Original Article

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The effect of jump topspin serve speed on reception quality in men's volleyball

Jiří Petrů [123ABD], **Tomáš Vencúrik** [1ACD]

[1] Faculty of Sports Studies, Masaryk University, Brno, Czech Republic
[2] Center of Sport Activities, Mendel University in Brno, Brno, Czech Republic
[3] Volleyball Brno, Brno, Czech Republic

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Abstract: *Background*: The essential activities contributing to winning a volleyball game are serve, offense, and block. The study aimed to determine if the increasing speed of the jump topspin serve negatively affects the reception quality. *Methods*: The serve speed was measured in sixty-five professional volleyball players. A total of 1270 jump topspin serves were analyzed. The quality of the reception after the serve was evaluated on a 6-level scale: (1) Serve error, (2) Perfect, (3) Good, (4) Negative, (5) Half error, (6) Ace. *Results*: The average speed of the analyzed serves was 88.2 $km \cdot h^{-1}$. The Kruskal-Wallis test points to a statistically significant difference between the quality of reception based on the speed of serve ($p < 0.001$; $\eta^2 = 0.16$). The large effect (Hedges' g) between the quality of reception based on the speed of serve was: Perfect vs. Negative ($g = -1.1$); Perfect vs. Half error ($g = -1.14$); Perfect vs. Ace ($g = -1.27$). The chi-square test showed a statistically significant association between reception quality and serve speed categories ($p < 0.001$). *Conclusions*: The increasing speed of the jump topspin serve significantly affects the reception quality. If the speed of the topspin serve exceeds 92 $km \cdot h^{-1}$, it can be a great benefit for the serving team, although the risk of serve error increases.

Keywords: elite players; serve speed; pass; performance analysis; team sports

Corresponding author: Tomáš Vencúrik, email: vencurik@fsps.muni.cz

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INTRODUCTION

The pivotal determinants contributing to victory in a volleyball game encompass the serve, offense, and block [1]. In volleyball, critical actions, such as offense and serve, are characterized by high-speed strikes involving explosive movements like sprinting, vertical jumping, and ball striking [2,3]. Volleyball success can be comprehensively explained by two primary performance indicators: the effectiveness of reception and complex two success [4]. Considering the game's system and organization, the serve emerges as the inaugural offensive play, profoundly shaping the eventual outcome of the game. Notably, the advent of the jump topspin serve as the method of choice to initiate games that occurred during the late 20th century, predominantly championed by Brazilian players, as documented by Coleman [5]. The jump topspin serve is rooted in the mechanics of an attacking strike – the spike. The kinetic sequence of a jump topspin serve encompasses distinct phases, including the ball toss, run-up, jump, flight phase, the ball hit in flight phase, and the player's landing [6]. The basis of the correct jump topspin serve essentially resides in the spike technique, except for frontal velocity, which is lower in the spike [7]. Both the spike and jump topspin serve share a common motor foundation, delineated into four phases: the approach, arm cocking, arm acceleration, and follow-through [8,9].

Barzouka et al. [10] reported that male players employed the jump topspin serve in approximately 75.4% of instances. The prevalence of the jump topspin serve can be attributed to its propensity to significantly disrupt the receiving team's ability to construct effective offensive combinations following its execution despite a comparatively higher error rate when compared to other serve types [11]. Lima et al. [12] emphasized that the jump topspin serve has emerged as an indispensable skill, particularly in men's volleyball. They further underscored that due to the inherent characteristics of the jump topspin serve, its execution predominantly aims for the shortest feasible distance. This strategic choice is intertwined with minimizing the ball's flight time to the opponent's court, reducing the reaction time available to the receiving player. The receiver's movement initiation time takes around 0.3 seconds from the ball contact of the serving player [13]. Zahálka et al. [14] validated that the jump's height serves as a reliable indicator concerning the execution of the jump topspin serve, particularly in relation to the ball's velocity. Considering the technical resemblance between the spike and the jump topspin serve, Sarvestan et al. [15] introduced an intriguing recommendation related to specific factors affecting spike speed, such as ball positioning. From a biomechanical perspective, spike height and spike speed represent the primary variables underpinning the assessment of success rates, as established by prior studies [16–18]. Baena-Raya et al. [19], in their investigation of factors influencing both serve and spike speed, assert that the optimal toss technique plays a pivotal role in facilitating the effective transmission of power and speed from horizontal to vertical trajectories.

Coleman [5] documented that the average velocity of the jump topspin serve, as observed in his research on male players in 1993, registered at 85 kilometers per hour ($km \cdot h^{-1}$). In contrast, Moras et al. [20] reported that the mean jump topspin serve speed, assessed during the 2004 Men's Olympic Qualifying Tournament, was approximately 83 $km \cdot h^{-1}$. It's worth noting that investigations into ball speed in the context of volleyball are relatively scarce, and the relationship between ball speed and the speed of the hitting arm remains an underexplored area of study, as highlighted by Lima et al. [12]. No prior studies comprehensively evaluated the potential association between serve speed and its effectiveness [20]. The primary conclusion drawn from their research was the absence of a significant association between serve speed and superior outcomes pertaining to its effectiveness. Consequently, our research endeavors to focus on the interplay between the speed of the jump topspin serve and the quality of reception in volleyball.

We aim to ascertain whether the increasing speed adversely affects reception quality and to discern any potential association between the categories denoting the quality of reception and the corresponding categories delineating serve speed.

MATERIAL AND METHODS

Participants

The data used in this study was measured in the men's 1st division in the 2018–2019, 2019–2020, and 2020–2021 season in the Czech Republic. Sixty-five professional volleyball players from all teams in the 1st division participated in the study. Players were 26.9 ± 5.8 years old, with body height of 196.3 ± 4.6 cm and body mass 84.3 ± 4.2 kg. The data are routinely collected during the official games, so ethical approval was not required [21]. Nevertheless, the study conformed to the recommendations of the Declaration of Helsinki.

Procedures

The serve speed was measured by a trained research team member with the radar gun (Bushnell Velocity Speed Gun, Bushnell Outdoor Products, Overland Park, KS, USA). The radar gun is reliable for measuring serve speed [22]. The team member carrying the measurements stood six meters from the end line of the volleyball court and held a radar gun in his hand. Before the serve, he stood behind or opposite the serving player (variants depending on which side the serve was currently served from); this position aimed to minimize the angular deviation in the measurement. Before the attempt, the radar was aimed at the future point of contact of the serving player with the ball and pressed the trigger. After the serve was made, the display showed the highest speed of the ball. There was only a shift to the left and right according to the zone from which the serving player was ready to serve. After the serve, the type, speed of serve, and reception quality were recorded.

For the notational analysis of the jump topspin serve, we used the six-point scale (Table 1) in the Data Volley software (Genius Sports Italy, Salerno, Italy) [20]. A performance analyst into the Data Volley software recorded data in real time. After the end of the game, the data was synchronized from the timeline of the video recording of the game, and at the same time, the correctness of the recorded data was checked. With fifteen years of experience with this activity at the national and international levels, the performance analyst recorded the data from all games mentioned in this research. He is currently a lecturer in the field of scouting and the use of Data Volley software for the National Volleyball Association.

Statistical analysis

Data are presented as mean ± standard deviation. A total of 1270 serves were processed. The normality of data distribution was verified by the Shapiro-Wilks test. The data's normality was violated, so non-parametric statistics were used. The Kruskal-Walis test determined differences between the reception quality based on the serve speed. Effect size eta squared (η^2) was used for Kruskal-Walis test, magnitude: < 0.06 = small effect; 0.06–0.14 = moderate effect; > 0.14 = large effect [23]. The effect size Hedges' g and 95% confidence intervals were used for the pairwise comparison of individual categories of reception quality based on the speed of serve. Hedges' g values are interpreted as 0.2 for small, 0.5 for medium, and 0.8 for large effect size. Serve speed was divided into four intervals < 69 km·h^{-1}, 70–83 km·h^{-1}, 84–97 km·h^{-1}, > 98 km·h^{-1}. The Chi-square test expresses the association between categories of reception quality and established categories of serve speed (χ^2). Effect size is calculated based on Cramer's V (Volker, 2006) as: 0.1 = small effect; 0.3 = medium effect; 0.5 = large effect. The level of statistical significance was set as α = 0.05. IBM SPSS Statistics 26 software (IBM Corp., Armonk, NY, USA) was used for statistical analysis.

Table 1. Combined coding of serve-pass activities

Serve		Reception/pass	
=	Wrong – error		Serve Error – there is not a reception.
-	Negative because the opponents receive perfectly. The serve created little or no problems for the passing team and can combine with all offensive players.	#	Perfect – the ball from the passing player is directed between zones II and III with the appropriate height into the ideal space for the set. This type of reception then allows the setter to combine without problems with all players in all possible offensive combinations.
+	Good because the opponents cannot attack with a combination. The serve created problems for the passing team, which cannot combine with all the offensive players; eliminated in this situation, is the attack in the first sequence.	+	Good – the ball from the passing player goes into the front zone. It is distinguished from an excellent reception by the dispersion outside the ideal space for the pass, and, as a rule, the reception height does not correspond to the previous assessment. With this reception type, the passing player can combine with all players but with little time and space difficulties.
+	Positive because the opponents can only perform a high attack. The serve created problems for the passing team, which cannot combine with all the offensive players, eliminated in this situation, is the attack in the first sequence.	-	Negative – the nature of the ball's flight from the passing player does not allow it to combine with all offensive players. As a rule, there are only two reception variants, high to zone IV and high to zone II (I). Very often, this reception is also not done by the passing player.
/	Half point because the opponent reception goes over the net and a home player kills or blocks. Serve flies after the first contact from the passing team to the side of the serving team, so-called "free".	/	Half Error – the ball from the passing player is directed to the opponent's half; thus, there is no offensive phase. The game does not end, but the passing team goes into the defensive part of the game immediately after the pass.
#	Point: an ace or a reception error. The opponent fails to react, or the ball is lost after the first contact.	=	Ace – after the passing player, none of his teammates touch the ball again. Or the ball touches the field of the passing team directly from the serve.

RESULTS

Figure 1 shows the descriptive statistics of serve speed related to reception quality. The reception quality decreased as the serve speed increased. The Ace or direct point from the serve was achieved at an average speed of 95.2 ± 9.6 $km{\cdot}h^{-1}$. On the other hand, Perfect reception (from the point of view of the serving team) was achieved at an average value of 78.6 ± 14.4 $km{\cdot}h^{-1}$. The Kruskal-Wallis test points to significant difference between the reception quality based on serve speed ($p < 0.001$; $\eta^2 = 0.16$). The effect size of the pairwise comparison points to a large effect between the reception based on the speed of serve: Serve Error vs. Perfect ($g = 0.93$); Perfect vs. Negative ($g = -1.1$); Perfect vs. Half Error ($g = -1.14$); Perfect vs. Ace ($g = -1.27$). A pairwise comparison between the other reception categories indicates a medium or small effect (Figure 2).

Table 2 contains the frequency of reception quality concerning the categories of serve speed. Players' most errors (Serve Errors) were made when serving at a speed above 84 $km{\cdot}h^{-1}$ (77.4%). On the other hand, we can see that the most Aces (95.8%) and Half Errors (88.9%) were achieved by players who served at speed also above 84 $km{\cdot}h^{-1}$. Based on the chi-square test, we can claim that the association between reception categories and serve speed categories is statistically significant ($\chi^2 = 25.6$; df = 15; $p < 0.001$). Cramer's V indicates a medium effect ($V = 0.26$) between categorical variables.

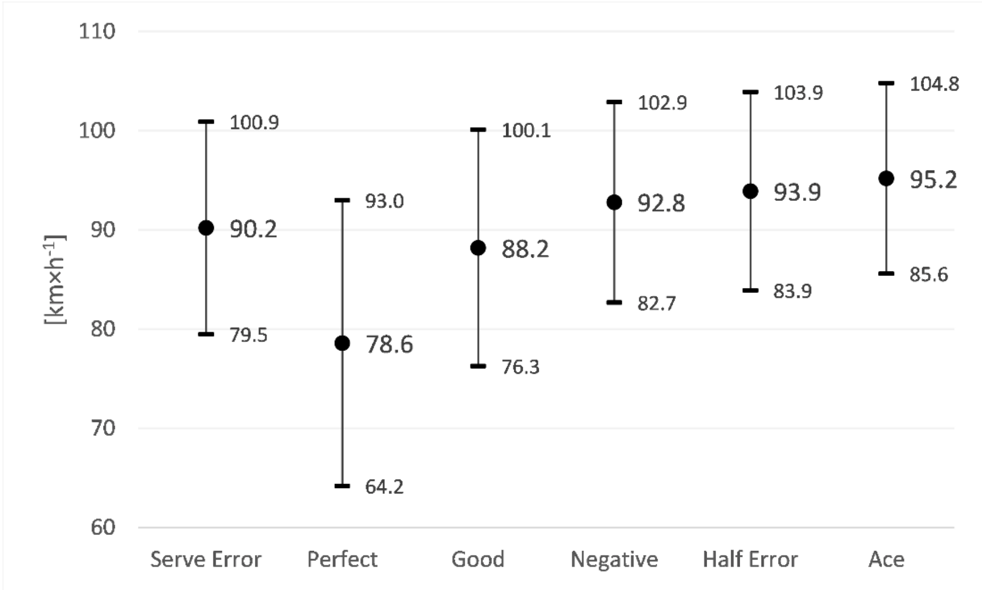

Figure 1. Mean values and standard deviation of serve speed related to reception quality.

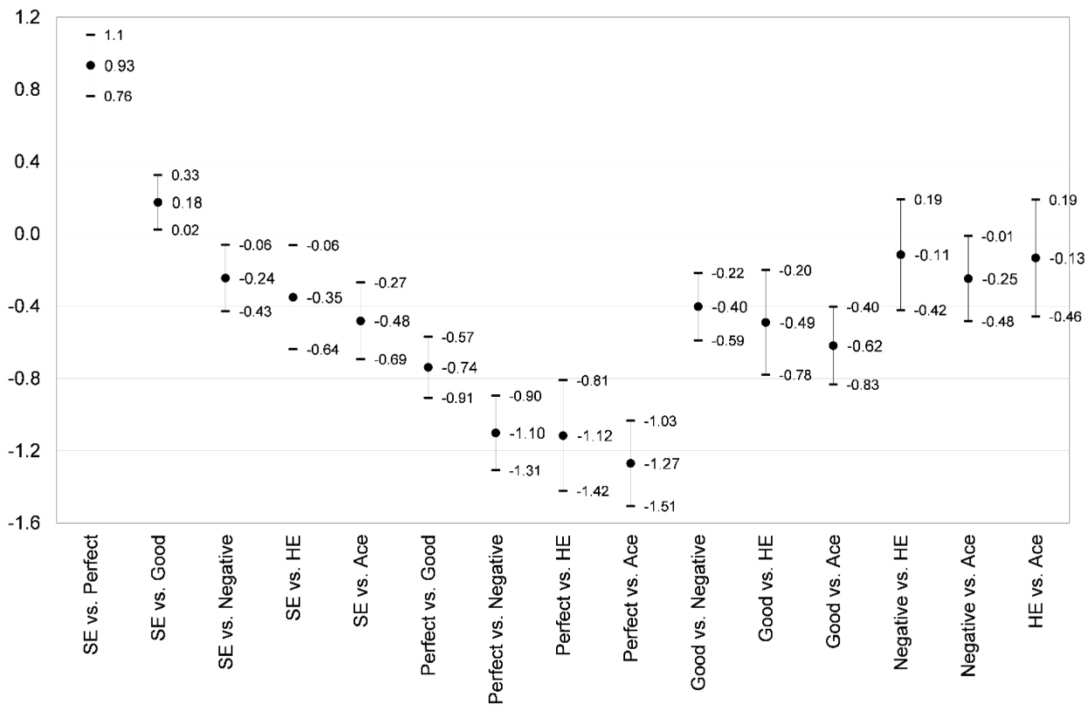

Figure 2. Effect size and 95% CI of pairwise comparison of reception. SE – Serve Error, HE – Half Error.

Table 2. Frequency distribution of reception according to serve category

Reception	Serve category				Total
	< 69 km·h-1	70–83 km·h-1	84–97 km·h-1	> 98 km·h-1	
Serve Error	15 (4.4%)	62 (18.2%)	178 (52.4%)	85 (25.0%)	340
Perfect	65 (24.9%)	100 (38.3%)	62 (23.8%)	34 (13.0%)	261
Good	26 (8.0%)	72 (22.0%)	160 (48.9%)	69 (21.1%)	327
Negative	7 (4.1%)	20 (11.7%)	77 (45.0%)	67 (39.2%)	171
Half Error	2 (3.7%)	4 (7.4%)	27 (50.0%)	21 (38.9%)	54
Ace	3 (2.6%)	2 (1.7%)	56 (47.9%)	56 (47.9%)	117
Total	118	260	560	332	1270

DISCUSSION

The primary objective of this investigation was to examine the influence of the velocity of a jump topspin serve on its effectiveness in volleyball. Our findings, derived from effect size pairwise comparisons, reveal a substantial impact of serve speed on reception quality. Specifically, we consider the results of comparisons between Perfect and Negative ($g = -1.1$), Perfect and Half Error ($g = -1.14$), and Perfect and Ace ($g = -1.27$) to be of paramount significance. In contrast, pairwise comparisons involving other reception categories indicate moderate or minor effects. These data substantiate that the speed of the jump topspin serve exerts a notable influence on the quality of reception. These conclusions align with those presented in the study by Palao and Valades [24], positing that a serve's success depends on factors such as contact height, direction, and ball speed. The effectiveness of the serve appears to be a pivotal determinant in the outcome of individual offensive plays [20]. Our data analysis reveals a discernible pattern: as the average speed of the jump topspin serve increases, the reception quality tends to decrease. Specifically, when reception is assessed as Perfect, the serve's average speed is 78.6 $km \cdot h^{-1}$. In cases rated as Good, the serve achieves an average speed of 88.2 $km \cdot h^{-1}$. For Negative ratings, the speed averages 92.8 $km \cdot h^{-1}$, Half Error is associated with 93.9 $km \cdot h^{-1}$, and serves culminating in Aces exhibiting an average speed of 95.2 $km \cdot h^{-1}$. These observed values underscore a noticeable trend of rising jump topspin serve speed being inversely associated with a decline in reception quality.

Coleman [5] has documented that the mean speed of the jump topspin serve executed by male players stood at approximately 85 $km \cdot h^{-1}$. This observation aligns with the findings of Moras et al. [20], who reported a similar mean jump topspin serve speed, measured at the Men's Olympic Qualifying Tournament in 2004, at roughly 83 $km \cdot h^{-1}$. Furthermore, Bhasi and Sadanandan [25] present an average jump topspin serve speed of 87 $km \cdot h^{-1}$ for players aged between 19 and 25 years. Our data, with an average speed of 88.2 $km \cdot h^{-1}$, are consistent with the research conducted by Pekyavaş et al. [26] who assessed the average speed of the jump topspin serve among foreign players competing in Turkey's 1st division and reported it as 88.4 $km \cdot h^{-1}$. Collectively, this information suggests a discernible trend of long-term increase in the average speed of jump topspin serves within the men's category.

Evaluating the attainment of maximum vertical jump height in the context of volleyball offensive plays has been a recurrent subject of sports analysis [15,27–29]. This focus on jump height is underpinned by its recognition as a pivotal parameter contributing to enhanced volleyball success, as Ziv and Lidor underscored it [30]. Forthome et al. and Terol-Sanchis et al. [31,32] have reported a correlation between spike velocity and multiple factors, including the maximal isokinetic torque developed by the internal rotators of the dominant shoulder, the height at which a player makes contact with the ball during a spike, and the player's body mass index. Zahálka et al. [14] have posited that jump height is a reliable indicator for executing a jump topspin serve, predominantly due to its influence on ball speed. Furthermore, Bhasi and Sadanandan [25] have established a positive relationship between jump topspin serve speed and variables such as take-off speed, the height of the player's center of gravity at the point of ball contact, and the distance covered during the flight phase before impact. Sarvestan et al. [15] have corroborated that higher angular velocities of the hip and knee joints, in conjunction with efficient arm swing mechanics, can contribute to increased jump height during real-game offensive actions. They have also emphasized the influence of various situation-specific parameters on spike velocity, which can fundamentally alter a player's performance. Marcelino et al. [33] assert that serving constitutes the initial offensive action for a team. Consequently, Ciuffarella et al. [34] recommend the use of the jump topspin serve as the most effective technique in terms of facilitating subsequent defensive plays. However, it is imperative to acknowledge its relatively elevated error rate, which necessitates strategic consideration by coaches in its deployment.

We consider a limitation of our research to be the fact that the processed data also includes serves with a lower speed, a phenomenon that has become more prevalent at the top level over the past decade. Specifically, these are shortened serves targeting zones II, III, and IV of the receiving team. The presence of such data within our dataset introduces a potential source of distortion in our findings, constituting a constraining factor in our overall research endeavor. Excluding these lower-speed serves from our analysis could conceivably result in a higher overall average speed for serves executed with the primary intent of achieving maximum speed. Furthermore, our research is subject to additional constraints stemming from the intricate interplay between serve and pass dynamics. Factors such as the direction of the serve, the number of players involved in the receiving team's pass, the trajectory of the serve, the reaction time of the passing players, and the point of origin of the serve are all critical parameters that influence the outcomes and could be used as contextual variables in future research [35].

CONCLUSION

Based on the obtained findings, it is possible to deduce that the utilization of the jump topspin serve can be advantageous for the team, particularly when elite athletes consistently attain average speeds exceeding 92 $km \cdot h^{-1}$. Conversely, when a player's serve registers a sustained decline in average speed below 83 $km \cdot h^{-1}$ over an extended duration, it becomes imperative for the player or their coach to contemplate adopting an alternative approach to initiate the game. This is due to the diminishing efficacy of the serve, leading to a notable decrease in the team's defensive prowess.

The jump topspin serve proves effective in upholding the desired speed parameters. Currently, speed assessment of serves is a commonly employed tool for appraising the skill level of elite players, yet this practice is not yet common within youth categories. Due to the long-term acquisition of the jump topspin serve technique, we recommend regularly monitoring the speed of the serve from the adolescent categories, both in training and in games. These longitudinal data records will serve as valuable feedback for players, bolstering their technical proficiency and success with the jump topspin serve. Therefore, an avenue for further research could involve enhancing jump topspin serve speeds among adolescent volleyball players. The intrinsic motivation for young athletes could stem from the pursuit of achieving the highest speed recorded during training, serving as a primary driving force for performance-oriented players. Feedback on their attained speeds can inspire young players to push their limits. We posit that coaches could use our results to facilitate long-term comparisons of their players' jump topspin serve speeds across various age groups and performance categories.

Additionally, an intriguing future research direction could involve examining the effectiveness of serves characterized by a high element of surprise. In such serves, speed may not play as pivotal a role. For most players, this "shortened serve" is intertwined with a serve that maximizes speed, and the type of serve employed often remains concealed until the moment of contact with the ball.

Conflicts of Interest: The authors declare no conflict of interest.

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