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A longitudinal study of the success factors in high-level male Volleyball

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Abstract

In Volleyball a team's performance in skills is connected to the game result and to the team's success in a championship. In order to identify the determinant parameters for the success in male volleyball, performance data for all teams of 12 Greek Volleyball championships from 2005-06 until 2016-17 (n=143) was used. The effectiveness of fourteen (14) parameters from 5 basic volleyball skills: serve, attack after passing, attack after defence, block and reception was examined. The findings lead to the conclusion that the best predictors of a team's success in final ranking are serve aces, passing errors, precise pass and attack after passing or after defence. The relevant discriminant function has classified correctly 77.6% of the teams in positions 1-4, 5-8 and 9-12. Furthermore, among teams in positions 1-2 and 3-4 (n=48) the variables attack win and attack error, after reception and defence have significantly higher scores and are able to discriminate correctly 83,3% of the original cases.

Keywords: match analysis; skills; attack; performance indicators; outcome.

1 Introduction

Quantitative analysis, performance evaluation and statistical processing are becoming an increasingly important process for those involved in several sports and, in particular, in team sports (O' Donoghue, 2010). Especially in volleyball, it is important to collect data from the observation and evaluation of the sport skills in order to carry out match analysis, to make decisions during matches and to analyze home team and opponents in a competition (Coleman, 2002). Volleyball is offered for such analyses due to the large number of contacts made by players during the match so as to ensure the adequate analysis of a team's technical and tactical performance (Peppler, 2002).

Volleyball consists of a series of individual skills that are highly relevant to the team's performance and success (Patsiaouras, Moustakidis, Charitonidis, & Kokaridas, 2011; Patsiaouras, Moustakidis, Charitonidis, & Kokaridas, 2010; Drikos, Kountouris, Laios, & Laios, 2009; Palao, Santos, & Urena, 2004). Three of them are scoring skills: serve, attack (split in attack 1 after reception & attack 2 after defence), block, and the rest are non-scoring skills: pass, setting and dig (Nishijima, Ohswava, & Matsuura, 1987). Scoring skills have a stronger correlation with the result (Laios & Kountouris, 2005). However, as for the serve, in more recent studies, Pena, Rodriguez-Guerra, Busca, and Serra (2012) have pinpointed the limited importance of the technical skill of the serve and in extension to this, Kountouris, Drikos, Aggelonidis, Laios, and Kyprianou (2015) mentioned that in men's high-level volleyball serve is a disadvantage for the team which is to perform it.

On the other hand, the attack is the main factor to predict whether a team will win or lose (Castro, Souza, & Mesquita, 2011; Drikos & Vagenas, 2011; Marcelino, Mesquita, &

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Alfonso, 2008) without distinguishing attack after a pass from attack after defence. Zetou, Moustakidis, Tsigilis, and Komninakidou (2007) using data from an Olympic tournament proved that effectiveness in complex 1 (pass-setting-attack 1) can predict winners in Men's top-level volleyball, and attack after defense is the most important skill for a team's performance during complex 2 (serve-block-setting-attack 2) (Zetou, Tsigilis, Moustakidis, & Komninakidou, 2006). In addition, the block is the skill that differentiates teams of level 1 from the teams of level 2 with data from 2000 Olympic Games (Palao, Santos, & Urena, 2004), but its recording and evaluation is difficult since only blocks with a touch of the ball are recorded.

Many coaches attribute the main reason for a defeat to a poor efficiency in the reception. The importance of reception has been confirmed in many types of studies (Barzouka, Nikolaidou, Malousaris, & Bergeles, 2006; Papadimitriou, Pashali, Sermaki, Mellas, & Papas, 2004; Eom & Schutz, 1992), while other studies (Drikos, 2018; Florence, Fellingham, Vehrs, & Mortensen, 2008; Lobietti, Michele, & Merni, 2006) proposed the avoidance of direct errors to be of equal importance with accurate pass.

Most of the previous studies were carried out using accumulated data of volleyball skills from a tournament (Patsiaouras et al., 2011; Palao et al., 2004) or a single championship (Stamm, Stamm, Torilo, Thompson, & Jairus, 2016; Drikos et al., 2009) in order to determine the most important of them. The primary aim of the present study is to identify those parameters that discriminate the teams ranked in positions 1-4 from those ranked in positions 5-8 and 9-12, through a longitudinal analysis of 12 championships of the Greek Volleyball League. An additional aim is to point out the determinant performance indicators that classify the teams of the first 4 positions of a professional championship in two groups: those that are placed 1-2 and having an advantage for playoffs comparing to those placed in 3rd-4th positions.

2 Method

In the Greek men's league, during the last twelve years, a system to collect, elaborate and analyze statistical data has been established. The official system used in men's Greek Volleyball Professional League is Data Volley (Data Project, 2000) with the main purpose to record and analyze the performance of teams and players. The skills recorded are serve, reception, attack 1 (after the pass), attack 2 (after defense) and block.

In the Greek Volleyleague, 12 teams compete every year. The sample (n=143) of the present study consists of the performance data of each team of the Greek male Volley league from 12 seasons (2005-06 until 2016-17). A team which disqualified before the end of the regular season from the championship 2011-12 was excluded from the sample. The primary recorded and evaluated skills from 1562 matches were: 257.184 serves, 216.140 passes, 181.811 attacks 1 (after the pass), 103.106 attacks 2 (after the defense) and 109.022 blocks. For the evaluation scale of each skill, a six-level ordinal scale is employed, with the value of "one" indicating a poorly executed skill and the value of "six" an excellent executed skill. The entire evaluation scale is presented in table 1. Further definitions for the evaluation scale per skill are included in: Drikos and Ntzoufras (2015) about the serve, Costa, Alfonso, Barbosa, Coutinho, and Mesquita (2014) about the attack, Palao et al. (2004) about the block, and Drikos (2018) about thereception.

The reliability of the data collection and entry was checked by an independent observer as following: all the matches are video recorded and for each championship five particular match days were randomly selected (30 matches per season, 23% of the total sample) and an independent observer who was a volleyball coach, expert in evaluation and recording of volleyball performance data and excellent user of the software, re-evaluates all the skills. The Adjusted K Cohen was Adjusted K= .81, very good (Altman,

1991). Set statistics included percentages (%) of the following fourteen (14) performance indicators: 1) Serve Error %, 2) Serve Ace %, 3) Serve over % (result in overpass) 4) Pass Error %, 5) Pass over the net % (Overpass), 6) Pass precise % (Pass perfect %+Pass excellent %), 7) Attack 1 Errors %, 8) Attacks 1 stuffed by kill block %, 9) Attack 1 win %, 10) Attack 2 errors %, 11) Attacks 2 stuffed by kill block %, 12) Attack 2 win %, 13) Block points % 14) Block errors%.

Table 1. Evaluation ordinal scale for scoring skills and reception.

Skill/ Level	Scoring Skills			Non-scoring skills
	Serve	**Attack 1,2**	**Block**	**Pass**
6	Ace (point)	Win-kill (point)	Win-kill (point)	Excellent pass. All options for attack without adjustments for the setter
5	Over The ball to the serving team	The ball to the attacking team with good conditions or to the defending team with bad conditions	The ball to the blocking team with good conditions or to the attacking team with bad conditions	Good Pass. All options for attack
4	One option for attack for the receiving team	The ball to the attacking or defending team with medium conditions	The ball to the blocking or attacking team with medium conditions	Two options for attack from the sidelines
3	Two options for attack for the receiving team	The ball to the attacking team with bad conditions or to the defending team with good conditions	The ball to the blocking team with bad conditions or to the attacking team with good conditions	One option for attack or attack out of the system
2	All options for the attack on the receiving team	Stuffed by a Kill block (lost point)	Error on the net (Incorrect touch of the net, lost point)	Overpass The ball was passed directly to the serving team court.
1	Error (lost point)	Error (lost point)	Error (lost point)	Error (lost point)

A three-group MANOVA was conducted comparing all fourteen performance indicators (dependent variables) between the 3 groups of teams ranked each year in positions 1-4, 5-8, 9-12. A follow-up linear discriminant analysis (stepwise method) was conducted to determine which of the selected performance indicators classified correctly the teams in the 3 groups. Proper scatter, normality and box plots were used to check the assumptions of linearity, normality and outliers. Box's M test was used to check the assumption of homogeneity of covariance matrices. Validation of the discriminant model was conducted using "leave one out" classification with each case being classified by applying the classification function on all the data except the particular case. A second discriminant analysis was used to identify performance indicators that discriminate teams ranked in positions 1-2, which have the home advantage in playoffs, against teams ranked

in positions 3-4 in order to have a possible more detailed differentiation between top-teams of the championship.

3 Results

Table 2 summarizes all the variables employed in this study for teams' performance-related statistics for all groups.

Table 2. Performance indicators for the whole group (n=143) as well as group 1-4 (n=48) group 5-8 (n= 48) and group 9-12 (n=47). Values are presented as mean ± SD.

Performance Indicator	All teams (n=143)	Group 1-4 (n=48)	Group 5-8 (n=48)	Group 9-12 (n=47)
Serve Error %	.157 (±.022)	.157 (±.023)	.154 (±.021)	.161 (±.021)
Serve Ace %	.060 (±.012)	.065 (±.013)	.061 (±.011)	.054 (±.008)
Serve Over %	.036 (±.014)	.038 (±.014)	.037 (±.013)	.036 (±.013)
Pass Error %	.066 (±.010)	.066 (±.010)	.069 (±.010)	.078 (±.013)
Overpass %	.040 (±.019)	.038 (±.017)	.039 (±.020)	.043(±.020)
Pass precise %	.578 (±.056)	.600 (±.056)	.580 (±.054)	.557 (±.053)
Attack 1 error %	.085 (±.012)	.078 (±.010)	.086 (±.011)	.092 (±.012)
Attack 1 block %	.094 (±.015)	.080 (±.011)	.097 (±.010)	.104 (±.014)
Attack 1 kill %	.517 (±.039)	.552 (±.031)	.515 (±.022)	.484 (±.028)
Attack 2 error %	.098 (±.016)	.090 (±.016)	.099 (±.014)	.101 (±.016)
Attack 2 block %	.103 (±.016)	.091 (±.034)	.108 (±.014)	.111 (±.014)
Attack 2 kill %	.457 (±.038)	.486 (±.034)	.455 (±.026)	.429 (±.031)
Block kill %	.264 (±.058)	.263 (±.053)	.263 (±.056)	.264 (±.066)
Block error %	.339 (±.084)	.338 (±.081)	.329 (±.010)	.347 (±.067)

There were no missing values, extreme scores, or outliers in the data set, and the basic statistical assumptions were tested and met. In particular, there was no multicollinearity between the dependent variables as the simple correlations, presented in table 3 were all <|.65|). A statistically non-significant Box's M test (p=.066) indicated equal variance-covariance matrices of the dependent variables (performance indicators) across the ranking group, while the Bartlett Test of Sphericity verified the presence of significant correlations among the fourteen dependent variables (approx. x2=2437.76, p=.000) and thus, the use of Wilk's Lambda in assessing the multivariate effect is feasible. The main results of MANOVA showed that the linear combination of the fourteen performance indicators differentiated significantly across the team groups: (Wilk's Lambda=.248, F (28, 254) =9.15, p=.000, partial η2 =.502). A series of F tests were carried out on the significant main effect of MANOVA and the results (presented in table 4 in italics) with respect to the factor team group were highly significant (p<.001) for the following performance indicators: Serve aces, Pass errors, Pass precise, Attack 1 errors, Attacks 1 stuffed by kill block, Attack 1 win, Attack 2 errors, Attacks 2 stuffed by kill block and Attack 2 win. This finding was further examined by Scheffe post hoc comparisons tests because the homogeneity of variance was present. All the results are shown in table 4.

Table 3. Correlation matrix of selected performance indicators.

	Serve Error %	Serve Ace %	Serve over %	Pass Error %	Over pass %	Pass precise %	Attack 1 error %	Attack 1 block %	Attack 1 kill %	Attack 2 error %	Attack 2 block %	Attack 2 kill %	Block kill %	Block error %
Serve Error %	1													
Serve Ace %	.472	1												
Serve Over %	-.122	.030	1											
Pass Error %	.291	.091	-.198	1										
Overpass%	-.259	-.184	.580	-.139	1									
Pass precise %	.223	.214	-.491	-.088	-.632	1								
Attack 1 error %	.224	-.151	-.198	.340	.009	-.093	1							
Attack 1 block %	.080	-.275	.007	.409	.027	-.301	.371	1						
Attack 1 win %	.111	.446	-.186	-.174	-.342	.548	-.453	-.645	1					
Attack 2 error %	.185	-.126	-.214	.158	-.145	.151	.508	.284	-.203	1				
Attack 2 block %	.039	-.248	-.013	.170	-.067	-.084	.265	.532	-.333	.238	1			
Attack 2 win %	.173	.460	-.210	-.028	-.301	.393	-.271	-.490	.644	-.318	-.391	1		
Block kill %	-.188	-.042	-.084	-.014	.038	-.059	.027	.017	-.024	.017	-.059	.144	1	
Block error %	.145	.161	-.180	.131	-.288	.290	.028	-.107	.085	.009	-.008	.041	-.323	1

Table 4. Test of between subjects' effect (in italics) and multiple comparisons with a mean difference (significance in brackets) and 95% Confidence Intervals.

Performance Indicator	G 1-4 vs G 5-8	G 1-4 vs G 9-12	G 5-8 vs G 9-12	CI 95%
Serve Error %	.003 (.753)			-.007 to .014
F(2,140)=1.52		-.004 (.615)		-.015 to .007
p=.223			-.008 (.224)	-.019 to .003
n^2= *.021*				
Serve Ace %	.005 (.127)			-.001 to .010
F(2,140)=11.47		.011 **(.000)**		.005 to .017
p=.000			.006 **(.026)**	.001 to .012
n^2= *.141*				
Serve Over%	.000 (.987)			-.006 to .007
F(2,140)=.64		.003 (.577)		-.004 to .010
p=.530			.002 (.674)	-.004 to .009
n^2= *.009*				
Pass Error %	-.003 (.377)			-.009 to .002
F(2,140)=14.98		-.012 **(.000)**		-.018 to -.006
p=.000			-.009 **(.001)**	-.015 to -.003
n^2= *.176*				
Overpass %	-.001 (.938)			-.011 to .008
F(2,140)=.92		-.005 (.423)		-.015 to .004
p=.399			-.004 (.632)	-.014 to .006
n^2= *.013*				
Pass precise %	.017 (.295)			-.010 to .045
F(2,140)=6.25		.039 **(.003)**		.012 to .067
p=.003			.022 (.148)	-.006 to .049
n^2= *.082*				
Attack 1 error %	-.009 **(.001)**			-.014 to -.003
F(2,140)=20.31		-.014 **(.000)**		-.020 to -.009
p=.000			-.055 (.052)	-.011 to .000
n^2= *.225*				
Attack 1 block %	-.017 **(.000)**			-.023 to -.012
F(2,140)=55.00		-.024 **(.000)**		-.030 to -.018
p=.000			-.007 **(.018)**	-.013 to -.001
n^2= *.440*				
Attack 1 win %	.037 **(.000)**			.023 to .051
F(2,140)=71.29		.067 **(.000)**		.053 to .081
p=.000			.030 **(.000)**	.016 to .044
n^2= *.505*				
Attack 2 error %	-.009 **(.020)**			-.016 to -.001
F(2,140)=7.33		-.011 **(.002)**		-.019 to .004
p=.001			-.002 (.795)	-.010 to .005
n^2= *.095*				
Attack 2 block %	-.016 **(.000)**			-.023 to -.010
F(2,140)=27.55		-.019 **(.000)**		-.026 to -.013
p=.000			-.002 (.718)	-.010 to .004
n^2= *.282*				
Attack 2 win %	.031 **(.000)**			.016 to .046
F(2,140)=42.36		.057 **(.000)**		.041 to .073
p=.000			.026 **(.000)**	.011 to .041
n^2= *.377*				
Block kill %	-.0001 (1.0)			-.030 to .029
F(2,140)=.003		-.0008 (.998)		-.031 to .029
p=.997			-.0007 (.999)	-.030 to .029
n^2= *.000*				
Block error %	.009 (.874)			-.033 to .051
F(2,140)=.563		-009 (.862)		-.052 to .033
p=.571			-.018 (.571)	-.061 to .-024
n^2= *.251*				

The follow-up discriminant analysis yielded a discriminant function (Wilk's Lambda= .290, x2= 168.22, p=.000, η2=.82) which indicated that the model including the nine variables was able to discriminate the three-team groups (1-4, 5-8 and 9-12). To assess the relative contribution of each performance indicator in maximizing the multivariate difference between the three groups, the (discriminant) structure coefficients were examined. Structure coefficients >|.30| are meaningful and indicate the substantial contribution of the respective independent variables in the separation between the levels of the dependent variable (Pedhazur, 1997). Five performance indicators possessed a meaningful structure coefficient (SC) with regards to the multivariate separation between the three groups of teams ranking (SC values in order of size in parenthesis): 1) Attack 1 win (-.70), 2) Attack 1 stuffed by kill block (.61), 3) Attack 2 win (-.54), 4) Attack 2 stuffed by kill block (.41) and 5) Attack 1 errors (.37). Their combination leads to the substantive interpretation that the main difference between the three groups of teams reflects mainly the status of attack 1 and 2. Based on the discriminant function cross-validation results showed that 77.6% of the original cases are classified correctly (87.5%, 68.8 % and 76.6% for teams 1-4, 5-8 and 9-12, respectively).

In order to distinguish performance indicators that discriminate top level teams (n=48) ranked in positions 1-2 from them ranked in positions 3-4, a second follow–up discriminant analysis was used to examine the contribution of performance indicators, and the results showed that, initially, a significant function is revealed (Wilk's Lambda=.626, x2= 20.59, p=.000, η2=.61) and, secondary, four variables were selected to enter in the final model yielding meaningful structure coefficients (SC values in parenthesis): 1) Attack 1 win (-.72), 2) Attack 1 error (.58), 3) Attack 2 error (-.48), and 4) Attack 2 kill (.45). These variables were able to classify correctly the 83.3% of the original cases (79.2% and 87.5% for teams 1-2 and 3-4, respectively).

Table 5. Performance indicators for teams ranked in positions 1-2 (n=24) and 3-4 (n=24), p values of equality of means and correlation coefficients between performance indicators and the discriminant function Values are presented as mean ± SD.

Performance Indicator	Group 1-2 (n=24)	Group 3-4 (n=24)	p-value	Correlations between variables and discriminant function
Attack 1 error %	.074 (±.011)	.081 (±.009)	.016	.576
Attack 1 kill %	.567 (±.029)	.536 (±.026)	.000	-.727
Attack 2 error %	.084 (±.015)	.097 (±.014)	.004	.476
Attack 2 kill %	.497 (±.037)	.475 (±.028)	.021	-.455

4 Discussion

The present study aimed to analyze performance indicators in the context of Greek Volleyball male League in a period of twelve years. More specifically, it attempted to highlight those variables that distinguished the final ranking of the teams. Teams ranked in the positions 1-4 differ from teams ranked 9-12 in serve aces, passing errors, precise pass, and in attack 1 and 2, win, error or blocked. There is not a differentiation in serve errors, serve caused overpass and block. The comparison between teams of positions 1-4 with those of positions 5-8 highlights as important factors all the variables connected

with attack either after reception or defense expressed as percentages of win, error and blocked attacks. Especially in win attacks, teams of the superior group are 4% better at the attack of complex 1 and 3% better at the attack of complex 2 than the inferior group. Also, there is a difference of 1% in attack errors and 2% in attacks stuffed by opponent's block. The importance of block avoidance in attack is related to an uncared part of the game: the attack coverage (Laporta, Nikolaidis, Thomas, & Alfonso, 2015) which is more effective in counterattack phase (Hilenio, Garcia de Alcaraz, Busca, Salas, & Camerino, 2017). Attack coverage is a pre-contact defensive action that coincides with the team's own attack hit during which players of the attacking team manage to volley the blocked ball before it lands in their own court (Hileno & Busca, 2012). Thus, coaches have to work more on attack coverage systems aiming to reduce the numbers of blocked attacks landed in their team's court.

There are slight but significant variations of attack for men's volleyball in both complexes of the game. The teams of the first group present 55.2% in win attack after reception against 51.5% of the second group and 48.4% of the lowest group, while in attack after defense the respective values are: 48.6%, 45.5% and 42.9%. The importance of attack as a whole skill independent of the previous action of the game is confirmed by many studies (Rodriguez-Ruiz et al., 2011; Patsiaouras et al., 2010 Marcelino et al., 2008). This study reconfirms the importance of both attack types as separate skills with different reference values.

The lowest group teams which try to avoid relegation are worse comparing to the teams 5-8 in serve aces, reception errors and win attack 1 and 2. It seems that lower group teams differ from the higher ones, not only in attack skills but also in the ability to win a direct point with their serve and to avoid a passing error. This is a finding in agreement with Pena, Rodriguez-Guerra, Busca, and Serra (2013) who found a similar result for team categories in Spanish men's league.

On the second level of our analysis, a more detailed approach to the teams of the superior group (1-4) is used. The teams ranked 1-2 differ from those ranked 3-4 only in attack variables connected to win and error attack 1 or 2. The discrimination of the superior group teams, in those placed in the first 2 positions of the ranking and keeping a home advantage against those placed in positions 3 and 4 is possible with fewer variables. Thus, in order to rank in the preferred pole positions, there is an urgent need for top-level teams to increase win attacks and to reduce errors in attack during both complexes of the game.

Teams independently from group category manage the serve errors in order to reduce direct lost points, thus serve errors do not differ among groups. Block does not seem to be an important factor for teams' discrimination. Recording and evaluation of block is a trivial and difficult procedure. Blocking is a scoring skill but it is a part of the defence tactic. So, its evaluation has as a premium criterion the touch of the ball. Attempts for a block without a touch of the ball are not recorded. With the use of another variable for the block (numbers of win block per set) Pena and Casals (2016) showed that the ability to block comes to be decisive when matches become tied. In our analysis, values of the variable, win and error blocks do not differ among groups significantly.

Regarding the accuracy of the discriminant functions, a tendency is revealed for the percentage of correct classification of cases which is higher for the teams 1-4 (87.5%) and teams 9-12 (76.6%) than for teams 5-8 (68.8%). Also, the ability of the discriminant function to classify with success top teams in groups 1-2 and 3-4 (totally 83.3%, 40 out of 48 teams) highlights the direct connection of skills' performance with the game outcome and consequently with the teams' ranking.

Overall, using fourteen primary variables from all the teams of 12 championships in a row from the Greek men's Volley league the important performance indicators for classification in the first 2 privileged positions of the league, in the superior group of teams

1-4, in the medium group 5-8, and, finally, for the relegation group (9-12) was specified and quantified. The model can correctly classify 77.6% of the original cases of the 3 groups. Also, a correct classification of 83.3% is achievable for the superior group to discriminate teams of the positions 1-2 from those of positions 3-4.

From an applied point of view, the results can utilize as references for the process of selecting and developing players or system to play and for the establishment of goals for practice and competition.

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