Performance Analysis in Volleyball: Problem of Merging Attack and Counterattack Spike as One Variable

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Abstract: The purpose of this study was to present the multiple regression model with attack and counterattack spike as separate variables is more appropriate than the model with the attack and counterattack spike merged as one variable. Two multiple regression analyses were conducted that determine the relationship between situational efficiency parameters of volleyball game phases with the set score. Game phases included into both regression models were the serve, reception, spike, block and dig. One of the regression models had an attack and counterattack spike as two separate variables and the other one had them merged as one. A sample was 40 randomly selected volleyball sets played in the European League for Men in 2011 and 2012. Although the sample wasn't recent, the purpose of this methodologically based study was to present deficiency of merging attack and counterattack spike as one variable. Both multiple regression analyses determined a high and positive relationship between the situational efficiency of volleyball game phases with the set score. The spike as a merged variable had 32.5% of common variance with the set score. But when separated into two variables, the attack spike had only 8.9% of common variance and counterattack spike 26.5%. Although the spike was the game phase that had the highest relationship with the set score, the spike in the counterattack was the one that contributed. Ultimately the serve, reception and dig had higher common variance with the set score then the attack spike. Conclusion was that the attack and counterattack spike need to be considered as separate variables because of specificity of the attack and counterattack complexes of the volleyball game.

1 INTRODUCTION

The volleyball game consists of six phases that are sequentially executed, the serve, reception, setting, attack, block and dig (Busca and Febrer, 2012). The game phases that one team sequentially executes are organised as a game complex. The two main game complexes in volleyball are an attack and counterattack. The attack complex consists the reception, setting, attack spike and the counterattack the serve, block, dig, setting, counterattack spike. Both the attack and counterattack complex have their specificities and should be considered separately. The attack has more predictable conditions and, more importantly, a structured attack that takes place in specific sequences. On the other hand, the counterattack is characterized by a less structured, slower game that is the result of more variable conditions in which the counterattack begins (Marcelino, et al., 2009). After the attack spike, the ball is faster, has a straight trajectory and involves the participation and interconnection of a greater number of game factors (Afonso, et al., 2005).

Among all volleyball phases, points are mostly achieved by successful spikes (Marcelino, et al, 2008) followed by blocks and serves and opponent's mistakes. Spike is the phase of the volleyball game that shows the highest correlation with winning (Marcelino, and Mesquita, 2006). In top volleyball, the average number of points scored in a match is 45.5 by spike, 10.0 by block and 5.0 by serve (Marcelino, and Mesquita, 2006). Furthermore, Barzouka, et al. (2006) also determined spike's relationship with the score, but both in the attack and counterattack. The frequency of strong spikes is significantly higher in the attack phase (Castro, and Mesquita, 2008), with an emphasis on a faster pace of game in the same phase (Afonso, et al., 2005). In contrast, in the counterattack, the tempo of the attack in the game is slower, which reduces the probability of winning a point, allowing the opponent's block to have more blockers (Afonso, et al. 2005).

The most important characteristic of volleyball is that the game phases are executed in a manner that an efficiency of every game phase is partially determined by the previous one. According to the

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aforementioned sequentiality of volleyball game, the phases that the team can not win the point are not irrelevant for the score. The preceeding phases impact spike's efficiency in a different manner in the attack and counterattack. Costa, et al. (2010) determined that a stronger serve greatly reduces the quality of the opponent's attacking actions. Papadimitriou, et al. (2004) determined that the quality of reception significantly differentiates the attack tactics chosen by the setter. Barzouka, et al. (2006) also determined that the excellent performance of the Olympic-level setters and spikers is highly related to the performance of the actions that preceded them. The results showed that the frequency of the setter's excellent performances is significantly higher when they are preceded by an excellent reception compared to a good reception (49.0 % : 23.4 %). Similarly, spikers had a higher frequency of excellent performance when the setter had an excellent set, compared to a very good or only good one (79.4 % : 51.4 %; 79.4 % : 28.3 %) (Barzouka, et al., 2006).

Some reserchers considered spike as a merged variable in their performance analysis studies (Yiannis and Panagiotis, 2005; Valladares, et al., 2016; Silva, et al., 2014). Also, some researchers separated variables related to different complexes (Stutzig, et al., 2015). Given the specificities of the attack and counterattack complex in volleyball, the assumption was that attack and counterattack spike would have different relationship with the set score. The purpose of this study is to present the multiple regression model with attack and counterattack spike as separate variables is more appropriate than the model with attack and counterattack spike merged as one variable.

2 METHODS

The data were collected from the existing videos of volleyball matches. It was done by the first author, who has multiannual playing experience, an A coaching license and a multiannual coaching experience in men's volleyball. The reliability analysis was conducted with the help of an expert with multiannual playing, coaching and notational analysis work experience.

2.1 Set of Entities

The sample was 40 volleyball sets from matches played in the European Volleyball League for Men in 2011 and 2012. Only the data from one set of a match and only one team were collected in order to avoid interdependence of the sets. Both the team and the set were randomly selected.

2.2 Set of Variables

The predictor variables were the efficiency coefficients of the five phases of the volleyball game: serve, reception, spike, block, dig, and their intrateam variability. The setting was excluded from this study because of its specific situational efficiency analysis. The efficiency coefficient of each game phase was defined as the arithmetic mean of scores of all performed technical skills within a particular phase in one set. Each performed skill was evaluated with a score (1 – 4) according to precisely defined criterion. The score 1 was an error, 2 was an advantage for the opponent, 3 was an advantage for the team being evaluated, and 4 was an ideal performance (reception, dig) or a point won (serve, spike, block). The criterion variable was the set score defined as a relative point difference, the point difference in a set divided by the total number of points. If the team won the set, the relative point difference was positive and on the contrary, if the team lost the set, the relative point difference was negative. The authors believe that the same point difference does not represent an equal outcome of the set in the case when the result is 15 : 13, 25 : 23 or 31 : 29. For this reason, the result in the set was defined as a relative point difference.

2.3 Statistical Analysis

A reliability analysis was conducted on a sample of 3 randomly selected sets. Spearman's rank correlation and Cohen's kappa were calculated to determine the degree of agreement between the two different measurements of the same measurer (the first author) and two different measurements (the first author and the expert) at intervals of 4 – 6 weeks (test-retest method).

The descriptive statistics were: arithmetic mean (Mean), standard deviation (σ), minimum (Min) and maximum (Max). Normality of distribution was determined by the Shapiro-Wilk test.

Two separate multiple regression analyses were conducted to determine the relationship between the efficiency coefficients of the volleyball game phases and the relative point difference in the set. The first one was conducted with the attack and the counterattack spike merged as one variable. The second one was conducted with attack and the counterattack spike as two separate variables.

The collected data were analysed with the computer program Statistica for Windows 13.3 (TIBCO Software Inc.).

3 RESULTS

Reliability analysis results determined a high correlation between the two measurements of the same measurer conducted at two-time points (R = 0.91; κ = 0.92) and the two different measurers (R = 0.92; κ = 0.88).

Two separate multiple regression analyses were conducted in order to determine the relationship of the efficiency coefficients of volleyball game phases and the relative point difference in the set. The first model had attack and counterattack spikes merged as one variable. The second model had them as two separate variables with a total of six game phases.

Both regression analyses showed that all predictors had a high and significant relationship with the set score. The efficiency coefficients of phases of the volleyball game and the variability of the phases explained a total of 80.0 and 80.7% of the variance of the relative point difference in the set. The first multiple regression analysis showed that spike was a game phase with the highest amount of common variance with the score, 32.6%. But when spike was separated into attack and counterattack spike, attack spike had 8.8% of common variance with score whilst the counterattack spike had 26.5 which is 3 times higher.

Table 1: Descriptive statistics results.

	Mean ± σ	Min	Max
Relative point difference	-0.01 ± 0.13	-0.32	0.25
Efficiency coefficient – serve	2.14 ± 0.20	1.75	2.50
Efficiency coefficient – reception	2.98 ± 0.26	2.55	3.50
Efficiency coefficient – spike	3.04 ± 0.24	2.44	3.65
Efficiency coefficient – att. spike	3.12 ± 0.29	2.40	3.82
Efficiency coeff. – counteratt. spike	2.95 ± 0.40	1.75	4.00
Efficiency coefficient – block	2.29 ± 0.39	1.00	3.00
Efficiency coefficient – dig	1.95 ± 0.28	1.22	2.61

Legend: Mean – arithmetic mean, **σ** – standard deviation,
Min – minimal result, **Max** – maksimal result.

Table 2: The results of two multiple regression analyses (attack and counterattack spike as two separate variables in the second analysis).

			β	b	t	R^2 part. (%)	p
R	0.89	Intercept		-2.29	-11.31		0.00
R^2	80.0%	Efficiency coefficient-serve	0.35	0.25	4.37	16.7	0.00
R^2_{adj}	76.5%	Efficiency coefficient-reception	0.27	0.14	3.31	11.9	0.00
F	26.3	Efficiency coefficient-spike	0.48	0.26	5.74	**32.5**	0.00
p	0.00	Efficiency coefficient-block	0.22	0.08	2.65	5.3	0.01
		Efficiency coefficient-dig	0.39	0.19	4.69	12.9	0.00
R	0.90	Intercept		-2.17	-10.64		0.00
R^2	80.7%	Efficiency coefficient-serve	0.36	0.25	4.45	17.1	0.00
R^2_{adj}	77.2%	Efficiency coefficient-reception	0.29	0.15	3.63	12.8	0.00
F	23.0	Efficiency coefficient-att. spike	0.20	0.10	2.33	**8.9**	0.03
p	0.00	Efficiency coefficient-counteratt. spike	0.42	0.14	4.70	**26.5**	0.02
		Efficiency coefficient-block	0.15	0.05	1.70	3.6	0.10
		Efficiency coefficient-dig	0.37	0.18	4.48	12.2	0.00

Legend: R – coefficient of multiple correlation, $\mathbf{R^2}$ – coefficient of determination, $\mathbf{R^2_{adj}}$ – adjusted coefficient of determination, **F –** Fisher's test value, **β** – standardized regression coefficients, **b** – unstandardized regression coefficients, $\mathbf{R^2_{part}}$ – partial coefficient of determination**,** **t** – t–test value, **p** – significance level.

4 DISCUSSION

The purpose of this research was to present the multiple regression model with the attack and counterattack spike as separate variables as a more appropriate model than the one with the attack and counterattack spike merged as one variable.

Descriptive parameters showed that the attack spike is the game phase that had the highest situational efficiency coefficient, 3.12 out of 4, the maximal possible efficiency coefficient. The counterattack spike had a lower efficiency coefficient than the attack spike, 2.95. The game phase with the second highest efficiency coefficient was the reception with almost equal values as the counterattack spike. Next one was the block and serve, and the dig had the lowest situational efficiency coefficient, 1.95. The counterattack spike also had a higher standard deviation then the attack spike (0.40), the highest standard deviation of all game phases. It means that the teams were the most heterogeneous in the counterattack spike. This could be due to unstable conditions where the counterattack spike is performed. For comparison, serve had the lowest standard deviation, 0.20. The reason is that serve has the most stable conditions for execution, with no preceding game phase to disturb the performance.

However, a situational efficiency coefficient of a game phase does not represent its relationship with the set score. So multiple regression analyses were conducted to determine the aforementioned relationship. The results of both multiple regression analysis showed that the situational efficiency coefficient of the game phases had a high and significant relationship with the set score, 80.0% and 80.7%. In the first model, all regression coefficients of game phases were positive, an increase in their efficiency coefficients had a positive impact on the set score. The spike was the game phase that explained the most variance of the set score (32.5%), followed by serve (16.7%), dig (12.9%) and reception (11.9%) and finally block with only 5.3%.

Unlike the first regression model, the model with the attack and counterattack spike separated, block had no significant relationship with the score. Even in the first multiple regression model the block had the lowest common variance with the score. So when the spike was separated into two variables, the counterattack spike took over some of the block's common variance with the score due to its significant intercorrelation (0.40) and the block remaind with unsignificant relationship with the score. Statistically insignificant relationship of the block with the score could be unexpected. Marcelino et al. (2008) determined that the block points were a high indicator for success in volleyball. But they considered only the phases that win the points, the serve, spike and block, and each phase separately. Due to phases' intercorrelations and the ones with the other game phases, multiple regression parameters for the block are expected to be lower.

Also the attack spike and the counterattack spike had very different amounts of common variance with the score in the second regression model. The attack spike had 8.9% of common variance with the score and the counterattack spike 26.5% which is 3 times higher. As mentioned, a high efficiency coefficient does not imply a high impact on the set score. So attack spike being the game phase with the highest efficiency coefficient of all phases, had the second lowest amount of common variance with the set score. Contrary to the attack spike, counterattack spike had 26.5% of common variance with the score. It means that counterattack spike is the game phase that differentiates a winning from a losing set. Stutzig, et al. (2015) also determined that the best predictors for the score and the team level are the variables related to complex 2 (effectivity of counter-attack, effectivity of medium and slow attack-tempo) whilst the impact of complex 1 variables (action sequences of reception, setting and attacking) were marginal. Drikos, et al. (2021) state in their study that K1 (attack complex) does not differentiate teams of various performance levels. Even the weakest teams in a tournament can achieve a high success rate by playing under ideal conditions in K1. On the contrary, the variable differentiating the performance level between teams ranked in the upper group and the two other groups of lower-ranking was the effectiveness of attack after the reception (Drikos, et al., 2021).

The results also show that due to sequentiality of the volleyball game, the phases that the team can not win the point are not less relevant. The reception and dig had an unexpectedly high amount of common variance with the score considering that they are the phases that the team can not win the points with. They had a total of approximately 25% of common variance with the set score.

Laporta, et al. (2017) state that there are even six types of complexes in volleyball. Authors consider the serve as a separate complex (K0). Then they differentiate 5 complexes depending on the action the complex begins with, the reception, block-dig (serving team), block-dig (receiving team), attack coverage, freeball/downball. They also state that authors shouldn't incorporate K0, K3, K4 and K5 into K2 (counterattack). This shows that after the attack spike (K1) conditions of the game become more and more unstructured and with more possible variants. Hileno, et al. (2020) introduced also undefined complex (KU) referring to the actions that are difficult to classify. But the regression analysis model needs to be as simple as possible so including 5 or even 6 different types of spikes according to the complex would lead to other problems. The model might become too difficult to explain.

Practical application in the training process would be that the coaches have to produce the unstable conditions that the counterattack spike is executed in. Specifically, unstable conditions are reffered to as many as possible variants of the counterattack complex. Situational drills would be the better choice then the competitive conditions like the volleyball game itself. The drills that produce game situations give coaches better control of the game factors being practised. Practising in controlled conditions, the team has the possibility of more repetitions of the same game situation. Training in competitive conditions like the volleyball game itself the same game situation occurs many times less. The counterattack spike is a game phase that is executed mostly eight in a sequence and in unpredictable conditions. So it would be too exhausting for the players to accomplish necessary repetitions. But to be noted, practising in the competitive conditions is the best option when unpredictable situations have to be produced.

5 LIMITATIONS AND IMPLICATIOS

European League for Men is a top level volleyball competition so the limitation of this study is that its results could not refer to women's competition or other levels of competition. It is difficult to assume that the differences in the relationship with the set score between attack and counterattack spike would be similar if the volleyball sets were played in a women's competition or lower level. It is possible that in a women's competition, the attack spike is a phase that better differentiate winning from losing sets because spikes are not as strong as in men's competition and the teams might be less homogeneous. So the implication of this study is that further research should be conducted with volleyball sets collected from the lower level of competition or from the women's competition.

6 CONCLUSIONS

The multiple regression model with the attack and the counterattack spike as two separate variables showed that counterattack spike had 3 times higher relationship with the score. Also even three game phases had a higher relationship with the score, the serve, reception and dig. Only the block had a lower relationship than the attack spike. The scientific application of the results is to separate spike as the attack and counterattack spike when possible due to their specificity. The practical application of the results of this research is a recommendation for teams to place additional emphasis in the training process primarily on increasing the efficiency of the counterattack spike and also the phases that improves its execution, the block and the dig. Training process has to be more creative to produce the unstable conditions that the counterattack spike is executed in.

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