Monten. J. Sports Sci. Med. 4 (2015) 1: 19–24
Original scientific paper
UDC 796.325

The Importance of Loosely Systematized Game Phases in Sports: The Case of Attack Coverage Systems in High-Level Women's Volleyball

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A B S T R A C T

Change is ubiquitous, but its degree and rate often affords detection of emerging patterns and establishing behavioral dynamics based on expected regularities. Match analysis capitalizes on such regularities, capturing information relevant for enhancing structure and reducing improvisation to a minimum. However, what if a game phase is only loosely regular, defying pattern systematization? Is it still possible to unfold principles of behavior capable of abstracting over-arching patterns? Our research focused on analysis of complex IV (KIV) or attack coverage in volleyball. Fourteen matches from the 2013 Volleyball Women's World Grand Champions Cup were analyzed. Results showed the occurrence of KIV corresponded to fewer than 5% of the total number of actions, and plays where a team successfully conquered a point after attack coverage was circa 1%, meaning this game complex will only make a difference in balanced matches. Overall, twenty-nine attack coverage structures emerged, denoting very high organizational variability. Attack coverage therefore provides an example of principle-based and not structured-based game phase. Associative analysis showed that quick attack tempos constrain the emergence of more complex attack coverage structures. The search for principle-based instead of structure-based game phases may provide useful insights for comprehension of game dynamics and for informing training processes.

Key words: *structured improvisation, principle-based systemic organization, volleyball.*

Introduction

Although change is the most ubiquitous fact of reality, its degree and rate are often reduced enough making it possible to detect emerging patterns and establish expected behavioral regularities (McGarry, Anderson, Wallace, Hughes, & Franks, 2002). Match analysis capitalizes on such regularities (Garganta, 2009; Lames & McGarry, 2007), attempting to understand the game logic and the relationships within a team and between teams (Ciuffarella et al., 2013). Resulting information aids in the optimization of training processes (Lames & McGarry, 2007; McGarry, 2009). Therefore, researchers and practitioners search for game regularities with the expectancy that performance will benefit from them (Dutt-Mazumder, Button, Robins, & Bartlett, 2011). In this context, Dynamic Systems Theory has brought about a deeper theoretical framework, presenting a set of elements in dynamic interaction according to a common goal (Walter, Lames, & McGarry, 2007).

Often, dynamic systems are complex enough as to possess subsystems, which, despite being slave to the overall system, exhibit partial independence (Thelen, 2005). This partial autonomy of subsystems may promote the occurrence of disturbances from within the system, causing the system to enter a transition period marked by instability until the system returns to its previous state or achieves a new stable state (McGarry et al., 2002). This is achieved through self-organization in response to non-linear constraints (McGarry, 2009), and often generates *novel patterns* (Walter et al., 2007). This effect of novelty should advise researchers to exert caution when generalizing results or when extrapolating conclusions into future competitions (Walter et al., 2007).

Team sports have been characterized as dynamic systems (Walter et al., 2007), with relationships between teammates, opponents, and the environment over time, in the search to score a point and simultaneously to prevent the opponent from scoring (Lames & McGarry, 2007). Such complex and often antagonist interactions generate self-organized patterns, and the emergent structures allow researchers and practitioners to capture the regularities and hopefully diminish the role of randomness (Bergeles & Nikolaidou, 2011; Peña, Rodríguez-Guerra, & Serra, 2013). Hence, the degree of structure is enhanced, whereas the degree of improvisation is left to a minimum (Bergeles & Nikolaidou, 2011; Miskin, Fellingham, & Florence, 2010). However, what ensues when a system is only loosely regular, when its patterns are so diversified that defy systematization? Indeed, randomness occurring at various levels and time scales is deemed to create disturbances in the system, ultimately creating uncertainty regarding the outcome (Aicinena, 2013;

Received for publication February 7, 2015

García, Ibáñez, Cañadas, & Antúnez, 2013). Could we still find emerging *principles* of behavior capable of abstracting overarching patterns? Instead of having a set of predetermined structures for each game scenario, could we instead find some general, loosely systematized principles that could then be easily applied to a wide number of game scenarios and their variations?

This possibility will be explored providing the example of volleyball. Research systematized the game logic and its subsystems, the most relevant being game complexes (K's), which have their own inner logic, despite integrating the broader system that is the game of volleyball. Complex I (KI) or side-out consists of service reception, setting and attack, while complex II (KII, counter-attack or side-out transition) consists of serve, blocking, defense and counter-attack (Costa, Afonso, Brant, & Mesquita, 2012; Costa, Ferreira, Junqueira, Afonso, & Mesquita, 2011; Rodriguez-Ruiz et al., 2011). Some authors also highlight the K0 (autonomizing the serve), KIII (transition or counter-attack to a previous counter-attack), KIV (attack coverage) and KV (freeball and downball), all having their own internal logic and, therefore, being considered separately in research and in training (Hileno & Buscà, 2012).

One such complex, KIV, consists in recovering the ball and restructuring the offensive phase after the ball touches the block and returning to the attacking team's court (Hileno & Buscà, 2012). The literature is outdated and highly simplistic when approaching this game complex, bringing about two main structures: *a)* the 3//2 system, consisting of three players near the attacker (first line of coverage) and two far from the attacker (second line of coverage); and *b)* the 2//3 system, which is the opposite of the 3//2, having two players near the attacker and three further back in the court (e.g. Asher, 1998; Selinger & Ackermann-Blount, 1986). Despite this apparent simplicity, what would happen if the game constraints became so complex or diversified so as to challenge the structuration of rigid attack coverage systems? Indeed, research has been showing that volleyball attack systems are increasingly fast and complex (Afonso, Mesquita, & Marcelino, 2008; Castro & Mesquita, 2008; Ciuffarella et al., 2013; Costa et al., 2012), and this is expected to impact upon the possibilities of KIV structuring, as has been hinted by Hileno and Buscà (2012). Relevant to our case, this was the only scientific paper we found concerning KIV. This might be particularly relevant in female volleyball, since a stronger weight of KII induces longer rallies and, therefore, more opportunities for playing in KIV (Bergeles, Barzouka, & Nikolaidou, 2009; Costa et al., 2012).

Therefore, our purpose was to examine attack coverage in high-level women's volleyball and to verify whether structured systematization is possible or if a loose-principled approach is more suitable. We hypothesize that attack coverage will likely require a loosely systematized approach; hence we expect a rigidly structured approach not to be suitable in this game phase. The implications of this specific case might be broadened into research questioning similar themes and inform about the degree of structuring that a given phenomenon concedes.

Methods

Sample

Fourteen matches from the 2013 Volleyball Women's World Grand Champions Cup were analyzed, including twelve of the highest ranked National Teams. A total of 52 sets were analyzed, including 6815 ball possessions, 2042 of which occurred in KI and 4773 in KII. The Ethics Committee at the Centre of Research, Education, Innovation and Intervention in Sport of University of Porto provided institutional approval for this study.

Instrument

The matches were filmed with a video camera positioned circa 9 meters from the side of court and at a height of circa 3 meters (Sony® Handycam HDR-CX240, 1080p, USA). Data were registered in a worksheet created with IBM® SPSS® Statistics Version 21. Total actions of the teams, occurrence of KIV, the complex that the team was in the moment of KIV (KI or KII), final effect after of KIV, KIV structure (i.e., player distribution in the court), number of coverage lines, quality of first contact, attack zone and tempo were analyzed.

Variables

Game complex previous to the attack coverage considered the KI (attack after serve-reception) and the KII (counter-attack) (Castro, Souza, & Mesquita, 2011; Silva, Lacerca, & João, 2013).

Setting zone was evaluated by the number of attack options afforded to the setter, following a model similar to that of Esteves and Mesquita (2007), according to which we divided the court in three different functional zones (Figure 1). In zone A the setter had all attack options available; this zone is defined as the region from the center line to 2 meters away and spaced 1 meter from the right line and 3 meters from the left line. Zone B still allows quick attacks, but limits the number of attack combinations available, and is located 2 meters to 4 meters from the centerline and laterally 1 meter from the right line and 4 meters from left line. Zone C comprises the remainder of the court, affording only the realization of high sets to the extremities or to the back row.

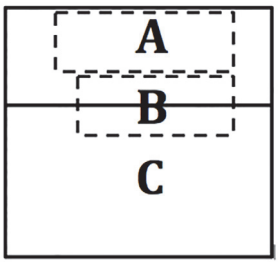

Figure 1. Setting zones

The attack zones were defined according to the FIVB rules, with the court divided into six zones (numbered 1 to 6). For our purposes, zones 5, 6 and 1 were grouped into the category of second line attacks.

Attack tempo denotes the relationship between the attacker and the setter in the play, implying the notion of timing and not

corresponding to a specific time length. We defined three attack tempos, based on Afonso and Mesquita (2007): 1 (the attacker will be in the air, during or shortly after the set); 2 (after the set, the attacker takes two steps); and 3 (three or more steps taken after the set).

Concerning the *attack coverage structure*, a field format was used, thereby not making use of pre-established categories, as our goal was to list all the structures emerging from the plays. As there are, to our knowledge, no references defining what an effective attack coverage is, we considered that to participate effectively in attack coverage the player must be facing the attacker or the blockers, and be in the medium to low body position described by Selinger and Ackermann-Blount (1986), ready to engage. The *number of attack coverage lines* was measured counting from the net to the end line (Table 1).

Attack coverage effectiveness was characterized by the effect of the play following it: the team terminated the play by scoring, terminated the play by losing the point or the rally continued.

Variables and Testing Procedures

Descriptive statistics were used to register the events. We first attempted constructing of three distinct predictive models, using Multinomial Logistic Regression: *a)* a model predicting the efficacy of attack coverage based on game complex, setting zone, attack zone, attack tempo, attack coverage structure, and attack coverage lines; *b)* a model predicting the attack coverage structure, based on game complex, setting zone, attack zone, and attack tempo; and *c)* a model predicting the number of attack coverage lines, also based on game complex, setting zone, attack zone, and attack tempo. No significant model could be achieved, as very strong data dispersion inhibited detection of repetitive game patterns.

As a second step, a more modest associative analysis was performed to examine relationships between the several variables under analysis, even if a more global and comprehensive model could not be achieved. A Chi-square testing with Monte Carlo correction was conducted. Where p was ≤0.05, cells containing adjusted residuals above |2.0| were analyzed. Cramer's V was calculated to evaluate the Effect Sizes. Results of this second analysis somewhat support those obtained through the first analysis, and its implications will be discussed in detail.

Reliability analysis

Intra-observer reliability analysis was conducted circa one month after the original observations, and achieved a Cohen's Kappa between 0.81 and 0.89. Inter-observer reliability analysis was conducted by an experienced volleyball coach and researcher and achieved a Cohen's Kappa between 0.75 and 0.84.

Results

Descriptive analysis

Attack coverage occurred in 277 occasions, corresponding to 4.1% of the plays. Of these, 128 (46.2%) occurred after KI and 149 (53.8%) after KII. Twenty-nine different KIV structures appeared, under four groups: one-line formations, two-line formations, three-line formations and four-line (see Table 1).

Table 1. Attack Coverage Formations

No. lines	No. structures	Frequency of occurrence	Percentage
1	5 (1, 2, 3, 4, 5)	13	4.8
2	10 (1//1, 1//2, 1//3, 1//4, 2//1, 2//2, 2//3, 3//1, 3//2, 4//1)	167	60.1
3	10 (1//1//1, 1//1//2, 1//1//3, 1//2//1, 1//2//2, 1//3//1, 2//1//1, 2//1//2, 2//2//1, 3//1//1)	93	33.5
4	4 (1//1//1//1, 1//1//2//1, 1//2//1//1, 2//1//1//1)	4	1.6

Overall, 4.7% of attack coverage scenarios presented a system with one line of coverage (*n*=13), 60.3% a two-line system (*n*=167), 33.6% a three-line system (*n*=93), and 1.4% comprised a four-line system (*n*=4).

Concerning the quality of first contact, 48.7% of attack coverage occurred after setting in zone A (*n*=135), 38.6% after setting in zone B (*n*=107), and 12.6% after setting in zone C (*n*=35). Attack coverage followed attacks in zone 2 in 28.9% of occasions (*n*=80), zone 3 in 12.3% (*n*=34), zone 4 in 47.3% (*n*=131), and second line in 11.5% (*n*=32). With regard to attack tempo, tempo 1 occurred in 9.0% of the plays preceding attack coverage (*n*=25), tempo 2 in 41.5% of the plays (*n*=115), and tempo 3 in 49.5% (*n*=137).

Finally, 22.9% (*n*=61) of the counter-attacks following attack coverage resulted in attack error (i.e., they ended up being ineffective), 54.5% (*n*=151) offered continuity in play, and only 23.5% (*n*=65) resulted in scoring a point.

Associative analysis

Attack coverage formations presented a significant association with attack tempo (χ^2=99.416, p≤0.001, V=0.424). Several attack coverage formations associated positively with tempo 1: 1//2 (2.2), 1//4 (5.6), 3//1 (2.5), 5 (3.2). No cell revealed significant associations with tempo 2. Tempo 3 associated negatively with the 1//4 structure (-2.2).

There was also a significant association between attack coverage formation and attack zone (χ^2=124.123, p≤0.030, V=0.386). Three formations associated with attacks in zone 2: 1//1//2 (2.2), 2//1 (-2.6), 2//3 (2.2). Four formations associated with attacks in zone 3: 1 (2.9), 1//4 (4.7), 2//3 (-2.4), 3//1 (3.4). One formation associated negatively with attacks in zone 4 (1//4; -2.1) and one positively with second line attacks: 2//1//1 (2.4).

Finally, there was association with quality of first contact (χ^2=76.615, p≤0.035, V=0.372). The following cells associated with balls passed into setting zone A: 1//3//1 (-2.3), 1//4 (2.3), 2//2 (2.6), 2//3 (-2.7). Balls set in zone B associated with 2//2 (-3.3) and 2//3 (3.0). Associations emerged in the following cells for balls set in zone C: 1//1//1//1 (2.6) and 1//2//1//1 (2.6), 1//3//1 (2.2). No significant association was found with game complex (p=0.538, V=0.310) and attack coverage effect (p=0.101, V=0.355).

Considering the number of attack coverage lines, there was an association between the number of lines and game complex (χ^2=9.554, p=0.023, V=0.186). KI associated positively with the emergence of two-line systems (2.4) and negatively with three-line systems (-2.3). The inverse relationships were observed for KII.

No association was found between number of coverage lines and quality of first contact (p=0.203, V=0.124), attack zone (p=0.145, V=0.127), attack tempo (p=0.117, V=0.136), and effect of attack coverage (p=0.179, V=0.127).

Discusion

Science has aimed at revealing hidden but meaningful patterns that improve our ability to anticipate and better cope with expected constraints. Systemic approaches attempt to understand the relationships within the subsystems and how such interactions influence the evolution of the system's behavior over time (McGarry et al., 2002). Armed with these conceptual lenses, researchers in match analysis try to capture meaningful game patterns in an effort to better systematize its understanding and hopefully translate that knowledge into better practices (Dutt-Mazumder et al., 2011). Using the example of the attack coverage (complex IV) in volleyball, we posed the question of what would happen when a system's behavior refused rigid structuring. Our aim was to verify is there were such scenarios in high-level sport and, if so, if it was still possible to find a principle-based organization to inform practice.

Results showed that the occurrence of KIV corresponded to fewer than 5% of the total number of actions, suggesting that it may not be as relevant to the outcome as other game complexes analyzed by the literature, such as complexes I (Laios & Kountouris, 2005; Zetou, Moustakidis, Tsigilis, & Komninakidou, 2007) and II (Marcelino, Mesquita, Sampaio, & Moraes, 2010). Furthermore, the overall percentage of plays where a team successfully conquers a point after attack coverage is around 1%. However, performance at the highest level often depends on the little details that produce all the difference (Marcelino et al., 2010).

Additionally, we highlight the emergence of 29 different attack coverage formations, each occurring with low frequency. Indeed, only two out of the 29 structures presented a rate of occurrence greater than 10%, namely the 2//2 structure with 11.9%, and the 2//3 structure with 13%. This denotes a considerable structural variability under this game complex. The 3//2 structure, one of the systems depicted in dedicated volleyball manuals (e.g., Asher, 1998; Selinger & Ackermann-Blount, 1986), occurs in only 7.2% of the situations. Consequently, a highly structured approach to KIV is not warranted, thereby confirming our hypothesis. Instead, a principle-based view may be more suitable (e.g., 'if you are near the attacker and not involved in other actions, try to cover the attack').

Acting upon general principles instead of rigid, predetermined structures is consistent with accepting the role and weight of change in most phenomena. And although some game phases in different sports may be prone to detailed structuring (Garganta, 2009; Lames & McGarry, 2007; McGarry et al., 2002), others may resist such pretensions and increase the challenge of guiding good practices, meaning a dynamic system can be so complex and the interactions between its subsystems so diversified (Thelen, 2005) that self-organizing behavior will generate a number of different outcomes. Notwithstanding, our data suggests that some principle-based guidelines are possible. The association between attack tempo and attack coverage structure revealed an effect size of V=0.424, meaning an extremely good relationship between the two variables. Thus, attack tempo seems to highly constraint the type of organizations possible in each attack coverage sequence. Specifically, tempo 1 is associated with a number of two-line structures and with a one-line structure. No three- or four-line structures were associated with tempo 1. Therefore, despite the quickest attack tempo promoting more feeble opposition from the blockers and defenders due sheer game velocity (Ciuffarella et al., 2013; Costa et al., 2012), it also impairs the attacking team's chances of structuring solid attack coverage.

The very strong effect size verified for the association between attack coverage systems and attack zone (V=0.386) is, we believe, a side effect of attack tempo, since quicker attack tempos usually associated with zone 3, and slower attack tempos with zones 2, 4, and 2nd line (Palao, Santos, & Ureña, 2007). We extend this reasoning to the setting zone (V=0.372), as this variable severely constraints the options that are available for developing quicker attacks (Marcelino, César, Afonso, & Mesquita, 2009; Palao et al., 2007).

Providing a very specific example from volleyball, we hope to shed improved comprehension of what our results suggest. When a team attacks by position 6, for example, a number of different scenarios could have preceded that attack. In a highly systematized attack coverage approach, each such scenario would warrant a very specific structure, defining which players would cover each location of the court depending on a number of variables besides attack zone, such as: zone of first contact, zone of second contact, involvement of attackers in quick attacks and/or in combination plays, and so on. Conversely, a loosely systematized approach would merely require defining one broad action principle (e.g., cover near the attacker if you are close to him/her, cover the backcourt if you are further away), which would then be applied plastically to each emerging game scenario. This would afford a more natural response to emerging game constraints, besides imposing a much smaller load to the players' memory.

Conclusion

In summary, the volleyball game promotes few occurrences of complex IV. Two major factors may contribute to this: *a)* when the attacker faces the block, he might miss the attack, score a point, or put the ball into the opponent's court, with or without a touch on the block; situations in which the ball deflects on the block and returns to the attacking team's court is reduced; and *b)* when the ball does return to the attacking team's court after being deflected by the block, it often results in a point by the blocking team; on fewer occasions, the team is able to defend the ball, but not allowing the construction of an organized attack; on very few occasions, the team will be able to counter-attack and score a point. Nonetheless, those few occasions may be highly relevant for balanced matches, as most are expected to be at the highest levels of practice.

The associations between the emerging attack coverage structures and game variables such as attack tempo, game complex, and others were scarce, with considerable variation and no clear patterns emerging. Therefore, a principle-based approach may be more rational than more strictly structured approaches. Notwithstanding, we suggest that much research is warranted to better understand the actual role of complex IV in high-level women's volleyball and similar game phases in other sports.

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