ATHLETES UNLIMITED VOLLEYBALL SCORING SYSTEM

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Abstract: Athletes Unlimited has developed a scoring system for the sport of volleyball that is designed to highlight the individual performance of an athlete within the context of overall team performance. Given the nature of the Athletes Unlimited unique competition format, the scoring system should account for both the player's measurable individual statistical impact, as well as their intangible influence on team outcomes. Historical data from international competition matches were used to craft the initial models, which were then refined through simulations, compared against actual match results, and integrated with the team and MVP point structures that appear in all Athletes Unlimited scoring systems.

Introduction

This paper explains the construction of the innovative scoring system to be employed by the Athletes Unlimited (AU) professional volleyball league, balancing three guiding principles — simplicity, accuracy, and parity of opportunity — in the construction of team and individual point systems.

The Athletes Unlimited model elevates the competitive experience for both athletes and fans by creating an individual leaderboard for competitors in team sports. The ability of each league's unique scoring system to reward players for high performance creates a dynamic competition in which every play matters for the season standings. Success of the model depends on being able to define metrics for individual performance that, when combined with team performance, credibly reflect the athletes' on-court experience during an intense, short season.

The sport of volleyball has much to gain from a scoring system that can amplify all of these aspects of the holistic competitive experience. However, to develop a scoring system that creates the environment for meritocracy across the entire league roster, there are unique challenges and idiosyncrasies of the sport (and its statistical measures) to consider. Most notably, volleyball is a highly team-oriented sport; rallies are won by the strength of a team's dynamic, and the intensity of professional women's volleyball has evolved the need for specialized positions that perform specific skills, each one contributing to the choreography of a rally with immense precision. With athletes who build entire careers out of specializing in a position that may or may not garner as much usage as another, how can Athletes Unlimited develop a scoring system that gives all athletes across all positions a fair shot at the top of an individualized leaderboard?

Using historical data generated from international competition at the highest level, Athletes Unlimited has built on the previous work of sports statisticians, industry experts, and professional athletes to achieve the balance of simplicity, accuracy, and parity of opportunity in a

comprehensive scoring system that allows any athlete, from an Outside Hitter to a Libero, to achieve greatness through dedicated superior performance.

This paper will focus primarily on the development of the individual point system, as it is the piece of the scoring system that presents the most statistical challenges for discussion. The scoring model for team performance is also substantially new for the sport of volleyball, but both that and the MVP point systems follow the same core philosophy and function as other AU sports and will be treated in less detail here. To read more about how these point systems were developed and tested for Athletes Unlimited softball, please visit the References section to learn more about the white papers authored by Philip Maymin and Soham Mahabaleshwarkar.

Individual Point System

1.1. Principles of the system

One of the primary foundations of the Athletes Unlimited league model is the evaluation and assignment of value to an individual athlete's performance within the context of team success. In the inaugural season of volleyball, the player pool will consist of 44 athletes who will be distributed across four teams of 11. Each weekend of competition will consist of a full round-robin between the four teams (Gold vs. Orange, Blue vs. Purple / Gold vs. Blue, Orange vs. Purple / Gold vs. Purple, Orange vs. Blue), during which players accumulate points based on a) Individual Performance, b) Team Results, and c) MVP Voting, producing a ranking of all players from 1 to 44. The teams will be reconstituted after each week of competition through a draft format, creating entirely new team rosters. At the conclusion of the five-week season, the accumulated points in each of the three categories determine the final rankings. There are no rankings for the teams as in a traditional league structure.

As with all Athletes Unlimited sports leagues, the volleyball scoring system needed to be developed in such a way that it satisfied three guiding principles: simplicity, accuracy, and parity.

To satisfy the goal of simplicity, we sought to develop a system that does not require complex statistical calculations or significant background experience in the sport to follow along. In doing so, the system should be designed in a manner that can be visually and verbally represented in ways intuitive to the viewer and allow a casual viewer to easily grasp the scoring system during game play.

The scoring system must also accurately account for outcome and performance. The points awarded for individual performance and MVP points should demonstrate, both in quantitative and qualitative terms, the influence the individual athlete had on their team's prospects for winning. The values placed on skills and events during a match should reflect widely accepted statistical measurements of success within the sport. These are supplemented by the value of the MVP awards, which can capture the intangible qualities of an athlete's performance and their contributions to the team dynamic as recognized by their peers.

Finally, perhaps the greatest challenge is engineering a system that affords players across all positions the opportunity to rank highly in the leaderboard if their performance is superior within their position. A challenge in volleyball is the varying usage rate of different positions on a team; put differently, some positions are far more likely to participate in key touches that contribute to rally wins than others. To achieve satisfactory parity of opportunity, the AU scoring system should make it possible for a player in any position to finish in the top ten on the leaderboard, provided that they perform at the highest level from match to match.

1.2. Challenges of volleyball by position

Volleyball is composed, at its most basic level, of six fundamental skills performed by players: serve, pass, attack, dig, set, and block. While systems can vary widely, the most common positions occupied by players performing these skills in high-level professional and international volleyball are the Outside Hitter (OH), Middle Blocker/Attacker (MP), Opposite (OP), Setter (SET), and Libero (LIB). The main challenge in designing a system that meets all of the three principles previously discussed is that usage (number of touches and importance of touch type to rally wins) varies widely across positions. The following chart shows which skills are most commonly performed in a position. Note the contrast between an Outside Hitter, who gets five skills' worth of touch opportunities, versus a Libero, who only gets two.

Table 1: Most common skills performed per position based on historical match data

Position	Serve	Pass	Attack	Dig	Block	Set	TOTAL
OH	Yes	Yes	Yes	Yes	Yes		5
OP	Yes		Yes	Yes	Yes		4
MB	Yes		Yes	Rarely	Yes		3
SET	Yes			Rarely	Yes	Yes	3
LIB		Yes		Yes		Rarely	2

The imbalance in touch opportunities adds up over the course of a match. For example, the charts below show that, in a typical set, a Setter will touch the ball more than twice as often as a Libero.

Figure 1: Average number of touches per set, designated by position
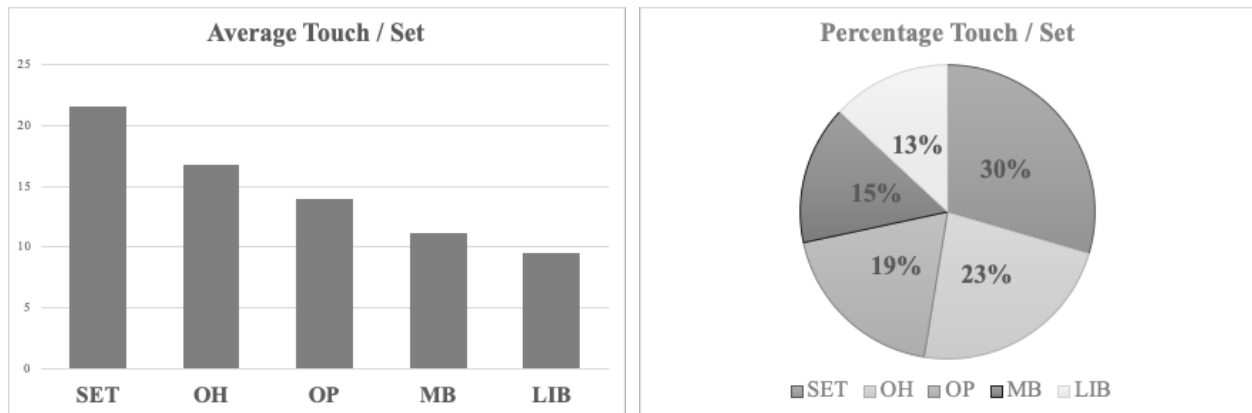
This discrepancy introduces a major problem in the holistic evaluation of player performance across positions and puts certain positions at a great disadvantage to others. Historically, most individual evaluation systems have focused on their skill performance in isolation, which allows for a good comparison of players relative to others that perform those same skills, and to some degree allows for comparison of the overall performance in a single position. There is substantial literature that addresses the evaluation of skill performance at the time of ball contact ((Florence et al., 2008), (Drikos et al., 2019), (Silva et al., 2014), (Asterios et al., 2009), (Miskin et al., 2010)), but where these models fall short is in the comparison of the quality of all players in all positions. A more recent study (Fellingham, 2020) evaluated players based on their influence on rally outcomes, rather than attempting to grade their performance of individual skills, but the comparisons drawn from this model still remain useful only when evaluating a single position group. This evaluation technique also requires larger datasets than would be generated in a single match, which is the unit by which Athletes Unlimited measures player performance.

1.3. Initial Approach

In evaluating multiple options for the system, the balance of the three guiding principles was best achieved through a model that awarded points for the successful performance of a skill and deducted points for terminally poor performance of a skill. Awarding points for individual skill performance allows for the overall outcome of a rally (i.e. the win or loss of a point) to be broken down into its components — the skills performed by players in their respective positions — and further quantified. The allocation of points for team wins (which are simply a function of aggregate rally wins) already reflects the outcome of the rally in a player's score. The individual points need to measure the value of an athlete's performance to the likelihood of team success, as well as separate an individual's performance from the team's overall performance. In other words, how do we reward an individual player for an excellent performance in a losing effort? This model has the added benefit of following the existing league model for softball (Mahabaleshwarkar and Maymin, 2020), and as such would be familiar to Athletes Unlimited fans.

1.4. Skill Point Values

In determining the point values that should be awarded for the performance of the various skills, Athletes Unlimited began with a model developed by Joe Trinsey while working with the United States Women's National Volleyball Team (USWNT) during the 2016 Rio Olympics. This model fractionalizes the value of a single rally win (point) into its component parts based on skill performance. For example, if the offense (receiving team) won the rally and scored a point, how much of the point was a good pass worth? A medium pass? A good set? The actual attack?

Based on extensive analysis of historical FIVB scoresheets, a good assumption is that an offense (receiving team) will win the rally 60% of the time, with the defense (serving team) winning 40% of the time. One can extend this concept into the offensive and defensive segments of an individual rally as well: in other words, if a team has generated a first contact when the ball comes over the net to the other team (from a serve or from an attack), the other team can reliably be expected to win the rally 60% of the time in aggregate.

Using data from USWNT matches, Trinsey, through Markov-chain analysis, was able to determine the exact value of each contact that a player executed in a match, as well as the difference in value between a well-executed skill and a poorly-executed skill. Translating this statistical analysis into a point system posed a few challenges: (1) In order to get the exact value of a volleyball contact, significant subjective grading of first contacts (passes and digs) are required and (2) Significant value is accrued by player actions that don't directly score a point, such as setting the ball accurately, closing a double-block, or digging the ball perfectly rather than poorly. These non-scoring actions rely on data gathered by specifically-trained statisticians, and they might feel too subjective or complex to players and fans.

The first step to translating Trinsey's research into a scoring system was to reduce the subjective evaluations of non-scoring contacts as much as possible. Six grades of passing and digging were reduced to one each, and block touches that did not directly result in a point were eliminated. Finally, subjective evaluations of setting accuracy were changed to the objective result of an assist.

For easy calculation, fractional values were translated into integer values. As mentioned previously, the receiving team has about a 60% chance to win the rally. Therefore, a missed serve reduces the serving team's chance to win the rally from 40% to 0%, or a reduction of 0.4. Likewise, a good pass increases the receiving team's chance to win the rally from 60% to about 70%, or an increase of 0.1. These numbers were converted from decimals of -0.4 to 0.1 to "-4" or "+1" respectively. This was done for all skills, yielding the following results:

Table 2: Initial skill point values assigned to skills and events in the Athletes Unlimited scoring system

SKILL	VALUE	SKILL	VALUE
Service Ace	+6	Pass Error	-6
Block Stuff	+6	Set Error	-6
Attack Kill	+4	Attack Error	-6
Dig	+2	Serve Error	-4
Assist	+1	Dig Error	-4
Good Pass	+1	Block Error	-4

This particular set of point values factored highly on simplicity. It also factored highly in accuracy, in that the value a player added or removed from a rally was closely represented. However, certain positions vastly eclipsed others in potential points scored in a three-set match, and certain positions could undergo wild swings from positive points to negative points. The chart below shows the difference in point totals for the mean, the high performance (80th percentile), and the low performance (20th percentile) of each position. On average, Setters had the highest point values (due to so many touches), and the Liberos had the fewest (so few relative touches) by a margin that was deemed much too large (85%) to satisfy the objective of parity of opportunity by position.

Table 3: Average individual point totals per position based on the initial values found in Table 2

| POSITION	MEAN		80th		20th	
SET	191	100%	451	82%	-114	-158%
OP	119	62%	540	99%	-255	-354%
OH	112	59%	547	100%	-337	-468%
MB	95	50%	305	56%	-164	-228%
LIB	29	15%	130	24%	-72	100%

Adjustments to the scores were required to improve parity between positions, with the aim to make adjustments that yielded the maximum impact on equality with minimal impact on accuracy. The basis for these adjustments leaned heavily on the experience of athletes, coaches, and volleyball statisticians. Based on additional data simulations factoring in guidance from these professionals, a revised system increased the value of digs, reduced the value of assists, and eliminated negative points for dig and block errors. This gave a result set with much closer mean results (30%).

Table 4: Revised Skill Point Values in the Athletes Unlimited scoring system

SKILL	TRUE VALUE	ADJUSTED VALUE	SKILL	TRUE VALUE	ADJUSTED VALUE
Service Ace	+6	+6	Pass Error	-6	-6
Block Stuff	+6	+6	Set Error	-6	-6
Attack Kill	+4	+4	Attack Error	-6	-6
Dig	+2	+2.5	Serve Error	-4	-4
Assist	+1	+0.5	Dig Error	-4	None
Good Pass	+1	+1	Block Error	-4	None

Figure 2: Comparison of average individual point totals between the initial and revised scoring systems
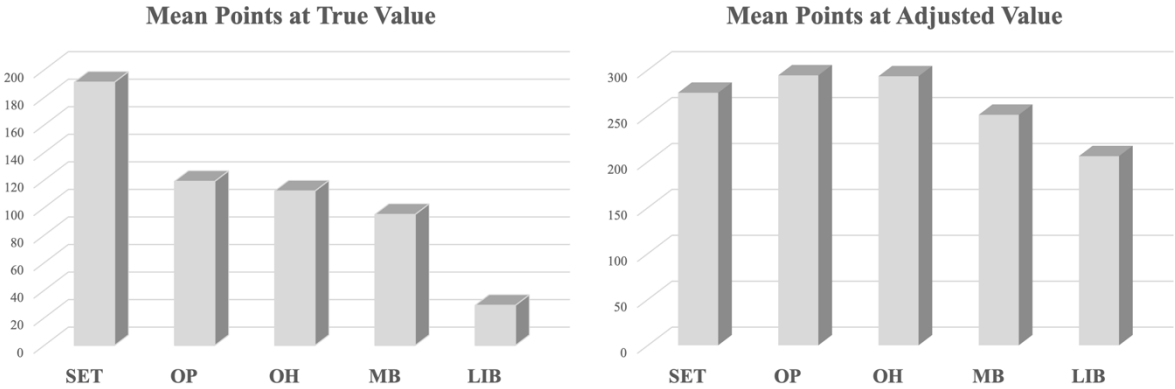
1.5. Discussion of Parity

The departure from true-value points to improve parity was a required compromise in order to optimize for two competing principles. Digs were adjusted to raise the impact of the Libero's potential contributions in a skill of the game that they were likely to perform the most. While this also would raise the value of this skill across positions, Liberos typically have the most digging opportunities, and by increasing the value from 2.0 to 2.5, this rewards the position in a way that improves competitiveness with insubstantial impact on accuracy.

Setting is perhaps the most difficult position to accurately evaluate because so much of a Setter's assist rate is dependent on the attacker's prowess, and to some degree their team's defensive abilities. While consistently better sets get attacked at a higher percentage, the efficiency range varies narrowly between perfect and medium set quality. In reducing the assist point value from

1.0 to .5, we reduced the value of the Setter getting so many touches, but a strong argument can be made that the original point award reflected significant value added by the attacker.

Dig errors and block errors fall into their own category of consideration for adjustment. When making a true-value accounting for a point, it is typical to assign some negative value to an action that terminates with a defensive player touching the ball and the rally ending. A block error (commonly called a "tool") is when the blocker touches the attack but the ball is killed, either going to the floor on their side or going out of bounds. A dig error can be assigned when the digger touches the ball but the ball doesn't stay in play. In close accounting, one of the defensive players will likely be assigned an error if they are close to the ball and theoretically should have been able to touch it. In true-value accounting, every terminal play is assigned a culprit on the defensive side, and multiple players are often assigned partial responsibility for allowing a kill to occur.

With true-value accounting, an individual defender's team still had a 40% chance of winning the rally at the point of attack, but the ball touched the defender (either on the block or dig), ending the rally and thus holding the defender responsible for that 40% of the point. The trouble with assigning value this way is two-fold: first, it somewhat ignores the ability of the attacker, and second, it becomes highly subjective when making missed-dig judgements.

To the first point, it can be strongly argued that over an extended period of evaluation, better blockers get tooled less than poor blockers. But in the evaluation of a single play, it is difficult to assess how much of the ball getting tooled off the block was a function of poor blocking and how much was a function of highly skilled execution by the attacker. The same question can be asked of diggers: how much of the outcome was simply a strong play by the attacker versus a mistake by the digger? Because of these ambiguities and their subjective manner of evaluation, the revised system removes penalties for block and dig errors, adjusting their values from -4.0 to 0.0. In addition, this had the effect of boosting scores for Liberos and Middle Blockers, positions that see a lot of block and dig opportunities, and the two positions that happen to struggle most in true-value accounting.

In the context of the Athletes Unlimited scoring system, true-value accounting fails to provide all players in all positions an adequate chance at climbing the leaderboard. However, any departure from true-value in the name of parity introduces a certain amount of subjectivity on the part of those who develop the system. Striking a balance between what the data demonstrates and how a league may need the data to function is the art of developing a scoring system such as this one. While no scoring system perfectly evaluates every possible individual event that can take place in a match, Athletes Unlimited strives to achieve a balance between the three guiding principles of simplicity, accuracy, and parity of opportunity to maximize the competitive experience for athletes and fans alike.

1.6. Outcome dispersion by position

The parity-oriented modifications to the point system had two main outcomes:

1. At the mean, the position groups became much more closely aligned in their point dispersion ranges, with Liberos going from 15% relative to the top score up to 70%. The 70% threshold was suggested as the acceptable dispersion range based on results from the Athletes Unlimited 2020 softball season, and subsequent simulations and real-match historical analysis bore out this number. Also, even at a 70% dispersion, the alignment still maintained a distribution that matched "true value" or "market value", in that Outside Hitters and Opposites were the most highly valued positions, then Setters, Middle Blockers, and Liberos. In other words, if the lowest group were within 70% of the highest point-scoring group at the mean, the system will achieve an acceptable balance of accuracy and equality.

2. The other effect of the point system was that the most highly valued positions had the widest range of potential total points, with Liberos having the lowest overall elasticity of results. In other words, positions like Outside Hitters and Opposites have the most to gain from a high-quality performance, but the most to lose from a poor one. Setters, Middle Blockers, and Liberos in particular require consistent high performance to do well, but a poor performance will not set them as far back in the leaderboard.

Figure 3: Dispersion of points awarded during a match by position based on highest and lowest possible performance
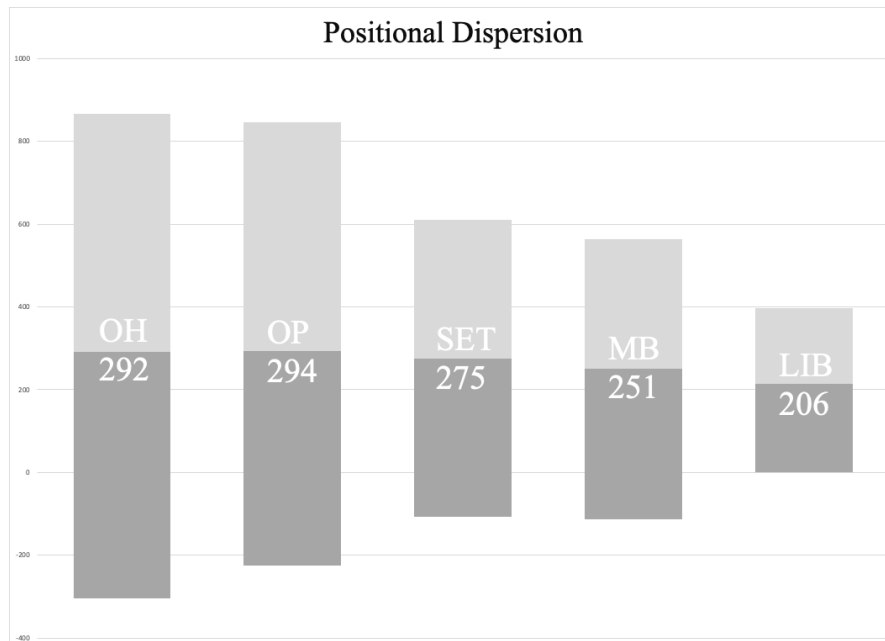
On average, the ranking of positions by point score was Opposites, Outside Hitters, Setters, Middle Blockers, and Liberos, in that order. As described earlier, while Opposites and Outside Hitters have the potential to finish very high in the rankings, there also exists the greatest potential to finish on the low end. Liberos, on the other hand, will need greater performances to finish high, but a poor performance has lesser consequence on their final rankings.

1.7. Data Simulations

While the initial point dispersion analysis appeared to indicate a robust scoring system that properly balanced AU's three guiding principles, data simulations only surveyed outcomes at the match level. To ensure that parity would be maintained beyond just one match, additional data simulations needed to be conducted at a larger scale so that statistical trends over a 30-match season could be made visible, factoring in actual team rosters. The following tables break down the number of players per position during the inaugural Athletes Unlimited season, both across the league and by roster:

Table 5: Total league player count by position

	Outside	Opposite	Middle	Setter	Libero
League	12	8	12	8	4
Team	3	2	3	2	1

The dataset used for testing the various models was generated by VolleyMetrics and consists of five years of historical data from international competition, as well as professional leagues in Italy, Turkey, Germany, and other European leagues. Each data record represents a match played by an individual in a position and includes the quantity and quality of each skill touch during the match. The data was normalized for three sets to match the format (see Section 2, Team Point System) established for an Athletes Unlimited match. Over 15,000 total records were included, providing high confidence in the statistical significance of the resulting analysis. Three main simulation sets were run, each with a different assumption:

1. For the first simulation, it was assumed that all players in the pool were of equal talent, would have equal playing time, and would have performances from set to set that matched the mean performance curve. This simulation would provide a baseline with which to compare other simulation results.

2. The second simulation was modified to assume equal playing time, but with the talent level divided across the position group in roughly thirds, with the top level at the 60th percentile, the middle group at the mean, and the lower group at the 40th percentile of the performance curve. This version of the simulation worked to approximate a more realistic demographic of talent distribution across the league and to give a more probable result set.

3. Finally, the third simulation modified the parameters further to account for likely position usage. In other words, it was assumed that the better players were likely to play more rallies. In positions with a group of three players on a team (OH, MB), two of the players performed at the 60th percentile and got 80% of the usage, while the third player performed at the 40th percentile and was assigned 20% usage. In positions where there are two players on a team (OP, SET), one player performed at the 60th percentile and got 80% of the usage, while the second player performed at the 40th percentile and was assigned 20% usage. In the case of Liberos, since there was only one per team, they received a boost in the outcomes due to their 100% usage. This simulation is the closest variant to a real-life environment and should lend even more credibility to the result set.

Across all simulations, a limit was determined that all players would lie no more than ±1 standard deviation away from each other, based on the assumption that there would be no major disparity in talent from one player to another. Ultimately, the basis for measurement was what percentage of a position group made it into the top 10 or the top half (22) of the league over a simulated season. By comparing the results of each simulation against the results of the historical data, the system can be evaluated for both accuracy and parity of opportunity: first, how well does the system mirror the historical data in rewarding the top performing athletes; and second, is there satisfactory positional representation amongst the top 10 athletes or the top half of the league roster?

Based on this data, a simulation was run for 15 matches, or the number of matches one individual will participate in over the course of a 30-match season. For each player based on position, a point value was randomly selected in the range of ±1 standard deviation from the player's assigned mean value. This was iterated over 15 times to simulate the play of one league and 44 players.

Each simulation was then run 300 times to further increase the sample size and magnify the visibility of possible statistical variance over numerous iterations. Based on these 300 simulations for each player, the system can then calculate the average points across 300 simulations, the maximum, and the minimum for each player, as well as the average across the league to provide a benchmark of the amount of variance to expect in one season. Once the first simulation was complete, the increasingly complex assumptions previously discussed were layered in to further model real-life scenarios: first, creating tiers of talent using a multiplier based on their potential availability and time in the game; and second, determining position usage based on tier.

Once each simulation had generated the point values for each player in a league iteration, the next step was to break down the top 10 and the top 22 athletes in terms of positional representation.

Outcomes from the first simulation set (equal value) fell predictably along the results seen by the original dispersion charts. Outsides and Opposites were highly represented, with Setters, Middles, and Liberos underrepresented. The greatest value gained from this particular set of parameters was in verifying that the simulation correctly modeled an already known outcome.

Figure 4: Dispersion of average total season points by position, given equal values in all variables
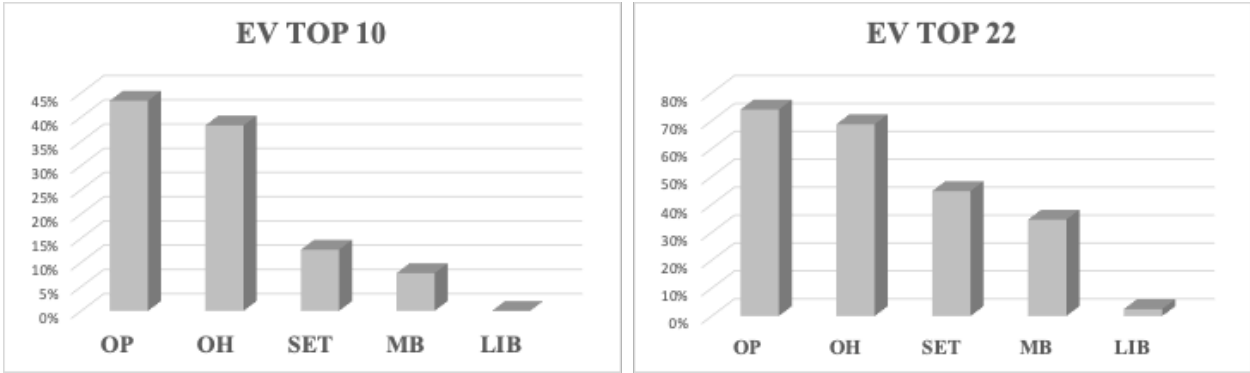
The modification to adjust for talent (weighted) showed slightly improved parity, with more Middles and Liberos represented. However, the likelihood of a Libero charting high on the leaderboard was still too low.

Figure 5: Dispersion of average total season points by position, weighted by player ability
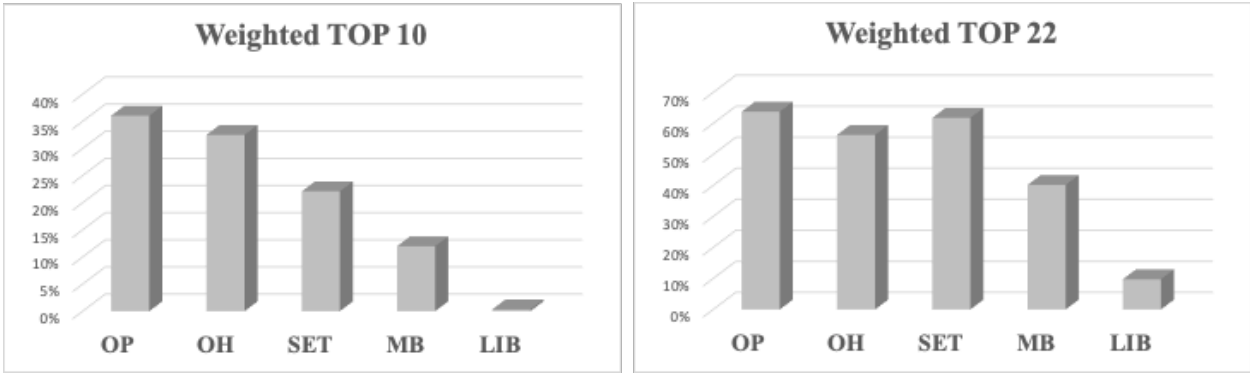
The final simulation, run with both talent and usage modifications, showed acceptable accuracy and equality, as most position groups were well represented.

In conclusion, the simulations demonstrated that the most-likely scenario of usage (playing time based on talent) within a position group on the team showing strong parity, the proposed point system achieved our goals.
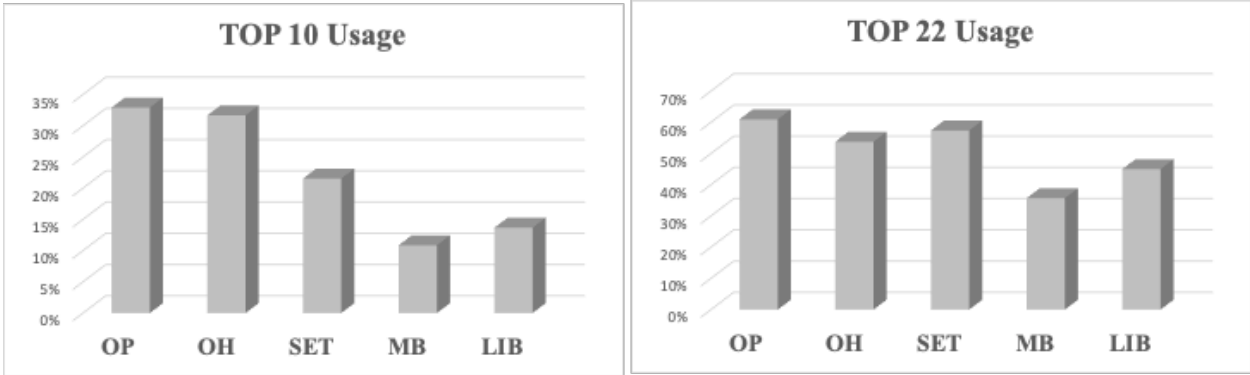
1.8. Comparison against historical matches

The final step in validating the individual point system was to score a group of teams in their actual historical matches, using position performance to generate top 10 and top 22 results based on this new scoring system. The data for these matches came from the 2019 FIVB season of Volleyball Nations League and World Cup matches. This dataset provided some unique benefits in that multiple teams played each other during the year, approximating the round-robin format that is endemic to Athletes Unlimited.

Data was provided as native DataVolley files (.dvw) that required translation to a spreadsheet format, then were read into code that calculated points based on skill performance. The first group of teams evaluated included Brazil, China, USA, and Dominican Republic. The second group included Korea, Japan, Serbia, and Russia.

MVP voting was carried out through a randomized system with probability weights for players to win MVP based on their total individual points through the game. Based on observations regarding the correlation between individual points and MVP awards during the 2020 AU softball season (see section 2.2, MVP Voting), the algorithm was designed to randomly select MVP winners out of the top 9 performing players, weighted by probability as follows: 30, 20, 15, 12, 10, 5, 3, 3, 2. A number was randomly selected between 1 and 100, and a player was assigned MVP points based on this selection. As with softball, the algorithm selected three MVP winners, awarding them 60 points, 40 points, and 20 points respectively.

Based on the same dataset, simulations were carried out to investigate the individual and positional dynamics between players and whether the resulting leaderboards were reasonable considering real-world skill and playing time. It was assumed Liberos play 100% of the time since there is only one per team. Other position players were put to play only 80% of the time, which somewhat equalized the points scored between the two.

Tables 1 and 2 in the Appendix demonstrate outcomes very similar to the simulation results, where Outsides and Opposites are highly represented, with Setters, Middles, and Liberos acceptably distributed through the result set.

Team Win and MVP Point Systems

2.1. Team Wins

The Athletes Unlimited model for assigning value based on team performance awards points not just for the overall win of a game or match, but also for segments within the match. This method of allocation ensures that the winner of the overall match will earn at least as many points as the losing team, if not more. The system thus increases the number of data points available for performance evaluation, despite the short season. In effect, the segments create a larger number of "micro-games" within the context of a smaller number of overall games or matches, rewarding the losing team in a tight match or increasing the reward for a dominant win relative to a close win. This widens the dispersion of outcomes possible within a match, even with only five weeks of competition and a limited number of possible team rosters. Thus, "every moment counts" in any given match: players have opportunities to earn points at every level of action, increasing the dynamism and excitement of competition that Athletes Unlimited strives for.

A current FIVB volleyball match is scored by teams playing best of five (first team to win three) sets, with each set being played to 25 points, win by two. The exception is the fifth set, which is played to 15 points, win by two. This system created two undesirable challenges for the Athletes Unlimited match structure. First, it creates the potential for an unequal number of point scoring opportunities from match to match. If a match is won in three sets, there are far fewer rallies to be played and therefore fewer opportunities for players to perform skills that score individual points than if the match extends to four or five sets. The second challenge was the physical load that would be required of players to play three matches on consecutive nights that could potentially go to five sets each. It was thought that back-to-back-to-back matches would put an undue physical strain on the athletes, reducing quality of play and increasing the probability of injury.

The best solution to both issues was to control for the total number of points available to earn over the course of the match. There were several possible approaches in this vein, including a quarter system, a running total, and a clock-based system, all of which involved some deviation from the standard. In a desire to keep the format familiar to current volleyball standards, we chose to play a fixed number of sets.

Initial work explored a fixed match of five sets to 15 points, with increasing point values for each set won. As with any sport, the fewer the opportunities for points, the more likely a random winner will emerge. In other words, as excellently illustrated in previous research (Fellingham et al., 1994), the more points (or longer) you play, the more likely the superior team will be the winner. In considering a set to 15 points, it was determined that this point-total introduced an excessive random element into the set outcomes — the better team didn't have enough of a chance to prove their superiority over time. Another strong factor arguing against sets to 15

points was the fact that a team would likely get through only one-and-a-half rotations, making lineup and individual personnel factors much more relevant than overall team quality. A fixed match of three sets to 25 points (win by two) and awarding victory to the team with the greatest number of points across the three sets addresses both of the previously stated concerns.

In order to determine the point values associated with winning each set and winning the overall match, one approach is to identify the balance of team, individual, and MVP points the average player should be able to earn. The highest priority of achieving this ratio is to ensure that winning matches and sets provide the greatest value to a player. However, team wins cannot be so heavily weighted that they obscure the performance of good players.

Using the results of the Athletes Unlimited 2020 softball season to compare against the results of the simulations performed earlier, as well as taking into consideration the high amount of team collaboration required for peak performance in the sport, we found that the ideal balance between the three point categories was 65% for team points, 30% for individual points, and 5% for MVP points. Knowing both the average amount of individual points a player can earn based on our previous simulations, as well as knowing that 65% of a player's total points should constitute team points, we could then determine the total number of team points available in a match and test different valuations of set and match win points that add up to that total.

All 300 seasons of the final individual simulations were rerun using different variations of win points to measure the impact of different points values on outcomes. These numbers were also compared against data from real matches to compare the results against each other and against realistic expectations. The results of this analysis showed that awarding 40 points for each athlete for a set win and 60 points for the overall match win yielded the most equitable outcomes. It also prevents ties between the two teams, as the team who wins the overall match must always receive a majority of points by winning at least one set. Rather than guarantee a victory for the team who wins "best of three", it allows the opportunity for the team that is behind to come back and earn points in a meaningful set that may not have otherwise taken place.

Figure 7: Three possible match outcomes and the team points awarded to each team

	Team	Set 1	Set 2	Set 3	Total Points
		+40 ↑	+40 ↑	+40 ↑	+60 ↑
Match 1	Team A	25	25	27	77
	Team B	22	20	25	67
		+40 ↑	+40 ↑		+60 ↑
Match 2	Team A	25	25	23	73
	Team B	22	20	25	67
				+40 ↓	
		+40 ↑	+40 ↑		
Match 3	Team A	25	25	20	70
	Team B	23	23	25	71
				+40 ↓	+60 ↓

The takeaway from this breakdown is that *every set matters*. In the third match, under more traditional match rules, the match would have been over after the second set and Team A would have won. In the Athletes Unlimited system, the final set led to an overall victory for Team B, earning 20 more points overall than Team A. Even if you change the order of the set wins and losses in that match, it still makes for exciting play because the fan can't anticipate the final outcome for each team until all of the sets have been completed.

In the event of a tie at the end of the third set, an overtime will be played to settle the match win. Overtime will run first to five points winning by two, or first to ten points. Individual points do not accumulate over the overtime period, as rewarding individual points in sets not granted to all matches can create unfair advantages for the athletes who participate in overtime.

With confidence that the values assigned to each skill will produce highly accurate measurements of a player's contribution to team success — and with appropriate balancing of simplicity and parity of opportunity — the individual rankings should ensure that the highest performing players among those on winning teams rise to the highest ranks of the leaderboard. However, it should also provide an opportunity for equally talented athletes to do well for themselves, even when they may find themselves on a losing team.

2.2. MVP Voting

MVP points in Athletes Unlimited are points that are awarded to three players per match for outstanding play. These bonus points are decided by the players themselves at the end of the match, and players can vote for players from either team. There are no restrictions on who they can vote for (they can vote for themselves) but they must pick three players. Additionally, the members of the Unlimited Club at the time of each competition are able to cast votes that have the cumulative weight of one player.

The MVP category deliberately introduces a human element (and thus unpredictability that is difficult to model) into the awarding of points. However, based on the outcomes of MVP voting during the 2020 AU softball season, there is solid evidence that athletes who accumulated substantial individual points during a game were likely contenders for MVP. To simulate the likely outcome of a particular MVP vote, the data simulations were then modified to weight the top nine athletes of a match by their total individual point earnings and then select three randomly, to account for some possible discrepancy between individual points earned and intangible impact on the match (see section 1.8, Comparison against historical matches). For the MVP awards, the top MVP will receive 60 points, the second 40 points, and the third 20 points. These latter values have the added advantage of fitting within our designated balance of the three point categories, as well as preserving continuity from Athletes Unlimited softball.

The concept of an MVP vote often goes against the grain of the consistency and reliability of observed statistical patterns, yet it remains integral to the holistic experience of playing in or watching a sporting event. It is often the intangible or singular skill that an athlete executes that drives the unpredictability and excitement of a match: the exceptional attack, the thrilling ace, the well-timed block that gave the defensive team a chance to fight another day. No scoring system can properly reward all events in all contexts; sometimes, the scoring system may overvalue or undervalue a skill given the context, or fail to value it at all. The principle of the MVP vote is founded on trust in the players' expertise in the sport, to allow them to award their fellow teammates (or even their opponents) for exceptional performance.

Conclusion

Athletes Unlimited presents league competitions where athletes compete for rankings on an individual leaderboard in team sports. The objective is to create an intense competition for athletes and fans alike in which every play matters, from the first serve of the season to the very last. For our unique scoring system to work, it must accurately reflect a player's success throughout the season, taking into account both their individual performance and their ability to create winning teams. Athletes Unlimited achieves this goal by awarding each athlete for their individual performance on the court measured through familiar statistics, the performance of their team in each match and in sub-match units, and through MVP awards voted on by their peers.

The most challenging of these three elements to calibrate is individual performance, where we must balance the three principles of simplicity, accuracy, and parity of opportunity. To satisfy

the principle of simplicity, we sought to build a system that uses only familiar volleyball statistics that can be easily identified and calculated by a fan during play. Using historical data, we identified twelve individual performance areas correlated to team success that can be assigned value. To balance for parity of opportunity, we focused on modifications that had minimal impact on accuracy and that also had rationale in addition to parity.

Regarding team wins, we modified the traditional match format to play a fixed three sets to 25 points, with the match winner as the team scoring the most cumulative points across the match. This modification serves multiple competitive and practical objectives. It ensures that every point in the match is important to the team as well as to the players, increases the competitive units across a short season, and decreases the variability among players for individual scoring opportunities. At the same time, it provides for a more predictable playing load for players, allowing for better injury prevention and training management.

We established the values across the three scoring elements to establish their relative importance. Team wins are substantially the most important scoring element, in order to capture the essence of competition. Individual statistics provide the basis for the second most important element, to recognize the measurable individual performance. The MVP award is the final important scoring element, allowing for capture of intangible contributions to team success as identified by the athletes themselves.

Taken together, our simulations based on historic game data combined with the success of the Athletes Unlimited Softball model left us strongly convinced that the winner of Athletes Unlimited Volleyball will be the player whose high levels of individual performance and intangible contributions leads their teams to higher than average winning performance. We are also confident that competition for every position on the leaderboard will be meaningful and dynamic, leading to an exciting and dynamic leaderboard for fans.

Finally, it is important to acknowledge the significant work achieved by professionals in the field to evaluate the skills and develop the metrics that inform this scoring system. As noted throughout, there may not exist a single mathematically optimal assignment of actions to points; instead, any ranking system requires not only a careful and thoughtful balancing of competing values, but also constant monitoring and re-evaluation upon implementation. Understanding volleyball through data analysis and statistical trends can bear out significant competitive advantages for those willing to embrace these methods; therefore, it requires radical transparency to share this work more broadly in the interest of the sport at large. The approaches and solutions explored here may serve as a foundation while continuing to be re-examined and built upon in volleyball, other Athletes Unlimited scoring systems, and new sports and leagues yet to be formed.

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Appendix

Table 1: A re-scoring of historical match data for the Brazil, China, United States, and Dominican Republic teams yielded a simulated leaderboard of the top 22 players across a 30-match season, modified for a fixed 3-set format.

Pos.	Player Name	Team	Set Points	Sets Won	Game Points	TP Won	Indiv. Points	Win Points	Total Points	Total Rank	Indiv. Rank
OH	Gabriela Guimaraes	Brazil	100	10	60	4	823	720	1543	1	1
OH	Ting Zhu	China	90	9	45	3	557	607.5	1164.5	2	3
MB	Mara Ferreira Leao	Brazil	100	10	60	4	439	720	1159	3	6
OP	Annie Drews	USA	110	11	45	3	459	697.5	1156.5	4	4
OH	Kelsey Robinson	USA	110	11	45	3	372	697.5	1069.5	5	7
L	Leia Henrique Da Silva Nicolosi	Brazil	100	10	60	4	344	720	1064	6	9
S	Macris Carneiro	Brazil	100	10	60	4	335	720	1055	7	10
OP	Lorenne Geraldo Teixeira	Brazil	100	10	60	4	294	720	1014	8	13
MB	Ana Beatriz Correa	Brazil	100	10	60	4	291	720	1011	9	14
S	Lauren Carlini	USA	110	11	45	3	303	697.5	1000.5	10	11
MB	Chiaka Ogbogu	USA	110	11	45	3	301	697.5	998.5	11	12
OH	Brayelin Elizabeth Martinez	DR	60	6	30	2	580	405	985	12	2
MB	Haleigh Washington	USA	110	11	45	3	282	697.5	979.5	13	17
MB	Xinyue Yuan	China	90	9	45	3	352	607.5	959.5	14	8
OH	Michelle Bartsch	USA	110	11	45	3	257	697.5	954.5	15	19
OH	Amanda Francisco	Brazil	100	10	60	4	225	720	945	16	22
S	Jordyn Poulter	USA	110	11	45	3	235	697.5	932.5	17	21
OH	Ana Paula Borgo Bedani Da Cruz	Brazil	100	10	60	4	187	720	907	18	25
OH	Jordan Larson	USA	110	11	45	3	199	697.5	896.5	19	24
OH	Changning Zhang	China	90	9	45	3	272	607.5	879.5	20	18
OP	Bethania De La Cruz De Pena	DR	60	6	30	2	451	405	856	21	5
S	Roberta Silva Ratzke	Brazil	100	10	60	4	131	720	851	22	30

Table 2: A re-scoring of historical match data for the Korea, Japan, Serbia, and Russia teams yielded a simulated leaderboard of the top 22 players across a 30-match season, modified for a fixed 3-set format.

Pos.	Player Name	Team	Points	Set Points	Game Points	Indiv. Points	Win Points	Total Points	Total Rank	Indiv. Rank
OH	Yeon Koung Kim	South Korea	383.5	100	45	767	652.5	1419.5	1	1
OP	Ana Bjelica	Serbia	311.5	110	60	623	765	1388	2	3
OH	Jelena Blagojevic	Serbia	299	110	60	598	765	1363	3	5
L	Mina Popovic	Serbia	293	110	60	586	765	1351	4	6
MB	Maja Aleksic	Serbia	244	110	60	488	765	1253	5	9
OH	Yuki Iishi	Japan	345	80	45	690	562.5	1252.5	6	2
OP	Heejin Kim	South Korea	286	100	45	572	652.5	1224.5	7	7
S	Sladjana Mirkovic	Serbia	218.5	110	60	437	765	1202	8	12
OP	Risa Shinnabe	Japan	307.5	80	45	615	562.5	1177.5	9	4
S	Dayeong Lee	South Korea	230.5	100	45	461	652.5	1113.5	10	10
L	Teodora Pusic	Serbia	164.5	110	60	329	765	1094	11	20
OP	Nataliya Goncharova	Russia	219.5	100	45	439	652.5	1091.5	12	11
S	Miya Sato	Japan	247	80	45	494	562.5	1056.5	13	8
MB	Irina Koroleva	Russia	201	100	45	402	652.5	1054.5	14	13
OH	Jaeyeong Lee	South Korea	198.5	100	45	397	652.5	1049.5	15	14
OH	Irina Voronkova	Russia	196.5	100	45	393	652.5	1045.5	16	15
OH	Kseniia Parubets	Russia	192.5	100	45	385	652.5	1037.5	17	17
MB	Ekaterina Efimova	Russia	188.5	100	45	377	652.5	1029.5	18	18
OH	Katarina Lazovic	Serbia	124	110	60	248	765	1013	19	25
OH	Bianka Busa	Serbia	112	110	60	224	765	989	20	27
S	Evgeniya Startseva	Russia	158.5	100	45	317	652.5	969.5	21	21
MB	Su Ji Kim	South Korea	150.5	100	45	301	652.5	953.5	22	22

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Joe Trinsey got his love of volleyball from his parents and older sister. He graduated from Stevens Institute of Technology with a degree in Applied Mathematics in 2009, and went on to coach all levels of the sport: from middle school to professional, on the men's and women's side, and both indoors and beach. He had the honor of serving on the staff of the USA Women's Olympics Team (indoors) at the 2016 Rio Olympic Games. Most recently, he was an assistant coach for the Canadian Women's National Team.

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