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Relationship between the set outcome and volleyball skills in a professional volleyball champion male team in Puerto Rico

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Abstract
Volleyball skills or factors that affect the outcome of a volleyball match can vary according to the level of league competition or team attributes. This study aimed to determine whether any volleyball skills or factor predicted set outcomes of the games played by the team that won the Male Championship Professional Volleyball League in 2016. A total of 33 matches and 133 sets were observed of the male volleyball championship team during the 2016 season. Errors in serve, points in serve, points in attack, blocking points, reception efficiency, total digs, complex I efficiency, complex II efficiency, and total errors were the variables assessed in this study. The result showed that the variables of errors in service, point service, blocking points, complex I efficiency, complex II efficiency, and total digs were significant predictors of set outcomes.

Keywords: Game analysis, volleyball skills, volleyball

Introduction
Volleyball has witnessed unprecedented growth over the past two decades and is one of the main five international sports (Fédération International de Volleyball, 2020) [5]. Volleyball has constantly been evolving the rules, technical skills, tactical approaches, type of strength and conditioning training, and the use of analytic data (Bergeles *et al*., 2009; Horta *et al*., 2017; Lirola & González, 2009) [2, 7, 9]. This evolution should affect how the volleyball game is currently played from a technical and tactical standpoint. The use of computerized systems, such as the Data Volley and Volleyball Information System, has enabled statisticians and researchers to identify volleyball skills or factors that are relevant to performance (Peña *et al*., 2013) [15].

Attack has been constantly identified in the literature as one the main volleyball skills to predict outcomes of games (Asterios *et al*., 2009; Drikos *et al*., 2009; Drikos & Vagenas, 2011; Monteiro *et al*., 2017; Patsiaouras *et al*., 2011; Zetou *et al*., 2007) [1, 3, 4, 12, 14, 18]. More importantly, errors in attack and attack efficiency, defined as the number of positive kill attacks minus the sum of attack errors and kill-blocks divided by total kill attempts, have been noted as decisive factors on winning and losing (Asterios *et al*., 2009; Drikos *et al*., 2009; Drikos & Vagenas, 2011; Monteiro *et al*., 2009; Patsiaouras *et al*., 2011; Zetou *et al*., 2007) [1, 3, 4, 12, 14, 18]. Patsiaouras *et al*. (2011) [14] and Asterios *et al*. (2009) [1] indicated that avoidance of errors during attack, and fewer attacks blocked significantly contribute to winning a match. On the other hand, Zetou *et al*.'s (2007) [18] findings suggested that the ace-point in the attack remains the most powerful tool for high-level teams and is a predictor to win.

In high-level competition, the service is used to either obtain a direct point or to disallow the opponent from mounting any kind of effective attack (USA Volleyball, 2009). Winning a point directly from the service has been identified as a predictor of winning in high-level competitions (Asterios *et al*., 2009; Patsiaouras *et al*., 2011; Silva *et al*., 2014; Zetou *et al*., 2006) [1, 14, 16, 19]. Serving efficiency ratio (ratio of lost serves to point serves) has also been taken into consideration for predicting outcomes. Analysis of the data collected from all the matches of the Male A1 Volleyball Professional League of 2005-2006 in Greece demonstrated

that the serving efficiency ratio was a better predictor of a teams' overall performance than any other variables tested (Drikos *et al*., 2009) [3]. The skill of blocking has emerged in various studies as a significant factor of game outcome (Palao *et al*., 2014; Patsiaouras *et al*., 2011; Peña *et al*., 2013; Zetou *et al*., 2006) [13, 15, 14, 19]. Patsiaouras *et al*. (2011) [14] explained that blocking generates situations that create great obstacles for opponent teams. In a few studies, the skill of reception has been associated with predicting game outcomes. Peña *et al*. (2013) [15] and Patsiaouras *et al*. (2011) [14] analyses showed that teams that exhibited fewer reception errors have a greater probability of winning the match. Concerning the dig skill, Monteiro *et al*. (2009) [12] and Zetou (2006) [19] found that digs were not significantly associated with the outcome of the set or predicting the winning team.

Complex I and complex II group different volleyball skills depending on the situation within a rally. Complex I involves serve reception, setting, and attack, while complex II includes service, block/defense, and counterattack (Frohner & Zimmermann, 1996) [6]. Monteiro *et al*.'s (2009) [12] study showed that attack efficiency in complex I is decisive in winning the set. In comparison, Peña *et al*.'s (2013) [15] results suggested that reducing errors during complex I is also relevant in positive outcomes. Enhancing the performance of complex II skills seem to be relevant to succeeding in competition (Peña *et al*., 2013) [15]. Zetou *et al*. (2006) [19] indicated that winning a point directly from the serve and winning a point from counterattack were the most determinant predictors to winning in complex II.

Volleyball skills or factors that affect the outcome of a volleyball match can vary according to the level of league competition or team attributes. Therefore, the objective of this study was to determine whether any volleyball skills or factors (complex I, complex II, or total errors) predicted set outcomes of the games played by the team that won the Male Championship Professional Volleyball League in 2016. The results of this study could be beneficial for professional coaches in Puerto Rico on how to assemble a team and to provide a better understanding of the game and how it can be influenced through training.

Methods

Subjects

A total of 33 matches and 133 sets were observed of the male volleyball championship team during the 2016 season. The number of actions observed was 15,913, in which 3,764 came from attack, 2,525 from receptions, 3,077 from serves, 1,487 from blocking, 1,447 from digs, and 3,613 from setting. The administration of the team permitted the use of the data. The protocol for the study was approved by the Institutional Review Board of the University of Puerto Rico at Río Piedras.

Experimental Approach and Procedures

This study aimed to determine which volleyball skills or factors (complex I, complex II, or total errors) of the games played by the championship team of the 2016 Puerto Rico Males Volleyball League were predictors of set outcomes. Errors in serve, points in serve, points in attack, blocking points, reception efficiency, total digs, complex I efficiency, complex II efficiency, and total errors were the variables assessed in this study. Statistical recording of match results was made by using the official statistical logistic package Data Volley Professional (2007). Matches were videotaped with a camcorder that was positioned 15 m behind the court. The rater in charge of observing and entering the data had over 15 years of experience using Data Volley at professional leagues and international events, such as the World Championships and the Olympics.

Statistical Analyses

A binary logistic regression was conducted to examine whether errors in serve, points in serve, points in attack, blocking points, reception efficiency, total digs, complex I efficiency, complex II efficiency, and total errors had a significant effect on the odds of observing the set lost category of set outcomes. Variance Inflation Factors (VIFs) were calculated to detect the presence of multicollinearity between predictors. Highly intercorrelated variables were excluded from the study. The reference category for set outcomes was set won. The purpose of this analysis was to use the independent variables to estimate the probability that a case is a member of one group versus the other. Binary logistic regression creates a linear combination of all the independent variables to predict the log-odds of the dependent variable. In this analysis, the overall significance of the regression model was tested by computing the χ^2 statistic, which is used with the *df* to compute the *p*-value (i.e., significance level). The model was evaluated based on an alpha of .05. A significant overall model means that the set of independent variables significantly predict the dependent variable. If the overall model was significant, the significance of each independent variable was assessed. An odds ratio (OR) was computed for each independent variable and shows the extent that each independent variable affects the probability that a case is a member of one outcome group versus the other.

Results

Assumptions: The assumption of the absence of multicollinearity was examined.

Variance inflation factors: Variance Inflation Factors (VIFs) were calculated to detect the presence of multicollinearity between predictors. High VIFs indicate increased effects of multicollinearity in the model. VIFs greater than 5 are a cause for concern, whereas VIFs of 10 should be considered the maximum upper limit (Menard, 2009) [11]. All predictors in the regression model have VIFs less than 5. Table 1 presents the VIF for each predictor in the model.

Table 1: Variance Inflation Factors for errors in serve, points in serve, points in attack, blocking points, reception efficiency, total digs, complex I efficiency, complex II efficiency, and total errors

Variable	VIF
Errors in Serve	4.14
Points in Serve	1.86
Points in Attack	2.85
Blocking Points	1.37
Reception Efficiency	1.25
Total Digs	2.02
Complex I Efficiency	3.97
Complex II Efficiency	3.11
Total Errors	3.68

Results

Table 2 summarizes the mean by skills and factors in set won and set lost. The model was evaluated based on an alpha of .05. The overall model was significant, $\chi^2(10) = 110.83$, $p < .001$, suggesting that errors in serve, points in serve, points in attack, blocking points, reception efficiency, total digs, complex I efficiency, complex II efficiency, and total errors

had a significant effect on the odds of observing the set lost category of set outcome. McFadden's R-squared was calculated to examine the model fit, where values greater than .2 are indicative of models with excellent fit (Louviere *et al*., 2000) [10]. The McFadden R-squared value calculated for this model was 61.

Table 2: Mean in set won and set lost for errors in serve, points in serve, points in attack, blocking points, reception efficiency, total digs, complex I efficiency, complex II efficiency, and total errors

Variable	M (Set Won)	M (Set Lost)
Errors in Serve	3.00	3.25
Points in Serve	1.15	0.41
Points in Attack	14.39	12.64
Blocking Points	2.54	1.63
Reception Efficiency	70.00%	69.05%
Total Digs	10.85	9.71
Complex I Efficiency	47.00%	24.00%
Complex II Efficiency	38.00%	24.00%
Total Errors	5.33	6.73

The regression coefficient for errors in serve was significant, B = 0.97, OR = 2.64, p = .008, indicating that for a one-unit increase in errors in service, the odds of observing the set lost category of set outcome would increase by approximately 164%. The regression coefficient for points in serve was significant, B = -1.53, OR = 0.22, p < .001, indicating that for a one-unit increase in points in service, the odds of observing the set lost category of set outcome would decrease by approximately 78%. The regression coefficient for points in attack was not significant, B = 0.18, OR = 1.20, p = .216, indicating that points in attack, did not have a significant effect on the odds of observing the set lost category of set outcome. The regression coefficient for blocking points was significant, B = -0.76, OR = 0.47, p = .005, indicating that for a one-unit increase in blocking points, the odds of observing the set lost category of set outcome would decrease by approximately 53%. The regression coefficient for reception efficiency was not significant, B = -0.00, OR = 1.00, p = .935, indicating that efficiency reception did not have a significant effect on the odds of observing the set lost category of set outcome. The regression coefficient for total digs was significant, B = -0.22, OR = 0.80, p = .018, indicating that for a one-unit increase in total digs, the odds of observing the set lost category of set outcome would decrease by approximately 20%. The regression coefficient for Complex I was significant, B = -15.44, OR = 0.00, p < .001, indicating that for a one-unit increase in complex I efficiency, the odds of observing the set lost category of set outcome would decrease by approximately 100%. The regression coefficient for complex II efficiency was significant, B = -9.32, OR = 0.00, p < .001, indicating that for a one-unit increase in complex II efficiency, the odds of observing the set lost category of set outcome would decrease by approximately 100%. The regression coefficient for total errors was not significant, B = -0.38, OR = 0.68, p = .094, indicating that total errors did not have a significant effect on the odds of observing the set lost category of set outcome. Table 3 summarizes the results of the regression model.

Table 3: Logistic Regression Results with errors in serve, points in serve, points in attack, blocking points, reception efficiency, total digs, complex I efficiency, complex II efficiency, and total errors

Variable	*B*	*SE*	95% CI	χ^2	*p*	*OR*
(Intercept)	9.77	2.84	[4.20, 15.35]	11.81	< .001	
Errors in Serve	0.97	0.37	[0.25, 1.69]	7.03	.008	2.64
Points in Serve	-1.53	0.42	[-2.35, -0.70]	13.24	< .001	0.22
Points in Attack	0.18	0.14	[-0.10, 0.46]	1.53	.216	1.20
Blocking Points	-0.76	0.27	[-1.29, -0.22]	7.73	.005	0.47
Reception Efficiency	-0.00	0.03	[-0.05, 0.05]	0.01	.935	1.00
Total Digs	-0.22	0.09	[-0.40, -0.04]	5.58	.018	0.80
Complex I Efficiency	-15.44	3.33	[-21.96, -8.92]	21.55	< .001	0.00
Complex II Efficiency	-9.32	2.65	[-14.52, -4.13]	12.39	< .001	0.00
Total Errors	-0.38	0.23	[-0.83, 0.07]	2.80	.094	0.68

Note: $\chi^2(9) = 104.67$, $p < .001$, McFadden $R^2 = .57$.

Discussion

This study examined whether any volleyball skills or factors (complex I, complex II, or total errors) predicted set outcomes of the games played by the team that won the Male Championship Professional Volleyball League in 2016. Errors in serve, points in serve, blocking points, total digs, complex I efficiency, and complex II efficiency were the skills found to be significant for predicting set outcomes.

In this study, winning a point directly from service was a strong predictor of set outcome, which is similar to findings in previous studies at high-level competitions (Asterios *et al*., 2009; Patsiaouras *et al*., 2011; Silva *et al*. 2014; Zetou *et al*., 2006) [1, 14, 16, 19]. Interestingly, errors committed in service also had a significant effect on the outcome of sets. These results may create some struggle to determine a service philosophy within a team. On the one hand, if a team is aggressive in serve that may increase the likelihood of obtaining direct points, but it also raises the probability of increasing errors. On the other hand, if the team adopts a conservative approach to serve, the possibility of obtaining a direct point decreases. Therefore, Drikos *et al*.'s (2009) [3] findings on serve efficiency (ratio of lost serves to point serves), which has been found to be a predictor for overall performance, might be a more balanced approach.

Like previous studies (Palao *et al*., 2014; Patsiaouras *et al*., 2011; Peña *et al*., 2013; Zetou *et al*., 2006;) [13, 15, 14, 19], noted blocking is a significant factor predicting game outcome. When teams are selecting the members of the squad or designing the training, they should emphasize strengthening blocking capabilities. Contrary to Monteiro *et al*. (2009) [12] and Zetou *et al*. (2006) [19], total digs played a significant factor in set outcomes. These results suggest that teams who play good defense increase the probability of having success in complex II.

Attack has been regularly identified in the literature as one of the main volleyball skills to predict outcomes of games (Asterios *et al*., 2009; Drikos *et al*., 2009; Drikos & Vagenas, 2011; Monteiro *et al*., 2009; Patsiaouras *et al*., 2011; Zetou *et al*., 2007) [1, 3, 4, 12, 14, 18]. For this study, points in attack were not significant. However, complex I and complex II

efficiency, which most of the time concludes with an attack, were significant factors that predicted the outcome of sets. This caveat means that points in attack are still important because it increases the efficiency of complex I and complex II. This argument was stated by Zetou *et al*. (2007) [18] in which they concluded that the ace-point in attack was a predictor of winning. Errors in attack and attacks blocked decrease attack efficiency, and consequently, decreases the efficiency of complex I and II. These arguments are supported in previous studies, indicating that having fewer attacks blocked and avoiding attack errors could significantly contribute to winning a match (Asterios *et al*., 2009; Patsiaouras *et al*., 2011) [1, 14].

Contrary to previous studies (Peña *et al*., 2013 & Patsiaouras *et al*., 2001) [15, 14], reception efficiency was not a significant factor in predicting the outcome of the set. Although coaches relate a good complex I efficiency with a good reception efficiency, for this team, the receipt was not a determining skill. This result may suggest that good efficiency in attack is more important than reception efficiency.

Previous studies have shown digs are not significant in predicting game outcomes (Monteiro *et al*., 2009; Zetou *et al*., 2007) [12, 18]. However, the results of this study show that total digs are a significant skill in predicting set outcomes. Digs are important because it creates more opportunities for attack points in complex II.

Conclusion

The results of this study are useful for professional teams and coaches in Puerto Rico. It can provide a guide on how to assemble a team. Recruitment can be focused on finding players who excel at the skills that have a significant effect on the outcome of games. Besides, coaches should reconsider the amount of practice necessary to improve service efficiency, complex I efficiency, complex II efficiency, and total digs.

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