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Section III – Sports and Physical Activity

Serving Changes in Elite Women's Volleyball at the 2020–2024 Olympics

by

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This study analyzed the serving techniques in women's volleyball matches during the 2020 Tokyo Olympics and the 2024 Paris Olympics to reveal the development direction and evolving trends of serving techniques in current elite international competitions. Through video analysis, 64 matches were examined (228 sets in total), encompassing 9,857 serves. We evaluated statistically the serving aspect in Olympic women's volleyball matches, recording variables such as the types of the serve, the landing point of the serve, the effectiveness of the serve, and the position of the serve. Overall, the types of the serve in elite women's volleyball stabilized, with no significant differences ($p > 0.05$) among serving types. In terms of the effectiveness of the serve, serve disruptions ($p = 0.02$) increased significantly from 2020 to 2024, while service points, neutrals ($p = 0.19$) and errors ($p = 0.93$) showed no significant differences. Regarding the landing point of the serve, no significant differences were observed in zones 1 ($p = 0.23$), 3 ($p = 0.06$), 4 ($p = 0.56$), and 6 ($p = 0.22$). There was, however, a significant difference in the landing points of the serve at zones 2 ($p = 0.02$) and 8 ($p = 0.04$), and there was a very significant difference in the landing points of zones 5, 7 and 9 ($p < 0.01$). For the position of the serve, no significant differences were found among the serving positions ($p > 0.05$), with the right zone being the predominant serving position in women's volleyball. This study provides valuable insights for elite women's volleyball teams preparing for the 2028 Olympic Games. Coaches can tailor serving strategies based on match conditions and the physical attributes of players to optimize their performance.

Keywords: *women's volleyball; Olympic Games; serving; technique; comparative analysis*

Introduction

Volleyball has been one of the most spectator-friendly and highly competitive team sports in the Olympic Games since its debut as an official discipline at the 1964 Tokyo Olympics (FIVB, 2021). The Olympic volleyball competition, as the highest level of international play, sees its competitive manifestations reflect contemporary technical trends. With volleyball being a net-separated, skill-dominant antagonistic sport, athletes must undergo comprehensive development of their general physical abilities and fundamental techniques. According to the sport's characteristics, specialized training should focus on hitting mechanics. Technical-tactical proficiency in this sport critically determines overall competitive performance. Matches in net-separated, skill-dominant sports form a "technical chain" where each preceding technical element influences the subsequent one. Scoring in this category can be classified as either active or passive (Chen and Tian, 2016). In volleyball, the serve constitutes active scoring, with points scored directly from opponents' errors categorized as unforced points. A key trend in modern volleyball is the increasing variation in players' technical-tactical intensity (Imac et al., 2018). Volleyball has four scoring types, namely, serving, blocking, attacking, and opponent errors, with serving being the primary means of direct scoring (Raiola et al., 2016). Consequently, serve effectiveness has become a crucial element in gaining competitive advantage,

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often determining the outcome of a match (Bari et al., 2023).

As the initiating technical action of play, the serve has gained increasing tactical significance in modern volleyball. Effective serving requires both sufficient aggressiveness to pressure opponents and adequate consistency to avoid errors. In high-level competition, the serve has evolved beyond a fundamental skill into a critical offensive weapon, aiming either to score directly or disrupt the offensive rhythm of the opponent (Pawlik et al., 2024). In women's volleyball, it stands as one of the critical skills for increasing the probability of winning a match (Giatsis, 2023). Serving performance is mainly influenced by the types of serves (García-de-Alcaraz et al., 2016), each producing different serving effects. Owing to changes in volleyball rules, volleyball serving methods have been evolving continuously, shifting from traditional overhand serving to powerful jump serving, jump float serving, and stationary overhand float serving, all of which have significantly improved the serving speed and the accuracy of serving locations. The quality of volleyball serving is affected by multiple factors, such as the physical fitness and technical-tactical levels of athletes (Tao and Liang, 2019). Many researchers (Kitsiou et al., 2020; Quiroga et al., 2010; Stankovic et al., 2018) have conducted studies on various aspects of serving, such as the serve type, serve effectiveness, and how players' different roles in matches affect their serving techniques. Variations in the serve type, the serving landing zone, and the serve zone have also been observed between different genders.

This study examined the evolutionary trends and underlying factors in women's volleyball serving techniques by conducting a comparative analysis between the 2020 Tokyo Olympics and the 2024 Paris Olympics. It aimed to establish a theoretical foundation for the preparation of the 2028 Olympic Games and provide a technical reference for coaches and athletes to execute high-quality serves in competition.

Methods

Sample

The study sample included 38 matches (n = 38) of the women's volleyball competition at the 2020 Tokyo Olympics and 26 matches (n = 26) at the 2024 Paris Olympics, totaling 64 matches and 228 sets, with a total of 9,857 serves. Owing to video broadcasting limitations, 17 serves were not clearly observable, and thus the technical actions of 9,840 serves were analyzed.

Data Collection

Videos of the matches from the two Olympic Games were retrieved from public platforms, such as the official Olympic website, Tencent Video, and CCTV Video. All videos were played at 0.5× speed, and data collection was implemented through pause operations to ensure the accuracy of data recording. The study adopted video analysis and comparative methods, with recorded content including serve types, serve placements, serve effectiveness, and serve zones.

Reliability

The observer possessed specialized volleyball training credentials, including a National First-Class Athlete Certification issued by China's General Administration of Sport. Before official data collection commenced, a team was randomly selected from a match for preliminary data gathering. To ensure data reliability, a follow-up observation was conducted two weeks later. Reliability analysis was conducted using SPSS (version 27), with intra-observer Cohen's Kappa values exceeding 0.83, confirming satisfactory data reliability.

Variables

Stankovic et al. (2018) and Kitsiou et al. (2002) used indicator variables related to the focus of this study. In the present study, the variables used were the types of the serve, the effectiveness of the serve, the landing point of the serve, and the position of the serve.

The types of serves were classified into three categories: (1) a power jump serve: this serve used a running approach to jump and then hit the ball at the highest point toward the opponent's court, with a distinct spiking motion of the arm during contact; (2) a jump float serve: this involved a running approach jump or a standing jump and then striking the ball briefly in the air to make it fly to the opponent's court without rotation and with irregular drifting; (3) an overhand serve: this serve involved tossing the ball upward in place (without a running approach or a jump) and then hitting it toward the opponent's court.

Serve effectiveness was categorized into four

types: (1) a point: the opponent received the ball but failed to control it properly, and was unable to organize an effective attack, only passing or digging the ball over the net; (2) disruption: the opponent received the ball, but could not handle it effectively, resulting in an unstructured attack where they only managed to pass or dig the ball over the net; (3) neutral: the serve crossed the net, and the opponent could either smoothly initiate an attack or hit the ball over the net with limited offensive options; (4) error: the serve went out of bounds or failed to cross the net, or a foul was committed during the serving action.

The position of the serve was classified based on the baseline of the court, with the baseline segmented into three sections, each 3 m in length: the right area corresponded to position 5, the middle area corresponded to position 6, and the left area corresponded to position 1.

The landing point of the serve divided the court into nine 3 m × 3 m zones according to the on-court player positions: the front zone included zones 2, 3, and 4; the back zone included zones 1, 5, and 6; the middle zones were designated as 7 (the middle area between zones 4 and 5), 8 (the middle area between zones 3 and 6), and 9 (the middle area between zones 2 and 1).

Statistical Analyses

Descriptive statistical analysis was first conducted for all variables involved. Continuous variables (such as the proportions of various serve types and effectiveness rates) were reported as mean ± standard deviation (M ± SD) to visually illustrate the central tendency and dispersion of the data. To compare differences in serve technical metrics between the 2020 Tokyo Olympics and the 2024 Paris Olympics, the Mann-Whitney U test was employed. This nonparametric statistical method does not require data to follow a normal distribution. It is suitable for testing significant differences between two independent samples of ordinal data or non-normally distributed continuous data (such as the proportion data in this study). Statistical significance thresholds were set at $p < 0.05$ (significant) and $p < 0.01$ (very significant).

Results

Based on the actual performance characteristics of elite women's volleyball competition, this study conducted a comparative analysis of serving techniques between the 2020 Tokyo Olympic Games and the 2024 Paris Olympic Games. In particular, we examined four key dimensions: the types of the serve, the effectiveness of the serve, the landing point of the serve, and the position of the serve.

Mann-Whitney U tests revealed no significant differences ($p > 0.05$) in utilization frequencies among the three primary serve types across both Olympic Games. The jump float serve maintained dominant prevalence in elite women's competition (Table 1).

Statistical analysis revealed consistent M values across both Olympic Games: the power jump serve (M = 0.12) and the overhand serve (M = 0.03) demonstrated relatively low utilization frequencies. By contrast, the jump float serve showed high and stable adoption rates (Tokyo 2020: M = 0.84; Paris 2024: M = 0.85). The SD of the power jump serve decreased from 0.16 in the Tokyo Olympics to 0.09 in the Paris Olympics. The smaller SD indicates that the use of this serving type was more concentrated among specific players or for specific tactics. The SD of the stationary overhand serve increased slightly from 0.07 to 0.08, showing almost no change, which suggests that the use of this serving type remained scattered, with only individual players employing it. For jump float serves, the SD decreased from 0.18 to 0.11, and with a high M value, the reduction in SD reflects a more stable trend in the use of this serving type.

We also compared and analyzed the effectiveness of serving in women's volleyball matches between the 2020 Tokyo Olympics and the 2024 Paris Olympics. A total of 9,840 serving actions were statistically analyzed: 5,686 serves from the Tokyo Olympics and 4,154 serves from the Paris Olympics. Among them, the neutral was the most common. Statistical analysis revealed that among the four types of serve effectiveness, there were no significant differences in the point ($p = 0.50$), neutral ($p = 0.16$), and error ($p = 0.96$), while only the effectiveness of disruption showed a significant difference ($p < 0.05$) (Table 2).

In terms of point serve effectiveness, the M value remained identical between 2020 (M ± SD = 0.05 ± 0.03) and 2024 (M ± SD = 0.05 ± 0.02), with a slightly smaller SD, indicating overall stability. This result suggests that relying on serving points

is relatively uncommon in high-level matches, with teams likely depending more on tactical combinations to score. In terms of disruption serve effectiveness, there was an upward trend from 2020 (M ± SD = 0.06 ± 0.04) to 2024 (M ± SD = 0.07 ± 0.03). For neutral serve effectiveness, a slight decline was observed from 2020 (M ± SD = 0.80 ± 0.06) to 2024 (M ± SD = 0.79 ± 0.05), suggesting a marginal increase in the offensive nature of serves in elite women's volleyball matches in 2024. Regarding serving errors, there was no change between 2020 and 2024.

This study compared the landing point of serve patterns in elite women's volleyball between the 2020 Tokyo and 2024 Paris Olympics. In Tokyo, serves predominantly targeted zones 7, 8 and 9, followed by backcourt zones 1, 5, and 6, with minimal use of front court zones 2, 3, and 4. In Paris, the focus shifted significantly toward zones 7 and 8, while front court zones 2, 3, and 4 remained the least utilized. Statistical analysis revealed non-significant differences in targeting consistency for zones 1 (p = 0.23), 3 (p = 0.06), 4 (p = 0.56), and 6 (p = 0.22) across both Olympic Games. However, significant reductions occurred in zones 8 (p = 0.04) and 2 (p = 0.02), indicating declining tactical emphasis on zones 8 and 2. Highly significant changes emerged in zones 5 (p < 0.01), 7 (p < 0.01), and 9 (p < 0.01), with zone 9 usage sharply decreasing, while zones 5 and 7 targeting markedly increased.

In this study, we also conducted a comparative analysis of the position of the serve in women's volleyball matches between the 2020 Tokyo Olympics and the 2024 Paris Olympics. Among the three positions of serves, the right zone served as the primary serving area in both Olympics. The M value of serving from the left zone showed a slight increase from 2020 (M ± SD = 0.35 ± 0.17) to 2024 (M ± SD = 0.38 ± 0.15), but with p = 0.15, there was no statistically significant difference. The M value of serving from the middle zone showed a slight decrease from 2020 (M ± SD = 0.14 ± 0.13) to 2024 (M ± SD = 0.12 ± 0.12), but with p = 0.28, there was no statistically significant difference as well. Similarly, the M value of serving from the right zone remained stable overall from 2020 (M ± SD = 0.50 ± 0.18) to 2024 (M ± SD = 0.50 ± 0.09), and with p = 0.90, no statistically significant difference was observed.

Table 1. Comparative analysis of serving types.

	2020		2024		p
	N	*M* ± *SD*	N	*M* ± *SD*	
Power jump Serve	702	0.12 ± 0.16	488	0.12 ± 0.09	0.24
Jump Float Serve	4,817	0.84 ± 0.18	3,581	0.85 ± 0.11	0.50
Overhand Serve	167	0.03 ± 0.07	85	0.03 ± 0.08	0.37
Total	5,686	-	4,154	-	-

*Note: * means 0.01 < p < 0.05, the difference is considered significant;*
*** indicates p < 0.01, the difference is considered to be very significant*

Table 2. Comparison of serve effectiveness.

	2020		2024		*p*
	N	*M* ± *SD*	N	*M* ± *SD*	
Point	275	0.05 ± 0.03	197	0.05 ± 0.02	0.50
Disruption	323	0.06 ± 0.04	294	0.07 ± 0.03	0.02*
Neutral	4,530	0.80 ± 0.06	3,264	0.79 ± 0.05	0.19
Error	558	0.10 ± 0.04	396	0.10 ± 0.04	0.93
Total	5,686	-	4,154	-	-

*Note: * means 0.01 < p < 0.05, the difference is considered significant;*
*** indicates p < 0.01, the difference is considered to be very significant*

Table 3. Comparison of serve placement zones.

	2020		2024		*p*
	N	*M* ± *SD*	N	*M* ± *SD*	
1	213	0.04 ± 0.03	135	0.03 ± 0.03	0.23
2	41	0.00 ± 0.01	12	0.00 ± 0.00	0.02*
3	55	0.00 ± 0.01	22	0.00 ± 0.00	0.06
4	57	0.00 ± 0.02	30	0.00 ± 0.01	0.56
5	278	0.05 ± 0.04	351	0.08 ± 0.05	＜0.01**
6	481	0.09 ± 0.06	400	0.10 ± 0.05	0.22
7	1,388	0.24 ± 0.10	1,236	0.29 ± 0.09	＜0.01**
8	1,596	0.28 ± 0.08	1,026	0.25 ± 0.07	0.04*
9	1,019	0.18 ± 0.08	542	0.13 ± 0.06	＜0.01**
Total	5,128		3,754		

*Note: * means 0.01 < p < 0.05, the difference is considered significant;*
*** indicates p <0.01, the difference is considered to be very significant*

Table 4. Comparison of serve zones.

	2020		2024		*p*
	N	*M* ± *SD*	N	*M* ± *SD*	
Right area	2,015	0.35 ± 0.17	1,563	0.38 ± 0.15	0.12
Middle area	814	0.14 ± 0.13	515	0.12 ± 0.12	0.28
Left area	2,857	0.50 ± 0.18	2,076	0.50 ± 0.09	0.92
Total	8,686	-	4,154	-	-

*Note: * means 0.01 < p < 0.05, the difference is considered significant;*
*** indicates p < 0.01, the difference is considered to be very significant*

Discussion

This study investigated changes in serving techniques in women's volleyball matches across two Olympic Games to analyze and reveal trends in serving strategies employed by elite women's volleyball teams during competitions. The research collected serving technique data from the main matches of the women's volleyball competitions at the 2020 Tokyo Olympics and the 2024 Paris Olympics. Using a comparison method, the study analyzed changes in serving techniques across multiple dimensions, including serving types, serving effectiveness, serving landing zones, and the serving position area. The analysis revealed significant differences in serving effectiveness and serving landing zones among athletes between 2020 and 2024. Data showed that the elite women's volleyball players tended to use jump float serves, which is consistent with the findings of Kitsiou et al. (2020) who studied the types of serving in the 2018 FIVB Volleyball World League for both men and women. Their study indicated that in the 2018 World League finals, male players predominantly used power jump serves, while female players preferred jump float serves, revealing a clear distinction in the types of the serve between genders. The jump float serve, as a low-impact, high-reward serving technique, ranks among the strongest predictors of match outcomes (Rangubhet, 2025). The study by Laclote-Gutierrez et al. (2025) indicated that serving strategies were primarily influenced by the athlete's physical attributes, opponent strength, and the match environment. They place relatively lower demands on leg and upper limb strength, while power jump serves require higher levels of lower limb and upper body strength. Most athletes cannot fully execute the entire motion of a power jump serve, of which contact point is higher than that of a jump float serve. The higher the contact point, the sharper the flight angle of the ball, the faster its velocity, and the stronger its attacking power upon reaching the opponent's side (Alexander et al., 2013). Power jump serves are predominantly utilized by specific athletes at the beginning of matches. However, in the middle and late stages of matches, some athletes who primarily use this serve may switch to jump float serves to maintain stability and mitigate risks (Marcelino et al., 2012). This strategy may be related to the psychological quality of athletes. When the team experiences consecutive point losses, it can affect their on-court performance, thereby influencing their serving. Stankovic et al. (2018) found that outside hitters and opposites tended to use power jump serves more frequently in matches, a preference that may be related to their in-game role. Different in-game roles impose varying requirements on athletes' comprehensive qualities, such as strength and speed. In summary, the types of the serve of women's volleyball players can be reasonably determined based on various factors, including their physical fitness, psychological quality, on-court positions, and biomechanics.

In terms of the effectiveness of the serve, the findings of this study indicate that from 2020 to 2024, the disruptive effectiveness of serves in elite women's volleyball significantly increased, while direct points and error rates remained stable. This tactical evolution can be interpreted through two dimensions: the match style and psychological mechanisms. From a match style perspective, this discovery aligns closely with the emphasis on "continuity" in women's volleyball highlighted by Hileno et al. (2023). Compared to men's volleyball, which pursues direct point-ending opportunities through high-risk serves (more aces and higher error rates), women's volleyball tends to adopt a more stable serving strategy centered on the jump float serve. By placing the ball precisely, it increases, thereby seeking winning opportunities in longer rallies, the difficulty of the opponent's first pass. From a psychological perspective, athletes' serving decisions can be influenced under high-pressure environments like the Olympics. Gorgulu and Gokcek's (2021) research on the "ironic process" reminds us that simply instructing athletes to "avoid errors" may backfire under intense pressure. The trend observed in this study suggests that elite female volleyball players may have shifted their tactical objectives for serving away from the extremes of "avoiding errors" and "pursuing aces" toward the more pragmatic goal of "pursuing effective disruption". This may represent a more sustainable and effective psychological and tactical choice under high-pressure conditions. Analysis of video footage also reveals that while serving to the seam zone or baseline increases the frequency of aces, it comes with a higher risk of errors (Fernandez-Echeverria et al., 2015). During matches, serve effectiveness is influenced not only by serving technique but also

by factors such as serve quality, the mental state, and tactical strategy. Faster serves reduce the opponent's reaction time, making them more threatening. Stankovic et al. (2018) noted that the stage of the match and the mental state are important latent variables determining serve consistency. Tactically, targeting areas away from the libero yields better results. Servers also aim for the main attackers, secondary attackers, or weak receiving zones to disrupt the opponent's first pass and apply tactical pressure.

Analysis of the landing point of the serve during the 2024 Paris Olympics indicated that elite women's volleyball teams directed their serves predominantly towards zones 5 and 7. Conversely, serves targeting zones 2 and 9 declined progressively, while serves aimed at zones 6 and 8 stabilized. This pattern suggests that elite women's teams prioritize target serving or zones serving strategies, specifically attacking reception weaknesses within the opposing team. These findings align with research by Barzouka et al. (2020) and Valhondo et al. (2018), indicating that when teams are evenly matched, servers often exploit gaps between passers' defensive positions to enhance the effectiveness of the serve. Regardless of their specific match situation or role on the court, the majority of serves were biased towards the court centerline region, primarily concentrated in zones 5 and 7. This likely reflects strategic attempts to increase reception difficulty and neutralize the opponent's primary attack option.

Analysis of the position of the serve from 2020 to 2024 revealed no statistically significant differences in the distribution across the three positions of the serve among elite women's volleyball players. However, the right zone emerged as the predominant service location. This finding aligns with research by Quiroga et al. (2010), which indicated that the position of the serve among elite women's players was linked to the subsequent defensive position. Specifically, 80% of players favored initiating serves from the right zone and subsequently defending zone 1. Conversely, only 47% preferred serving from the left or the middle zone before defending zone 5. Serving from the right zone offers right-handed players optimal body alignment, facilitating serves driven down the line towards the opponent's centerline zone 7 or zone 5, or crosscourt towards the opponent's zone 9 or zones 1 and 2. Similarly, left-handed servers often select the left zone. Video analysis further indicated that power jump serves were predominantly executed from the left zone, sometimes supplemented by the middle zone.

Conclusions

The results of this study indicate that the serving techniques of elite women's volleyball teams remained generally stable from 2020 to 2024. Jump float serves were the primary serving method for women's volleyball teams, with certain athletes employing the power jump serve and individual athletes using overhand serves. The increase in disruption of the effectiveness of the serve among elite women's volleyball teams, while the error rate and the point rate of serves remain stable, indicates that top teams maintained serving stability while enhancing aggression. By disrupting opponents' first passes through serves, they undermined the offensive structure of the opposing team. The effectiveness of the serve in women's volleyball matches may be influenced by factors such as serve quality, the types of the serve, tactical strategies, and mental states. The right zone remained the most common serving area, with serve placement zones gradually shifting toward zones 5 and 7 from 2020 to 2024. Elite women's volleyball teams have placed greater tactical emphasis on serving to specific targets or zones to disrupt the first attacking points of the opponent.

Practical Implications

This study emphasizes the need to analyze serving techniques through a multidimensional approach that considers tactical strategies, physical fitness, match conditions, and other factors. The findings can help provide a theoretical reference for elite women's volleyball teams preparing for the 2028 Olympic Games. Our study results suggest that coaches should refine the application of different serving styles under varying match conditions, focusing on variables such as serve placement zones, serve effectiveness, and serve zones. By analyzing serving techniques, coaches should integrate athletes' individual characteristics and real-time match conditions to purposefully select serving styles and deploy serving landing spots, thereby improving the accuracy and efficiency of serves.

Limitations

Although this study reveals the changing trends in serve types, serve effectiveness, serve placement zones, and serve zones among elite women's volleyball teams from 2020 to 2024, several limitations remain: (1) limitations in the research sample: the study only included 64 matches from two Olympic Games and did not incorporate other elite women's volleyball competitions; (2) subjectivity in video analysis: the reliance on video analysis introduced subjective bias; (3) generalizability constraints: the conclusions were primarily derived from Olympic video analysis, and their applicability to other elite women's volleyball events requires further validation.

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