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An Analysis of Float Serves in Women's Collegiate Volleyball

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AN ANALYSIS OF FLOAT SERVES IN WOMEN'S COLLEGIATE VOLLEYBALL

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ABSTRACT

AN ANALYSIS OF FLOAT SERVES IN WOMEN'S COLLEGIATE VOLLEYBALL

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Volleyball coaches generally have the belief that getting a serve to float, i.e. hitting the ball in such a way that spin is minimized causing unpredictability in the ball's movement in the air, is the aspect that makes the ball most difficult to pass. This analysis explores whether or not a serve floats, the serve's direction, location, and speed to determine what creates the most effective serve in regards to pass rating. The findings show that successfully getting the ball to float on a serve is indeed important. Also, serving the person immediately across from the server, and serving to the area between the server and the sideline are important indicators of serving success.

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I. INTRODUCTION

Serving is the skill that begins each rally in the sport of volleyball. It is the first offensive opportunity for the serving team and does not involve the direct influence of an opponent. It is a self-controlled skill that can lead to immediate points (service aces) gained for the serving team. Of course, service errors can also lead to an immediate loss of points for the serving team. The quality of the serve also plays a crucial role in the success of the serving team in subsequent rallies as it determines how well the receiving team can put the ball in play. In fact, serve receptions are generally rated based on how many attacking options the receiving team's setter has when running his/her offense. Thus, serving is a critical component of a team's ability to win matches in the sport of volleyball.

In elite volleyball, there are three types of serves used. The first is a standing float. This is performed with the player keeping both feet planted on the floor and hitting the ball with an overhead swing, directing it over the net. A successful float serve results in unpredictable movements of the ball, much like the knuckleball in elite levels of baseball. This unpredictable movement makes it difficult for the receiver to pass accurately. However, consistently getting the ball to float in this manner is difficult and takes precise training.

The second type of serve commonly used in elite volleyball is a jump float serve. The mechanics are identical to those of a standing float, but the player contacts the ball after approaching then jumping in the air raising their point of initial contact. The potential for unpredictable ball movement is maintained with the jump float serve, but the height of initial contact allows for more power from the server and a flatter or more downward flight path. Again, consistently getting the ball to float in this manner is difficult and takes precise training.

The last serve type is a jump serve or top spin serve. This is performed by tossing the ball high in the air with spin, approaching with footwork similar to that of an attack, jumping, and hitting the ball with top spin which yields a steep downward trajectory as it goes over the net. Top spin serves are generally the fastest of the three serving techniques and can be compared to a fastball in baseball. These serves lack the unpredictable nature found in float serves due to the rapid downward rotation put on the ball. Out of these three serve types, the jump float serve is the most commonly used within women's collegiate volleyball.

Regardless of serve type, serving is a unique skill within the sport as it is the only skill unaffected by the touch that happens just prior. In volleyball, the success of every contact, except serving, directly relies on the quality of the prior contact. For example, the quality of a set depends on how well the ball was passed to the setter. The outcome of an attack depends on whether or not the set was in the proper location. Most compelling for the study at hand, however, is that serving is the skill to start this chain reaction, but is not in itself impacted by any other skill. If the serving team can make it difficult for the receiving team to accurately put the ball in play to its setter, it is more difficult for the receiving team to get an accurate set and, consequently, an effective attack. This immediately puts the serving team at an advantage in defending the initial attack from the receiving team, allowing them to dig the ball more easily and run a sound offense in transition. Therefore, coaching staffs across all levels of volleyball include service training as a regular and critical component of practice.

This study aims to determine what components result in the most effective serve within collegiate women's volleyball in order to inform training efforts. Though many uncontrollable factors may influence the success of a serve (crowd noise, match intensity, match score, player fatigue, etc.), the components of interest in this study focus on those that are controllable by the server and can be improved with specific training efforts: float, location, direction and speed.

II. LITERATURE REVIEW

The critical nature of serving is well known within the sport of volleyball. The change to rally scoring implemented within NCAA Division 1 Women's Volleyball in 2001 placed even greater importance on serving. Before this change, side-out scoring was used and service errors did not result in an immediate point for the receiving team as points could only be awarded to the serving team. A missed serve simply transferred the serving responsibility to the opposing team, who then had the opportunity to score. The rule change introduced an interesting dichotomy to the serving component of volleyball. Teams want to serve tough, but not so tough that too many errors are made. Therefore, many researchers have attempted to analyze just how important serving is in relation to a match's outcome.

Zetou et al. (2007), Cothran (1992), Hawkins, Fellingham, and Page (2023), and Silva, Lacerda, and Joao (2014) have determined that serving is a vital component in predicting a team's ability to win games. More specifically, teams that win more have more service aces and fewer service errors than teams that lose more games (Silva, Lacerda, & Joao, 2014). Further, since reception errors also affect team score negatively, serving is the only skill in volleyball strongly indicative of both winning and losing games (Silva, Lacerda, & Joao, 2014). Thus, the focus of improving serves is increasing across the sport of volleyball (Yiannis & Panagiotis, 2005).

Strategies implemented behind the service line vary widely depending on coaching style, player skill level, and the serve receive strategy implemented by the opposing team (McGown, 2014). For example, many teams try to serve the perceived weakest passer on the opposing side, regardless of where they are located on the court. Other teams note particular areas on the court to serve when scouting opposing teams. The next step, then, would be for coaches to determine the best serve their players can execute in order to maximize the potential of serving on their team's ability to win games, regardless of the chosen strategy to execute during a given match.

Float

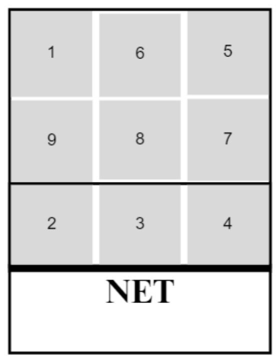
MacKenzie et al. (2012) and Huang, Chenfu, and Lin-Huan (2007) have shown that a jump float serve combines two key characteristics. These two characteristics are height of initial contact and float. However, the latter study fails to use subsequent pass quality as an indicator of serve efficacy. Reiser et al. (2020) and Depra et al. (1998) showed that the effectiveness of a float serve is found in the unpredictability of the ball's flight. This random movement happens as a result of exerting a force on the ball to increase its velocity while simultaneously minimizing its rotational velocity (Depra et al., 1998). Lateral displacement has been measured up to 1.5 meters (Reiser et al., 2020). A change that large requires significant adjustments in extremely short periods of time by the receiver in order to pass the ball accurately. Successfully getting a serve to float consistently is difficult, takes precise training, and even depends on the type of ball used

(Hong et al, 2020). However, no studies have attempted to grade whether or not the ball actually floated after a jump float serve was attempted.

Speed

Moras et al. (2008) analyze the impact of serve speed in professional men's volleyball. Results suggested that there was no significant relationship between speed and serve efficacy in relation to both pass quality and error percentage. Another study uncovered an interaction between the reception location and the serve speed (Paulo et al., 2016).

Figure 1: Court Breakdown by Zone

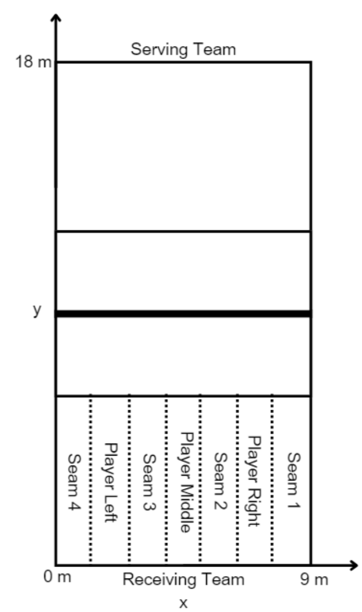


This study used the general 9 zone breakdown of a volleyball court to classify serve locations. They concluded that serves sent to the right back corner of the receiving team's side of the court (zone 1) have shorter flight time and greater initial velocities than those served to the left back corner (zone 5) (Paulo et al., 2016). Lithio and Webb (2006) determine the best way to minimize the flight time of a serve based on three physical forces acting on the ball (gravity, air resistance, and the force resulting from spin), but do not include float serves in their analysis. There is little research analyzing the optimum speed of a float serve in women's volleyball.

Direction

Kitsiou et al. (2020) showed the difference in serve direction preferences between men's and women's volleyball, but ultimately did not determine an optimum direction for serving in either gender's sport. Lithio and Webb (2006) determined that cross-court serves allow for faster serves, but did not use subsequent pass grade as an indicator of serve effectiveness. We are aware of no literature analyzing the impact of serve direction on pass quality.

Figure 2: Hudl's Court Coordinate System and Seam Division



Location

Location in the context of this study refers to where the serve is received on the opposing team's court. Serves can either land in a "seam" or in a "passing lane". Seams are the areas between two passers or between one passer and a side line. Passing lanes are the lanes in which a receiver is standing. A study done by Fatah (2022) asserts that setters do make their decisions based on the zone of the court in which the ball is received, but did not draw a conclusion on which zone setters have the most difficulty with. Elftmann (2012) determined that zone 1 was this troublesome location, but did not analyze the disparity between serving in seams and serving right at a player. Lopez-Martinez et al. (2021) determined that the optimal serve location in women's beach volleyball is between the two players, but beach volleyball has many different rules and strategies making it difficult to compare to indoor volleyball. Even experienced indoor volleyball coaches generally believe that serving into a seam is more beneficial than right at a player as it requires the player to move to the ball in a very short period of time. However there is little evidence supporting this claim (Stone, 2021).

Ultimately, research has shown the impact serving has on winning games within the sport of volleyball, but there is a current dearth of research breaking down the effect of float, speed, direction and pass location to build an optimum serve.

III. METHODOLOGY

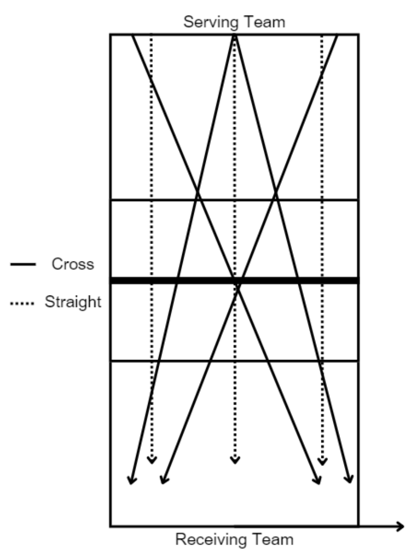
Data for this project were partially provided by Hudl and were collected during the 2018 NCAA Division 1 Women's Volleyball season. Data were sorted to include only serves made to Brigham Young University during the 2018 season to eliminate team-to-team variability. The other portion of the data was collected through slow-motion video analysis. The data provided by Hudl did not include a variable indicative of whether or not the ball floated on each service attempt. In order to classify a successful float serve, video of each serve stored on Hudl's primary volleyball platform, VolleyMetrics, was reviewed in slow motion. To maintain consistency, if the ball rotated less than 180°, it was deemed a successful float. If the ball rotated more than 180°, it was deemed an unsuccessful float serve. Serves that were true top spin serve attempts were also separated into their own category, but ultimately removed from the study as there were too few in the sample to properly analyze their impact. Similarly, midzone serves, or serves that landed in front of the 3-meter line, were also removed due to small counts. Service errors were also removed from the dataset as the response of interest in this study corresponds to the grade of the reception, a skill not even attempted when a service error is made. Therefore, it should be noted that this study does not account for service errors in assessing serve efficacy. The resulting data include 538 serves made to Brigham Young University during the 2018 season.

As previously stated, this study analyzes the impact of four components of a serve: float, speed, serve direction, and serve location. Float is a binary categorical variable that was determined based on ball rotation. If the ball had minimal rotation on an attempted jump float serve, it was deemed a “successful” float serve. If the ball had too much rotation, it was deemed an “unsuccessful” float serve. Thus, float is represented as a dummy variable for the purposes of this analysis with 0 and 1 corresponding to unsuccessful and successful float serves respectively.

Speed is a numeric variable that was initially estimated in milliseconds by subtracting the time stamps provided by Hudl for the pass and serve events. An estimated speed in miles per hour (MPH) was then calculated to make it more interpretable for NCAA women’s volleyball programs. This was done using x and y coordinates of both the serve and pass to determine an approximate linear distance in meters between the two events. Then, the distance in meters was divided by the time difference in milliseconds between each event to result in an approximate speed in meters per millisecond. This was then converted into miles per hour by multiplying by a factor of 2236.936. It is important to note that these speeds are likely a slight underapproximation because we are not accounting for the arc in the service path, and thus the computed distance is too small. Speeds were then divided into categories based on an elite coaching staff's prior knowledge of target speeds. Slow serves are serves less than 39 MPH, medium serves are between 39 MPH and 42 MPH, and fast serves are above 42 MPH.

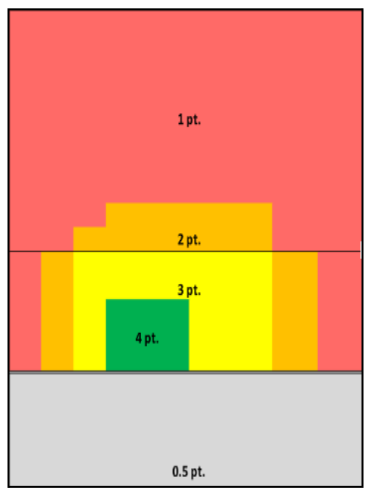
The location of the serve was defined by the categorical variable "seam". The volleyball court was divided by partitioning the court into 7 equally wide seams, as shown in Figure 2, using the x and y coordinates of the court. The x and y coordinates where the ball was received as recorded by Hudl were then used to categorize the serving location into one of these 7 areas.

Figure 3: Diagram of Possible Serve Directions: Classification of Cross and Straight Serves



The direction variable was created by categorizing each serve into one of two categories: cross or straight. Serves served at an angle were classified as "cross" serves where serves that were served straight ahead of the serving player were classified as "straight" serves.

Figure 4: Court Breakdown Showing Areas for Each Pass Rating



The pass grade variable was provided by Hudl and was scored on a 4-point scale. It is important to note that the ratings of these passes are ultimately subject to the subjectivity of the trained analyst breaking down the matches. While there are general rules that all analysts follow, it is impossible to account for every potential scenario that could happen with a pass. Therefore, analysts sometimes must use their own discretion to rate pass quality. Regardless, these ratings are still used commonly by collegiate coaching staffs and are generally regarded as an accurate representation of serve receive performance. A 4 rating corresponds to a perfect pass where all possible plays for all hitters are available for the setter to choose from. A 3 is a good pass where most plays are available, but all hitters are still available. A 2 is a medium pass where at least 1 attacker, usually the middle hitter, is no longer available as part of the play. A 1 is a poor pass where the setter either only has one option of where to set, is forced to bump-set, or a non-setter has to take the second ball. A 0.5 rating is an overpass, and a 0 is a pass error.

IV. RESULTS

Table 1: Chi Square Table of Counts for Successful and Unsuccessful Float Serves in Each Pass Rating Category

Pass Grade	0	0.5	1	2	3	4
No Float	9	12	39	43	92	63
Float	15	8	64	61	81	51

Table 2: Chi Square Standardized Residuals Exploring the Difference in Pass Grade Between Successful and Unsuccessful Float Serves

Pass Grade	0	0.5	1	2	3	4
No Float	-1.05	1.1	-2.28	-1.5	1.67	1.76
Float	1.05	-1.1	2.28	1.5	-1.67	-1.76

Analysis was done using Pearson's Chi Square testing. Float was found to be a statistically significant indicator of pass grade at the $\alpha = .05$ level, X^2 (5, N=538) = 12.57, p = .02. Unsuccessful float serves resulted in good passes 60% of the time with an average pass rating of 2.55 compared to successful float serves which resulted in good passes only 47% of the time with an average pass rating of 2.27. Alternatively, successful float serves resulted in 148 poor passes compared to only 103 poor passes made when serves did not float. Table 2 shows that this signal is driven by 1 point passes. There are fewer than would be expected when the serve does not float and more than expected when the serve does float.

Table 3: Chi Square Table of Counts for Cross and Straight Serves in Each Pass Grade Category

Pass Grade	0	0.5	1	2	3	4
Cross	18	11	60	68	125	91
Straight	6	9	43	46	48	23

Table 4: Chi Square Standardized Residuals Exploring the Difference in Pass Grade for Each Serve Direction

Pass Grade	0	0.5	1	2	3	4
Cross	0.62	-1.42	-2.71	-0.97	1.01	2.74
Straight	-0.62	1.42	2.71	0.97	-1.01	-2.74

Similarly, direction was found to be statistically significant, X^2 (5, N=538) = 15.39, p = .009, with straight serves resulting in good passes 43% of the time compared to 58% with cross court serves. The average pass grade for straight serves was 2.15 compared to cross court's average of 2.52. As seen in the table of standardized residuals, this significance is driven by there being an unusually small number of 1 passes made off of cross court serves and an unusually small number of perfect passes made off of straight serves.

Table 5: Chi Square Table with Counts for Each Individual Seam and Passing Lane by Pass Grade

Pass Grade	0	0.5	1	2	3	4
Seam 1	1	1	10	8	7	1
Seam 2	8	2	9	15	17	16
Seam 3	3	2	18	9	33	26
Seam 4	0	2	11	8	9	2
Left Passer	5	6	21	14	35	20
Middle Passer	5	3	12	16	46	34
Right Passer	2	4	22	34	26	15

Table 6: Chi Square Standardized Residuals Exploring the Difference in Serve Location Between Each of 4 Seams and 3 Passing Lanes

Pass Grade	0	0.5	1	2	3	4
Seam 1	-0.23	-0.04	2.29	1.27	-0.83	-2.34
Seam 2	3.16	-0.34	-1.27	0.68	-1.27	0.58
Seam 3	-0.59	-0.84	0.16	-2.5	0.92	1.89
Seam 4	-1.26	0.78	2.26	0.84	-0.5	-2.13
Left Passer	0.26	1.31	0.47	-1.54	0.6	-0.38
Middle Passer	-0.09	-0.73	-2.72	-1.71	1.95	2.42
Right Passer	-1.38	0.1	0.64	3.91	-1.67	-1.83

In analyzing the effect of serve location, the difference between each of the 4 seams and each of the 3 passer lanes resulted in a significant result, X^2 (30, N=538) = 70.14, $p < .001$. The standardized residuals uncover that aces, or 0 point passes, in seam 2 happen less often than would be expected if there were no difference between court locations. Similarly, 1 point passes happen more often in seams 1 and 4. Alternatively, 4 point passes happen less often in those seams and more often than expected when serving to the middle back passer. Note, this chi square approximation may be incorrect due to small counts in some categories.

Table 7: Chi Square Table with Counts for All Serves Landing in Seams Compared to All Serves Landing in Passing Lanes

Pass Grade	0	0.5	1	2	3	4
Seam	12	7	48	40	66	45
Passing Lane	12	13	55	64	107	69

Table 8: Chi Square Standardized Residuals Exploring the Difference in Serve Location Between All Seams and All Passing Lanes Grouped Together

Pass Grade	0	0.5	1	2	3	4
Seam	0.97	-0.51	1.4	-0.48	-0.77	-0.26
Passing Lane	-0.97	0.51	-1.39	0.48	0.77	0.26

To solve this issue, the test was simplified to comparing the mean pass grade for serves landing in all seams versus serves landing all passing lanes. The test was insignificant, X^2 (5, N=538) = 3.37, p = .64, signaling that there may not be any real difference between serving into a seam versus straight at a passer. However, the first test with all 7 locations being considered signals that there may be underlying patterns when serving at specific seams on the court that a future study with more data could more fully uncover.

Table 9: Average Pass Grade and Overall Good Pass Percentage for Serves Landing in Seams vs. Serves Landing in Passing Lanes

	Seam	Passing Lane
Avg. Pass Grade	2.34	2.46
Good Pass %	45%	49%
Attempts	247	320

Table 10: Average Pass Grade for Each Seam and Passing Lane

Location	Average
Seam 1	1.839286
Seam 2	2.313433
Seam 3	2.637363
Seam 4	1.968750
Left	2.346535
Middle	2.754310
Right	2.233010

This breakdown would suggest that seams 1 and 4 may result in the lowest pass grades on average.

Table 11: Chi Square Table with Counts for Each of 3 Speed Categories

Pass Grade	0	0.5	1	2	3	4
Fast	2	1	9	3	15	1
Medium	3	4	22	19	29	21
Slow	19	15	72	82	129	92

Table 12: Chi Square Standardized Residuals Exploring the Difference in Pass Grade for Each of 3 Speed Categories

Pass Grade	0	0.5	1	2	3	4
Fast	0.55	-0.15	1.44	-1.4	1.99	-2.52
Medium	-0.74	0.21	0.92	0.02	-0.6	0.06
Slow	0.37	-1.09	-1.62	0.75	-0.54	1.32

Speed categories were also analyzed using a Chi Square test. The test showed that speed was not a statistically significant indicator of pass grade X^2 (10, N=538) = 12.89, p = .23. However, the standardized residuals do give an indication that fast serves have more perfect passes than would be expected if speed had no effect on pass grade. It is important to note that these speeds are underapproximations and future analysis could be done with better data to fully analyze the impact of speed on serve efficacy.

V. DISCUSSION

In summary, serves served straight on with successful float are the most difficult to receive in women's volleyball. There is some evidence that suggests that seams 1 and 4 may be the most difficult locations to receive from, but more data would be needed to confirm this suggestion. The average pass grade for a serve that is served at the passer directly in front of the server with float and in seams 1 or 4 is 1.36. It is important to note that this analysis was done based on pass grades from Brigham Young University's 2018 team. This team was a Final Four team that season, so the assumption can be made that this team is a good representation of the best collegiate teams in the nation. That is, what works against this team would likely work against most teams within collegiate volleyball.

In most rotations, the serve receive pattern used by Brigham Young University included an outside hitter, a libero, and either a defensive specialist or another outside hitter. This same pattern is used by most women's collegiate teams, making it easily comparable to other teams. This may be why seams 1 and 4 perform better than other locations. Seam 4 is where the front row outside hitter typically would be forced to pass the ball. Seam 1 usually has another outside hitter or a defensive specialist passing. With liberos typically standing in the middle passing lane between seams 2 and 3, both of these serving locations keep the ball away from the player who is usually the most skilled passer. Additionally, serving in seams 1 and 4 often forces an offensive player, usually not as skilled at serve-receive, to receive the ball. Future studies could randomize the position specialty of the player passing in seams 1 and 4 to determine if the effect seen here is a result of confounding variables, or if it is an impact entirely based on court location.

The analysis also uncovered an interesting detail about serve direction. That is, if you serve straight on at a player, they typically pass worse as opposed to serving in a cross-court direction. This could be due to the shorter path and therefore shorter flight time giving the receiver a shorter reaction time to make adjustments as needed, especially when the ball is floating. Additionally, most women's volleyball players serve in the direction they are approaching. This makes it relatively simple for the passers to tell whether or not the ball will come in their direction. Therefore, a passer generally turns their body to face the server. When the serve is diagonally across the court, this turning to face the server simultaneously turns the passer's body towards the setter, regardless of what side of the court the server is on. This could make it easier for the receiver to pass the ball to the setter since they are facing that direction. When a server approaches straight at a passer, the passer's body is facing the server instead of being angled towards the setting zone. This forces the passer to rely more heavily on the angle of their arms to accurately pass the ball.

For future research, it would be beneficial to collect more accurate data on speed to determine an optimum speed which can consistently produce a float serve. Additionally, it would be beneficial for players and coaches to know the interaction between float and speed. That is, if an athlete is not able to consistently get the ball to float, what are the speeds they should be aiming for to maintain an effective serve? Additionally, future studies could take service errors into account. If more errors occur when trying to serve straight on in these edge seams, it may change the overall game-related impact of this serving strategy.

In summary, a serve that has float and is served directly at the player immediately across the court from the server is the most effective serve in terms of pass grade. Seams 1 and 4 in particular may be the most effective locations to serve and speed is not a significant indicator of pass grade.

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