Serving to Win: A Statistical Exploration of Optimal Serves in Beach Volleyball

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Abstract

Serving is the only part of a game of volleyball that is the same every time. Despite this, serving strategy and philosophy vary greatly. Teams who use the analytically optimal serve the most can gain a distinct advantage. In identifying the optimal serve, conclusions about best serve type, best serve location, and relationships between errors and effectiveness can be understood. This study analyzed 200,000 serves throughout the FIVB 2022 women's beach volleyball season with metrics such as serve type, serve location, error rate, and which team won the rally through location heatmaps, linear regression, and bar plots. jump-topspin serves were found to be more effective than jump-float serves. However, jump-topspin serves resulted in more errors; the serve effectiveness had no relationship with errors, but there was a strong relationship between serve effectiveness and errors for jump-float serves. These results will guide training and in-game beach and indoor volleyball serving strategies.

Introduction

Volleyball is played with two people outside on a beach or with six people indoors on hardwood, but serving remains the same. Serving is essential, because how well an opposing offense can return a serve determines how well the setter can set up the hitter. If the pass is high and close to the net, the setter can deliver an easy ball to hit, almost always leading to the receiving team's point. Still, if the setter can barely keep the ball alive, the hitter may only send over a free ball, giving the serving team the advantage.

Serving happens at the beginning of each rally, and no matter what happens in a game, the conditions for serving are the same. Despite how crucial serving is and how controlled the serving conditions are, making them easier to study and generalize, the volleyball world has little consensus on what serve type is optimal and should be used the most. By identifying the optimal serve in beach volleyball, players can practice hitting this exact type of serve to exact locations on the court, which they know will have the best outcome, giving an advantage over a team that guesses which serve would be the best. In finding the optimal serve in beach volleyball, conclusions about serve types, amount of errors, and serve location can be generalized to beach and indoor volleyball.

This study will focus on serves during the 2022 FIVB women's beach volleyball season using metrics such as serve type, serve location, winner of rally, error frequency, quality of pass, and quality of opposing attack to find the optimal serve. Using the statistics, the relationship between error frequency and effectiveness will be measured in various ways, and the areas of the court served to most effectively will be compared to their own error frequency. Using these various comparisons, the optimal service type and location will be determined.

Foundational Knowledge

There are four types of serves that the dataset records: jump-float, standing float, jump-topspin, and sky ball. Understanding the nature of each serve is important when interpreting the analysis results. A jump-float serve and a standing float serve rely on the server hitting the ball with a flat hand so that the ball has no spin and moves unpredictably through the air like a knuckleball, making it difficult for the passers to predict where the ball will go. In contrast, a standing float is performed by tossing the ball in front of the server, taking two or three steps, jumping, then hitting the ball with “float.” A standing float is performed by the server tossing the ball slightly in front of the server and delivering the same serve while remaining on the ground. A jump-topspin serve aims to create a topspin on the serve so it drops like a curveball; by doing so, the server can hit the ball harder, therefore serving faster without worrying about the ball flying too far out of the court. The serve is performed by throwing the ball in front of the server and letting the ball roll off the tips of the finger so that the ball spins forward. Then, the server takes two to four steps and will jump and hit the ball while snapping their wrist to create even more topspin. Because the ball drops, the server can hit the ball much harder, so it aims to beat the passers with speed, not lateral movement. Finally, a sky ball is an underhand serve in which the server tries to launch the ball as high as possible while still landing the ball in the receiving team's court. A sky ball serve falls fast, making it difficult to receive, and by serving it so high, passers have a difficult time predicting where the ball will land, especially as the sun gets in their eyes in outdoor beach volleyball.

Literature Review

Serving is the only part of volleyball where a single person has total control of the outcome and where the choice of technique is not affected by the conditions set by the flow of the game. Therefore, volleyball statistics have long been used to try to uncover the secrets of and optimize the serve. This review will outline the advances in serving data and outline where this paper may offer breakthroughs or fill gaps in knowledge.

Before making any conclusions about volleyball serving as a whole, it is important to acknowledge that this study was conducted only using women's beach volleyball data and there are massive differences in serving between men and women. The most obvious difference between men and women, when serving, are their choices in serve type. As outlined by a study comparing serving between men and women, men opt to jump-topspin serve 46.9% of the time and jump-float or standing float the other 53.1% of time, while women opt to jump-topspin serve 19.9% of the time and jump-float serve or standing float serve the other 80.1% (Koch & Tilp, 2009). Additionally men more often set the ball overhand with their hands, while women prefer to set underhand with a bump set. Another study, which looks at indoor volleyball serving, found that men prefer to jump-topspin serve while women prefer jump-floats (Kitsiou et al., 2020). The study also found that men and women servers varied in serve location. When playing indoor volleyball, women aimed jump-topspin serves to the middle and jump-float serves to the sidelines, while men tended to aim jump-topspin serves to the sidelines and would serve jump-float serves closer to the net, therefore serving shorter than women.

In terms of the performance of each serve type, although measured differently, a study on serving in Italy's top indoor's men's league had similar conceptual results. It was found that topspin serves, although resulting in more errors and negative outcomes, yield far more positive outcomes than the jump-float serve. Whilst the jump-float serve had far fewer negative outcomes, it rarely resulted in positive outcomes, and overwhelmingly resulted in neutral outcomes (Ciuffarella et al., 2013). In terms of position data, another study found similar results to Ciuffarella et al., with 74% of women's serves and 75% of men's serves going to the back third of the court (Dyba, 2013). FInally a study on international men's beach volleyball supports the idea that the jump-topspin serve is harder to perform. At the beginning of beach volleyball sets, points one through seven, men serve jump-topspin 89.7% of the time, but for the final six points of a set, that number drops to 27.3% as players get more fatigued (Jiménez-Olmedo et al., 2012).

In terms of comparing error percentage between different serve types, serve locations, and knockout percentage based on serve type and location, this paper builds upon past studies while offering a new dataset and different metrics. This paper fills in gaps of knowledge and has the potential for breakthrough in its identified correlation between errors and knockout percentage between different serve types. The benefit of being a player is feeling firsthand that aggression in depending on serve type leads to errors and affects outcome. The data concludes what I as a player believe to be true, which is that as you are aggressive and make more errors when jump-float serving, the knockout percentage will also increase, but when jump-topspin serving, errors and aggression do not correlate with a greater knockout percentage.

Methodology: Data Collection

The data used in this study was provided by Brian Hurler, a performance analyst for the US National Beach volleyball team. The dataset included nearly every contact with the ball during the FIVB Beach Pro Tour: Elite 16, FIVB Beach Pro Tour Challenge, FIVB Beach Pro Tour Finals, and FIVB World Championships. However, it should again be noted that the data is limited to only women's matches. The dataset is over 2.6 GB; of the over 1.6 million rows of data, over 200,000 were serving data. Within the actual dataset, data about each set included the type of serve, where the serve went (within a six-by-six grid of the receiving side of the court), a brief description of how the opponent was able to return the ball (either negative opponent free attack, ok no first tempo possible, positive no attack, or an ace), and which team won the point.

Methodology: Variables and Metrics

The data only provides the outcome for each serve. To measure a serve on a serve type or player basis, the variables are primarily converted into three metrics: knockout percentage, break percentage (also known as “side out percentage”), and error percentage. Knockout percentage is meant to measure the number of times the serve forces the other team not to be able to run everything in their offense, also known as “out of system”. Being out of the system entails overpassing, getting aced, or passing an out-of-system pass. Knockout percentage refers to serves that put the other team out of system over the total number of serve attempts (which includes errors). Error percentage is the frequency of errors, where the serve is out, and a point is given to the other team. Finally, break percentage is the frequency at which the serving team wins the rally on their serve.

$$\text{KO\%} = \frac{\text{Ace} + \text{Out of System Pass} + \text{Overpass}}{\text{Serve Attempts}}$$

$$\text{Error\%} = \frac{\text{Missed Serves}}{\text{Serve Attempts}}$$

$$\text{Break\%} = \frac{\text{Serve Points Won}}{\text{Serve Points Played}}$$

Methodology: Data Processing

For data cleaning, the evaluation of the serve was converted from short phrases to a number 0-3: negative opponent free attack = 3, ok no first tempo possible = 2, positive no attack = 1, or an ace = 0. The location data originally came on a three-by-three grid labeled 1-9, with each zone having a letter representing the subzone A-D. To simplify plotting of the locations, the zones were converted to a six-by-six grid, each with an x and y location. From there, the data was binned into each serve type and then further binned to each location on the court.

Results: Overall Data

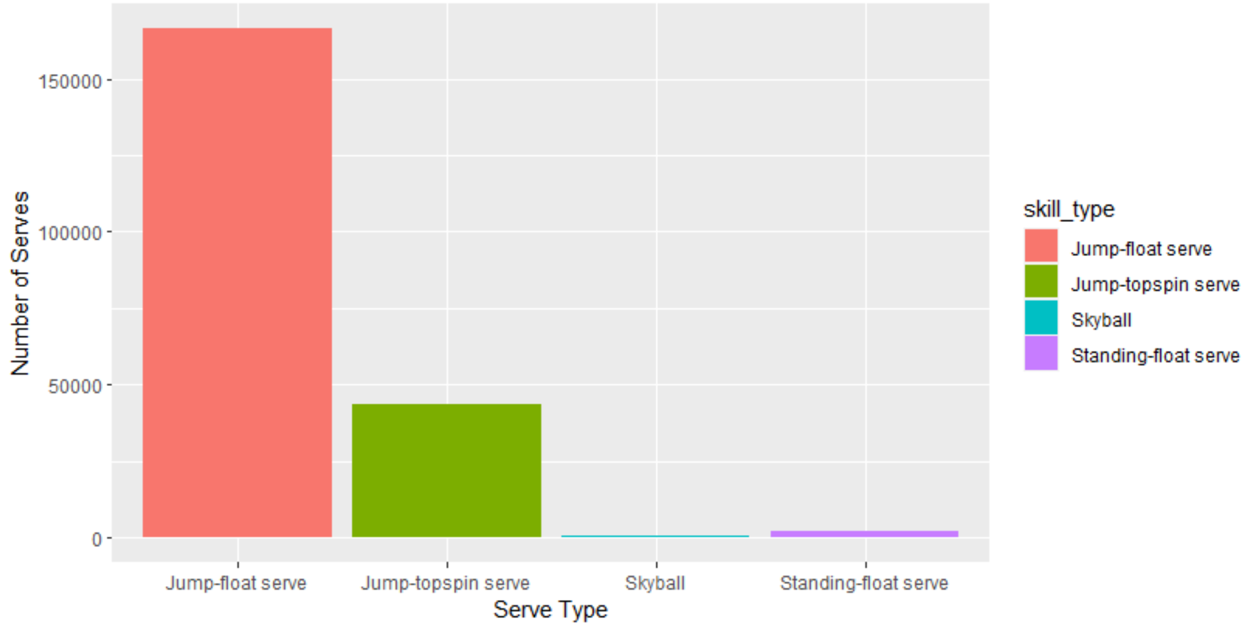


Figure 1: Bar Graph for number of occurrences of type of serve in the dataset

Figure 1 illustrates how often each serve was used in the data frame. The jump-float is the most popular, while sky balls and standing float serves are rare. Due to the limited data on standing floats and sky balls, they will not be analyzed in detail because sky balls are never used consistently and are more of a gag that people do at the end of games. Additionally, jump-floats are superior to standing floats—and thus used more frequently—because when the ball is contacted at a higher point, the path the ball takes is flatter and, therefore, shorter, meaning that it takes less time to reach the passer because it is hit harder and still makes it into the court. jump-topspin serves are still used consistently but not near the amount that jump-float serves are used.

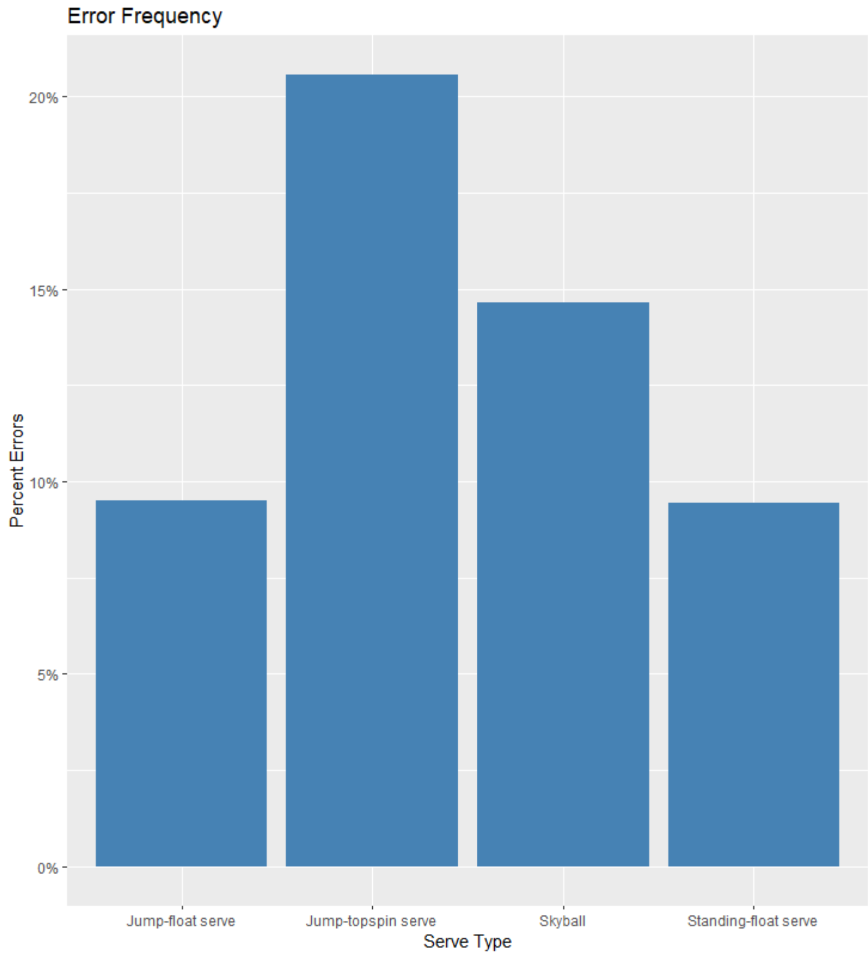


Figure 2: Bar graph for percentage of errors per serve type

As seen in Figure 2, the jump-topspin serve is by far the riskiest serve as it is the hardest to perform and has an error frequency more than double a jump-float serve, the safest serve. To reiterate, an error means the serve hits the ground outside of the receiving team's court, granting the receiving team a point and the serve. The results from skyball and standing float error frequency are inconclusive because of the limited amount of occurrences since no players use them consistently.

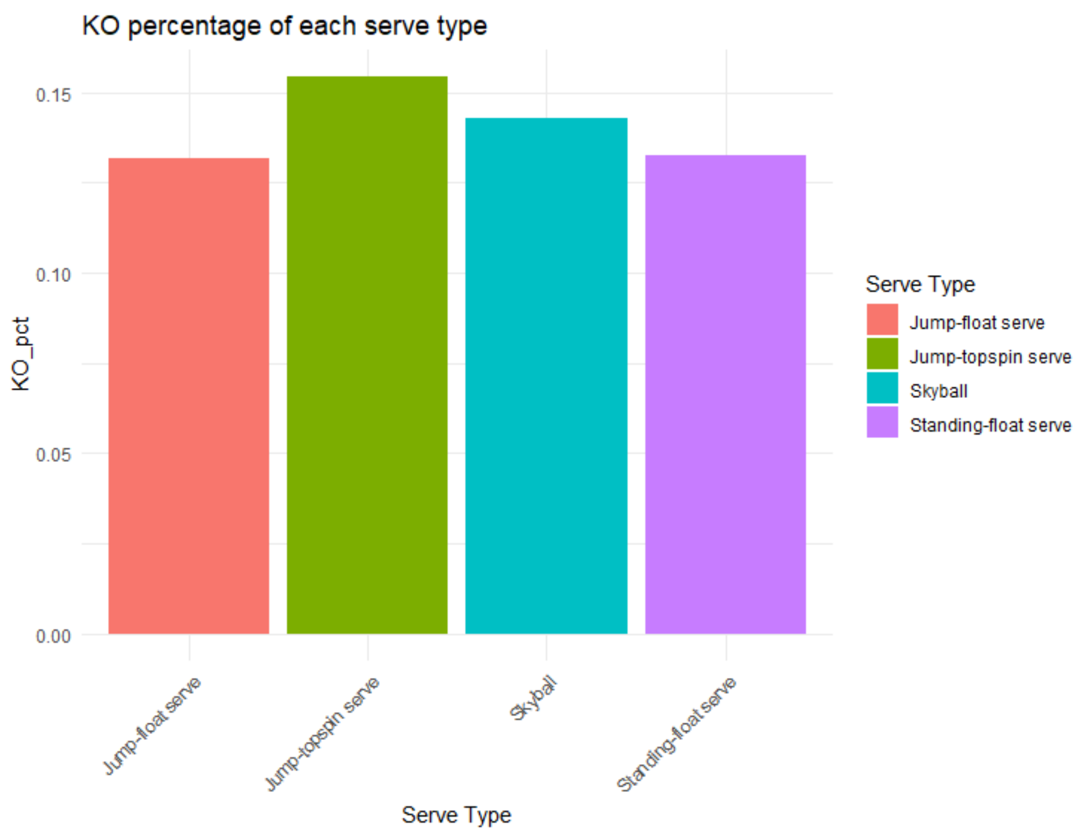
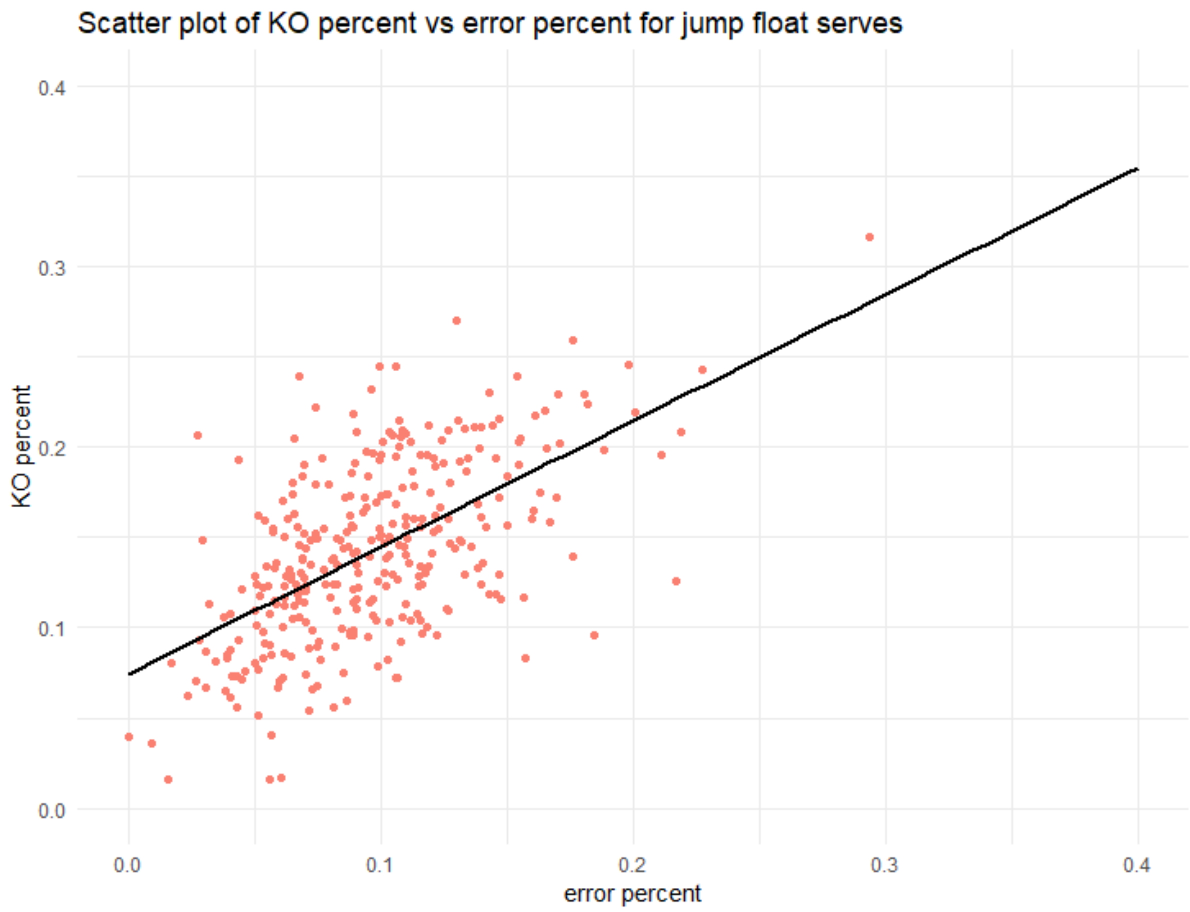


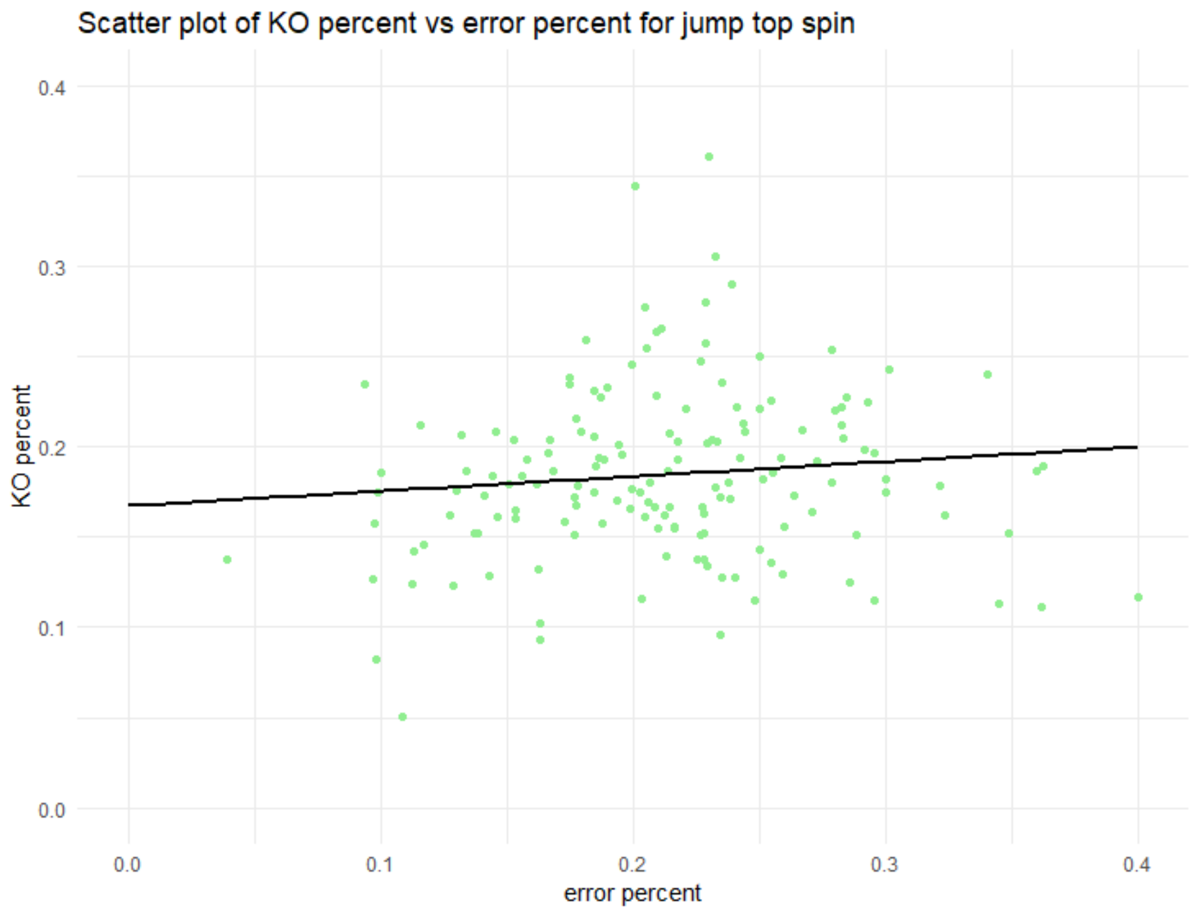
Figure 3: A bar graph representing the knockout percentage of each serve type

Yet again, the data for sky balls and standing float serves aren't conclusive due to the lack of occurrences. Figure 3 demonstrates that the error percent of jump-topspin serves is greater than the jump-float serve. In this case, the error% means that for around 21% jump-topspin serves, there is no chance of adding to the knockout percentage. That means for the serves that go in, there is approximately 0.155 / (1-0.21) = 0.196 chance that the serve knocks the receiving team out of the system. On the other hand, for jump-float serves, there is a 0.13 / (1 - 0.095) = 0.144 chance that the serve knocks the receiving team out of the system. Therefore, although the jump-topspin serve is more risky and will result in more errors when it goes in, it will be far more effective.



- $y = 0.074567 + 0.700290x$
- $R^2 = 0.3407$
- p-value $< 2.2e-16$

Figure 4: Linear relationship between knockout percent and error percent for jump-float serve



- $y = 0.16952 + 0.06911x$
- $R^2 = 0.008972$
- p-value = 0.243

Figure 5: Linear relationship between knockout percent and error percent for topspin serve

In both graphs, each data point represents the knockout percentage and error percentage of a player's season total for each type of serve, if they had served said serve type more than 100 times. For jump-float serves, there is a strong positive linear relationship between the number of errors and knockout percentage, with an R-squared of 0.3401 and a p-value far less than 0.01. Yet, a negative correlation is to be expected, because when you make an error, you have no chance of putting the other team out of system, meaning that by committing more errors, you have fewer chances to put the other team out of system naturally, leading to a lower knockout percentage. Nevertheless, the relationship is positive.

This is because, at the highest levels, errors aren't a reflection of mistakes but a reflection of how aggressive and fast a serve is, especially for float serves. After all, the ball doesn't curve down like a top spin by serving faster; it makes it much harder to keep the ball from missing far. Therefore, the more aggressive you are with your serve, as signified by error percent, the greater the knockout percentage you will have. On the other hand, there is no clear relationship between errors and knockout percentage for jump-topspin serves, with an R-squared of 0.008972 and a p-value of 0.243. Since there is close to no correlation and relationship between errors and knockout percentage, there is a way to have a high knockout percentage without a high error percentage. jump-topspin serves, therefore, can be much better than jump-float serves because there isn't a high error percentage associated with a high knockout percentage. Therefore, the success of a jump-topspin serve has more to do with the skill and power of the server rather than the risk of error a server is willing to take.

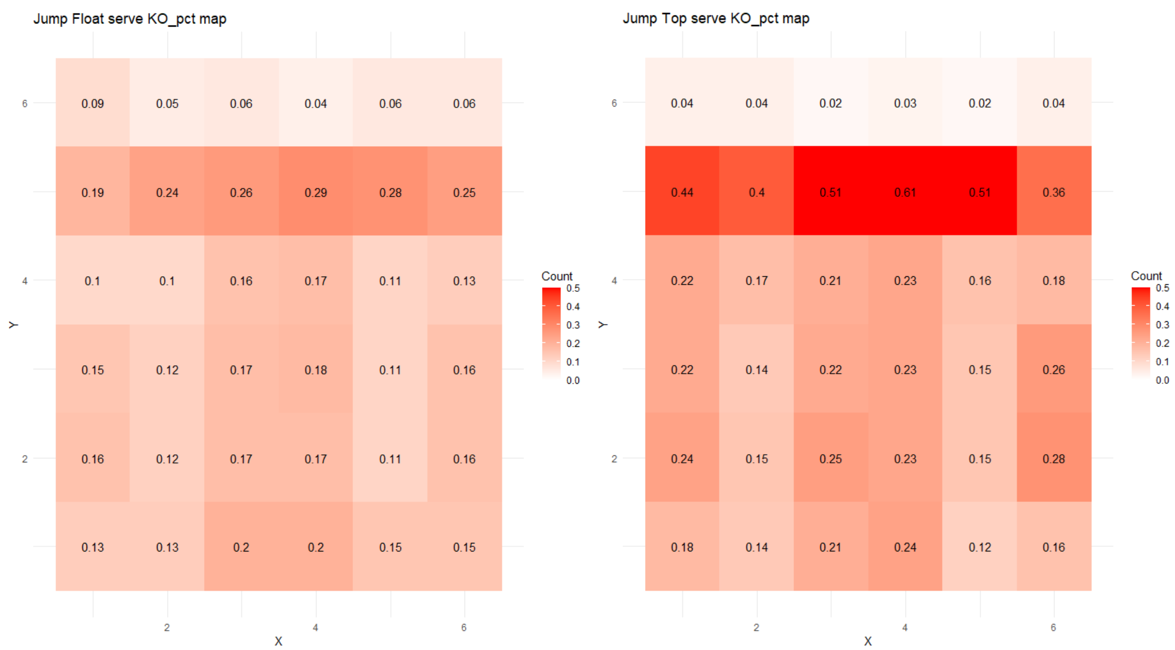


Figure 6: Knockout percentage for each serve type based on location (row 6 close to net, row 1 far from net)

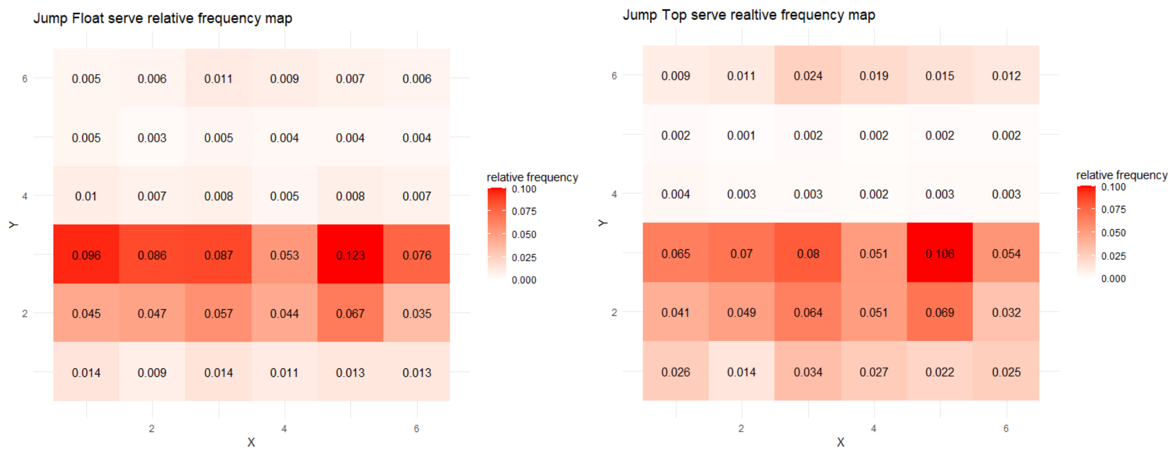


Figure 7: Relative frequency for each serve type based on location (row 6 close to net, row 1 far from net)

As demonstrated by Figure 6, jump-topspin serves have an all-around higher knockout percentage in almost all zones of the court, compared to jump-float spins. This supports the previous conclusion that even though jump-topspin results in more errors, they are more effective overall. Additionally, both serves seem to achieve the highest KO percentages in row 5. That's because the only way a ball can land in rows 6 and 5 is if it hits the top of the net and rolls over, which is not something that severs aim for and is neither a serve that the passers are ready for and are essentially either lucky for the server or unlucky for the passer. Looking at the relative frequency of serve location, it is clear that the first half of the court is the hardest to hit because, for a serve to be fast, the ball takes a flatter path rather than a slow, lofty serve. A flat trajectory reduces how much a ball drops, making it more likely to clear the net and reach the opposing court, as demonstrated by Figure 7, which illuminates how very few serves went to rows 4-6 for both serve types. Furthermore, serves only land in the front few rows if they hit the net. This explains why the knockout percentage there is so high: because there are so few serves that go short, the knockout percentage is a bit inaccurate, and the passers aren't ready. For both jump-topspin and jump-float serves, most serves go to rows 2 and 3 because those are the most natural places for a hard serve that lands to land. Additionally, for both serve types, it is clear that the highest knockout percentage within the high-frequency rows (rows 2 and 3) occurs in columns 1, 3, 4, and 6, or in other words, from columns 2 and 5. That is simply because the two passers will stand in columns 2 and 5 to cover more court between them. Therefore, by serving columns 3 and 4, the serve goes between the two servers, forcing them to make a split-second decision on who's going to pass the ball and then forcing them to take steps to move toward the ball, increasing the amount of time it takes to react to the serve. The same logic applies to rows 1 and 6, but rather, the passer has to decide whether the ball is in or out and has to take time to move to the ball. Overall, jump-topspin serves have a higher knockout percentage overall, in the high-frequency rows, between passers, and on the sideline, making it a better overall serve in terms of knockout percentage.

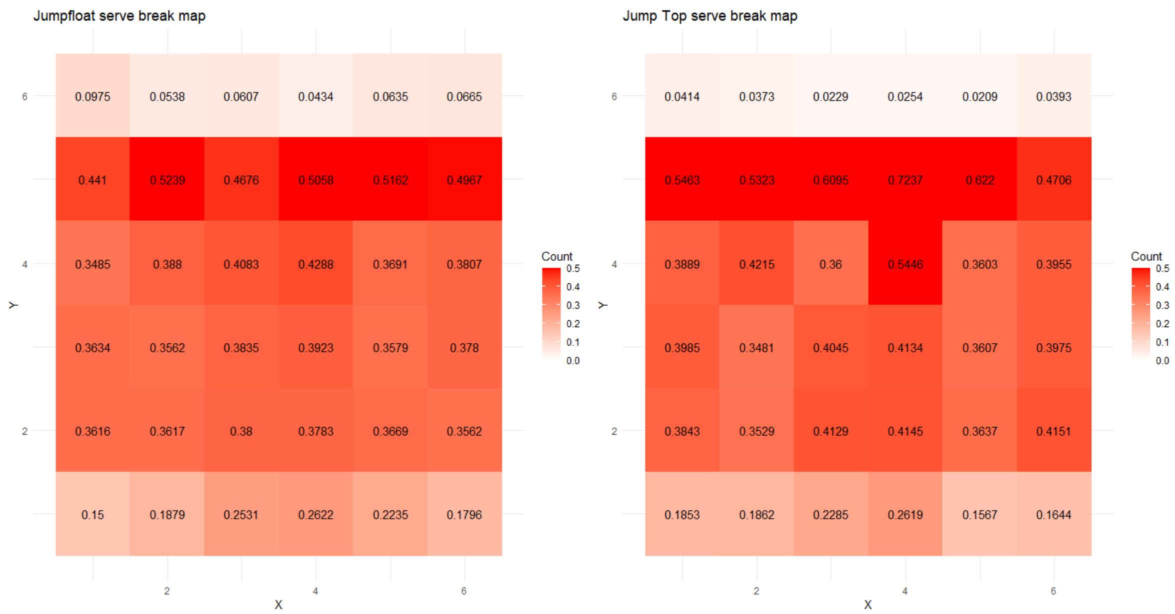


Figure 8: Break% map based on serve location

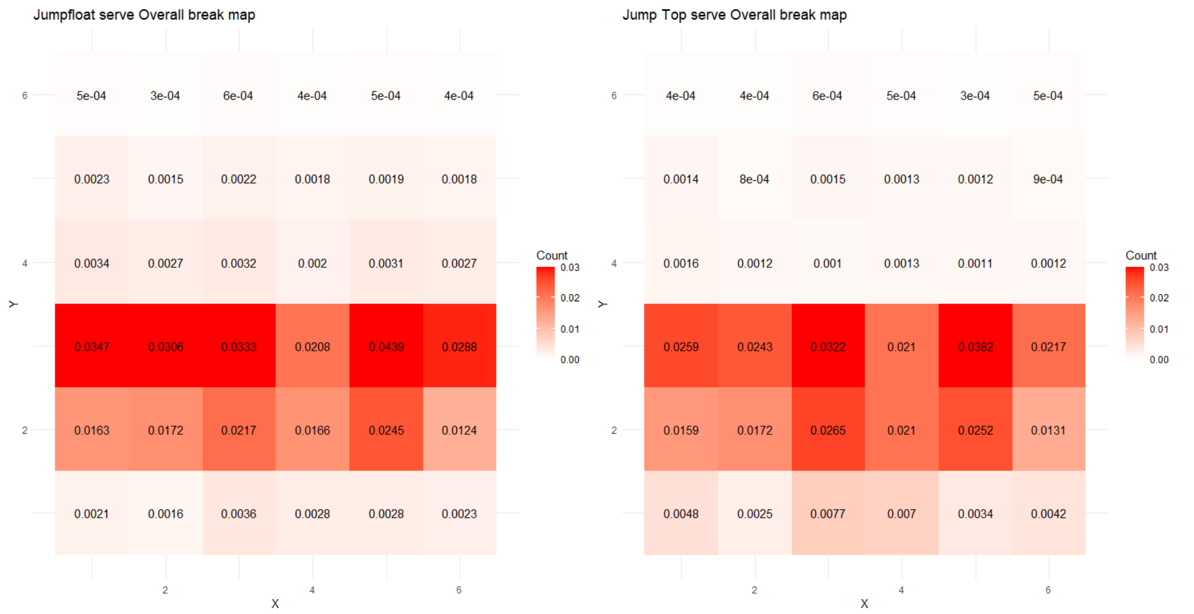


Figure 9: Break% x relative frequency based on serve location

While knockout percentage is important while evaluating the quality of a serve because it shows how well the receiving team returned the serve, it doesn't take into account what happens after the receiving team returns the ball and ultimately who wins the point. Break% is simply the percentage that the serving team wins the point. As demonstrated by Figure 7, a vast majority of serves go to rows 2 and 3, so a serve type having a good break% in those rows is so important that when evaluating the break% of a serve, most of the attention should be on the break% in those rows. For both serves in the high-frequency rows (rows 2 and 3), the break% is significantly below 50%. In volleyball, receiving the serve is an advantage because the receiving team can attack first, giving them an advantage. They get to attack more times throughout the rally, and a proper attack will put the other team out of system again, giving the receiving team an advantage. Even in terms of break%, the jump-topspin serve has an advantage over the jump-float serve, although there is a slight caveat. In terms of break%, jump-topspin serves are better in the high-frequency rows when the passer is forced to move the sideline or in between other passers in columns 1, 3, 4, and 6 by 3-5%, but jump-float serves are better by 1-2% when the ball goes directly at the passers in columns 2 and 5. A jump-float serve would be better than a jump-topspin serve when it is served directly at the passer because of its unpredictable, knuckleball-like lateral movement. While a jump-topspin serve drops in a predictable pattern, making it easy to receive straight on, the slight movements of a jump-float serve keep the passers guessing and makes it difficult to receive even if the passer doesn't have to move much to receive the ball. Knowing that a jump-topspin serve is significantly more effective when aimed away from columns 2 and 5 means that overall the jump-topspin serve is better in terms of break% since the servers will be aiming for the areas away from the passers when serving.

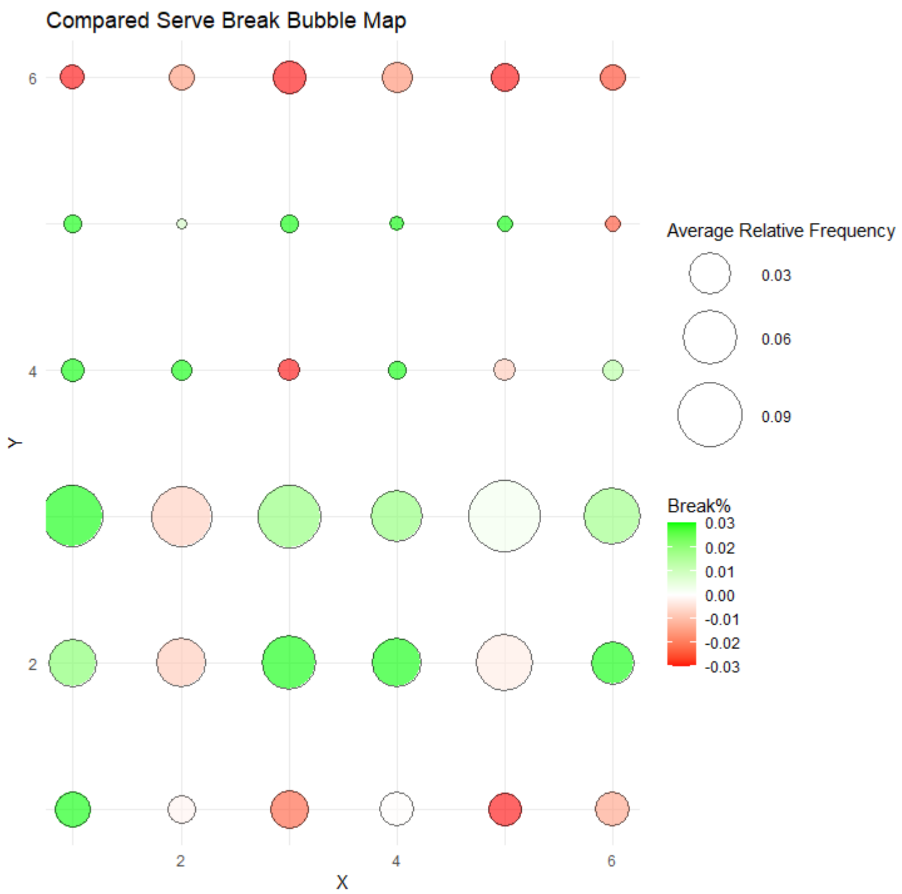


Figure 10: Bubble map showing average relative frequency in size and Topspin break% - jump-float break%

Finally Figure 10 is another way of visualizing Figures 8 and 9. The size of the circles represent the average frequency of both serves and the color represents break% for jump top serves at that location subtracted by jump-float break% in the same location, meaning green favors jump-topspin serves and red favors jump-float serves. Using average relative frequency doesn't take into account how the two serve types are served to different locations at different frequencies, though what is clear is that in the high-frequency rows of 2 and 3, 9 out of 12 spots favor jump-topspin serves again demonstrating how jump-topspin serves are more effective where the servers would be aiming.

Conclusion

In conclusion, the statistically optimal serve in beach volleyball is a jump-topspin serve away from the passers in columns 1, 3, 4, and 6. Although jump-topspin serves result in more errors, losing points, the jump-topspin serve has a much higher knockout percentage and has a much higher break percentage in the areas that servers should be aiming for. Furthermore, since error% and knockout% are not correlated for jump-topspin serves, unlike for jump-float serves, there is more upside in developing an accurate and powerful topspin serve.

The key takeaway away from this paper that can be used in indoor volleyball is the correlation between errors% and knockout%. Since for jump-float serves knockout% and error% are correlated coaches have to expect more errors out of highly effective jump-float serve yet can challenge jump-topspin serves to limit their errors while mostly maintaining high knockout%. It also demonstrates how jump-topspin serves have more upside because high-level servers can realistically have high knockout% with limited error%.

Limitations and Future Work

Some confounding variables that would affect this study include: jump-topspin servers are generally considered harder than jump-float serves, meaning potentially better servers would use it; more errors could occur with jump-topspin serves since they are susceptible to weather conditions because they require a toss; and that the data is limited to women's play.

Future work would include running similar tests but on both men's beach volleyball data and indoor volleyball data. Further work would also include getting speed and lateral movement data of serves and seeing how those variables correlate to knockout%, break%, and error%.

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