



World Tennis Number: The new gold standard, or a failure?

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ABSTRACT

The United States Tennis Association (USTA) has recently implemented World Tennis Number (WTN), as their official rating system. It is unknown if this rating system is accurate, therefore, the objective of this study is to determine the predictability of WTN in match outcomes, comparing it to the accuracy at which Universal Tennis Rating (UTR) predicts match outcomes. We collected matches from the 2022 USTA Boys' 16 & 18 National Championships. For WTN, UTR, and USTA ranking, we compared the predictability of match results using the Area-Under-Receiver-Operating-Characteristic (AUROC) Curve. Of the 806 matches analyzed, players with better WTNs, better UTRs, and better USTA rankings won in 76.8%, 76.7%, and 64.3% of matches, respectively. The predictability of WTN difference between players was comparable to that of UTR difference between players (AUROC, WTN: 0.847 vs UTR: 0.859, P-value = 0.14), and was superior to that of the difference in USTA rankings between players (P-value < 0.001). As WTN was superior to USTA ranking and was as accurate as UTR in terms of predicting match results, its use as a rating system is validated. This result can support the use of WTN for seeding criteria in USTA tournaments.

Key words: Tennis rating, World Tennis Number (WTN), Universal Tennis Rating (UTR), United States Tennis Association (USTA)

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INTRODUCTION

In the world of sports, rating systems are derived from competitive matches, and are used to determine the competitive level of play that a team or player competes at. Rating systems can be used in various scenarios, whether by fans and sports bettors for recreation, or by sporting associations to determine their rankings.

Tennis players often determine who they practice with based on their ratings. The closer their ratings, the more likely there will be a competitive environment, allowing for optimal practice. In tournaments, seeds, derived based on ratings and rankings, are of substantial significance, as they can change the outcome of the tournament. Inaccurate ratings can cause inaccurate seeding, which could result in unfair circumstances. When colleges recruit tennis players, coaches will initially look at the player's rating in order to grasp the level of the player. Ultimately, if a player's rating is accurate, it can lead to optimal practice environments, adequate seeding in tournaments, and proper college recruitment processes.

Currently in the sport of tennis, the most prominent player rating system is known as Universal Tennis Rating (UTR). UTR is on a 1.00 to 16.50 scale based on match results, where 1.00 is a rating for beginners, and 16.50 is a rating for top professionals (Vernon, 2022). It has been widely acknowledged as a gold standard of rating systems for tennis players (Kramer, 2017). The United States Tennis Association (USTA) has USTA Rankings for players, based on the amount of

points that a player has. Points are amassed based on how far into the draw a player reaches, and the level of the tournament (USTA, n.d.). As this is a ranking system, not a rating system, players in the same age division cannot have the same USTA Ranking. The International Tennis Federation (ITF) developed a rating system called World Tennis Number (WTN), which is on a 40-point scale, where 40 is a rating for beginners, and 1 is a rating for top professionals (Tennis New Brunswick, 2022). Recently, the USTA implemented WTN as the official rating system for the USTA, and it will be used as an aid for seeding in tournaments (USTA, 2022). However, as WTN has been newly introduced to the USTA community, one may doubt using WTN as the official rating system. In fact, there is no study supporting WTN as an accurate rating system, specifically when predicting match outcomes. Therefore, it is necessary to investigate the validity of WTN as a rating system. If WTN is shown to accurately predict match outcomes, not only does the decision by the USTA to implement WTN become supported, but using WTN as a rating system, just like UTR, also becomes supported.

Therefore, we conducted this study to determine if WTN is an accurate rating system in terms of the predictability of match outcomes by comparing it with UTR and USTA Rankings.

METHODS

We collected matches from the 2022 USTA Boys' 16 & 18 National Championships in Kalamazoo, Michigan, which started on August 5, 2022, and ended on August 14, 2022. The

reason we chose to retrieve match data from this tournament was due to several factors. We chose this tournament because it is a junior USTA tournament, which is relevant in the perspective of our study. Not only that, but the volume of data that can be collected from this tournament also surpasses nearly all other junior USTA tournaments. Also, as this is the biggest junior USTA tournament of the year, there are high level players, high level stakes, and as a result, there are many college coaches present. Consequently, these players are most likely to give it their all, and not “throw,” meaning that the skill levels between players in a match would not differ far from the ratings between the players, if the ratings are indeed accurate. In addition, the level of play at this tournament is very concentrated. Any good rating system should be able to easily predict match outcomes between players of vastly differing skill levels. However, the best rating systems are accurate at predicting match outcomes between players with similar skill levels. Therefore, through the data collected from a high volume of matches with highly concentrated skill levels, we will be able to have an accurate determination of the predictability of match outcomes by rating systems. In order to analyze anything, we needed to first determine the matches that would be analyzed. In the tournament, not every match would result in an accurate analysis of the predictability of the rating systems. If the match didn't start, there was no data. If opposing players had the same WTN or UTR rating, it would cause errors in the analysis. Therefore, to determine the matches that would be analyzed, we gathered all the matches, and then removed the matches that did not start, the matches where players had equal WTNs, and the matches where players had equal UTRs. The remaining matches would be used in our analysis.

We retrieved match data from the official USTA tournament website, including the draw stage, the round, games won by each player, sets won by each player, and the winner. We retrieved player data from the USTA and UTR websites, including name, residency, and section, and in addition, each player's WTN, UTR and USTA rankings, both prior to the tournament's start and after the tournament's conclusion. Between the players in a matchup, the higher the numerical value of the UTR, the better the player, and the lower the numerical value of the WTN and USTA ranking, the better the player. The main outcome was the match results of players with better WTNs, UTRs, and USTA rankings.

For each of the 806 matches, we collected data about the match and about the players in the match. In every match, we randomly assigned a player as “Player 1,” and the other player would be “Player 2.” Categorical data is shown as Frequency (Percentage) in the table. Quantitative data is shown as Mean (Standard Deviation) in the table. For matches, we collected the age division (16s or 18s), the draw stage (main or consolation), the round, number of games won and lost by Player 1, number of sets won and lost by Player 1, the match result in Player 1's perspective (win or lose), and if a player retired (yes or no). For players, we collected the USTA Rankings of Player 1 and Player 2, the UTRs of Player 1 and Player 2, the WTNs of Player 1 and Player 2, and the sections of Player 1 and Player 2.

Firstly, characteristics of included matches were analyzed. Categorical variables were presented as numbers (% proportions), and continuous variables were presented by means (standard deviations). Then we analyzed the correlation between difference in WTN and difference in UTR by using a correlation analysis. When calculating the values, the differences were based on how much better Player 1's rating was in comparison to Player 2's rating. As stated before, the lower the numerical value of the WTN, the better the rating, and the higher the numerical value of the UTR, the better the rating. Therefore, the difference in WTN was calculated by (Player 2's WTN) - (Player 1's WTN), and the difference in UTR was calculated by (Player 1's UTR) - (Player 2's UTR). We created one graph for all matches.

The main outcome was the match results of players with better WTNs, UTRs, and USTA rankings. We calculated the proportion of matches won according to the difference in rating (accuracy). To calculate accuracy, we divided the number of matches won by Player 1 within the particular rating difference, by the total number of matches within the particular rating difference. Using a classical confusion matrix model, we calculated the sensitivity and specificity of Player 1 match outcome predictions according to WTN, UTR, and USTA Ranking. To calculate sensitivity, we divided the number of correctly predicted wins by the sum of the number of correctly predicted wins and incorrectly predicted losses. To calculate specificity, we divided the number of correctly predicted losses by the sum of the number of incorrectly predicted wins and correctly predicted losses.

We calculated the win percentage based on whether Player 1's rating was higher or lower for each of WTN, UTR, and USTA Ranking. We also calculated the accuracy, sensitivity, and specificity with 95% confidence intervals (CIs) of each rating when predicting match results for all matches, for the Boys' 16 Singles Division, and for the Boys' 18 Singles Division. We compared the predictability of match results between WTN, UTR, and USTA ranking by comparing the Area Under Receiver-Operating-Characteristic (AUROC) Curve with Bonferroni corrected P-values. When interpreting the results of an AUROC curve, the higher the AUROC, the better the prediction of the model. Bonferroni corrected P-values were calculated by multiplying the number of comparisons with the P-values to reduce type I error. A P-Value < 0.05 was considered statistically significant. All statistical analyses were performed by using R software and State 17.0 (Statacorp, TX, US).

RESULTS

At the 2022 USTA Boys' 16 & 18 National Championships, there were a total of 886 singles matches in the tournament, with 443 matches in the Boys' 16 Singles Division and 443 matches in the Boys' 18 Singles Division. In 66 matches, the match did not start, due to players withdrawing or defaulting. In 11 matches, opposing players had the same WTN. In 3 matches, opposing players had the same UTR. There were no matches where opposing players had the same WTN and same UTR. Therefore, a total of 80 matches were excluded from the data, resulting in a total of 806 matches being analyzed, with 413 matches in the Boys' 16 Singles Division and 393 matches in the Boys' 18 Singles Division. This information is shown in Figure 1.

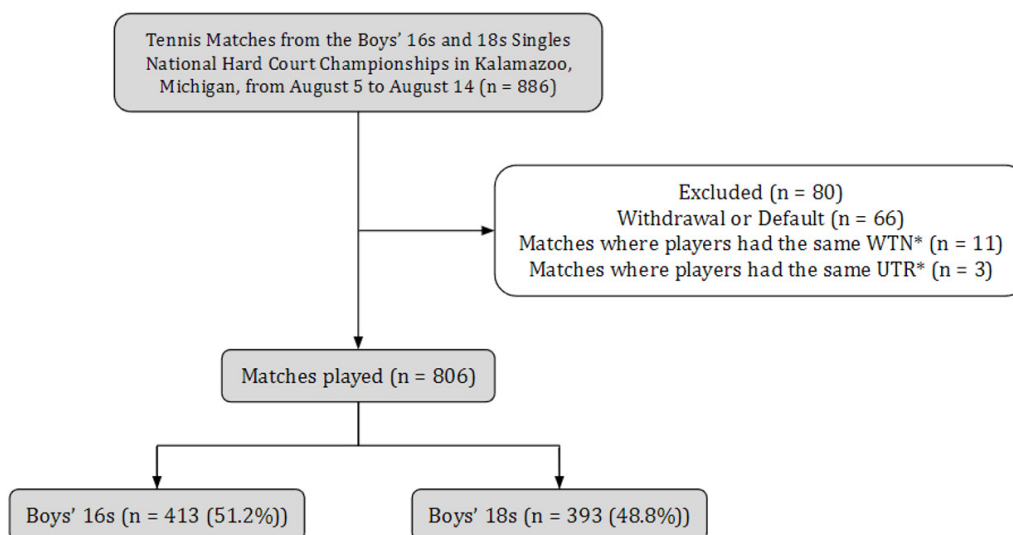


Figure 1. Flowchart for inclusion of matches. (WTN abbreviates World Tennis Numbers, UTR Universal Tennis Rating).

In Table 1, the characteristics of the 806 matches played are shown. On average, Player 1 won more games, sets, and matches, and had better USTA rankings, UTRs, and WTNs.

Table 1

Characteristics of the 806 matches played.

Total number	806
Matches	806 (100%)
Age Division (16 : 18)	413 (51.2%) : 393 (48.8%)
Match Distributions	
Main Draw Stage	433 (53.7%)
Consolation Draw Stage	373 (46.3%)
Main Draw Stage Rounds	
Round of 256	191 (44.1%)
Round of 128	126 (29.1%)
Round of 64	64 (14.8%)
Round of 32	30 (6.9%)
Round of 16	13 (3.0%)
Quarterfinals	5 (1.2%)
Semifinals	2 (0.5%)
3rd Place Playoff	1 (0.2%)
Final	1 (0.2%)
Consolation Draw Stage Rounds	
Round of 128 Qualifier	58 (15.5%)
Round of 128	117 (31.4%)
Round of 64 Qualifier	59 (15.8%)
Round of 64	53 (14.2%)
Round of 32 Qualifier	31 (8.3%)
Round of 32	22 (5.9%)
Round of 16 Qualifier	15 (4.0%)
Round of 16	5 (1.3%)

Quarterfinals Qualifier	8 (2.1%)
Quarterfinals	3 (0.8%)
Semifinals	0 (0%)
Final	2 (0.5%)
Match Information	
Games won by Player 1	9.73 (4.09)
Games lost by Player 1	9.27 (4.17)
Sets won by Player 1	1.18 (0.91)
Sets lost by Player 1	1.04 (0.92)
Match won by Player 1	434 (53.8%)
Retired	32 (4.0%)
Player Information	
Player 1 USTA* Ranking	144.61 (240.79)
Player 2 USTA Ranking	146.80 (172.82)
Player 1 UTR	11.21 (0.95)
Player 2 UTR	11.09 (0.92)
Player 1 WTN	12.51 (3.80)
Player 2 WTN	12.97 (3.61)
Section of Player 1 : Player 2	
Caribbean	2 (0.2%) : 2 (0.2%)
Eastern	81 (10.0%) : 90 (11.2%)
Florida	89 (11.0%) : 68 (8.4%)
Hawaii Pacific	8 (1.0%) : 5 (0.6%)
Intermountain	22 (2.7%) : 30 (3.7%)
Mid-Atlantic	33 (4.1%) : 36 (4.5%)
Middle States	31 (3.8%) : 27 (3.3%)
Midwest	82 (10.2%) : 63 (7.8%)
Missouri Valley	29 (3.6%) : 33 (4.1%)
New England	30 (3.7%) : 27 (3.3%)
Northern	15 (1.9%) : 18 (2.2%)

Northern California	69 (8.6%) : 63 (7.8%)
Pacific Northwest	22 (2.7%) : 21 (2.6%)
Southern	120 (14.9%) : 136 (16.9%)
Southern California	86 (10.7%) : 88 (10.9%)
Southwest	19 (2.4%) : 19 (2.4%)
Texas	68 (8.4%) : 80 (9.9%)

Categorical variables were presented as number (% proportions), and continuous variables were presented by means (standard deviations). (USTA abbreviates United States Tennis Association, UTR Universal Tennis Rating, WTN World Tennis Number).

The difference in UTR and the difference in WTN were strongly correlated ($r = 0.892$, $P < 0.001$) (Figure 2). Also, there are several outliers, suggesting that there may be disagreement between the rating systems for certain pairs of players.

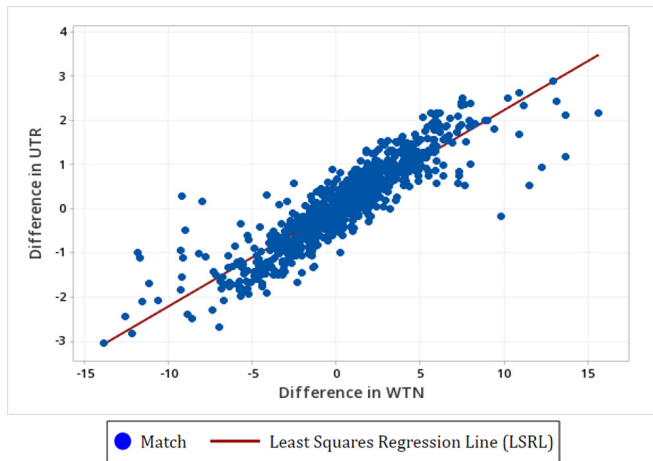


Figure 1. Scatter plot for correlation between difference in WTN and difference in UTR.

For both WTN and UTR, as the absolute difference in rating increases, the proportion of matches won by the player with the better rating increases. More than 80% of matches were won by the player with the better rating when the absolute difference in WTN ≥ 3 , and when the absolute difference in UTR ≥ 0.8 .

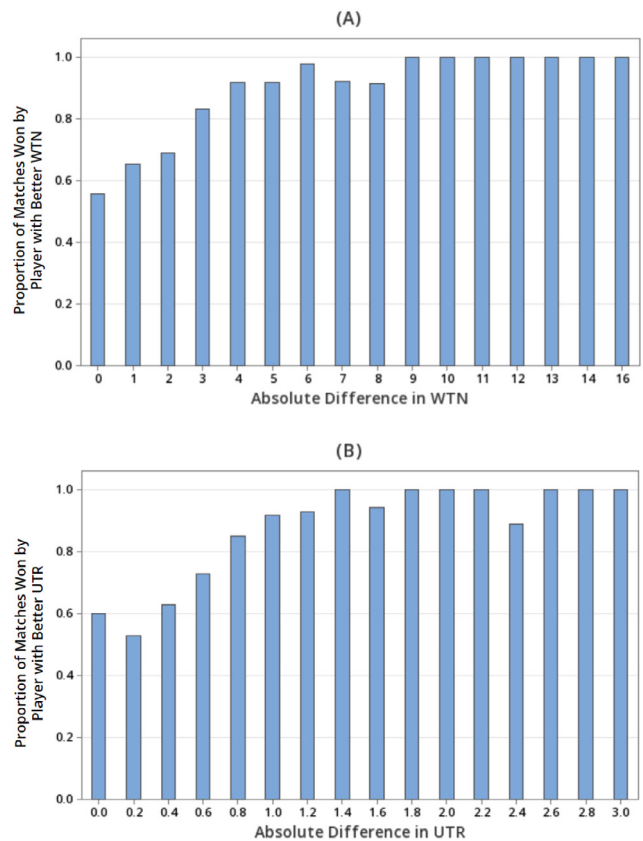


Figure 3. Relationship between the absolute difference in rating, and the proportion of matches won by the player with the better rating at those differences.

More than three quarters of players with better WTNs (77.9%) and those with better UTRs (78.0%) won the match. Differences in WTN and differences in UTR have comparable accuracy (76.8% [95% CI, 73.7%-79.7%] vs 76.7%[95% CI, 73.6%-79.6%]), sensitivity (79.5% [95% CI, 75.4%-83.2%] vs 79.0%[95% CI, 74.9%-82.8%]) and specificity (73.7% [95% CI, 68.9%-78.1%] vs 73.9% [95% CI, 69.2%-78.3%]) in predicting match results. Results were similar in the analysis for each division. However, USTA ranking has lower accuracy, sensitivity, and specificity when compared with WTN or UTR (Table 2).

Table 2

The accuracy, sensitivity, and specificity of predicting match results based on the differences of WTN, UTR, and USTA rankings between Player 1 and Player 2.

		Player 1 wins the match, number (%)	Accuracy (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)
Total (n = 806)	Player 1 WTN < Player 2 WTN	345 (77.9%)	76.8% (73.7%-79.7%)	79.5% (75.4%-83.2%)	73.7% (68.9%-78.1%)
	Player 1 WTN > Player 2 WTN	89 (24.5%)			
	Player 1 UTR > Player 2 UTR	343 (78.0%)	76.7% (73.6%-79.6%)	79.0% (74.9%-82.8%)	73.9% (69.2%-78.3%)
	Player 1 UTR < Player 2 UTR	91 (24.9%)			
	Player 1 USTA < Player 2 USTA	292 (66.7%)	64.3% (60.9%-67.6%)	67.3% (62.7%-71.7%)	60.8% (55.6%-65.8%)
	Player 1 USTA > Player 2 USTA	142 (38.6%)			
16s (n = 413)	Player 1 WTN < Player 2 WTN	175 (79.5%)	76.8% (72.4%-80.8%)	77.4% (71.4%-82.7%)	75.9% (69.2%-81.9%)
	Player 1 WTN > Player 2 WTN	51 (26.4%)			
	Player 1 UTR > Player 2 UTR	173 (79.4%)	76.3% (71.9%-80.3%)	76.6% (70.5%-81.9%)	75.9% (69.2%-81.9%)
	Player 1 UTR < Player 2 UTR	53 (27.2%)			
	Player 1 USTA < Player 2 USTA	162 (68.6%)	66.6% (61.8%-71.1%)	71.7% (65.3%-77.5%)	60.4% (53.0%-67.5%)
	Player 1 USTA > Player 2 USTA	64 (36.2%)			
18s (n = 393)	Player 1 WTN < Player 2 WTN	170 (76.2%)	76.8% (72.4%-80.9%)	81.7% (75.8% -86.7%)	71.4% (64.3%-77.8%)
	Player 1 WTN > Player 2 WTN	38 (22.4%)			
	Player 1 UTR > Player 2 UTR	170 (76.6%)	77.1% (72.6%-81.2%)	81.7% (75.8%-86.7%)	71.9% (64.8%-78.2%)
	Player 1 UTR < Player 2 UTR	38 (22.2%)			
	Player 1 USTA < Player 2 USTA	130 (64.4%)	61.8% (56.8%-66.7%)	62.5% (55.5%-69.1%)	61.1% (53.7%-68.2%)
	Player 1 USTA > Player 2 USTA	78 (40.8%)			

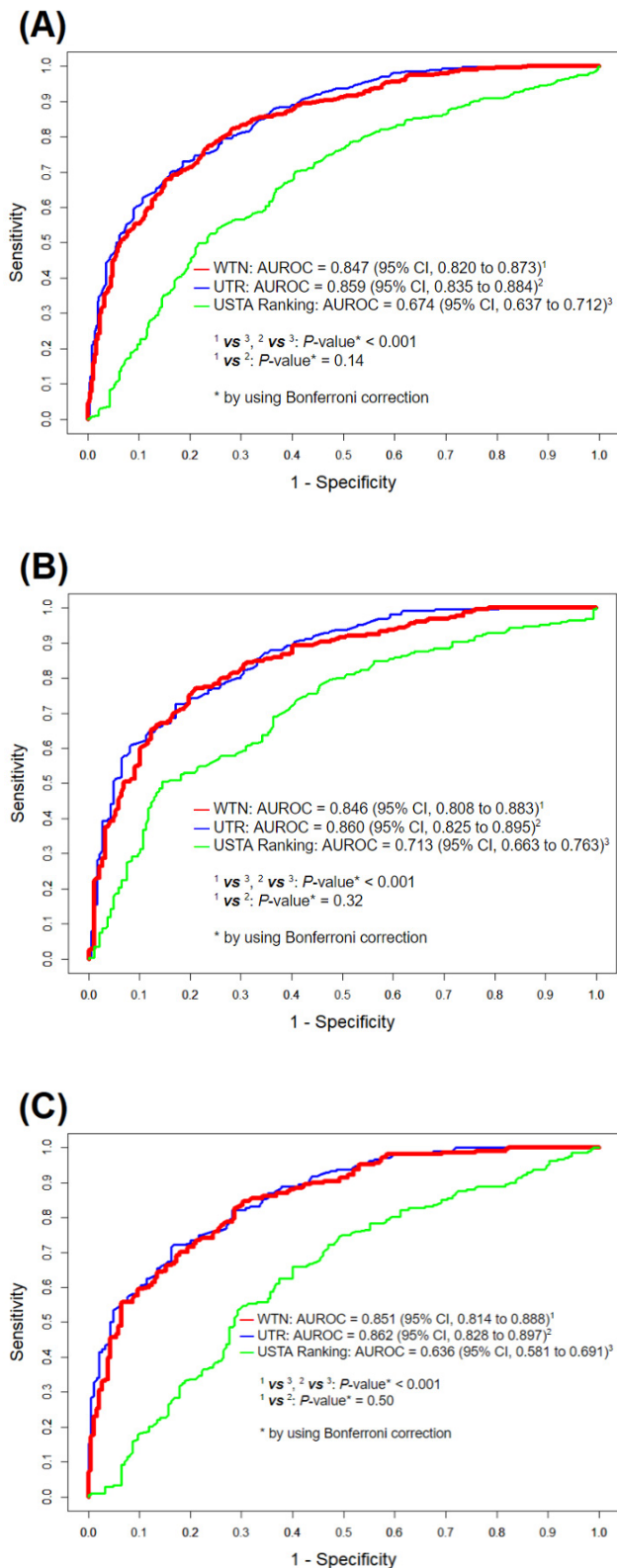


Figure 4. Receiver-Operating-Characteristic (ROC) Curves for match outcome predictability of WTN, UTR, and USTA in Boys' 16 Singles, Boys' 18 Singles, and All Matches. (A) All Matches (B) Boys' 16 Singles (C) Boys' 18 Singles. A classification model using WTN difference has a statistically comparable AUROC with that using UTR and has a significantly higher AUROC compared with that using USTA ranking. The results were similar regardless of age groups. (*WTN abbreviates World Tennis Number, UTR Universal Tennis Rating, USTA United States Tennis Association (ranking)).

WTN abbreviates World Tennis Number, UTR Universal Tennis Rating, USTA United States Tennis Association (ranking), CI Confidence Interval.

There were no significant differences in AUROCs between difference in WTN and difference in UTR in predicting match results. (0.847 [95% CI, 0.820-0.873] vs 0.859 [95% CI, 0.835-0.884]; P=0.14) However, differences in USTA Ranking had lower AUROC. Results were similar in analysis for each age division.

DISCUSSION

From our results, we can determine that WTN and UTR have similar predictability of match results, whereas USTA Ranking falls behind. WTN and UTR are consistent in predictability regardless of age division, whereas USTA Ranking has slight variations in predictability between age divisions.

To our knowledge, there has been no prior published study that investigated the predictability of WTN or UTR. Our study is the first to compare and analyze the predictability of those two rating systems. Although there is no other study for us to compare with, we will identify this study's strengths and limitations.

The main strength of this research is the reliability of the data. In this research, we were able to gather match data from 806 matches. In addition, all these matches were from a single tournament. This means that each player will have the same rating throughout the tournament, regardless of round. Therefore, this provides stability for the analysis. However, what really makes our research reliable is the reliability of the players' ratings. The tournament which we gathered data from is the biggest national tournament of the year for junior USTA players. This means that only the top players from around the nation would be able to play in the tournament, as selections were based mainly off of USTA ranking, and a few were selected based on UTR (USTA, n.d.). All these top players not only have high USTA Rankings, but in order to amass these points, they would have had to play a lot of matches. And for both rating systems, the more matches a player plays, the more reliable their rating can be. Therefore, by collecting match data from matches played between players with reliable ratings, our analysis becomes more accurate and reliable.

We acknowledge limitations of this study. We collected data from matches between high level players who frequently play matches, which means that this research provides definite validity for the aforementioned group of players. However, the results of this study may not guarantee validity for recreational players who play matches less frequently and at a lower level. Therefore, future research, spanning more tournaments of various levels, will be needed in order to guarantee validity for all groups of players.

WTN and UTR use similar algorithms to calculate ratings for players. Both rating systems analyze the pre-match ratings of the players. Then each respective algorithm predicts what the match outcome will be, with WTN predicting sets won by each player, and UTR predicting the percentage of games won by each player. Each player's rating will go up or down, based on the match results, when compared to the prediction based on ratings (Lawn Tennis Association [LTA], 2022).

Although WTN and UTR were very similar in match outcome predictability, they were not identical. This means that WTN and UTR did not agree all the time. If this were to be true, then the two rating systems would essentially be equal. That means that there must be factors to why there are similarities, but also differences between WTN and UTR.

WTN bases player ratings using match results from 2016 onwards. UTR bases player ratings on the thirty most recent matches played within the past year. For both rating systems, what matters is not the outcome of the match itself, but instead the number of sets won by each player, for WTN, and the number of games won by each player, for UTR. For UTR, if the difference between UTRs is +2, the match is not counted towards UTR. Also for UTR, each player is given a reliability of their rating. The more matches a player has, the more the reliability of their rating increases.

For both rating systems, recent matches carry more weight, whereas older matches carry less weight. For WTN, results from sanctioned competitions carry more weight, as opposed to results from club or recreational events (Tennis New Brunswick, 2022). For UTR, the longer the match format, the more weight is given. Also for UTR, the more reliable the opponent's UTR is, the more weight is given.

Both rating systems use nearly identical methods to determine player ratings. Therefore, it makes sense that they would be very similar. However, each system has its own way of choosing matches, and also weighing matches, which can cause a slight difference when rating players.

Reasons why WTN and UTR are similar, with USTA ranking lagging behind, could be explained by the difference between rating and ranking systems. WTN and UTR are rating systems, dependent on the player's match performance and opponent's rating, whereas USTA Ranking is a ranking system, dependent on the number of points a player has. Although it may not seem like a vast difference, it very much is. WTN and UTR, as rating systems, make it so that every player is "connected," in a way. Your rating is dependent on your performance, and also your opponent's ratings, which allows accuracy within relative skill. Although there may be a bit of "luck" played into it, such as certain players having strengths or weaknesses against others, ultimately, that is all part of skill. USTA Ranking is based on how many points a player has, and points are collected based on how far into the tournament a player gets to, and the tournament level. The further a player progresses into a tournament, the more points they will acquire, and the higher level a tournament is, the more points will be available. It may be true that the best player will win the tournament, therefore winning the most points. However, depending on where a player is placed in the draw, they could win varying amounts of points. This means that, although skill is obviously a factor in obtaining points for USTA Ranking, luck of the draw, which has nothing to do with skill, could very much change the outcome of the number of points a player comes out of the tournament with.

CONCLUSION

From this study, it is shown that WTN and UTR are similar, and both ratings are better than USTA Ranking, in predicting match outcomes. Therefore, as WTN is similar to UTR, the use of WTN as a rating system is validated. The results from

this study can support the use of WTN as the official rating system of the USTA and as a prominent factor in seeding criteria in USTA tournaments. The results from this study can also support the use of WTN in the college recruiting process, which is very important in both the junior tennis world and for colleges. As of the date of submission of this article, UTR is the only numerical-based rating system that colleges use for recruiting, but with the introduction of WTN, college coaches will be able to recruit new players more effectively because of the added reliability of another player rating system. With two reliable rating systems from different sources, there may be a race to create an even better rating system. In conclusion, the introduction of WTN, this newly improved rating system, into the tennis community, will create a ripple throughout the tennis world.

CONFLICT OF INTEREST AND FUNDING

The authors declare that they do not have any conflict of interest and that they did not receive any funding to conduct the research.

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