

Serve speed and its influence on performance effectiveness in junior sitting volleyball: Evidence from the V Parapan American Youth Games 2023

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Published online: August 31, 2025

Accepted for publication: August 15, 2025

DOI:10.7752/jpes.2025.08178

Abstract:

Background: The serve in sitting volleyball is a fundamental skill that contributes to both offensive and defensive team strategies, serving as the initial opportunity to exert control over the rally. Its effectiveness can influence the opponent's reception, limit attacking options, and create scoring opportunities. Despite its importance, there is limited scientific evidence regarding the determinants of an effective serve, particularly within junior elite categories of para-volleyball, where technical and tactical demands differ from the standing version of the sport. **Objective:** To examine the relationship between serve speed and performance effectiveness in elite junior sitting volleyball players. **Methods:** A total of 593 serves were recorded during the V Parapan American Youth Games 2023. Ball velocity was measured using a Stalker Sport 2 radar gun. Serve effectiveness was evaluated through systematic observation, in which four trained experts categorized each serve into four predefined performance levels. Statistical analyses compared ball speed according to serve type and sex and assessed associations between velocity and effectiveness. **Results:** Significant differences in ball velocity were found between serve types ($p < 0.05$), with jump serves presenting higher speeds than standing serves. No significant differences in serve speed were observed between male and female athletes. Furthermore, there was no statistically significant association between serve speed and performance effectiveness ($p > 0.05$). **Conclusions:** In elite junior sitting volleyball, faster serves do not necessarily result in higher effectiveness during competition. These findings challenge the assumption that increased ball speed automatically enhances performance outcomes, highlighting the need to integrate tactical precision, placement strategies, and technical consistency alongside speed development in training programs for paravolleyball.

Keywords: ball velocity, serve technique, para-volleyball performance, game strategy, skill assessment, elite youth athletes

Introduction

Sitting volleyball is a sports discipline included in the Parapan American Games, an event that originated in 1999 for athletes from the Americas and was later extended to the junior category in 2005 (Hanrahan & De Luigi, 2023). This modality features two teams, each composed of six players in the senior category and three in the junior category, whose primary objective is to make the ball touch the opponent's court floor. To achieve this, players employ various technical-tactical elements, both offensive and defensive, with the serve being a key action in the game's dynamics.

In volleyball, both in its conventional and sitting versions, the serve initiates the sequence of play and can be classified according to its intentionality (García-Tormo et al., 2006). Defensive intentionality focuses on accurate ball placement to facilitate reception and enable counterattacks, with the floating serve being particularly valued for its stability and control. Conversely, offensive intentionality aims to generate a direct point through a powerful serve, which, while carrying a higher risk of error, can destabilize the opposing team (World ParaVolley, 2022). In both cases, effective serve execution requires a combination of accuracy, strength, and motor coordination, factors that have been previously analyzed in conventional volleyball (Ramirez-Campillo et al., 2021). Reception tactics are organized according to the type of serve executed. Floating serves require fewer receivers, whereas powerful serves demand greater organization and player distribution due to the higher ball velocity (Bujang et al., 2024). Research in conventional volleyball has shown that ball speed upon impact is a determining factor in generating offensive opportunities, as higher velocity reduces the receiver's reaction time and limits the opponent's attacking options (Pawlik et al., 2024). Additionally, several studies have examined serve effectiveness in relation to game context conditions, including athlete category and competitive level (Fernandez-Echeverria et al., 2015).

In elite conventional volleyball, ball speed during the serve can range between 90 and 110 km/h (Quiroga et al., 2010). The jump serve, in particular, has been identified as one of the fastest variants, with reported speeds between 19.99 ± 1.98 and 22.70 ± 3.27 m/s (Häyrinen et al., 2011). Similarly, the jump float serve has shown significantly higher initial speed compared to the static serve (MacKenzie et al., 2012), reaching velocities between 12 and 22 m/s (43 to 79 km/h). However, serve speed does not always translate into greater effectiveness, as accuracy and placement are also critical determinants of its tactical impact (Altundag et al., 2024). Despite this, it remains unknown whether serve speed is related to serve effectiveness in youth competitive contexts of sitting volleyball. Although the analysis of the serve in conventional volleyball has advanced considerably, scientific evidence in sitting volleyball, particularly in youth categories and real competitive contexts, remains scarce.

Considering the specific characteristics of this modality, such as the net height, court dimensions, and players' functional profiles, it is necessary to explore how technical variables like serve speed influence the development of the game. In this context, the present research sought to answer the question: Is there a significant relationship between serve speed and its effectiveness during competition in elite youth sitting volleyball athletes? Therefore, the objective of this study was to analyze the relationship between serve effectiveness and ball speed in elite junior sitting volleyball athletes, providing empirical evidence to improve understanding of performance determinants in this sport. The findings aim to generate useful information for coaches and players, helping to optimize training strategies and enhance competitive effectiveness.

Material & methods

Participants This study analyzed a total of 593 serves performed during six official sitting volleyball matches by elite junior athletes at the V Parapan American Youth Games 2023. This event was organized by the Americas Paralympic Committee and took place in Bogotá, Colombia. The athletes were aged between 14 and 20 years and classified into two disability categories: VS1 (athletes with greater physical impairment, including a complete or highly visible disability) and VS2 (athletes with a lower degree of disability, which is minimal or less apparent).

Instruments Data collection was conducted using a customized Excel (Microsoft®) spreadsheet, which recorded variables such as the serving team, service location, type of serve, direction, ball speed, and efficiency (Table 1).

To measure the ball speed in sitting volleyball, a Stalker Sport 2 radar gun (Stalker, Inc.) was used, with a measurement accuracy of $\pm 3\%$ and an operational frequency of 24.125 GHz (Figure 1a). This instrument has been validated in previous studies on the same sport (Makar et al., 2024).

Table 1. Data collection sheet, analysis variables, and response categories.

Serving Team	Location	Location	Direction	Efficiency
Argentina (A)	Zone 1 (D)	Floating (F)	Parallel (P)	(1) Direct point
Brazil (B)	Zone 6 (C)	Power (P)	Diagonal (D)	(2) Serve that initiated gameplay
Colombia (C)	Zone 5 (I)			(3) Serve fault (net)
Venezuela (V)				(4) Serve fault (out of bounds)

Procedure A team of four experienced observers examined and categorized the serves performed during the official matches. One observer was responsible for recording the data in the spreadsheet based on the information provided by the other three observers. The data entry followed a structured left-to-right approach, ensuring consistency in information collection and minimizing uncertainty.

Before data collection, a training and familiarization period was conducted to standardize the criteria used in recording technical actions. The training ensured consistency in identifying and classifying the variables under analysis. A second observer was responsible for capturing the ball speed using the radar gun at the exact moment the athlete executed the serve (Figure 1b).

The radar gun was mounted on a tripod at a height of 1.60 m, allowing for directional adjustments toward the serving team. It was positioned courtside, perpendicular to the net, at approximately 3–4 meters from the court (press zone), enabling visibility of both service areas (Figures 1b and 2). The remaining observers were positioned in the same area to verbally relay information. In case of disagreement between the two primary observers, the third observer made the final classification decision.

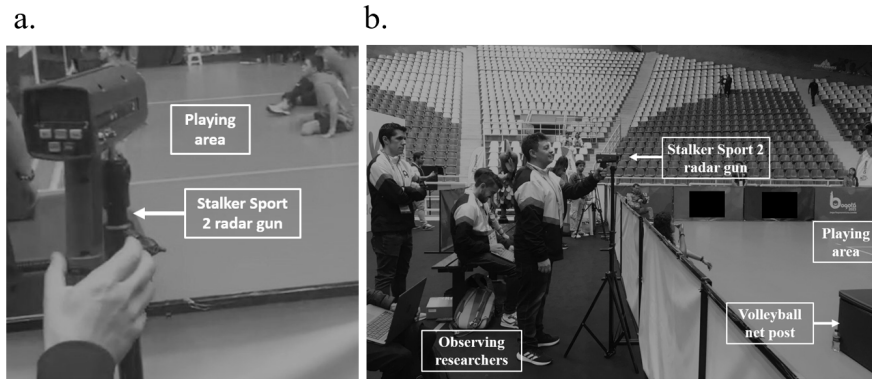


Figure 1. Logistics for data collection.

This research was approved by the organizing committee of the V Parapan American Youth Games 2023, with researchers assigned to the Education and Legacy division. The study was classified as "minimal-risk research" in accordance with Colombian scientific, technical, and administrative research regulations (Resolution No. 8430 of 1993). No intentional intervention or modification was made to the athletes, as data collection relied on systematic observation, registering relevant phenomena, behaviors, and events related to the study variables (Bernard, 2017).

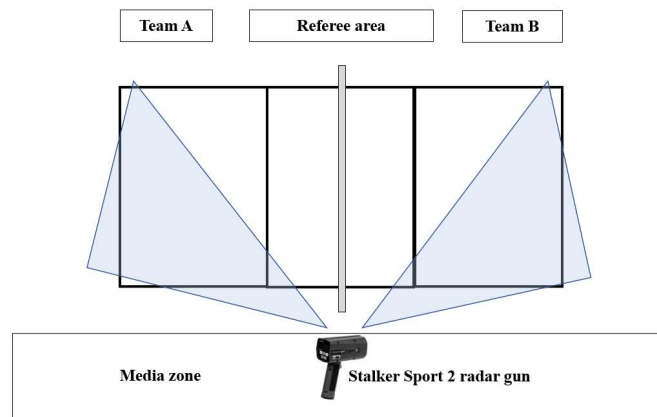


Figure 2. Positioning of the radar gun and observers during competitive matches.

Data Analysis

Data analysis was conducted using JASP (Jeffreys's Amazing Statistics Program), version 0.18.1, after a thorough review and data cleaning process. Graphs were generated using GraphPad Prism 10. Initially, a normality test (Kolmogorov-Smirnov) was performed to assess the distribution of continuous variables. Depending on the normality assumption, either parametric (t-tests, ANOVA) or non-parametric (Mann-Whitney U, Kruskal-Wallis) tests were applied where appropriate. A univariate analysis was performed using measures of central tendency (mean, median) and dispersion (standard deviation, interquartile range) for quantitative variables. Categorical variables were analyzed through frequency distributions, all with 95% confidence intervals. For comparisons of service speed by gender and service type, an independent-samples t-test was conducted when data were normally distributed; otherwise, the Mann-Whitney U test was used. To evaluate the association between service effectiveness and ball speed, a one-way ANOVA was applied if assumptions of normality and homoscedasticity were met; otherwise, the Kruskal-Wallis test was employed. Additionally, effect sizes (Cohen's d) were calculated to determine the magnitude of group differences. The interpretation of effect sizes followed these thresholds: trivial (< 0.2), small ($0.2-0.59$), moderate ($0.60-1.19$), large ($1.2-2.0$), or very large (> 2.0) (Lakens, 2013). Statistical significance was set at $P < 0.05$.

Results

Regarding the general characteristics of the sample, a total of seven teams were evaluated, including four men's teams and three women's teams. Six matches were analyzed, accounting for a total of 593 serves (352 [59%] by men and 241 [41%] by women) performed by 28 athletes (16 men [57%] and 12 women [43%]). Figure 3 illustrates the number of serves recorded for each team by gender. It is noteworthy that, for both men and women, the Brazilian team registered the highest number of serves, with a total of 244.

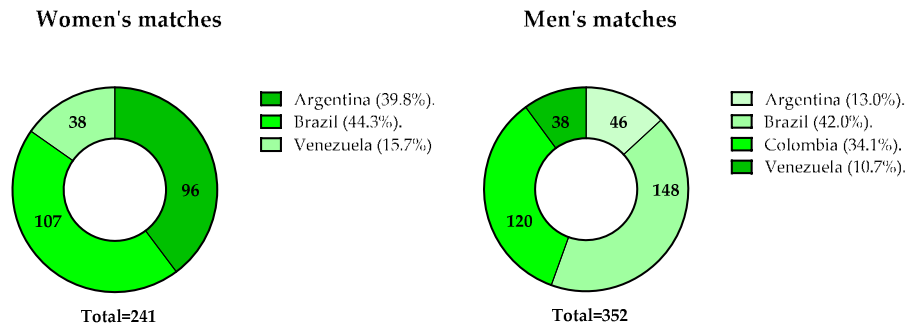


Figure 3. Frequency of serves by gender and country.

No statistically significant differences were found in serve speed between female players (22.1 ± 6.5 km/h) and male players (22.3 ± 4.6 km/h; $p = 0.633$), as presented in Table 2. However, greater variability was observed among female players, with serve speeds ranging from 4.0 to 41.0 km/h, compared to 11.0 to 35.0 km/h in males. Regarding the type of serve, significant differences were identified ($p = 0.001$), with higher ball velocities recorded in power serves (25.4 ± 4.8 km/h) compared to float serves (19.7 ± 4.5 km/h). The maximum ball velocity was also greater in power serves (41.0 km/h) than in float serves (33.0 km/h).

Table 2. Serve speed by sex and type of serve

Serve speed according to sex				
	Women	Men	p value	Cohen's d
Serves evaluated (n)	241	352		
Speed (km/h)	22.1 ± 6.5	22.3 ± 4.6	0.633	d=0.213
Minimum speed (km/h)	4.0	11.0		
Maximum speed (km/h)	41.0	35.0		
Serve speed according to type of serve				
Serve type	Float	Power	P value	
Serves evaluated (n)	329	264		
Speed (km/h)	19.7 ± 4.5	25.4 ± 4.8	0.001*	d=1.321
Minimum speed (km/h)	4.0	8.0		
Maximum speed (km/h)	33.0	41.0		

Note: Speed values are expressed as mean $\pm$ standard deviation. *Significant differences

A total of 593 serves were evaluated and categorized according to their outcome: out of bounds ($n = 42$), into the net ($n = 19$), rally continued ($n = 420$), and direct point ($n = 112$). The highest mean ball speed was observed in serves that resulted in direct points (22.9 ± 5.4 km/h), followed by out-of-bounds serves (23.2 ± 6.6 km/h), rally continues (22.1 ± 5.3 km/h), and net errors (20.9 ± 6.1 km/h). Minimum ball speeds ranged from 4.0 km/h (rally continued) to 10.0 km/h (net), while maximum speeds ranged from 33.0 km/h (net) to 41.0 km/h (rally continued). Although there were observable differences in average speeds across serve outcomes, these were not statistically significant ($p = 0.178$), as shown in Table 3.

Table 3. Relationship between ball speed and effectiveness in competitive matches

	Out of bounds	Net	Rally continued	Direct point	p value	Cohen's d
Serves evaluated (n)	42	19	420	112		
Speed (km/h)	23.2 ± 6.6	20.9 ± 6.1	22.1 ± 5.3	22.9 ± 5.4	0.178	d=0.213
Minimum speed (km/h)	8.0	10.0	4.0	8.0		
Maximum speed (km/h)	38.0	33.0	41.0	38.0		

Note: Speed values are expressed as mean $\pm$ standard deviation.

Discussion

The results of this study provide relevant insights into the performance of young sitting volleyball athletes, focusing on ball speed during service and its relationship with game effectiveness. A total of 593 serves were analyzed during the V Parapan American Youth Games 2023, and it was determined that the average ball speed was similar between genders, approximately 22 km/h, with no significant differences. These findings align with previous research indicating that service speed is not the sole determinant of success in the game (Marszałek et al., 2018).

A crucial aspect identified in this study is the lack of association between service speed and effectiveness in terms of points scored. This finding suggests that other factors, such as service accuracy and strategic placement, may play a more influential role in athlete performance. Previous research has shown that, in conventional volleyball, service effectiveness is more related to direction and variability in execution than to absolute speed (Cavedon et al., 2022). This implies that coaches should prioritize the development of tactical awareness and service precision rather than focusing solely on increasing ball speed.

Additionally, studies have indicated that physical factors such as vertical reach and core strength are highly correlated with higher service speed (Cavedon et al., 2022). This suggests that training programs should focus on improving these capabilities to optimize player performance. Moreover, research on the morphological-motor status of sitting volleyball athletes has revealed that specific anthropometric characteristics can influence game effectiveness (Bratovčić et al., 2017). Considering these characteristics in training planning would allow for the design of personalized strategies for each athlete, maximizing their performance.

Another relevant aspect is the importance of psychological training. Ahmadi et al. (2020) highlighted that mental preparation and practice time are determining factors in the success of elite players. The inclusion of psychological strategies in athlete preparation could enhance their concentration, stress management, and decision-making abilities during service. Similarly, the study by Liu et al. (2025) emphasizes the need to understand physical adaptations in sitting volleyball players to optimize injury prevention and improve long-term performance. From a tactical perspective, the literature suggests that variation in service types is crucial for game success (Mardila et al., 2024). While in conventional volleyball, a combination of floating and powerful serves has been shown to be effective, further research is needed in sitting volleyball to understand how these variations can influence game dynamics. Comparing different service styles and their impact on performance could be key to developing more effective strategies.

From a practical standpoint, these findings can be highly useful for coaches seeking to optimize their players' performance in sitting volleyball. Instead of focusing exclusively on service speed, coaches should implement specific training sessions to improve precision and tactical decision-making during the game. Additionally, incorporating strength training aimed at enhancing vertical reach and core stability can significantly contribute to better performance. Psychological training strategies should also be included to improve players' confidence and emotional control in high-pressure situations. These adaptations in training planning can contribute to a more comprehensive development of athletes and improved competitive performance. Despite the contributions of this study, certain limitations must be considered. The sample was restricted to participants in the V Parapan American Youth Games 2023, which limits the generalization of the findings to other competition levels or populations. Additionally, the lack of a more in-depth psychological analysis prevented the exploration of aspects such as motivation and stress management, which could influence performance. Furthermore, the absence of a longitudinal follow-up hinders the evaluation of players' progress over time. These limitations underscore the need for future studies incorporating more comprehensive and contextually rich analyses.

Conclusions

This study analyzed the relationship between service speed and its effectiveness in young sitting volleyball players. The results revealed that the average service speed was similar between genders, with values close to 22 km/h, and that there was no significant association between speed and service effectiveness. This challenges the notion that higher ball speed automatically translates into better game performance.

The findings highlight the need for coaches to focus their training strategies on developing precision and tactical decision-making rather than solely emphasizing service speed. Additionally, evidence suggests that improving vertical reach and core strength could contribute to a more effective service, implying the need to integrate specific exercises to strengthen these capabilities in training programs.

From a tactical standpoint, it is essential to further analyze the influence of different service types on game dynamics. The lack of a clear relationship between speed and effectiveness suggests that developing diversified strategies may be key to optimizing performance in youth sitting volleyball. Finally, future studies incorporating psychological analyses and longitudinal follow-ups are recommended to better understand the factors influencing the competitive success of these athletes.

Conflicts of interest

The authors report no conflicts of interest.

References:

- Ahmadi, S., Marszałek, J., Gutierrez, G. L., & Uchida, M. C. (2020). Sitting volleyball players: Differences in physical and psychological characteristics between national and league teams. *Kinesiology*, 52(2), 169–177. <https://doi.org/10.26582/k.52.2.3>
- Altundag, E., Soyulu, C., & Akyildiz, Z. (2024). Multidimensional analysis of serving speed in volleyball players by position, sets, and league types: Interactions and statistical differences. *BMC Sports Science, Medicine and Rehabilitation*, 16(1), 240. <https://doi.org/10.1186/S13102-024-01031-Z>
- Bernard, H. R. (2017). Research Methods in Anthropology: Qualitative and Quantitative Approaches - H. Russell Bernard -. *Research Methods in Anthropology: Qualitative and Quantitative*
- Bratovčić, V., Mikić, B., Mehmedinović, S., Šarić, E., & Kostovski, Ž. (2017). Morphological motor status of top quality sitting volleyball players in Bosnia and Herzegovina. *Journal of Physical Education and Sport*, 17(2), 764–769. <https://doi.org/10.7752/JPES.2017.02116>
- Bujang, Arisman, Haqiyah, A., Kusumawati, M., Ekowati, & Muslimin, M. (2024). The role of biomechanics in improving volleyball service performance. *Altius: Jurnal Ilmu Olahraga Dan Kesehatan*, 13(2), 227–239. <https://doi.org/10.36706/ALTIUS.V13I2.90>
- Cavedon, V., Sandri, M., Golia, S., Brugnoli, C., Bolčević, F., Zancanaro, C., & Milanese, C. (2022). Predictors of Ball Velocity in the Sitting Volleyball Serve: A Causal Analysis. *International Journal of Sports Medicine*, 44(8), 576–583. <https://doi.org/10.1055/A-2038-3333/ID/R9718-0017/BIB>
- Fernandez-Echeverria, C., Gil, A., Moreno, A., Claver, F., & Moreno, M. P. (2015). Analysis of the variables that predict serve efficacy in young volleyball players. *International Journal of Performance Analysis in Sport*, 15(1), 172–186. <https://doi.org/10.1080/24748668.2015.11868785>
- Hanrahan, N., & De Luigi, A. J. (2023). Adaptive Volleyball. *Adaptive Sports Medicine: A Clinical Guide: Second Edition*, 265–272. https://doi.org/10.1007/978-3-031-44285-8_22
- Häyrinen, M., Mikkola, T., Honkanen, P., Lahtinen, P., Paananen, A., & Blomqvist, M. (2011). Biomechanical analysis of the jump serve in men's volleyball. *British Journal of Sports Medicine*, 45(6), 543–543. * <https://doi.org/10.1136/BJSM.2011.084558.28>
- Hosmer, D. W., & Lemeshow, S. (2000). Applied Logistic Regression. *Applied Logistic Regression*. <https://doi.org/10.1002/0471722146>
- Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Frontiers in Psychology*, 4(NOV), 62627. * <https://doi.org/10.3389/FPSYG.2013.00863/BIBTEX>
- Liu, J., Yu, H., Cheung, W. C., Bleakney, A., & Jan, Y. K. (2025). A systematic review of pathophysiological and psychosocial measures in adaptive sports and their implications for coaching practice. *Heliyon*, 11(2), e42081. * <https://doi.org/10.1016/J.HELİYON.2025.E42081>
- MacKenzie, S., Kortegaard, K., LeVangie, M., & Barro, B. (2012). Evaluation of two methods of the jump float serve in volleyball. *Journal of Applied Biomechanics*, 28(5), 579–586. * <https://doi.org/10.1123/JAB.28.5.579>
- Makar, P., Silva, A. F., Silva, R. M., Janusiak, M., Smoter, M., & Clemente, F. M. (2024). The Agreement Between Bushnell and Stalker Radar Guns for Measuring Ball Speed in Throwing and Kicking. *Applied Sciences* 2024, Vol. 14, Page 10476, 14(22), 10476. * <https://doi.org/10.3390/APP142210476>
- Mardila, A. V., Victorian, A. R., Destriana, & Destriani. (2024). Exploring the impact of targeted overhand serve practice intervention: An approach to improve volleyball players' overhand serving skills. *Journal Sport Area*, 9(1), 55–64. * [https://doi.org/10.25299/SPORTAREA.2024.VOL9\(1\).14551](https://doi.org/10.25299/SPORTAREA.2024.VOL9(1).14551)
- Marszałek, J., Molik, B., & Gomez, M. A. (2018). Game efficiency of elite male sitting volleyball players with regard to athletes' physical impairment. *International Journal of Sports Science & Coaching*, 13(3), 383–390. * <https://doi.org/10.1177/1747954117716791>
- Pawlik, D., Bobula, G., & Mroczek, D. (2024). The effectiveness and types of serves used in elite women's and men's volleyball in the 2021/2022 season. *Scientific Reports* 2024 14:1, 14(1), 1–10. * <https://doi.org/10.1038/s41598-024-68262-5>
- Quiroga, M. E., García-Manso, J. M., Rodríguez-Ruiz, D., Sarmiento, S., De Saa, Y., & Moreno, M. P. (2010). Relation between in-game role and service characteristics in elite women's volleyball. *Journal of Strength and Conditioning Research*, 24(9), 2316–2321. * <https://doi.org/10.1519/JSC.0B013E318E3812E>
- Ramirez-Campillo, R., García-de-Alcaraz, A., Chaabene, H., Moran, J., Negra, Y., & Granacher, U. (2021). Effects of Plyometric Jump Training on Physical Fitness in Amateur and Professional Volleyball: A Meta-Analysis. *Frontiers in Physiology*, 12, 636140. <https://doi.org/10.3389/fphys.2021.636140>
- Sitting Volleyball Rules and Regulations - World ParaVolleyWorld ParaVolley. (2022). *World ParaVolley*. <https://worldparavolley.org/sitting-volleyball-rules-and-regulations/>