Is Improvement Objective? An Analysis of the Improvement and Performance of the Colorado Women's Volleyball Team.

Srihari Srinivasan, Brady Schiff, Ella Cridland

October 2024

1 Abstract

Improvement in sports is a nuanced concept, often complicated by the lack of standardized evaluation methods. This study seeks to develop an objective, data-driven framework to assess and monitor improvement in the University of Colorado Boulder Women's Volleyball team. Utilizing data recorded by the team's Technical Coordinator via the DataVolley software, we analyzed core volleyball skills, including serving, attacking, setting, blocking, and digging. A Random Forest model was employed to address data variability and consistent play enabling a structured analysis of performance trends. Alongside this model, an xGBoost model was utilized to work around data missing some variables. With both of these models, results indicated a high accuracy in assessing all skills of the game showing their validity as models to use when measuring volleyball. Spatial analysis of court zones revealed specific high-impact areas essential to strategic gameplay. These insights offer actionable recommendations for refining the training and optimizing team strategy. Beyond the technical analysis, this research combines expert knowledge with robust statistical methodologies, to establish a systematic approach to evaluating performance in volleyball, offering practical tools to monitor and enhance team improvement over time. Findings not only present an accurate framework for assessing individual improvement, but also highlight players with untapped potential, allowing for targeted skill development. In the end, we established a foundation to objectively judge ongoing improvement, as well as ways to enhance team dynamics and success.

2 Introduction

Improvement is a fundamental concept valued across all aspects of life. In education, it is often regarded as a key indicator of a student's ability to grasp and apply new information. In the workplace, improvement signifies an employee's

capacity to develop new skills and contribute more effectively to organizational goals. In sports, improvement is equally critical, as the collective growth of a team can lead to greater success beyond the talents of individual players. While there are awards that recognize certain forms of progress, such as the NFL's Comeback Player of the Year [3], the criteria for improvement often remain ambiguous. This raises an important question: how do we define and measure improvement, particularly in team-based environments?

Improvement is commonly defined as an enhancement in value or quality. In the context of sports analytics, what exactly are we measuring when we talk about improvement? For the purpose of this paper, improvement refers to an increase in performance over time, from an earlier point to a later one. This definition implies that improvement must be assessed by comparing two performance metrics, one initial and one subsequent. Therefore, before we can evaluate improvement, we must first establish clear and reliable methods for measuring performance. This leads us to the central aim of our study: to develop an objective way to quantify improvement for the University of Colorado Boulder Women's Volleyball team. To achieve this, we must analyze the key performance indicators in volleyball, determine what defines a skillful player, and how these factors contribute to the overall improvement of the team.

Quantifying improvement in volleyball poses significant challenges due to the diverse roles and skills required in the sport. Coaches often rely on subjective assessments of individual skills and position-specific contributions rather than standardized performance metrics. For some positions, such as outside hitters who are typically high scorers, performance may be easier to quantify using objective statistics like points scored or attack efficiency. However, for other roles, such as setters or defensive specialists, it is more difficult to evaluate performance based on traditional scoring methods. Without clear and consistent criteria for measuring the value of different positions, it becomes challenging to determine who is improving and by what standard. A logical starting point in addressing these challenges is to focus on the specific skills that define success in volleyball. By identifying and analyzing key skills, such as serving, blocking, setting, and spiking, performance metrics can be developed that more accurately reflect a player's contribution to the team's overall performance.

In volleyball, a play is limited to a maximum of three touches per team: typically a reception, a set, and an attack. Each rally begins with a serve, followed by these three actions in sequence, with teams rotating through the touches until one wins the point. Offensive strategies are generally built around this three-touch limit, although variations can occur. While the outcome of each point is clear, assessing the effectiveness and quality of skill combinations during these plays is more complex. Understanding how well these skills are executed is essential for correlating performance with overall success in the game.

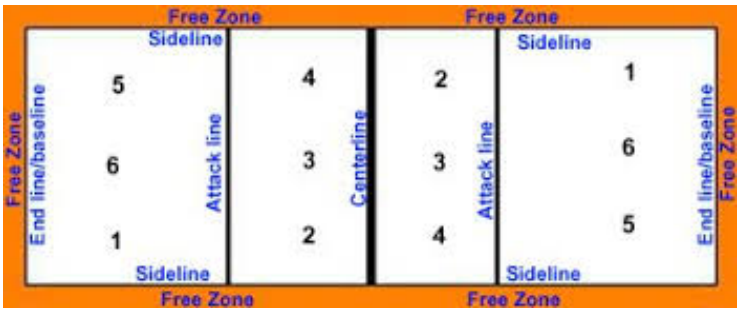

Figure 1: Volleyball Court Diagram

Volleyball involves six primary skills, each tied to specific court positions, as shown in Figure 1. The serve is initiated by the player in position 1. The serve aims to send the ball into the opposing team's zones, ideally resulting in an *ace*. The placement and speed of the serve are key metrics, with a successful serve being a significant performance indicator.

Following the serve, the reception occurs, typically by players in positions 1, 6, or 5. The reception is evaluated by how well it sets up the next play. Poor receptions can lead to immediate point loss, making the quality of this skill critical for defensive performance metrics.

Next, the set, performed by players in positions 2 or 3, is essential for facilitating a spike. While the set itself doesn't score, its quality is judged by how well it positions the ball for the attacker. The success of sets can be measured by their contribution to point-scoring plays, linking this skill to offensive performance.

The spike, executed by players in positions 4, 3, or 2, is the key offensive move. A successful spike, known as a *kill*, leads directly to points. The effectiveness of a spike is measured by its accuracy and power, making it one of the most direct performance indicators in volleyball [1].

On the defensive side, the block is performed by front-row players in positions 3 and 4. A *stuff block* immediately stops the opponent's attack and results in a point. The block's effectiveness is a crucial metric in assessing defensive strength.

Finally, the dig is executed by back-row players, including the libero in positions 5 or 6. Digs are defensive plays designed to keep the ball in play after an opponent's spike. The success of a dig is measured by its ability to transition the team into an offensive position, linking it directly to team defense and recovery metrics. For further information or clarification regarding each position and skill, reference Appendix A.1 and A.2 respectively.

In conclusion, this project centers on the critical objective of measuring improvement in the performance of the University of Colorado Boulder Women's Volleyball team. Recognizing the importance of data-driven decision-making, we aim to develop a robust metric that quantifies player performance and overall team improvement over time. While the concept of improvement can be sub-

jective, we contend that systematic analysis of performance metrics can yield actionable insights. With the support of Coach Eduardo Fiallos, the Technical Coordinator (TC) of the Women's Volleyball team, who emphasizes the value of data in evaluating player development, we are committed to utilizing game and practice data to establish clear benchmarks. Through this analysis, we aspire to create a reliable framework for assessing improvement, ensuring that the team's progress can be effectively monitored and enhanced in the future.

3 Literature Review

The data for this project is provided directly by the Division 1 Volleyball team, making it a primary source dataset. We are collaborating closely with Coach Fiallos to acquire this data. While this dataset offers numerous advantages, it also presents some notable challenges. As with any data, it requires a thorough cleaning process to enhance readability for analysis programs, facilitate analysis, and improve overall comprehension. The data is collected using a software tool known as DataVolley, which relies on manual entry by Coach Fiallos. This method ensures that the data is relatively straightforward to access and interpret, requiring minimal technical skills. However, the manual entry process introduces the risk of human error, making it difficult to identify inaccuracies. Such inaccuracies can skew results or adversely affect analytical models, potentially leading to misleading conclusions. Therefore, we must navigate these challenges carefully throughout our analysis.

Several studies have utilized the DataVolley package to measure performance and track improvement in volleyball. These studies developed their findings by ranking specific keystrokes [7], such as E# and B!, which were subsequently weighted to determine their contributions to effective scoring. Consistent with numerous other papers, they found that attacks significantly correlate with volleyball scoring [8]. However, their model overly concentrated on this correlation, neglecting other potential variables that could influence performance. As a result, the model arbitrarily categorized actions as scoring or non-scoring. This experience serves as a cautionary example for our study, illustrating the risks of hastily assigning values to actions without sufficient context. Such an approach can lead to oversimplified results that fail to accurately reflect overall performance.

Given that Coach Fiallos records plays by hand using the DataVolley package to facilitate this process, we can anticipate a high degree of accuracy in the reported data. He manually inputs computer data to correlate with specific plays and skills, as outlined in the introduction. Furthermore, Coach Fiallos reviews footage of the games to verify his inputs, which minimizes the possibility of misinputs. However, the possibility of typographical errors exists. The average volleyball movement occurs in less than a second, and multiple movements can happen within a single rally. While this highlights Coach Fiallos's exceptional skill and diligence, it remains essential for data analysts to recognize the potential for inaccurately reported values. Acknowledging these limitations

will help us interpret the data more effectively and mitigate the impact of any discrepancies on our analysis.

Human error presents a significant challenge when working with this data. Compared to other studies in the field, our dataset is well-structured and relatively easy to analyze. However, the potential for inaccuracies in data entry necessitates thorough verification to identify incorrectly input values. Relying solely on chance increases the risk of encountering misleading outliers, which can severely compromise the accuracy and reliability of our model if a substantial percentage of these erroneous data points goes undetected.

In the realm of volleyball performance analysis, additional research has investigated the strong correlation between specific performance metrics and team success. Many of these studies primarily focus on the essential skills required for effective gameplay rather than on overall improvement or performance trends. Evidence consistently shows that successful attacks are directly correlated with scoring and, by extension, winning matches [1]. This underscores the understanding that a team's offensive capabilities are significantly enhanced by its proficiency in executing successful attacks, ultimately leading to higher scores.

Moreover, further research has demonstrated a significant correlation between the quality of sets and the success of spikes [10]. Understanding the skills that influence scoring opportunities is essential for teams aiming to achieve optimal outcomes. This relationship is crucial for developing effective strategies that enhance overall team performance. By identifying similar performance metrics, coaches and players can discover areas for improvement, whether it involves refining the setter's technique or enhancing the hitter's timing and positioning. Throughout this paper, we emphasize that a successful spike is one of the most critical skills in volleyball, as it greatly impacts the outcome of each set, regardless of the current score.

In addition to skill-specific analyses, other studies have delved into the use of player performance metrics, emphasizing the value of analyzing individual contributions within team sports. One approach often explored is the plus-minus rating [5], which quantifies the impact a player has on the game based on point differentials while they are on the court. While this metric was originally used in sports like basketball and hockey, it provides valuable insights into how individual actions correlate with overall team success. Furthermore, it highlights the importance of adjusting for contextual factors, such as teammate performance, which can heavily influence results. This objective measurement of a player's influence aligns with our focus on creating a comprehensive performance metric for volleyball. Just as the plus-minus rating aims to account for a player's impact in a variety of in-game scenarios, we can adapt similar methodologies to better assess key volleyball skills, such as spikes, blocks, and digs, ultimately helping to quantify improvement.

In line with this, network-based models have been employed to capture the value of player interactions and contributions to team dynamics. These models offer a more comprehensive view of a player's role by focusing on their ability to facilitate successful plays through collaboration [4], rather than solely on individual statistics. This shift in focus provides a broader understanding

of how players can improve in their respective positions, especially in a sport like volleyball, where both offensive and defensive actions contribute to overall success.

Additionally, new frameworks have been developed to assess individual performance through objective measures in team-based environments, such as youth volleyball [2]. These frameworks consider a variety of factors, including technical skills and decision-making, offering a balanced perspective that transcends the limitations of traditional point-based metrics. This method is particularly useful for positions like setters and defensive specialists, whose contributions, although not always reflected in scoring, are critical to team performance.

In conclusion, while previous studies have successfully utilized sports data to make predictions and observations about performance, not all findings align directly with our current research objectives. However, these studies provide valuable methodologies for quantifying sports measurements, which we can leverage to develop an effective improvement model. By applying insights from these resources, we aim to utilize the data provided by Coach Fallios to create an accurate and actionable model that can enhance team performance and inform future strategies.

4 Data Exploration

Our initial exploration focused on analyzing volleyball's game flow. Unlike many sports, volleyball has a limited number of unique play paths, allowing for a more structured understanding of the data and enabling us to construct a flowchart vetted by field experts. Volleyball plays often follow identifiable trends, supporting predictable analysis and justifying a quantifiable approach to measuring play quality. Based on these trends, we developed a performance metric to assess players by assigning values to their skills, specifically evaluating how each play contributed to the overall point and team success.

In Figure 2, we examine the performance value distribution of volleyball skills. The data reveals that certain common play types dominate, suggesting consistent player strategies and moves. Specific skill types demonstrated reliability, leading to steady scoring distributions. This predictability helps us identify outliers, which can signal either exceptional performance or errors in execution.

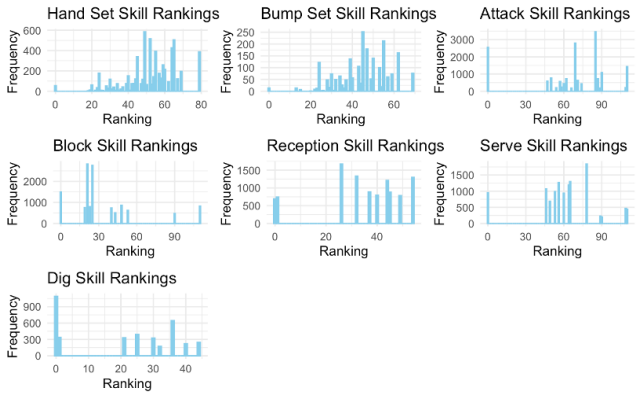

Figure 2: Volleyball Skill Peformance Distributions

Next, we applied win/loss adjustments to these performance values. The histograms of adjusted values show more variability, especially in impactful skills like setting. Successful setting often leads to a winning point, so adjustments to the distributions reflect both action frequency and its effectiveness, particularly when winning plays are involved. By adjusting the data according to match outcomes, we isolated each skill's contribution to team success and identified plays strongly associated with winning points. This adjusted data also provides insight into the variability of skill impact across matches and seasons, spreading the distributions and revealing patterns in player development.

In Figure 3, we visualize each player's performance values across multiple games and seasons to identify trends, including steady improvements or declines. Tracking each player's adjusted performance over time allowed us to pinpoint consistent enhancements or declines in specific skills, giving coaches actionable insights into areas needing improvement or strengths to leverage.

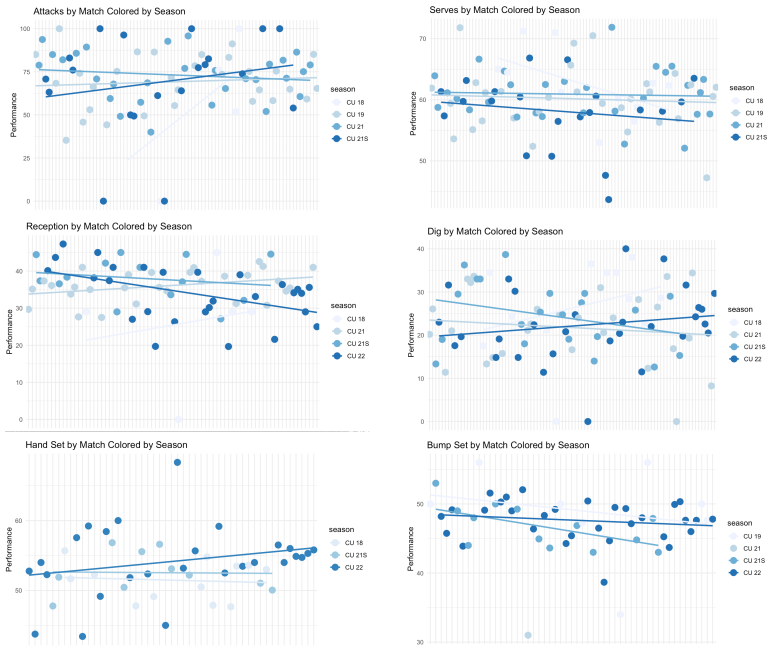

Figure 3: Volleyball Skills by Season

Spatial analysis plays a significant role in volleyball by examining positional data and movement patterns. By dividing the court into zones, we evaluated serve, attack, and defensive performance based on location. This spatial breakdown helps create data-driven strategies that leverage performance insights.

Evaluating player skills in specific zones and their decisions from different positions on the court supports tailored offensive and defensive strategies. Our findings show a clear link between court positioning and success rates, enabling focused training on high-impact zones to improve game efficiency. Figure 4 illustrates attack frequency by zone, highlighting a concentration in the center-left area of the serving team's court, possibly indicating either a strategic strength or an identified weakness in opposing defenses.

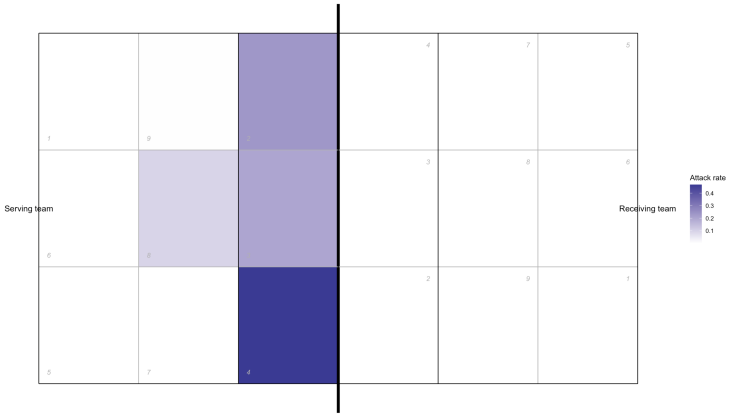

Figure 4: Volleyball Attack Rate Frequency by Starting Zones

We further refined this analysis in Figure 5, which identifies effective starting and ending zone combinations. Plays beginning in zones 2 and 3 and ending in zones 3 and 5 show high success rates, suggesting these routes are strategically advantageous. This insight could support targeted offensive strategies that exploit these high-performing zones.

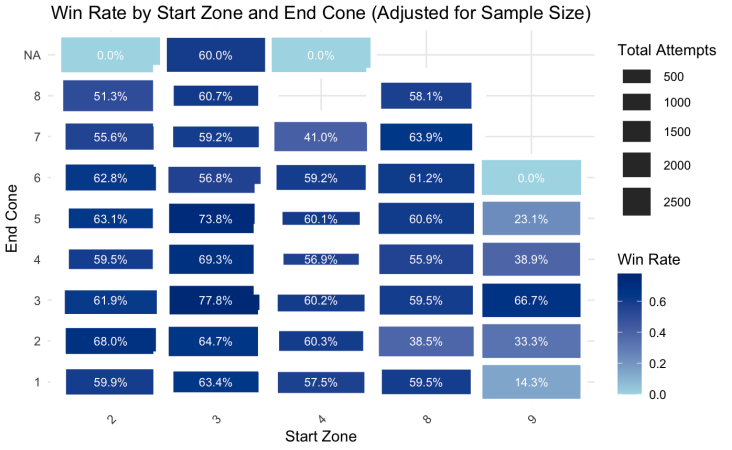

Figure 5: Point Win Rates by Start and End Zones

To balance sample-size differences across zone pairs, Figure 6 presents a weighted analysis of win rates based on attempt frequency. This approach prevents skewing from low-attempt zones, offering a more reliable view of effective plays. By emphasizing zone combinations with high success rates and sufficient data, the weighted plot pinpoints consistent, high-quality attack strategies. Teams can use this information to focus on zones that sustain strong

performance, supporting more strategic plays and data-based training.

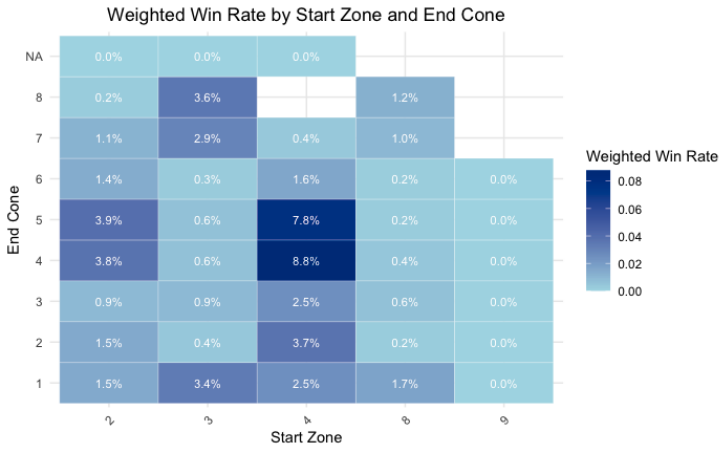

Figure 6: Point Weighted Win Rates by Start and End Zones

In conjunction with zone-based success rates, we aligned high-impact plays with individual players, creating a metric to assess each player's contribution to team success. This approach encourages players to prioritize effective zones, aligning individual goals with team strategy, and establishing a data-backed metric for skill assessment. Coaches can use this alignment to implement targeted training, motivating players to optimize their performance in these zones.

5 Methodology

To quantify performance and drive improvement, we employed multiple approaches, starting with a direct analysis of the data to build a predictive model. Volleyball plays typically follow logical sequences, allowing each play to be analyzed and predicted. For our model, identifying key predictor variables was essential, as was defining accurate response variables. To define the response variable, we consulted Technical Coordinator, Coach Fiallos, whose volleyball expertise provided a reliable basis for evaluating the strength of various plays. By assessing the actions preceding and following each play, we established a metric to measure play quality using a flowchart depicting the logical volleyball play sequences. For further information regarding the flowchart, reference Appendix A.3.

The initial analysis identified non-standardized values in the TC's assessments, resulting in repeated and inconsistent responses. The limited number of unique response values led to overfitting in models, rendering them generally ineffective. To address this issue, we implemented a parametric approach by applying a jitter function to normalize the performance values. This method

introduced small amounts of random noise to the data points, akin to incorporating a standard error, to create a more continuous distribution of values approximating a normal, bell-shaped, curve. Consequently, this adjustment enabled the development of models capable of accurately predicting a broader range of volleyball actions.

With these normalized values, a challenge emerged: the performance values were based only on preceding and subsequent actions, excluding over 100 additional predictor variables. To incorporate these variables, including cases where values were missing (NA), we developed a predictive regression model. Though a predictive model was not in our original project scope, it became worth investigating. To avoid the issue of NA data and extremely simplistic result values, the model was developed to isolate other predictor variables. Given the data's structure, a random forest model was appropriate [6]. This machine learning algorithm, which performs well with decision trees, aligns with the structured flow of volleyball. The random forest model identifies major variables first, followed by secondary ones, allowing for accurate predictions through successive decision nodes. With these nodes, we identified what other variables were strongly associated with a positive play. This will help the volleyball team identify areas of weakness and strength. Using these refined models, the team can easily analyze how any specific play was rated in the future.

To quantify individual player improvement across volleyball skills, we collaborated with CU Boulder's TC, to design a performance system that encompassed spiking, serving, setting, blocking, passing, and receiving. This expertise provided insights into each skill's significance and its contribution to overall performance in different game contexts. This expert-based performance system ensures that our data quantification aligns with real-world volleyball dynamics and coaching priorities.

For the analysis, we separated each skill into unique data frames, which included variables such as evaluation code, spatial location, action sequence, and player identity with their position. We further divided setting into hand sets and bump sets, enabling us to assess setters' hand-setting abilities specifically. This distinction ensures accurate assessment of setters' skills relative to others performing bump sets.

We analyzed skill execution effectiveness by incorporating skill sequences, including either the preceding or following actions based on the specific skill being evaluated. For example, to assess serve quality, we evaluated the next skill (typically an opponent's reception) to determine the serve's outcome. This sequential approach offers a comprehensive view of player performance, considering both individual skill quality and its impact on subsequent actions. Finally, we examined how each skill and its performance correlated with win proportions, factoring in spatial awareness and play locations on the court.

When analyzing the data, it became evident that missing values significantly impacted model performance. While imputation was relatively effective for random forest models, certain skills had missing values that were too inaccurate to impute reliably. Upon closer examination, we found that XGBoost models provided superior accuracy for skills with critical missing values. XGBoost, a

gradient boosting algorithm that builds and refines decision trees to improve accuracy, excelled in handling missing data efficiently[9]. Compared to random forest models, XGBoost demonstrated a higher capability for managing incomplete data without relying on imputation. By leveraging both XGBoost and random forest models, we systematically selected the most accurate model for each skill, ensuring optimal performance.

After predicting performance values and addressing missing data, we analyzed player performance trends over time by aggregating and summarizing the data at the skill level. For each skill, we calculated the average predicted performance rankings for individual players across matches. Using this aggregated data, we implemented a Shiny dashboard to allow dynamic exploration of performance metrics. The dashboard enables users to select a specific skill, player, and date range, and visualize the percent change in predicted performance over time. Additionally, we calculated cumulative percent changes to understand long-term trends and included an optional trendline for statistical insights. This interactive tool empowers stakeholders to monitor progress, identify improvement areas, and make informed decisions based on granular, player-specific data.

6 Results

The performance of the XGBoost random forest model varied across skills, revealing areas of both strong potential and opportunities for improvement. To evaluate prediction accuracy, we utilized Root Mean Square Error (RMSE), which measures the average difference between predicted and observed values. In this context, RMSE quantifies how far the model's predictions deviate from actual performance scores.

For the attack skill, the model achieved an RMSE of 29.6 points, underscoring the need for refinement to enhance its predictive precision. The block skill model performed slightly better, with an RMSE of 25.13 points, yet it still leaves room for optimization to provide more reliable metrics for coaches evaluating player performance. The serve skill model stood out with an RMSE of 2.84 points, demonstrating the highest accuracy and making it an excellent tool for assessing serve performance and improvement. Similarly, the hand-set model delivered solid performance, achieving an RMSE of 6.655 points, effectively capturing the nuances of hand-setting techniques.

In contrast, the bump-set model exhibited a higher RMSE of 7.86 points, reflecting the greater variability inherent in bump-set performance. Despite this, both the hand-set and bump-set models demonstrated greater accuracy compared to the block and attack models, likely due to reduced variability in setting data and the diverse combinations of plays impacting blocking and attacking. For digs, the model produced an RMSE of 20.34 points, indicating moderate accuracy but also revealing a margin of error that suggests further refinement is necessary to improve reliability. While the model captures general trends well, it may struggle with precise individual predictions for digs.

Notably, the reception model achieved an RMSE of just 0.56 points, demonstrating exceptional accuracy. This minimal error highlights the model's robustness and its ability to provide precise and actionable feedback for coaches evaluating reception performance.

Looking ahead, we aim to further refine the random forest model to develop a more accurate and comprehensive performance metric. Precision in performance assessment is critical for player improvement, and the enhanced model will enable the team to evaluate performance on every play. Once fully optimized, the model will provide reliable performance ratings even when some data, such as location or prior skill evaluation, is missing. By leveraging its structured ability to use available input data to predict missing variables, the model will accommodate critical factors more effectively, delivering more specific and actionable performance insights.

7 Discussion

The analysis revealed highly accurate models capable of predicting and evaluating performance across various skills. To track improvement over time, performance scores were averaged by game, providing a strong indicator of player development. For instance, consider Player 1 (with anonymized data to protect their privacy). During the 2022 season, Player 1 demonstrated a clear upward trend in their attacking performance, averaging higher scores later in the season compared to the start.

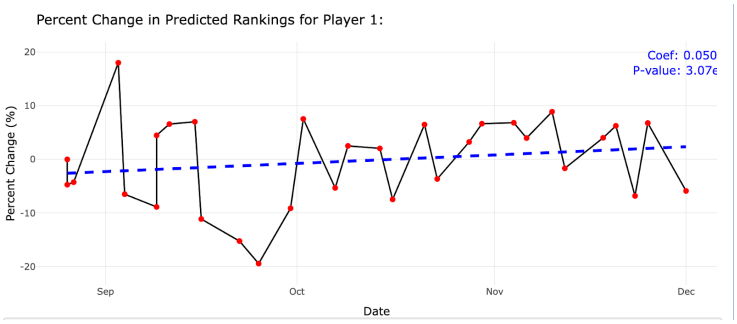

Figure 7: Percent Change in Predicted Attack Performance for Player 1

This improvement was particularly notable after October, with performance showing a steady upward trajectory. A statistical analysis supported these findings, with a p-value near zero indicating a significant positive correlation between time and average attack performance for Player 1. Conversely, the blocking performance for the same player exhibited a marked decline over the season.

Figure 8: Percent Change in Predicted Block Performance for Player 1

The negative trend in blocking performance was also statistically significant, as indicated by a p-value close to zero. In simpler terms, while Player 1 showed consistent improvement in their attacking ability, their blocking performance declined significantly. For a volleyball coach, these insights suggest a need to allocate more training resources to improving Player 1's blocking skills. At the same time, the player's growing expertise in attacking could make them a valuable mentor for younger players aiming to refine their offensive skills.

It's essential to consider these results within the broader context of player performance. While the data indicates clear improvement in attack (starting from a strong baseline of 79.1 out of 100), the decline in blocking performance (which began at 38 out of 100) highlights an area for urgent attention. The low initial score for blocking indicates significant room for improvement, and the downward trend underscores a gap in performance that needs to be addressed. Meanwhile, the steady rise in attacking performance, starting from an already high level, demonstrates the player's growth in a critical area.

While these quantitative models provide valuable insights, they must be interpreted alongside qualitative assessments to capture a complete picture. Factors such as player fatigue, mental health, or external pressures are not reflected in the data but can significantly influence performance. Coaches should supplement model outputs with direct observation and feedback to ensure a more holistic understanding of player development.

Ethical considerations are also vital in this analysis. Labeling athletes as "highly improved" or "negatively improved" can influence how they are perceived by coaches, peers, and recruiters, potentially affecting their careers and self-esteem. Additionally, protecting the privacy of student-athletes is critical. Excessive public exposure of data could lead to the identification of individual players, undermining their privacy and exposing them to unintended scrutiny.

To mitigate these risks, access to both the data and the models should be restricted to authorized personnel, such as coaches and relevant staff. Maintaining strict privacy protocols ensures that the analysis serves its intended purpose—improving performance—without compromising the well-being or privacy of the athletes. Balancing data-driven insights with ethical considerations and qualitative assessments is essential for fostering both player growth and

trust in the evaluation process.

8 Conclusion

Our goal was to determine whether improvement in volleyball performance is measurable and, if so, to identify the most ethical and effective way to assess it. By the end of this project, we confidently concluded that improvement is indeed measurable and can be systematically analyzed in volleyball. Across all key skills, we developed models that accurately predicted performance rankings for individual plays. These models are not only reliable but also easily replicable, offering volleyball staff a powerful tool for tracking and evaluating player development over time.

By leveraging these predicted performance rankings, we were able to measure changes across players and seasons with remarkable ease. Visualizing trends became as straightforward as interpreting a graph. Improvement, as revealed through these trends, is a challenging feat at the collegiate level, underscoring the value of the insights provided by this analysis.

For future applications, we recommend integrating these models into the DataVolley package to provide automated performance rankings directly within the software. This integration would enable volleyball coaches and staff to evaluate players more effectively while offering a standardized basis for measuring improvement, as demonstrated in this project. Additionally, future studies could expand this framework by incorporating a broader range of variables and working toward establishing a universal standard for what constitutes improvement. With an accurate method for measurement now in place, it is essential to further explore what improvement looks like for individual athletes and how it can be better understood and supported.

In conclusion, this project offers a new perspective on evaluating player performance and provides coaches across all sports with a clearer understanding of improvement. Improvement, often considered an abstract concept, is now quantified and given the attention it deserves. It is not an overstatement to say that improvement reflects an athlete's dedication and drive to succeed. Coaches are encouraged to prioritize the measurement of improvement, as it may hold the key to unlocking both individual and team success.

References

[1] Nikos Bergeles et al. Performance of male and female setters and attackers on olympic-level volleyball teams. *International Journal of Performance Analysis in Sport*, 9(1):141–148, April 2009.

[2] Elisa Bisagno et al. Assessing individual performance in team sports: A new method developed in youth volleyball. *Journal of Functional Morphology and Kinesiology*, 4(3):53, August 2019.

[3] Jared Dubin. Nfl comeback player of the year award criteria clarified to emphasize injury, illness after joe flacco's win. *CBS Sports*, June 2024. Accessed: 2024-10-03.

[4] Jordi Duch et al. Quantifying the performance of individual players in a team activity. *PLoS ONE*, 5(6), June 2010.

[5] L. M. Hvattum. A comprehensive review of plus-minus ratings for evaluating individual players in team sports. *International Journal of Computer Science in Sport*, 18(1):1–23, 2019.

[6] IBM. Random forest. *IBM*, n.d. Accessed: 2024-11-07.

[7] C. López-Serrano, M. P. Moreno, D. Mon-López, and J. J. Molina-Martín. Elite coaches' approach to quantifying technical actions and relative participation in volleyball players' performance. *Journal of Human Sport and Exercise*, 18(2):390–401, 2023.

[8] Rui Marcelino et al. The weight of terminal actions in volleyball. contributions of the spike, serve and block for the teams' rankings in the world league 2005. *International Journal of Performance Analysis in Sport*, 8(2):1–7, July 2008.

[9] NVIDIA. What is xgboost?, n.d. Accessed: 2024-12-15.

[10] Y. Yu, A. García-De-Alcaraz, L. Wang, and T. Liu. Analysis of winning determinant performance indicators according to teams level in chinese women's volleyball. *International Journal of Performance Analysis in Sport*, 18(5):750–763, 2018.

A Appendix

A.1 Volleyball Positions

Libero: A defensive leader who plays in the backcourt and can enter and exit the game without a substitution. They wear a different jersey and are primarily responsible for passing and defense.

Outside hitter: Plays on the left side of the court and is responsible for attacking, passing, and serving. They are usually the best at finishing the ball and receive most of the sets in a match.

Setter: Runs the team's offense and is responsible for setting the ball to attackers. They are often called the *quarterback* and can play in both the front and back row.

Middle blocker: The tallest player on the team who blocks the center of the net and is the first line of defense against the opposing team's hits. They are also known as the middle hitter.

Defensive Specialist: A player who focuses on defense and usually comes in for a player who can't play the back row. They can play in the front row if needed, but they must make a substitution with the referee.

Serving specialist: A player who is only subbed in to serve for their teammate. They are subbed out once the opposing team sides out.

Opposite: A player who is central to many attacks and is known as the team's *cleaner* and scoring juggernaut. They are usually a strong attacker with less defensive skill

A.2 Volleyball Skill Definitions

Serve: The action used to start the point, where a player launches the ball over the net into the opponent's court, aiming for placement and speed to score an ace.

Ace: A serve that lands directly on the opponent's court or results in an error by the receiving team, scoring a point without the ball being returned.

Reception: The defensive action taken after the opponent's serve, where a player controls the ball and passes it to the setter.

Set: A controlled pass, usually executed by the setter, to position the ball for an attacking player. The goal of the set is to assist a spike.

Hand Set: A precise overhead pass using the fingers to direct the ball into an optimal attack position, typically by the setter.

Bump Set: An underhand pass using the forearms to lift the ball, typically performed by non-setter players to assist in positioning the ball for an attack.

Spike: An offensive action where a player strikes the ball downwards into the opponent's court to score. A successful spike is called a *kill*.

Block: A defensive skill where front-row players attempt to stop the opponent's spike by intercepting the ball at the net.

Dig: A defensive move where a player attempts to save the ball from hitting the court after an opponent's spike, keeping the play alive.

A.3 Volleyball Visuals

Flowchart: A flowchart illustrating all possible play variations based on different volleyball skills. The flowchart is accessible via the following link: `https://www.canva.com/design/DAGT2TQ9B88/GKaq87hZd9axeDSmlhfCiA/edit?utm_content=DAGT2TQ9B88&utm_campaign=designshare&utm_medium=link2&utm_source=sharebutton`