of a specific game phase, the attack coverage. The observational tool may also be suitable for making diachronic or sequential analyses. In this regard, it would be highly interesting to analyze the coverage-defence relation or other concurrent relations such as the coverage-set or the coverage-counterattack. The internal structure of volleyball means that an exhaustive system can be created that includes macro-criteria, criteria, and categories and which allows researchers to determine the location of the team members within the corresponding context-time dimension.

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