ORIGINAL ARTICLE

A comparative analysis of volleyball skills in balanced sets for men and women in Asian competitions

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ABSTRACT

The study investigates volleyball performance indicators that distinguish winning and losing sets in men's and women's Asian competitions. It focuses on balanced sets, defined as those with a score difference of ≤ 5 points for men and ≤ 7 points for women, to avoid bias from lopsided sets. Data from the 2023 Men's and Women's AVC Challenge Cup was analysed. A six-level scale evaluated serve, reception, attack after reception and after defence, block and setting. Stepwise discriminant analysis identified the most significant performance indicators for winning a set in each gender. For men's teams, attack win percentage and serve win percentage were the most important factors. Teams with attack win percentages above 50% and serve win percentages above 7.5% exhibited a greater likelihood of winning. For women's teams, the analysis was not statistically significant, but attack win percentage after reception percentage showed the strongest influence. The study underscores the pivotal role of attack effectiveness in differentiating winning and losing sets, particularly for men's teams. Serve win percentage also plays a significant role for men. While the analysis for women's teams was inconclusive, attack success appears to be crucial. Future research could strengthen the findings for women's volleyball.

Keywords: Performance analysis, Volleyball, Sport analysis, Skills, Asian championship.

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INTRODUCTION

Volleyball is probably one of the most popular sports in the world. Therefore, numerous studies have investigated players' performance with the aim to determine the factors that will result in improving the performance and, consequently, competition (Silva et al., 2013).

This a sport that is inclusive of all genders, with separate tournaments. The decision to not have men compete against women or in mixed teams is based on differences in physical characteristics such as body composition, muscle mass, hormonal levels, and oxygen consumption. Technical skills are common to both genders, while the hierarchical structure of the game requires similar tactics (Drikos et al., 2018).

Volleyball skills depend on many external and unexpected factors, which the coaching process attempts to modify to achieve success. Great emphasis has been attributed to the coach's capacity to observe events that may become relevant to training and competition (Borrie et al., 2002). However, researchers have questioned the validity and reliability of subjective observations and suggest that a performance evaluation using game-related statistics may be very helpful in achieving better accuracy in coaching decisions (Sampaio et al., 2004). Literature on volleyball commonly focuses on the study of game-related and its effect on players and the team's performance. Also, some studies have focused on analyzing samples of high-level performance, especially in men's volleyball (Fatahi et al., 2022; Marcelino et al., 2008). For example, Palao, Santos, and Ureña studied the game-related team level for men and women derived from volleyball tournaments. Analysis yielded significant differences by the men's team level play on spike and block, while the women teams' levels were discriminated only on attack skills, and specifically, the spike (Palao et al., 2004). Examining the same tournament, Palao, Santos, and Ureña (2005) concluded that men's attack is more balanced than women's for the setter position (Palao et al., 2005).

Kountouris and colleagues found significant differences between men and women in terms of the effectiveness of five volleyball skills during the last four consecutive Olympics (2000–2016)(Kountouris et al., 2015). Their results indicated that at an elite level, serve and attack abilities are completely distinct between the genders. Bergeles et al. investigated the relationship between attack performance and setting performance, showing that higher setter performance directly correlates with better attacker performance in both men and women (Nikos et al., 2009). Palao et al.'s study based on performance data from the Sydney 2000 Olympics revealed notable discrepancies between male teams in attacking and blocking abilities, and among female teams in attacking prowess (Fatahi et al., 2022; Palao et al., 2009). Additionally, in a 2009 study, Palao et al. analyzed games from the Mediterranean Games of Almeria and determined that female players exhibited a more effective serving performance compared to males, whereas males excelled in serve reception, and attack effectiveness remained similar for both genders (Palao et al., 2009). Jo~ao et al., in their 2010 study, scrutinized games from various 2007 World Championships to discern statistical indicators that distinguish performance based on gender. Their focus lay on serve errors, attack proficiency, and reception skills (JoãTo et al., 2010).

Also, in volleyball Match Analysis research, significant focus has been on how contextual factors impacting the quality of the opposition affect technical and team performance. The competitive level of teams or the stage of the competition has been considered in various studies to ensure a homogeneous research sample, often choosing key moments like matches in the Olympic Games, the third phase of the World Championships, or the World League (Martínez et al., 2023).

However, studies were conducted in the male European Championship, without considering the differentiating effect of the competition analyzed, and the gender of the participants (Sánchez-Moreno et al., 2017). Comparing sets in which the competition load is similar could be highly important. It seems that the differences in points in the scoreboard in each set are related to significant indicators of technical performance so that the indicators are reduced, as the difference in points per set becomes equal (Martínez et al., 2023), although the performance of the finishing attack becomes more decisive (Drikos & Vagenas, 2011) Also, the technical-tactical behaviors of the teams could be altered, either due to the competition load of the set (Drikos & Vagenas, 2011), as well as the state of the scoreboard or the critical moment in the set. Thus, it seems that teams take on more risks when the scoreboard or sets are unbalanced, either when having an advantage or disadvantage in the scoreboard (Drikos & Vagenas, 2011; Marcelino et al., 2011); while the critical moments of the set and a scoreboard without little differences in scores, are associated with simpler blocking strategies and a lower level of risk related with the serve (Marcelino et al., 2011; Marcelino et al., 2012).

Hence A review of some studies showed that comparing sets in which the competition load is similar could be highly important. It seems that the differences in points in the scoreboard in each set is related with significant indicators of technical performance. Thus, it seems that teams take on more risks when the scoreboard or sets are unbalanced, either when having an advantage or disadvantage in the scoreboard (Drikos & Vagenas, 2011; Marcelino et al., 2011); while the critical moments of the set and a scoreboard without little differences in scores, are associated with simpler blocking strategies and a lower level of risk related with the serve (Marcelino et al., 2011; Marcelino et al., 2012). As for the state of the match, Ramos et al. with a high-level female sample, did not find differences in the tactical performance as a function of the state of the match (Ramos et al., 2017). In addition, Marcelino et al., with a sample of male World League teams, did not find significant differences that would allow them to establish a correlation between the final result of the set, and the following one (Marcelino et al., 2009). As the main goal of the study, we aimed to analyze the distinguishing abilities for balanced sets, categorizing them by gender in male and female competitions in Asia for this sport.

MATERIALS AND METHODS

Sample and variables

The study focused on the Men's and Women's Asian Volleyball Confederation (A.V.C.) Challenge Cup 2023, which was held in Indonesia for Women and Chinese Taipei for Men. In the A.V.C/ Challenge Cup 13 male and 11 female teams competed. To avoid bias from sets with clear score differences, a k-means cluster analysis was used to categorize balanced sets for each gender. A total of 61 sets for men with a score difference of ≤ 5 points and 21 sets for women with a score difference of ≤ 7 points were sampled and data were collected (N = 61 for men and N = 21 for women).

A six-level ordinal scale was employed for the evaluation of each skill, with the value of "*one*" indicating a poorly executed skill and the value of "*six*" indicating an excellent executed skill (Drikos & Tsoukos, 2018). Set statistics included variables of efficacy (the number of the categorized events divided by the total number of the skill and multiplied by 100) for the following eleven (11) key performance indicators (KPI): 1) Serve win (Swin%) 2) Serve Over (Sover%) 3) Serve Error (Serr%), 4) Reception precise % [Rec perfect + Rec excellent] (RPrc), 5) Attack 1 win (A1Win%), 6) Attack 1 blocked (A1Bl%), 7)Attack 1 Error (A1Err%), 8) Attack 2 win (A2Win%), 9) Attack 2 blocked (A2Bl%), 10) Attack 2 Error (A2Err%), 11) Setting error (StErr%).

Procedures

The data were recorded and processed by a volleyball expert scout man using Data Volley software (Drikos, 2018). To examine the intra-observer's reliability, a test-retest procedure of 20% of the total sample (12 sets from men and 5 sets from women randomly selected) following a four-week interval to avoid any possible adverse learning effects was established. Inter-observer reliability was examined by a second independent volleyball expert who was asked to evaluate the same selected 19 sets. The weighted kappa values for both procedures, intra-observer = 0.92, 0.84, 0.88, 0.91 and inter-observer = 0.92, 0.82, 0.89, and 0,95 for serve, reception, attack, block and setting, respectively showed very good values (Altman, 1990). Ethical approval was provided by the institutional university ethics committee, which was conducted following the 2013 Helsinki Declaration.

Statistical analysis

A stepwise discriminate analysis (DA) was performed to identify the contribution of each KPI to the win of a single set per gender. The DAs were planned to determine three items: which variables were best predictors for the teams' success in the classification of performance level, the discriminate function that best separates the two group means and the accuracy of the equation that best discriminates teams' level. The comment of the obtained discriminant functions depended on examination of the structure coefficients greater than |0.30|. It inferred that variables with higher absolute values have a greater contribution to discriminating between groups (Tabakhnick & Fidell, 2007). In more detail, loadings over .71 are considered excellent, .63 very good, .55 good, .45 fair and .32 poor (Comrey & Lee, 2013).To decrease the bias entered in the classification, jack-knifed classification was used. The statistical analysis was performed using SPSS 29.0 software and significances were tested at $p < .05$.

RESULTS

Male

Table 1 summarizes all the variables employed in this study for male teams' performance-related statistics.

Table 1. Descriptive statistics of the performance indicators for male teams.

Type of result	Lost		Win		Total	
	Mean	SD	Mean	SD	Mean	SD
SWin%	2.86%	3.53%	5.29%	4.69%	4.08%	4.31%
SOver%	2.81%	4.13%	4.12%	4.33%	3.47%	4.27%
SErr%	14.40%	8.32%	15.46%	7.22%	14.93%	7.77%
RPrc%	55.21%	14.03%	60.24%	11.09%	57.73%	12.85%
A1Win%	48.52%	10.12%	56.94%	10.41%	52.73%	11.06%
A1Blk%	10.61%	7.92%	8.09%	6.59%	9.35%	7.37%
A1Wrr%	7.41%	5.81%	6.48%	5.92%	6.94%	5.86%
A2Win%	43.39%	16.38%	46.22%	18.87%	44.81%	17.65%
A2Blk%	8.93%	10.88%	6.07%	7.46%	7.50%	9.40%
A2Err%	10.40%	9.37%	7.40%	9.15%	8.90%	9.34%
StErr%	1.50%	2.89%	1.89%	3.68%	1.69%	3.30%
N	61		61		122	

The test of equality of the two group means for "*type of result*" was significant for the KPIs SWin ($p = .002$), Pprc ($p = .030$) and A1Win ($p < .001$).

The eigenvalues, the canonical correlations, the chi-square values, the respective significances as well the correct classifications of the discriminant functions are presented in Table 2. The discriminate function was statistically significant ($p < .001$) and the canonical correlation coefficient (=.577), namely the measure of association between the discriminate function and the outcome variable, is moderate. Consequently, the squared canonical correlation (=.333) is the amount of variance accounted for by the discriminant function.

Table 2. Eigenvalue, test of the significance and classification table for the discriminant function for male teams.

Type of result	**Male**
Eigenvalue	0.498
Canonical Correlation	.577
Wilks' Lambda	.668
Chi-square	46.275
Df	11
p	<.001
Correct Classification	75.4% (77.0% for original cases)

To infer the meaning of the discriminant function and to assess the relative contribution of each performance indicator in maximizing the multivariate difference for type of result (win or lose) for each gender, the discriminant structure coefficients (SC) and the standardized canonical discriminant function coefficients (SCC) were examined (Table 3, *in italics* and underlined). 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). Only two performance indicators A1win (.587) and Swin (.418) possessed a meaningful structure coefficient (SC) with regards to the multivariate separation between the two groups of "*type of result*". The squared SC values indicated that 35% and 18% respectively of the variance in these two variables is accounted for by the discriminant function. Their combination leads to the substantial explanation that the main difference between the two groups of sets (win-lose) reflects mainly the status of win attack and serve points. The negative sign of the SCC index in the variables indicates the negative effect on the team's performance.

Table 3. Test of significance (*p*-values, in bold <.05) for the equality of group means (EQ), structure coefficients (SC, in bold>|.3|) and Standardized Canonical Coefficients (SCC) for male teams.

Performance indicators	**Male**		
	EQ	SC	SCC
SWin%	**.002**	***.418***	*,661*
SOver%	.089	*.222*	*,327*
SErr%	.452	*.098*	*,081*
RPrc%	**.030**	*.284*	*,302*
A1Win%	**<.001**	***.587***	*,640*
A1Blk%	.058	*-.247*	*-,088*
A1Err%	.382	*-.114*	*,107*
A2Win%	.378	*.114*	*-,065*
A2Blk%	.093	*-.219*	*-,380*
A2Err%	.076	*-.232*	*-,319*
StErr%	.523	*.083*	*,276*

Cross-validation results showed that the discriminant function was correctly classified for male teams 47 wins and 45 lost out of the 61 sets (predictive accuracy: 75.4%).

The importance of the two variables A1win % and Swin % in the accuracy of the discriminant function is presented in the scatter plot (Figure 1) with values of the two variables in the X and Y axis and labels the predicted groups for all the sets. Examination of the scatter plot reveals benchmark values of 50% for A1 Win and 7.5% for Swin (corresponding roughly to two aces for every 25 serves). A data point positioned above these reference values in both A1Win and Swin dimensions suggests a possible win per set for the team under investigation. It is important to note that aces are not an absolute prerequisite for winning a set. The scatter plot demonstrates numerous winning sets with a zero percentage of aces yet achieving a noteworthy A1Win ratio.

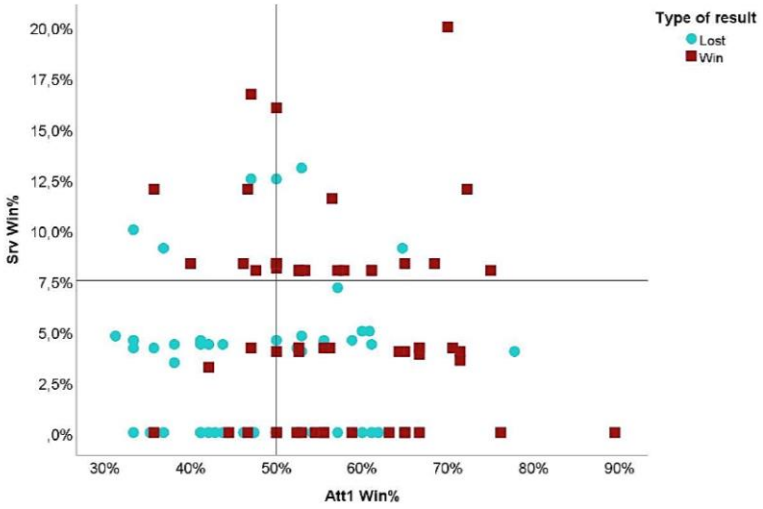

Figure 1. Scatter plot with values of the variables Att2Win% and Attl Win% and labels for the predicted groups for the sets of male teams.

Female

Table 4 summarizes all the variables employed in this study for male teams' performance-related statistics.

Table 4. Descriptive statistics of the performance indicators for female teams.

Type of result	Lost		Win		Total	
	Mean	Sd	Mean	Sd	Mean	Sd
SWin%	2.96%	3.48%	3.79%	5.12%	3.38%	4.34%
SOver%	3.75%	5.13%	3.25%	2.69%	3.50%	4.05%
SErr%	6.99%	5.52%	6.42%	5.14%	6.70%	5.28%
RPrc%	53.50%	10.15%	56.11%	10.40%	54.80%	10.24%
A1Win%	40.34%	8.42%	49.16%	14.22%	44.75%	12.38%
A1Blk%	5.37%	4.47%	4.06%	5.72%	4.72%	5.11%
A1Wrr%	4.34%	3.91%	3.78%	4.53%	4.06%	4.19%
A2Win%	36.36%	13.31%	40.41%	11.01%	38.38%	12.23%
A2Blk%	5.67%	6.21%	4.59%	6.03%	5.13%	6.07%
A2Err%	6.96%	7.22%	6.08%	4.96%	6.52%	6.13%
StErr%	2.44%	3.09%	2.17%	3.80%	2.31%	3.42%
N	21		21		42	

The test of equality of the two group means for "*type of result*" was significant for the KPI A1Win (p = .019).

The eigenvalues, the canonical correlations, the chi-square values, the respective significances as well the correct classifications of the discriminant functions are presented in Table 5. The discriminate function was not statistically significant (p = .500) and the canonical correlation coefficient (=.509), namely the measure of association between the discriminate function and the outcome variable, is moderate. Consequently, the squared canonical correlation (=.259) is the amount of variance accounted for by the discriminant function.

Table 5. Eigenvalue, test of the significance and classification table for the discriminant function for female teams.

Type of result	**Female**
Eigenvalue	0.350
Canonical Correlation	.509
Wilks' Lambda	.741
Chi-square	10.345
Df	11
p	.500
Correct Classification	47.6% (69.0 %for original cases)

To infer the meaning of the discriminant function and to assess the relative contribution of each performance indicator in maximizing the multivariate difference for type of result (win or lose) for each gender, the discriminant structure coefficients (SC) and the standardized canonical discriminant function coefficients (SCC) were examined (Table 6, *in italics* and underlined). Only performance indicators A1win (-.654) possessed a meaningful structure coefficient (SC) with regards to the multivariate separation between the two groups of "*type of result*" following by the A2win (-.287). The squared SC values indicated that 43% of the variance in this variable is accounted for by the discriminant function, leads to the substantial explanation that the main difference between the two groups of sets (win-lose) reflects mainly the status of win attack after reception. The negative sign of the SCC index in the variables indicates the negative effect on the team's performance.

Table 6. Test of significance (p-values, in bold <.05) for the equality of group means (EQ), structure coefficients (SC, in bold>|.3|) and Standardized Canonical Coefficients (SCC) for female teams.

Performance indicators	**Female**		
	EQ	SC	SCC
SWin%	.542	*-.165*	-.242
SOver%	.698	*.105*	.358
SErr%	.734	*.092*	.299
RPrc%	.415	*-.220*	-.331
A1Win%	**.019**	***-.654***	-.642
A1Blk%	.414	*.221*	.377
A1Err%	.669	*.115*	.265
A2Win%	.289	*-.287*	-.722
A2Blk%	.569	*.154*	.347
A2Err%	.648	*.123*	.110
StErr%	.799	*.068*	.213

Cross-validation results showed that the discriminant function was correctly classified for female teams with 10 wins and 12 lost out of the 21 sets (predictive accuracy: 47.6%). The predictive accuracy of the original cases is 69,0%, as discriminant function was correctly classified 15 wins and 14 lost out of the 21 sets.

The importance of the two variables A1win % and A2win % in the accuracy of the discriminant function is presented in the scatter plot (Figure 2) with values of the two variables in X and Y axis and labels the predicted groups for all the sets.

Examination of the scatter plot reveals benchmark values of 50% for A1 Win and 25% for A2 Win. A data point positioned above these reference values in both A1Win and A2 Win dimensions suggests a possible win per set for the team under investigation. It is important to note that the aces are not an absolute prerequisite for winning a set. An examination of the scatter plot reveals a preponderance of winning sets where the A2win ratio surpasses 25%. Conversely, there exists only a single instance where the team under investigation secured victory with an A2win performance below this threshold.

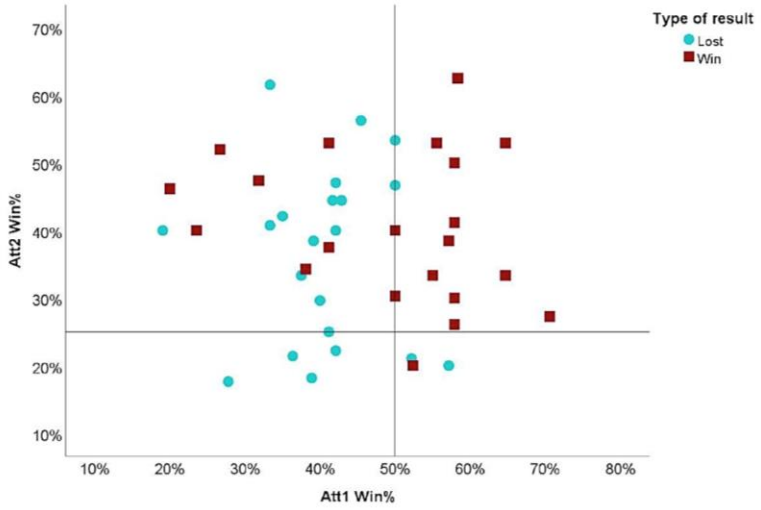

Figure 2. Scatter plot with values of the variables Att2Win% and Attl Win% and labels for the predicted groups for the sets.

DISCUSSION

This study aimed to identify volleyball skills, analyse the distinguishing abilities for balanced sets, categorizing them by gender in male and female competitions in Asia for this sport. The data found that efficacy and importance of skills were different for males and females.

The aforementioned statistical analysis delves into the comparison of group means for the "*type of result*," focusing on key performance indicators (KPIs) in male and female cohorts. The study identifies significant differences in KPIs SWin, Pprc, and A1Win in males, along with a notable outcome in the KPI A1Win for females. This essay aims to dissect the implications of these findings, emphasizing the importance of gender-specific analysis in assessing performance metrics.

Research on discriminating skills for balanced sets in Asia Men's and Women's Volleyball presents an opportunity for further investigation. Studies have shown that in both men's and women's volleyball, the

effectiveness of attacks is a crucial performance indicator for all set types, emphasizing the significance of sustained training across all skills, including serve and block (Drikos et al., 2020; Giatsis, 2023; Giatsis et al., 2023). Additionally, the technical indicators between winning and losing teams in women's volleyball have highlighted the importance of block points in determining success, especially in 5-set matches (Giatsis, 2023). Analyzing volleyball skills that best discriminate between winning and losing in sets with minimal score differences can provide valuable insights into the key factors influencing match outcomes, suggesting a need for further research to enhance understanding and performance in Asia's volleyball scene. Research by Drikos et al. identified that in sets with a minimum score difference, the effectiveness of attacks 1 and 2 are the most important performance indicators (Drikos et al., 2020). Some results show that in male volleyball, attack 1 is essential for winning as receiving is easier than serving (Ferrante & Fonseca, 2014; Kovacs, 2009). Men's teams have higher attack 1 efficacy due to serving difficulty and precise receptions leading to fast tempo spikes (García-de-Alcaraz et al., 2015). This results in a higher percentage of attack 1 for males compared to females (53% vs. 39%)(García-de-Alcaraz et al., 2015). 7.5% difference between men and women, were found in a study by Cieminski using data from European Volleyball Championships. Female volleyball shows lower attack 1 win values, leading to longer rallies and matches for women. Attack 1 is considered important based on its appearance as a discriminative variable with higher loading in discriminant functions for both genders (Ciemiński, 2018).

More analytically, with regard to serve skill in total sets, women tend to present higher values in serve aces and lower values to serve error than men. Thus, analysing the balance of serve errors and serve aces according to the serve efficiency ratio (SER) proposed by Drikos et al. (Drikos et al., 2009). Findings some study partly explain the different importance of the serve for each gender. Male teams more often risk at serve in order not to lose the rally directly (Drikos et al., 2019). This happens because of the overall performance in the skills of the complex 1 (side-out). Men present higher values than women in the quality of serve's pass (Palao et al., 2004) and, consequently, in the effectiveness of attack 1 (after serve's pass) (Ciemiński, 2018). Female teams served more conservatively comparing to male teams, as they lost fewer serves. The better SER is caused by the interaction between serve and reception because women receive serve in lower standards than men and thereafter attack 1 is not so efficient compared to men.

The statistical significance of the KPIs SWin, Pprc, and A1Win in males, with p-values of .002, .030, and <.001, respectively, underscores the distinct performance trends exhibited by this group. These findings suggest that males may excel in specific areas compared to their female counterparts, indicating potential discrepancies in skill sets or approaches towards achieving set targets. Moreover, the pronounced significance of A1Win (p = .019) in females hints at a noteworthy strength or advantage possessed by this group, warranting further investigation into the underlying factors contributing to this outcome.

The role of discriminant functions in differentiating between winning and losing outcomes for each gender is crucial in analysing performance indicators. In examining male performance, A1Win (SC = 0.587) and SWin (SC = 0.418) stand out with meaningful structure coefficients, signifying their significant roles in distinguishing between the two result categories. The squared SC values further reveal that 35% of the variance in A1Win and 18% in SWin is explained by the discriminant function. This underscores the importance of win attack and serve points in outcome differentiation among males.

Conversely, in the female category, it was observed that only A1Win (-0.654) and A2Win (-0.287) made significant contributions to the multivariate distinction between win and lose outcomes, with A1Win exerting the most substantial influence. The negative SCC index associated with these indicators implies a detrimental

impact on team performance. Evaluating these performance indicators in relation to the discriminant function sheds light on the factors that drive disparities in outcomes for male and female players.

The scatter plot highlights the importance of A1win % and A2win % in the accuracy of the discriminant function, with benchmark values of 50% for A1Win and 25% for A2Win. Data points above these values suggest a potential set win. Winning sets often have A2win ratios exceeding 25%, emphasizing its significance. Additionally, only one set was won with an A2win performance below 25%. This indicates the crucial role of A2win % in predicting set wins and underscores its importance in the analysis of the data.

The cross-validation analysis revealed a predictive accuracy of 75.4% in classifying male team outcomes, where they achieved 47 wins and 45 losses out of 61 sets. It is worth noting that although aces do contribute to winning sets, they are not always essential, as evident from some sets that secured notable A1Win ratios even with zero aces.

In contrast, the cross-validation results for female teams showed a lower predictive accuracy of 47.6%, correctly categorizing 10 wins and 12 losses out of 21 sets using the discriminant function. The original cases exhibited a slightly higher predictive accuracy of 69.0%, accurately identifying 15 wins and 14 losses out of the same 21 sets.

This study underscores the critical role of performance indicators in predicting outcomes and emphasizes the nuanced relationship between different variables and team success.

CONCLUSIONS

For men's teams, the analysis found that attack effectiveness and serving efficiency were the most important factors. Teams with attack effectiveness above 50% and serving efficiencies above 7.5% were more likely to win. For women's teams, the analysis did not produce statistically significant results, but attack effectiveness after reception showed the strongest influence. The study emphasizes the crucial importance of attack effectiveness in differentiating winning and losing sets, particularly for men's teams. Serving efficiency also plays a significant role for men's teams. While the analysis for women's teams was inconclusive, attack success appears to be important. Future research with a more extended sample could strengthen the findings for women's volleyball.

AUTHOR CONTRIBUTIONS

The concept was initially conceived by S.D., A.F, G.G. and SH. A. The introductory section of the paper was co-authored by R.M. S.D and A.F. SH.A. and G.G. provided support in the literature review, as well as contributing to the writing of the related works. The implementation was carried out by S.D., A. F. and R. M. Data was gathered by A.S. The Results and Analysis phase was conducted by S.D. and SH. A. The research work received proofreading and supervision from S.D, A.F. The final version of the manuscript was reviewed, edited, and approved by all authors.

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