Abstract:

The purpose of this study was to confirm the possible statistically significant differences between two groups of teams – the group of semi-finalists (1st–4th place), and other teams (5th–8th place), on the basis of 6 situational parameters (serve, serve reception, block, defence, attack and counter-attack) in each of the 6 game rotations. A sample of 19 games played at the 2003 European Youth Volleyball Championship in Zagreb was used. The games were recorded and analysed by means of the “Data Volleyball” software. Each game was analysed for both participating teams. Canonical discriminant analysis (standard method) was employed to determine any possible differences. Discriminant functions showed significant differences between the two groups in rotations 5 and 3 (p<.01). In other rotations (1, 6, 4 and 2) there were no significant differences between these two groups. From the aspect of game complexes we can conclude that on the basis of the variable/phases of Complex II we can see the differences more clearly between the two groups. On the level of the game phases the variable service had the largest loadings across the discriminant functions, followed by the variables attack, block, and counter-attack. Serve reception and defence had low loadings on the discriminant functions.

Key words: volleyball, discriminant analysis, situational parameters, rotations, data volley software, European Championship, youth

Introduction

Integral match analysis, or notational analysis, implies a chain of actions like observing, collecting, saving, processing, interpreting and presenting data about participating teams’ efficiency during a match. After the global (cumulative) match analysis the efficiency of each game’s phase (service, service reception, attack, block, defence and counter-attack) has to be analysed for a particular set and rotation. With regard to specific game rules, one volleyball team has to practise the technical–tactical elements in each of the 6 rotations. Accurately defined formation of the players in the first or second line in a particular rotation can result in a more or less efficient performance. That performance can be influenced by numerous factors: technical-tactical knowledge, anthropometric characteristics, physical condition/fitness, as well as cognitive abilities and personality traits. Strahonja (1983) analysed the relationships between specific motor abilities and performance in volleyball. The results showed that the greatest contribution to explaining performance is given by power and accuracy factors. A considerably lower contribution is made by the factor of speed of movement and speed endurance. Strahonja and Prot (1983) conducted an investigation on a group of 52 students of the Faculty of PE in Zagreb. The finding was that basic motor abilities: co-ordination, explosive power, accuracy, frequency of alternate movements, speed of movement, balance, strength and endurance are probably responsible for performance of volleyball players. Strahonja and Matković (1983) found a correlation between latent anthropometric characteristics and situational efficiency of volleyball players.

There are numerous research studies on the influence of game situational parameters on victory, defeat or final standings of volleyball teams. Eom and Schutz (1992a) attempted to extract, from among the selected technical-tactical components, the most powerful predictor or a group of predictors of team success. The study has shown that the differences between the matches won and the matches lost are more expressed in those technical-tactical elements that are executed while organizing a counter-attack: block, court defence, setting
and spike. Finally, the discriminant analysis has shown that block and spike are the most important elements for determining the success of a team. Using notational analysis of volleyball matches Marelić (1998) researched the characteristics of team play of international volleyball for juniors. An analysis of differences between 8 phases of play in volleyball showed, on the basis of the sets won and the sets lost, that the variables spike/attack and setting/counter-attack had the highest loadings on the discriminant function, whereas the variables block, defence, setting/attack and spike/counter-attack had low loadings.

Marelić, Rešetar and Janković (2004) determined the differences between 76 won and lost sets obtained from 20 matches played in the Italian A1 league. The canonical discriminant function significantly differentiated between the sets won and the sets lost (p<.00). The discriminant function was defined by the highest loadings of the variable spike/attack, and by somewhat lower loadings of the variables spike/counter-attack, serve reception, block and serve.

Palao, Santos and Urena (2004) studied the effect of team’s quality level on the performance of skills (serve, reception, spike, block and dig) in top-level volleyball at 33 male matches and 23 female matches of the 2000 Olympic Games in Sydney. In males, the results showed that block is the skill that differentiated the teams of level 1 from the teams of level 2. A reduction of error in relation to the level of the team was observed. In females, the authors found the significant difference in the performance of the spike in favour of the teams of level 1. An increase in success of reception, spike, block and dig in relation to the level of the team was observed.

The purpose of the present study was to find out any statistically significant differences between two groups of teams – the group of semi-finalists (1st–4th place), and other teams (5th–8th place), on the basis of 6 situational parameters (serve, serve reception, block, defence, attack and counter-attack) in each of the 6 game rotations. Such an approach to this research was inspired by many situations from practice where it has been indicated that balanced quality performance through all the rotations is one of the key factors to winning (Đurković, 2007). One of the specificities of this research is the sample - youth national volleyball teams (all previous studies have been conducted on the samples of either junior or senior national and international teams).

**Methods**

The sample was comprised of 19 games played by 8 national teams during the preliminary and final round of the 2003 European Youth Volleyball Championship held in Zagreb. Each game was analysed for both participating teams (representing the total of 38 cases). In the preliminary round the teams were divided into two groups: “A” (Poland, The Nederlands, Germany and Croatia) and “B” (Russia, Slovakia, Czech Republic and Italy). Matches in groups were played in a single round-robin system. The first two teams classified in each preliminary pool qualified for the semi-finals (1st–4th place) and third and fourth ones played for ranking (5th–8th place).

The set of predictor variables consisted of 6 standard situational efficiency indicators recorded for each team during the games: serve (serve), serve reception (reception), attack (attack), block (block), court defence (defence) and counter-attack (counter-attack). By using DATAVOLLEY software the quality of executing each game phase was evaluated on an ordinal 5-degree scale (Table 1). The first two degrees denote the positive realization - actions enabled either winning an advantage or winning a point; the third degree on the scale denotes the execution in which an action is continued without an advantage for the team, whilst the last two degrees denote the negative realization, for example, an action that gives an advantage to the opponent or an error committed by the own team. This procedure is standardized and used by the best national selections at all big international and national competitions.

The frequencies of each technical-tactical element were used to collect the necessary data. Further, although each technical-tactical element was ranked on the 5-degree scale, the collected frequencies were put in the formula:

\[
\text{Total number of frequencies} = (\text{No. of fr.}(=)\times x1) + (\text{No. of fr.}(=)\times x2) + (\text{No. of fr.}(=)\times x3) + (\text{No. of fr.}(+)\times x4) + (\text{No. of fr.}(#)\times x5)
\]

* fr. = frequencies

**Table 1. Ordinal 5-degree scale**

<table>
<thead>
<tr>
<th>Ordinal 5-degree scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double positive realization (#)</td>
<td>winning a point</td>
</tr>
<tr>
<td>Positive realization (+)</td>
<td>gaining advantage after an action</td>
</tr>
<tr>
<td>Neutral realization (/)</td>
<td>action is continued without advantage for the team</td>
</tr>
<tr>
<td>Negative realization (-)</td>
<td>action that gives advantage to the opponent</td>
</tr>
<tr>
<td>Double negative realization (==)</td>
<td>error, losing a point</td>
</tr>
</tbody>
</table>

61
Such a calculation produces values on the ordinal scale for each of the five situational efficiency indicators. These values can be further used for statistical analysis.

The criterion variable was defined binary differentiating between the games played by the semi-finalists (1) and the other teams (0).

Data analysis methods. The central and dispersion parameters were calculated for both groups of teams in all the 6 rotations. The discriminant analysis was used to determine any possible differences between the two groups of teams in each of the 6 rotations.

Results

The results of discriminant analysis (standard method) between the two groups of teams in each of the 6 rotations are presented in Table 2.

The position of players in the line-up, Complex II (counter-attack phase) and Complex I (attack phase) in rotations 5 and 3 are presented in Figure 1.

Table 3 shows the parameters of descriptive statistics of specific volleyball phases for both groups of teams for rotations 5 and 3.

Table 2. Discriminant analysis – standard methods

<table>
<thead>
<tr>
<th></th>
<th>λ</th>
<th>R</th>
<th>χ²</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROT1</td>
<td>.12</td>
<td>.32</td>
<td>3.68</td>
<td>6</td>
<td>.72</td>
</tr>
<tr>
<td>ROT6</td>
<td>.31</td>
<td>.49</td>
<td>8.88</td>
<td>6</td>
<td>.18</td>
</tr>
<tr>
<td>ROT5</td>
<td>.75</td>
<td>.66</td>
<td>18.51</td>
<td>6</td>
<td>.00</td>
</tr>
<tr>
<td>ROT4</td>
<td>.11</td>
<td>.32</td>
<td>3.58</td>
<td>6</td>
<td>.73</td>
</tr>
<tr>
<td>ROT3</td>
<td>.51</td>
<td>.78</td>
<td>30.37</td>
<td>6</td>
<td>.00</td>
</tr>
<tr>
<td>ROT2</td>
<td>.38</td>
<td>.53</td>
<td>10.66</td>
<td>6</td>
<td>.10</td>
</tr>
</tbody>
</table>

Legend: λ - eigenvalue, R - canonical correlation, χ² - chi-square test, df - degrees of freedom, p - level of significance

Figure 1. The position of players in the line-up, Complex II (counter-attack phase) and Complex I (attack phase) in rotations 5 and 3.

Table 3. Descriptive statistics of volleyball phases in rotations 5 and 3

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>ROTATION 5 – SEMI-FINALISTS</th>
<th>ROTATION 3 – SEMI-FINALISTS</th>
<th>ROTATION 5 – OTHERS</th>
<th>ROTATION 3 – OTHERS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>SERVE</td>
<td>20</td>
<td>2.57</td>
<td>2.00</td>
<td>3.14</td>
</tr>
<tr>
<td>RECEPTION</td>
<td>20</td>
<td>3.91</td>
<td>2.64</td>
<td>5.00</td>
</tr>
<tr>
<td>DEFENCE</td>
<td>20</td>
<td>2.97</td>
<td>1.00</td>
<td>4.25</td>
</tr>
<tr>
<td>BLOCK</td>
<td>20</td>
<td>2.28</td>
<td>1.00</td>
<td>3.50</td>
</tr>
<tr>
<td>ATTACK</td>
<td>20</td>
<td>3.76</td>
<td>2.33</td>
<td>4.67</td>
</tr>
<tr>
<td>CATTACK</td>
<td>20</td>
<td>3.68</td>
<td>2.00</td>
<td>5.00</td>
</tr>
</tbody>
</table>

Legend: N - number of cases, MEAN - arithmetic mean, MIN – minimum, MAX – maximum, SD - standard deviation
Table 4 shows the correlations between the variables and discriminant functions, as well as the results of centroids of the games played by the semi-finalists and the games played by other teams on the discriminant functions for rotations 5 and 3.

Table 5 shows the results of the classification of the games played by the two groups of teams on the basis of the discriminant functions for rotations 5 and 3.

Discussion and conclusion

The results presented in Table 2 make it possible to conclude that the discriminant function significantly discriminates between the two groups of teams (p<.01) in rotations 5 and 3. In the other rotations there were no significant differences between the semi-finalists and the other teams.

The obtained results for rotation 5 make it possible to conclude that the discriminant function significantly discriminates between the games played by the semi-finalists from the games played by the other teams (p<.01), with a relatively high canonical correlation (.66). It may be concluded that six volleyball phases can differentiate well between two groups of volleyball teams in rotation 5.

Table 3 (Rotation 5) represents data obtained by means of descriptive statistics. Arithmetic means, maximal and minimal results and standard deviations were calculated. The differences between arithmetic mean values in performance of a game phase could be noticed. The highest differences are to be seen in the variable serve (semi-finalists 2.57 vs others 2.27), counter-attack (semi-finalists 3.68 vs others 3.1) and attack (others 4.05 vs semi-finalists 3.68).

Table 4 (Rotation 5) shows the correlation between the variables and discriminant function as well as the position of the centroids of the games, played by both groups of teams, on the discriminant function. The structure of the discriminant function was bipolar. The semi-finalists were located on the negative pole and other teams on the positive pole. The negative pole was defined by the following variables: serve, counter-attack and defence, and the positive pole by the variables: attack, reception and block.

The discriminant function was defined by the highest loading of the variable serve (-.54). The serving player in rotation 5 is the middle blocker 2 (Figure 1). It is those players (Ostapenko/Russia and Mozdzonek/Poland) who were the most efficient servers in their teams. The variable counter-attack had a lower loading (-.33). That is very logical because counter-attack is the next chain in the chain of Complex II – a very aggressive serve (power jump serve) results in either scoring a direct point or in situations from which it is easier to realize a counter-attack. Variable attack (.29) was situated on the positive pole of the discriminant function. That means that other teams were even successful in this variable. Variables reception (.10), block (.08) and defence (-.06) had minimal loadings on the discriminant function.

The predictive power of the variables of Complex II is confirmed in the study conducted by Zetou, Tsigilis, Moustakidis, and Komninakidou (2006) who concluded that an “ace” in serve and successful spike in a counter-attack remain the most powerful aggressive tools for top-level teams and were predictors of victory. None of the three dig or the four block categories significantly discriminated to a game’s outcome.

Table 5 (Rotation 5) shows the results of the classification of the games played by the two groups of teams on the basis of the discriminant function. Out of 18 games played by the other teams, 16 were well classified, which amounts up to 88.89%, whereas out of 20 games played by the semi-finalists, 18 were well classified, which amounts up to 90%. The results (89.47% in total) confirm
a very high discriminant value of the suggested variables.

The obtained results for rotation 3 show that the discriminant function significantly discriminates between the games played by semi-finalists from the games played by the other teams (p<.00), with a very high canonical correlation (.78). It may be concluded that the six variables can differentiate well between the two groups of volleyball teams. Table 3 (Rotation 3) represents data obtained by means of descriptive statistics. The highest differences between arithmetic mean values in game phases are presented in block (others 3.45 vs semi-finalists 2.46), attack (semi-finalists 3.94 vs others 3.43) and serve (semi-finalists 2.69 vs others 2.46).

Table 4 (Rotation 3) displays the correlation between the variables and discriminant function as well as the position of the centroids of the games, played by both groups of teams, on the discriminant function. The structure of the discriminant function was bipolar. The semi-finalists were located on the positive pole and the other teams on the negative pole. The positive pole is defined by the following variables: attack, serve, reception and defence, and the negative pole by block and cattack. The discriminant function was defined by the highest loadings of the variable block (-.56). Taking into account that the variable block is situated on the negative pole, it can be assumed that the group of the other teams performed better in that variable. In rotation 3 blocks were performed by the setter, receiver attacker 1 and middle blocker 1 (Figure 1). Thus, logically, domination in the block by the other teams influenced slightly the domination in cattack (-.13).

Alfonso, Mesquita, and Palao (2006) analysed the impact of the blocking system and the number of blockers on blocking efficiency. The results showed that the use of the commit-block (blocking tactic) makes it difficult to formate double and triple blocks and does not increase the block effectiveness, or it does not enhance the opponent’s errors in spiking.

The variable attack, placed on the positive pole, had a high predictive value (.33) followed by the variable reception (.17). That is logical because efficiency in that variable is a precondition for efficiency in attack. The explanation may be found in the fact that spike in the phase of attack is mostly executed after a positive serve reception, upon which the setter has the opportunity to organize a fast and combined attack that will disrupt the opponent’s block and defence system organization. The results of the study of Janković, Marelić and Milanović (1991) confirmed the high values of co-operation between the setters and attackers in all situations of the game: during negative, alternate or ideal serve reception. It is obvious that a correlation between setting and attacking has the highest influence on the final success of a team. The similar results reporting on the correlation of reception, setting and attack were obtained by Eom and Schutz (1992b).

Even in this rotation the group of the semi-finalists predominated in serve (0.22), but the group of the other teams performed block and counter-attack phases better. Group of semi-finalists retained domination in Complex I (variables reception and attack). The results of the study by Yannis and Panagiotis (2004) showed that the Athens gold-medallist team of Brazil had, in addition to the previously said, remarkable reception effectiveness which led to an outstanding attack capability, thus re-establishing the attack as the most important skill in volleyball.

Table 5 (Rotation 3) shows the results of the classification of the games played by the two groups of teams on the basis of the discriminant function. Out of 18 games played by the other teams, 14 were well classified, which amounts up to 77.78%, whereas out of 20 games played by the semi-finalists, 17 were well classified, which amounts up to 85%. The results (81.58% in total) confirm a very high discriminant value of the suggested group of variables.

The results obtained enabled the conclusion that the two groups of volleyball teams could be better distinguished on the basis of the phases of Complex II. Actually, it was expected, since it is more difficult to win a point within that game complex. Even less successful teams can score a considerable number of points within Complex I. The main reason is that spike in the phase of attack is mostly executed after the positive serve reception, upon which the setter has the opportunity to organize a fast and a combined attack. Marelić, Rešetar, Zadražnik and Đurković (2005) made the efficiency performance model (of the volleyball phases) expressed in percentages, with the structure of points achieved within a certain phase of the game that one team should achieve in order to win a volleyball set. The authors concluded that successful teams have won about 9 points with spiking in Complex I and about 5 points with spiking in Complex II. Thus, the variable serve had the highest loadings on the discriminant functions followed by the variables attack, block and counter-attack. The variables reception and defence had lower loadings on the discriminant functions.
References


Submitted: April 8, 2008
Accepted: May 19, 2009

Correspondence to:
Assist. Tomislav Đurković, M.Sc.
University of Zagreb, Faculty of Kinesiology
Horvačanski zavoj 15, 10 000 Zagreb, Croatia
Phone: +385 1 36 58 641
Fax: +385 1 36 34 146
E-mail: tdjurko@kif.hr
ROTACIJSKA ANALIZA EKIPNE IGRE NA EUROPSKOM PRVENSTVU U ODBOJCI 2003. U ZAGREBU

Sažetak

Uvod

Integralna analiza utakmice podrazumijeva niz radnji usmjerenih na promatranje, praćenje, prikupljanje, pohranjivanje, obradu, interpretaciju i prezentaciju podataka o vlastitoj igri i igri protivnika za vrijeme i nakon utakmice. S obzirom na specifičnost odbojke ekipa se mora uvježбавati u svih 6 rotacija igre. Točno određeni raspored igrača na mreži i u polju u određenoj rotaciji može rezultirati više ili manje uspješnom igrom, na što utječe puno faktora, kao što su: tehničko-taktička znanja igrača, antropometrijske karakteristike, njihove motoričke, funkcionalne i kognitivne sposobnosti te konatifne osobine. Cilj ovoga istraživanja je usporedbu skupina požitivnih i kontrarnapada i ostalih varijabla u toj varijabli usmjerenih na promatranje, praćenje zasebno.

Promatran varijablama pad kontranapada varijablama promatranim varijablama). Najveća deskriptivna razina (usporedba srednjih ocjena u osnovi odabranog skupa varijabli nisu evidentirane u varijablama servis, prijem servisa i obrana polja, a pozitivni napad, prijem servisa i blok).

Najveću projektiju na diskriminacijsku funkciju ima varijabla servis (-.54). Do nje po veličini projekcije nalazi se varijabla kontranapad (-.33). Ti rezultati govore da grupa polufinalista dominira učinkovitošću u kompleksu II, tj. u fazama igre koje slijede nakon vlastitog servisa (uključujući servis). Vrlo je vjerojatno da agresivan servis (većina igrača na ovom turniru servirala je agresivan skok servis) u ovom rotaciji dovodi ili do izravnih poena ili do olakšanog kontranapada za reprezentacije polufinalista. Nižu projektiju ima varijabla napad (.29) u čijoj izvedbi je skupina ostalih ekipa bila ravnopravna, često i uspješnija. Varijable prijem servisa (.10), blok (.08) i obrana polja (.06) imale su minimalne projekcije na diskriminacijsku funkciju.

U rotaciji 3 strukture diskriminacijske funkcije je također bipolarna. Polufinalisti su smješteni na pozitivnom, a ostale ekipa na negativnom polu. Pozitivni pol definiraju varijable napad, servis, prijem servisa i obrana, a negativni varijabli blok i kontranapad.

Najveću projektiju na diskriminacijsku funkciju ima varijabla blok (-.56). S obzirom na to da se ta varijabla nalazi na negativnom polu, možemo pretpostaviti da je skupina ostalih ekipa bila uspješnija u toj fazi igre. S obzirom na dominaciju u fazi bloka, logički slijedi: dominacija skupine ostalih ekipa u varijabli kontranapad (-.13). Slijedeća varijabla po veličini je napad (.33), koja se nalazi na pozitivnom polu, što znači da su u toj varijabli bile učinkovitije ekipi polufinalistica, kao i u varijabli servis (.22). Varijabla prijem servisa (.17), nalazi se s niskom projekcijom na pozitivnom polu, što je i logično jer je učinkovitost u njoj jedan od preduvjeta za visoku učinkovitost u varijabli napad (precizan prijem omogućava brži i raznovrsniji napad protiv slabije organiziranog sustava bloka i obrane). Skupina polufinalista, dakle, zadržava dominaciju u kompleksu I.

Metode istraživanja

Uzorak entiteta čini 19 utakmica odigranih na EP kadeta u Zagrebu 2003. godine. Natjecalo se 8 reprezentacija koje su bile podijeljene u dvije skupine: skupinu "A" (Poljska, Nizozemska, Njemačka i Hrvatska) i skupinu "B" (Rusija, Slovačka, Češka i Italija). Nakon odigranih utakmica po skupinama, slijedile su utakmice za plasman. Prediktorski skup varijabli predstavljaju sljedeće faze odbojkaške igre: servis, prijem servisa, napad, blok i obrana i kontranapad. Kriterijska varijabla binarno je definirana i diferencira odigrane utakmice reprezentacija polufinalista (1) od ostalih reprezentacija (0). Podaci o odigranih utakmica blizanženi su s pomoću statističkog programa DATAVOLLEY. Statističkim programom Statistica 7.0. izračunati su deskriptivni pokazatelji za obje skupine ekipa, a diskriminacijskom se analizom provjerena razlika u igri između polufinalista i ostalih ekipa u toj fazi igre.

Rezultati

U rotaciji 5 struktura diskriminacijske funkcije je bipolarna. Polufinalisti su smješteni na negativnom, a ostale ekipa na pozitivnom polu. Pozitivni pol definiraju varijable servis, kontranapad i obrana polja, a pozitivni napad, prijem servisa i blok.

Rasprava i zaključak

Gledajući s aspekta kompleksa igre može se zaključiti da se na osnovi varijabli iz kompleksa II ove dvije skupine ekipa mogu puno bolje razlikovati. To je zapravo i logično jer je u kompleksu kontranapadu puno teže doći do poena. Naime, u odbojci ekipa koja prima servis i organizira napad u određenoj prednosti pa i manje kvalitetne eike završavaju fazu napada sa čak 55 - 60 % uspješnosti. Kada analiziramo vrijednosti samo na razini faza, onda se može vidjeti da je najveće projekcije na diskriminacijske funkcije imala varijabla servis, zatim varijabla napad, blok te varijabla kontranapad. Vrlo niske projekcije imale su varijable prijem servisa i obrana.