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Original Article

Methodological proposal for the quantification and analysis of the level of risk assumed in volleyball service execution in female high-level competition

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Abstract:
The development of volleyball in recent years has greatly conditioned the service, one of the most important elements of the game, with significant technical and tactical changes. A methodology based on observations is proposed using models to quantify and assess the risk levels assumed by volleyball players at the moment of the serve, and developing a system category for it that includes the main response levels that affect this element of the game. This methodology has been tested with a sample from Spanish and Italian leagues, and the results obtained show the validity of the proposed formula.
Key words: volleyball, serve, set the category, level of risk and effectiveness.

Introduction

The rules of the Fédération Internationale de Volleyball define the serve as "the act of putting the ball into play, by the back right player, placed in the service zone." (FIVB Rules 2009, Art. 12). The service is the only action in the game preceded by a period whereby the player has the ability to fully decide on the kind of action to be performed in advance of its execution. This feature of the service action, together with the fact that there is no direct intervention from other team players or opponents, allows the serving player to influence each playing sequence. However, a number of factors exist which may indirectly influence the service These include previous patterns of play, the level of the opponents, team rotation, period of the match, current score and physical status (Katsikadeli, 1998). Successful execution of the service action is therefore not only dependent upon good technique, but also upon decision-making ability. Decisions are made partly based on assessment of the degree of 'risk' associated with each possible service alternative (Boksem and Tops, 2008).

The necessity for effective decision-making prior to the execution of each service action suggests an important tactical element informs this aspect of the game. The server has a defined period of time (8 seconds) in which to decide upon the kind of service action to be executed, the zone of the court to which the service will be directed, and if the intention is to directly win a point or hinder the offensive action of the opposing team. Moreover, the player must consider other aspects not directly related to the execution of the service action. These may include assessment of the appropriateness of performing relatively 'risky' or 'safe' actions in the context of the overall match situation. (Kitsantas, 2000; Asterios et al., 2009; Drikos et al., 2009; Marcelino et al., 2009).

The concept of the assessment of risk in the execution of the service action was emphasised by Beal (1989) and Salas (2006), who stress the necessity of assuming certain degrees of risk when serving, especially when attempting to counteract opponents with offensive superiority. Subsequently, the need to assume certain degrees of risk throughout a match, in particular during execution of the service action, but also in order to counteract the receiving team's offensive strategies, has been emphasised by numerous previous authors (Katsikadelli, 1997; Patterson, 1999; Ejem, 2001; Guidetti, 2001; Papadimitriou et al., 2004; García-Tormo et al., 2006; Moras et al., 2008; Ureña et al., 2011).

Despite wide variation in the types of service action displayed in high level competition, actions utilised can be reduced to four basic forms: close float, long distance float, jump float and jump spin power (Costa et al., 2007; Moras et al., 2008; Palao et al., 2009; García-Tormo et al, 2009). The jump spin power is the most obvious example of an action with offensive intention. It is characterised by the achievement of high ball velocity and a descending trajectory, with the clear objective of attaining an ace, either through the impact of the ball on the court or an error in the receiving action (Over, 1993; Agelonidis, 2004; Maia and Mesquita, 2006; Moras et al., 2008; Palao et al., 2009; Ureña et al., 2011). All other service actions in the repertoire are characterised by a contact resulting in a floating trajectory, with the tactical intention of hindering the opposing team's offensive response, directing the ball to the areas of greatest conflict between players or trying to hinder a key opponent's offensive system (Guidetti, 2001; Lozano et al., 2003; Sagastume and Cayero, 2003; Moras et al., 2008; Ureña et al., 2011).

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Effective assessment of the degree of risk posed by differing service actions is clearly a crucial element in effective tactical decision-making during competitive volleyball. The aim of the present study is therefore to propose a methodology for the assessment and quantification of the levels of risk assumed by competitive volleyball players during match play.

Methodology

Sample

The unit of observation in this study was the service action executed by high-level volleyball players. Data was collected from a sample of 12 teams from the Italian Women's League (A1) and 14 from the Spanish Women's League (DH), over the 2009/2010 season. Match videos (Data Project) were used to perform the analyses, and frequency and sequential analyses were used to record behaviour patterns. The sample analysed comprised one match played by each of the teams in these leagues and the total number of service actions analysed was 2296.

To facilitate the registering and recording of data, a category system was devised based on the theoretical and empirical concepts, which tends towards molecularity and presents exhaustive and mutually exclusive characteristics (Anguera et al., 2000; Borrie, A. et al., 2002; Castellano et al., 2008; Sanchez-Algarra and Anguera, 2013). In order to assess the level of risk posed by each possible service performed, a formula was proposed which provides a range of numerical risk levels based on the type of service action utilised, the direction of ball travel, and the flight trajectory. (Figure 1)

Figure 1: formula for quantification of the risk posed by service performed

Risk level = (Service action x 2) + Direction + Trajectory

To quantify the level of risk, each of the *categories* contained in the formula was assigned a numerical value. This assignment was determined by taking into account the percentages of errors (faulty service, ball strikes the net or lands out of the court) (E0) and direct points (an 'ace') (E4) resulting from each possible service in the Italian Women's League (A1) in the 2009-2010 season. Based on these percentages, a numerical value was assigned to each category based on the relative likelihood of their being a direct outcome of the service performed (i.e. E0 and E4 combined) (García-Tormo et al., 2009). In order to make these calculations more simple to perform quickly by coaches or practitioners interested in assessing the degree of risk posed by available service alternatives, the value assigned to each category was produced by diving the resulting percentage by 10 and then rounded to the nearest whole number.

The variables and the quantification of each of the *categories* involved in the service are:

Service action

The categories corresponding to the service action are defined according to the type of hit, whether it is a jump or standing serve, and the distance of the server from the base line. In total, four categories of service action were utilised (Close float "CF", Long distance float "LF", Jump float "JF" and Jump spin power "JP") (Garcia-Tormo et al., 2009).

This variable has been given a greater weighting in the quantification of overall risk as the serving player has a period of time to make tactical decisions, and therefore assumes a voluntary degree of risk in the choice of serve action, whereas they have a smaller degree of control over the other variables due to the potential influence of error.

The numerical value of each of the service actions (Table 1) was determined by assessment of E0 and E4 for each.

Table 1: Numerical values for each category of service action

Categories	Codes	Percentages E0 + E4	Value
Close float	CF	11%	1
Long distance float	LF	22%	2
Jump float	JF	24%	2
Jump spin power	JP	43%	4

Direction of serve

The "direction of serve" was based on the service zone and the landing area of the ball. Three possible categories were identified; Parallel (P), medium diagonal (MD) and long diagonal (LD).

This variable is proposed to influence the overall degree of risk assumed as there are inherent trade-offs in accuracy for the increased power required to allow long travel distances. The numerical values assigned to each direction (based on percentages of E0 + E4), are presented in Table 2:

Table 2: Numerical values for each category of service direction

Categories	Codes	Percentages E0 + E4	Value
Parallel	P	35%	4
Medium diagonal	MD	27%	3
Long diagonal	LD	38%	4

Trajectory

The trajectory of the service hit describes the height of the ball relative to the height of the net Two possible categories were identified: Low (L) when the ball does not exceed the height of the net antennae (80cm above the height of the top of the net), and parabolic High (H) when it exceeds that height.

This variable is considered important in the evaluation of the level of risk, as a low ball which passes over the net without exceeding the height of the net antennae presents a higher degree of risk to the server (i.e. it is more likely to hit the net), than a ball which passes over the net by a wider margin. The numerical values assigned to the two possible trajectories (based on percentages of E0 + E4) are presented in Table 3.

Table 3: Numerical values for each category of trajectory

Categories	Codes	Percentages E0 + E4	Value
High	H	37%	4
Low	L	63%	6

Following definition of the variables proposed to influence the total level of risk posed by each possible service, a scale of values representing the relative level of risk posed by each possible combination of these variables was constructed through use of the previously proposed equation (Table 4). This resulted in identification and ranking of 10 levels of relative risk ranging from Level 9 to Level 18.

Table 4: Relative risks posed by all possible combinations of service variables

	Risk level	Type of serve	Direction	Trajectory
Codes	R9	CF	MD	H
	R10	CF	P/LD	H
	R11	CF	MD	L
		LF/JF	MD	H
	R12	CF	P/LD	L
		LF/JF		H
	R13	LF/JF	MD	L
	R14	LF/JF	P/LD	L
	R15	JP	MD	H
	R16	JP	P/LD	H
	R17	JP	MD	L
	R18	JP	P/LD	L

Content validation was utilised in order to establish the internal validity of the proposed method for quantifying the level of risk assumed by the serving player. This consisted of two procedures: the *"authority criteria"* method, known as the "*Delphi method"* in the business context (Skulmoski et al., 2007) and the "*justification of values*" resulting from technical/tactical aspects and the percentages of success/error.

The methodology based on "*authority criteria*" ("*Delphi method*") consisted of a series of informal interviews performed with a panel of experts comprising volleyball specialists with considerable professional experience and possessing the highest academic and governing body qualifications. During these interviews, these experts were required to rank order the possible combinations of service variables with regards to the degree of risk posed by each. The validity of the method was determined through comparison of the extreme values (R9 and R18) identified by both methods.

The second method used to verify the validity of equation was the "*justification of values*". Validity was established by examining the extreme values (R9 and R18) and relating them to the established values for each one of the categories determined in the formula.

Risk level "R9" is the lowest possible, and should be the product of the minimum values for each one of the *categories* comprising the formula (Table 5).

Table 5: Combination of variables comprising R9

Risk level	Type of serve	Direction	Trajectory	Result
R9	CF (1)	MD (3)	H (4)	
Values	1 x 2 (2)	3	4	9

Risk level "R18" is the highest possible, and should be the product of the maximum values for each one of the *categories* comprising the formula (Table 6).

Table 6: Combination of variables comprising R18

Risk level	Type of serve	Direction	Trajectory	Result
R18	PJ (4)	P – LD (4)	L (6)	
Values	3 x 2 (8)	4	6	18

Use of this method confirms that the calculated risk values correspond to the values established for the *categories* comprising in the proposed formula.

In addition to variables utilised in the formula proposed, the eventual outcome of all services performed must be considered, because it is a variable that will allow to analyse the outcome of the service actions according to risk assumed. Coleman (1975) produced a 5 category system for evaluating proposed service efficacy, in which "E0" results in error and "E4" results in a direct point (as previously described) but also consists of E1, E2, and E3 which correspond to increasing levels of difficulty faced by the opposing team in returning the ball.

Table 7: Category system of variable Efficacy

Categories	Efficacy 0	Efficacy 1	Efficacy 2	Efficacy 3	Efficacy 4
Codes	E0	E1	E2	E3	E4

Results and discussion

Frequency analysis indicates that the three most frequently performed types of service are found to be in categories, R12 (35,1%), R14 (24,6%), and R18 (10.7%).

Table 8: Frequencies and percentages of the risk level of the sample

	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	Total
n	31	153	215	806	149	565	18	75	39	245	2296
%	1.4	6.7	9.4	35.1	6.5	24.6	0.8	3.3	1.7	10.7	100

The three least frequently used types of service are found in categories R9 (1.4%), R15 (0.8%) and R17 (1.7%). This implies that the serves most frequently selected are those involving an intermediate risk (Table 9), especially the long distance float serve (LF) and the jump float serve (JF).

Table 9: description of the categories R12 and R14.

Risk level	Type of serve	Direction	Trajectory
R12	NF LF/JF	P/LD	L H
R14	LF/JF	P/LD	L

To date, there are few studies within the available literature addressing the concept of quantification of the risk assumed in the serve. In a pilot study (Garcia-Tormo et al., 2006), this evaluation is applied to a sample from the junior girls category (Spanish Girls Youth Championship, 2003), in which the greatest frequencies correlate to the lowest values. However, this may be because jump serves are rarely used in this category.

Subsequently, and following the same line of study, the levels of risk obtained from two Spanish female leagues (FEV and First Division) are described by Garcia-Tormo et al (2009). As is the case with the data in this investigation, in both leagues the categories with greater frequencies are R12 and R14. The differences are found in the highest risk levels, where frequencies are lower in the FEV, and non-existent in the First Division.

These findings suggest that comparatively more risky serves are more likely to be utilised in higher levels of competition than at the lower level.

The sequential analysis of the variables of "efficacy" and "level of risk" (Table 10) suggests that the high-risk serves (R17 and R18) are likely to result in either positive or negative direct outcomes but also are less likely to result in an 'intermediate outcome'. This finding further suggests the methods utilised to determine risk in this study are appropriate, as although there is a potentially high 'pay-off' from use of these service types, there is also a very high risk of failure. The most effective services, appear to be at the moderate risk levels of R13 and R14 and correspond to jump float serves with a low trajectory (a 'tactical' service with a floating nature), and attacking services resulting in a higher ball velocity.

Table 10: Adjusted residuals Level of risk - Efficiency.

	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18
E0	-1.239	-1.687	-1.462	-3.822	-0.456	2.548	3.372	4.995	0.640	1.817
E1	0.979	5.793	1.001	4.666	-3.449	-5.145	-1.641	-2.787	-0.452	0.647
E2	-0.653	-2.455	-0.151	0.199	0.191	2.042	0.725	-2.787	-0.452	0.647
E3	0.076	-3.056	0.047	-2.304	4.218	2.145	-0.890	-1.899	1.537	0.303
E4	0.591	-1.894	-0.095	-2.530	1.908	1.345	-0.904	-0.713	1.843	1.809

Relating efficacy to service actions (table 11), the results clearly show that the least effective action is CF (E1) and the most effective is JF (E3). This is likely to be because the most attacking serve (JP) involves a high probability of error.

Table 11: Adjusted residuals Type of serve - Efficiency

	CF	LF	JF	JP
E0	-3.839	0.362	-0.858	4.937
E1	5.690	-0.388	-2.508	-2.729
E2	-0.467	-0.088	1.120	-0.784
E3	-3.528	1.466	1.969	-0.335
E4	-1.699	-1.783	1.978	1.593

This findings coincides with those of Palao et al. (2009), who suggests that the power jump serves (JP) are appropriate for achieving direct points but involve a high risk of error. Moreover, they substantiate the findings that the jump float serve (JF) in women's volleyball is the serve which achieves the highest efficacy rate (E3), making reception difficult and minimising the attacking options of the rival team (Lozano et al., 2003).

Conclusions

A simple methodology has been proposed and has been demonstrated to be a valid tool for assessing the level of risk assumed by serving players in volleyball, based on the service action, direction, and trajectory. This methodology allows identification of performance patterns associated with successful and unsuccessful outcomes, and may therefore players and coaches tactical decision making.

The most frequently utilised serves in women's high-level competitive volleyball are jump serves with a tactical and attacking intention. In particular, the jump float serve appears to possess high efficacy with a relatively low risk of error, and the power jump serve which can be highly effective but may be considered to present an excessively high likelihood of error.

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