Analyzing tennis scoring systems: from the origins to today

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Abstract

This paper investigates tennis scoring systems that have been used throughout history — from Royal Tennis in 1490 to the most recent change to doubles Lawn Tennis in 2006. By identifying how the game has changed (such as technology in equipment), helps in establishing "reasonable" scoring systems that could be used for today. Based on this information and obtaining mathematical results of scoring systems, recommendations are given for men's and women's singles and doubles events. Actual matches are given to demonstrate why changes in many scoring systems are necessary.

1. Introduction

When analyzing tennis scoring systems it is useful to reflect on the history of tennis, as this helps in building an argument as to what are "reasonable" scoring systems for today. For example, why does a game of tennis contain four points to win followed by deuce if the scores are level after six points have been played? Would tennis be different if the next player to win the point if deuce is obtained is the winner, or an unbalanced game that required the server to win four points and the receiver to win three points without actually playing a deuce? Why does the US Open play a tiebreak deciding set, whereas the other three grand slam events use an advantage final set?

It can be important to understand changes in playing equipment, court dimensions, surface composition and player physique to help identify what scoring systems could be used for today. Parsons (2006) states "these days when there is so much concern about the dominance of power in the games, especially in men's tennis, it is fascinating to discover that there was similar anxiety at the end of the first Wimbledon Championships in 1877. An analysis was carried out of all the scorecards and concluded from the high proportion of service games won that the service was far too powerful for the long-term good of the game". Three remedies were suggested; heighten the middle of the net, to do way with first faults or to move the service line closer to the net. The All England Club chose the latter of reducing the size of the service court to 22ft.

The paper begins in section 2 with the history of tennis scoring systems. Section 3 looks at possible factors causing long matches to occur with examples of long matches that have occurred in recent times. Section 4 analyzes a range of scoring systems by identifying relevant characteristics, obtaining numerical results and giving recommendations of possible scoring systems that could be used today in men's and women's singles and doubles tournaments. Section 5 gives some concluding remarks.

2. History of tennis scoring systems

Various theories have been given for the origins of tennis. One theory is that the game was given to the French Royal Court in the 10^{th} century by a wandering minstrel. However, by the 11^{th} century early tennis was being played in French monasteries. Hands were used to hit the ball to begin with; gloves were used later on and during the 13^{th} century players started to use short bats. The French called this form of tennis *jeu de paume*, meaning "the game of the palm" because it was originally played with the hand, and what was called Real Tennis in Britain, Court Tennis in the United States and Royal Tennis in Australia. The version of Royal tennis as played today can be traced back at least as far as 1490 in

Urrungne France, which is possibly the oldest court in the world (Garnett, 1999). The modern version of tennis today (official name of Lawn Tennis) can be traced back to 1858, with the first lawn tennis club formed in Leamington in 1872, and the first official championships played in 1877 at Wimbledon. Tennis was a founding sport in the first modern Olympics in 1896 but was withdrawn in 1928 over disputes concerning the definition of an amateur. Returning as a demonstration sport in Los Angeles in 1984, it was reinstated as a full medal sport in Seoul in 1988. In 2010, there were 65 tournaments on the main tour in men's singles comprising of 4 Grand Slam, 10 Masters and 51 World Tour events. In 2010, there were 57 tournaments on the main tour in women's singles comprising of 4 Grand Slam, 11 Premier and 42 International events. Note that the Olympics is classified as a World Tour event in men's singles and an International event in women's singles.

The origins of the scoring system are more difficult to pin down that the antecedents of the game itself. Various references to the 0, 15, 30, 45 game structure have been noted during the 15th century, including a poem about the Battle of Agincout written in 1415. Originally it seems that the scoring was in fifteens going 15, 30, 45 but over time, instead of saying "forty-five", people started to say forty" for short and eventually was adopted as the official terminology. No-one really knows why counting in 15's originated. One hypothesis is that it is based around the clock face, the target score of 60 being a complete revolution of the minute hand. Another hypothesis which appears to be more plausible points to a French origin, since in the early middle ages, 60 was a key number in France in the same way that 100 is today. Most sports including tennis were played for money in the Middle Ages. There were laws in nearby Germany in the 14th and late 13th centuries that forbade stakes greater than sixty "deniers" and it happens that at about the same time there was a coin in circulation called a "gros denier tournois" which was worth 15 deniers. Perhaps the French tennis playing public was playing for one "gros denier tournois" per point up to the maximum stake of sixty deniers for a game (Gillmeister, 1997). The idea of "deuce" was introduced (at least as far as 1490) with a simple explanation - to ensure that the game could not be won by a one-point difference in players' scores. Hence deuce was derived from the French "a deux du jeu" - two points away from game.

2.1 Royal Tennis

The fixtures for professional Royal Tennis events can be found at the International Real Tennis Professional Association, and include each year the Australian Open, US Open, French Open and British Open, as well as the World Championships (every two years). The structure of a game which was recognized in 15th century tennis is still being used in Royal Tennis today and has carried through to Lawn Tennis. A player needs four points to win the game. If the score reaches deuce the game continues indefinitely until a player is two points ahead and wins the game. Sets however are played first-to-six games win the set, even if the opponent has five games. A match is typically best-of-three sets, except for the major open tournaments, in which matches are best-of-five sets. One fault is allowed on serve and a double fault results in the server losing the point. The spin of a racket (or toss of a coin) is used to decide the server of that match. As documented in the Laws of Real Tennis Australia (Garnett, 1999) – during a match the players shall change sides when two Chases have been made or when any player is at forty or advantage and one Chase has been made.

2.2 Lawn Tennis – singles

The major change in the scoring structure from Royal Tennis to Lawn Tennis is in the requirements to win a set. Originally in Lawn Tennis all sets were advantage where a player needed six games to win the set. If the score reached five games all, the set continued indefinitely until a player was two games

ahead and won the set. Another change from Royal Tennis is the rotation of service, where players rotate service after the completion of each game. One fault is allowed on serve and a double fault results in the server losing the point. The spin of a racket (or toss of a coin) is used to decide the server of that match. Men play best-of-five sets in grand slam matches and the Olympic Games gold medal match, and best-of-three sets in other matches on the main tour. Women always play best-of-3 sets.

This scoring system survived unchanged throughout the amateur era until 1968 when tennis was opened up to professional players, and tournaments became major television events. The tiebreak was invented by Jimmy Van Alen in 1965 to reduce the length of matches, and in 1970, the US Open became the first of the Grand Slam tournaments to use the tiebreak set, by originally playing a nine-point shootout (sudden death at 4-4) at 8 games all in the set (with the exception of the final set which was advantage). When the tiebreak was introduced at Wimbledon in 1971, it was called the 8-8 tiebreak, i.e., the first player to reach nine points with a lead of two. In 1979, the tiebreak was introduced when a set score reached 6 games all, as is the case today. The serving in a tiebreak is a rotation process where one player serves the first point, and serving then alternates after every two points. Among the Grand Slams, only the US Open today uses the tiebreak in the final set; the Australian Open, French Open and Wimbledon instead play an advantage final set. Olympic Games matches also use an advantage final set in both men's and women's singles matches.

2.3 Lawn Tennis – doubles

A best-of-three set match structure, where all sets are tiebreak sets are currently used in men's doubles events for the Australian Open, French Open and the US Open. A best-of-five set match structure is used in men's doubles events for Wimbledon where the deciding fifth set is advantage. A best-of-three set match structure is used in all grand slam women's doubles events where all tiebreak sets are used for the Australian Open, French Open and US Open, and an advantage deciding third set is used for Wimbledon. Olympic Games men's and women's doubles matches also use a best-of-three set match, where the deciding set is advantage.

In 2001 the Australian Open replaced the final set of mixed doubles with a match tie-break (first to 10 points and win by 2 points wins the match). Despite some criticism of the change by fans and former pros, the US Open and the French Open have since gone on to join the Australian Open in using the same format for mixed doubles. Wimbledon continues to play a traditional best-of-three set match with the final set being an advantage set.

In 2006 there was a change to the best-of-three sets scoring system used for doubles in men's and women's doubles tournaments on the main tour (excluding grand slam events). The main objectives of the change would appear to have been to reduce somewhat the average length of a match, to play matches that have a more predictable duration, and to reduce the likelihood of 'long' matches. The previous system was a best-of-three sets match structure, where all sets were tiebreak sets and games where standard "deuce" games. The system now used for these tournaments is a best-of-three sets system with the first two tiebreak sets using no-ad games, and the third set being simply a first-to-ten point's match-deciding tiebreak game. In no-ad games the next player to win the point if deuce is obtained is the winner.

3. Factors causing long matches

Long matches can cause problems for tournaments, can be unfair in the tournament setting and can also lead to injuries to the participating players (Barnett et al. 2006, Barnett and Pollard 2006). One factor that can lead to long matches is the use of the advantage set as the fifth set, as in the Australian Open, the French Open and Wimbledon. An advantage set requires a player to break serve to win the set, and this can be difficult to obtain when both players are serving a high percentage of first serves in with a "large" proportion resulting in aces. Other factors are long rallies and a greater than average number of points per game. These tend to occur more frequently on the slower court surfaces such as at the French Open.

3.1 Percentage of points won on serve

Table 1 represents the set score distribution for matches played in men's grand slam events across different time periods. The proportion of tiebreak games (7-6 score lines) increased from 11.4% in 1978-1982, to 12.1% in 1995-1999 and to 14.0% in 2000-2004. It is well documented (Barnett and Clarke, 2005) that the set score distribution is dependent on the percentage of points won on serve, such that increasing the percentage of points won on serve for both players will increase the proportion of tiebreaks played. This provides some justification that the percentage of points won on serve has increased in the last 30 years. A likely reason for this increase in serving performance is in the tennis racket. Haake et al (2007) concludes that if a player used rackets and balls from the 1870's, 1970's and 2007, then serve speeds would have increased by 17.5% since the 1870's, with a quarter of the change coming since the 1970's.

Score	1978-1982	1995-1999	2000-2004
6-0	6.3%	3.6%	3.9%
6-1	12.6%	10.9%	10.6%
6-2	20.7%	19.4%	18.1%
6-3	20.7%	21.9%	22.3%
6-4	19.8%	24.0%	22.7%
7-5	8.4%	8.1%	8.3%
7-6	11.4%	12.1%	14.0%

Table 1: Set score distribution for matches played in men's grand slam events across different time periods

Table 2 represents the percentage of points won on serve for men's and women's singles and doubles events in the 2001 Wimbledon, Australian Open and French Open. Overall, the results indicate that men win a higher percentage of points on serve compared to women for singles and doubles, and at all three grand slams. The results also indicate that for men and women, a higher percentage of points on serve occur at doubles events compared to singles events (at the same venue) and that there is an ordering of points won on serve with Wimbledon (grass) the highest followed by the Australian Open (hard) followed by the French Open (clay). This agrees with the results of Barnett and Pollard (2007).

Tables 3 and 4 represent the proportion of matches where the percentages of points won on serve for both players in men's (table 3) and women's (table 4) grand slam singles events in 2010 are greater than a specified amount. For example 7.2% of men's singles matches played at Wimbledon 2010 had both players winning more than 70% of points on serve. It can be shown that with a 70% chance of winning a

point on serve, the chance of winning a game on serve is 90.1% (Barnett and Clarke, 2005). With the advantage final set used at Wimbledon, Australian Open and the French Open, this gives some justification to show why long matches can occur in men's singles grand slam events.

Event	Wimbledon 2001	Australian Open 2001	French Open 2001
Men's singles	64.5%	61.9%	60.1%
Men's doubles		62.9%	
Women's singles	57.1%	54.9%	54.1%
Women's doubles		55.4%	
Mixed doubles		63.0%	

Table 2: Percentage of points won on serve for men's and women's singles and doubles events in the 2001 Wimbledon, Australian Open and French Open

Serving Percentages	Wimbledon 2010	US Open 2010	Australian Open 2010	French Open 2010
>70%	7.2%	3.1%	2.4%	0.8%
>65%	29.6%	7.9%	9.6%	7.1%
>60%	66.4%	39.4%	36.8%	30.7%
>55%	91.2%	71.7%	72.0%	55.1%
>50%	98.4%	89.0%	86.4%	81.1%

Table 3: Proportion of matches represented by serving percentages at men's grand slam singles events in 2010

Serving Percentages	Wimbledon 2010	US Open 2010	Australian Open 2010	French Open 2010
>70%	0.8%	0.0%	0.0%	0.0%
>65%	3.2%	0.8%	0.8%	0.8%
>60%	19.0%	8.7%	7.1%	1.6%
>55%	48.4%	21.4%	31.5%	15.0%
>50%	79.4%	40.5%	63.8%	43.3%

Table 4: Proportion of matches represented by serving percentage at women's grand slam singles events in 2010

In recent years there have been a number of grand slam matches decided in long fifth sets. In the third round of the 2000 Wimbledon men's singles, Philippoussis defeated Schalken 20–18 in the fifth set. Ivanisevic defeated Krajicek 15–13 in the semi-finals of Wimbledon in 1998. In the quarter-finals of the 2003 Australian Open men's singles, Andy Roddick defeated Younes El Aynaoui 21–19 in the fifth set, a match taking 83 games to complete and lasting a total duration of 5 h. The night session containing this long match required the following match to start at 1 am. Barnett and Clarke (2005) give a detailed analysis of this Roddick versus El Aynaoui match and conclude that whenever two players with dominant serves but relatively poor returns of serve meet, there is always a chance that if the match reaches a fifth set, it can go on for a long period of time. They showed from pre-match predictions that this match was likely to go longer than any other men's singles match played at the 2003 Australian Open.

The longest professional tennis match, in terms of both time and total games, was the more recent Wimbledon 2010 first-round match between Nicholas Mahut and John Isner. It lasted 183 games and required 11 hours and 5 minutes of playing time. Even with the introduction of a tiebreak set in 1970

long matches still occur and records of long matches can still be broken. Table 5 represents the fifth set match statistics, where the 1st Serve % of 67% and 74% for Mahut and Isner respectively, are both higher than the ATP tour average on grass of 61.9% (Bedford et al, 2010). It can be observed from the Aces that 22.4% and 23.1% of points served by Mahut and Isner respectively resulted in an ace. In the fifth set, Mahut won 82.5% of points on serve and Isner won 79.6% of points on serve, which are both significantly higher than the ATP tour average on grass of 65.5% (Bedford et al, 2010). It is also worth noting the relatively small number of break point opportunities for both players – 2 for Mahut and 5 for Isner.

Set 5 summary	Mahut	Isner
1st Serve %	231 of 343 = 67%	272 of 368=74%
Aces	77	85
Double Faults	12	4
Unforced Errors	25	33
Winning % on 1st Serve	208 of 231=90%	223 of 272=82%
Winning % on 2nd Serve	73 of 112=65%	61 of 96=64%
Winners	183	182
Receiving Points Won	84 of 372=23%	62 of 355=17%
Break Point Conversations	0 of 2=0%	1 of 5=20%
Net Approaches	82 of 106=77%	74 of 105=70%
Total Points Won	365	346

Table 5: Fifth set match statistics for Wimbledon 2010 first-round match between Nicholas Mahut and John Isner

3.2 Length of time to play a point

The longest match by time played at the Australian Open was between Rafael Nadal and Fernando Verdasco in a 2009 semifinal match, lasting for 5 hours and 14 minutes. The advantage fifth set score line was only 6-4, which suggests that best-of-five set matches with all tiebreak sets (such as the system used in the US Open) can still produce long matches. There was a match between Arnaud Clement and Fabrice Santoro played at the 2004 French Open that lasted for 6 hours 36 minutes, and is the longest match by time played at the French Open and the longest match by the number of games played at the French Open since the introduction of the tiebreak set. Although only 71 games were played in this match, the time duration was longer than the Roddick versus El Aynaoui match played at the 2003 Australian Open. Table 6 represents the percentage of points won on serve for each player for each set and the time taken to complete each set with the corresponding game score. It took an average time of 55.75 minutes to play each set in the first four tiebreak sets. These relatively long tiebreak sets must be due to the length of time to play each game, which is a combination of the number of points played in the game and the length of time to play each point. The average percentage of points won on serve for each player in the first four sets is 54.5% for Clement and 56.0% for Santoro, which are both less than the ATP tour average of 61.6%. Since there is a lack of dominance on serve, it is most likely that the length of time to play each point is higher than the ATP tour average time to play each point. Notice that the percentage of points won on serves for each player in the fifth advantage set is 64%, which is at least as high as any of the other sets, contributing to the 30 games and 173 minutes to play the final set.

Table 7 was taken from Croucher (1998) and gives the statistics on the time and number of points for three Grand Slam championships in 1991. For the men, the average number of points played is

significantly higher at the French Open on clay. This is a result of the percentage of points won on serve being less on clay than the surfaces of grass and hard, leading to longer games. For both men and women, the average time to play a point and the average play time per hour is significantly higher at the French Open on clay.

	Serving statistics (%)			
	Clement	Santoro	Time (min)	Score
Set 1	56	61	51	4-6
Set 2	50	64	46	3-6
Set 3	55	56	74	7-6
Set 4	57	43	52	6-3
Set 5	64	64	173	14-16
Match	58	60	396	

Table 6: Statistics for each set obtained from the Clement versus Santoro match played at the 2004 French Open

	French Open (clay)	US Open (hard)	Wimbledon (grass)
Men			
Avg. number of points	279	155	214
Avg. time per point	10.0s	7.6s	2.6s
Avg. play time per hour	14min 56s	9min 58s	3min 42s
Women			
Avg. number of points	122	119	200
Avg. time per point	11.0s	5.3s	5.9s
Avg. play time per hour	15min 43s	9min 41s	9min 18s

Table 7: Time and number of points for three Grand Slam championships in 1991

Based on the results from Table 7 and the likelihood of long matches in terms of time on clay and hard court, there is evidence to suggest that a tiebreak set may be too long in a best-of-five set match. One method to reduce the length of a tiebreak set is to use no-ad games as currently used in a range of doubles events. The characteristics of such scoring systems will be investigated in section 4.

4. Scoring Systems

4.1 Characteristics

Many papers appear in the literature in comparing scoring systems for tennis (Brown et al 2008a, Pollard et al 2007, Pollard and Noble 2004). Typical characteristics to make comparisons for these scoring systems are:

(i) P(A wins) where A is the better player/pair
(ii) Mean number of points in the match
(iii) Standard deviation of the number of points in the match
(iv) Efficiency of the scoring system
(v) 98% point of the cumulative distribution of the number of points

Table 8 lists the scoring systems to be analyzed by representing the game, set and match structure. The 50-40 game as outlined in Pollard and Noble (2004) is such that to win the game, the server requires

four points and the receiver requires three points. There is at most six points played in this type of game.

System	Event	Game	Set	Match
1	Royal Tennis	Deuce	First-to-six	3 or 5 sets
2	Pre-1970 men's Lawn Tennis	Deuce	All advantage	5 sets
3	Pre-1970 women's Lawn Tennis	Deuce	All advantage	3 sets
4	Aust./French/Wimb. men's singles Olympics men's singles (Gold medal) Olympics men's doubles (Gold medal) Wimb. men's doubles	Deuce	Final set advantage	5 sets
5	Aust./French/Wimb. women's singles Olympics men's and women's singles Olympics men's and women's doubles Wimb. women's doubles Wimb. mixed doubles	Deuce	Final set advantage	3 sets
6	US Open men's singles Aust./French/US Open men's doubles	Deuce	All tiebreak	5 sets
7	US Open women's singles Aust./French/US Open women's doubles Men's and women's singles Pre-2006 men's and women's doubles	Deuce	All tiebreak	3 sets
8	Aust/French/US Open mixed doubles	Deuce	Final set super tiebreak game	3 sets
9	Men's and women's doubles	No-ad	Final set super tiebreak game	3 sets
10	Alternate men's grand slam singles	No-ad	All tiebreak	5 sets
11	Alternate men's grand slam singles	50-40	All tiebreak	5 sets
12	Alternate men's grand slam singles	50-40	Final set advantage	5 sets
13	Alternate non grand slam doubles	50-40	Final set super tiebreak game	3 sets

Table 8: Types of scoring systems for men's and women's singles and doubles matches on the main tour

4.2 Results

Tables 9, 10 and 11 give numerical results for the five characteristics (i)-(v) for scoring systems 2-13 given in table 8. The statistical measures of p_a and p_b (the probabilities of player/pair A and player/pair B winning a point on their respective serve) are given to represent matches at the 'strong-serving' end (p_a = 0.77, p_b = 0.73), and at the 'weaker-serving' end (p_a = 0.62, p_b=0.58) (Brown et al 2008a). For the 12 scoring systems to be analyzed, the probability that the better player/pair wins the match, and the mean and higher moments of the number of points played, were evaluated using recursive methods (Brown et al., 2008b). The process used to estimate the distribution of the number of points in a match was based on using the Normal Power approximation (Pollard et al., 2007) and simulated results.

	2		3		4		5	
	p_a=0.77 p_b=0.73	p_a=0.62 p_b=0.58	p_a=0.77 p_b=0.73	p_a=0.62 p_b=0.58	p_a=0.77 p_b=0.73	p_a=0.62 p_b=0.58	p_a=0.77 p_b=0.73	p_a=0.62 p_b=0.58
(i)	0.778	0.752	0.730	0.707	0.723	0.743	0.690	0.701
(ii)	484.3	274.2	298.2	168.3	290.3	262.1	192.1	161.6
(iii)	218.2	73.8	165.0	51.6	99.5	63.6	93.1	44.6
(iv)	0.34	0.61	0.36	0.65	0.34	0.59	0.37	0.63
(v)	1049	442	750	295	582	395	480	261

Table 9: The five statistics for scoring systems 2-5

	6		7		8		9	
	p_a=0.77 p_b=0.73	p_a=0.62 p_b=0.58	p_a=0.77 p_b=0.73	p_a=0.62 p_b=0.58	p_a=0.77 p_b=0.73	p_a=0.62 p_b=0.58	p_a=0.77 p_b=0.73	p_a=0.62 p_b=0.58
(i)	0.708	0.741	0.669	0.697	0.656	0.670	0.658	0.658
(ii)	272.0	261.0	166.3	160.0	142.8	137.8	131.5	122.0
(iii)	60.7	61.6	40.3	41.4	21.8	24.5	20.5	20.5
(iv)	0.32	0.58	0.34	0.62	0.33	0.52	0.37	0.51
(v)	385	383	243	246	187	191	174	166

Table 10: The five statistics for scoring systems 6-9

	10		11		12		13	
	p_a=0.77 p_b=0.73	p_a=0.62 p_b=0.58	p_a=0.77 p_b=0.73	p_a=0.62 p_b=0.58	p_a=0.77 p_b=0.73	p_a=0.62 p_b=0.58	p_a=0.77 p_b=0.73	p_a=0.62 p_b=0.58
(i)	0.712	0.721	0.727	0.715	0.730	0.715	0.667	0.655
(ii)	248.9	229.9	210.0	196.3	211.7	196.6	112.5	105.2
(iii)	55.7	52.7	48.6	45.7	52.0	46.3	19.9	18.8
(iv)	0.36	0.55	0.50	0.60	0.51	0.61	0.48	0.56
(v)	354	333	306	286	323	290	158	146

Table 11: The five statistics for scoring systems 10-13

4.3 Discussion

Royal Tennis, at least as far back as 1490, used a scoring structure such that matches were the best-of-five or best-of-three sets, sets were first-to-six and games were deuce games. It would appear that when Lawn Tennis was introduced to Wimbledon in 1877 that the service could be an advantage (discussed in the introduction), and therefore using first-to-six games could present a significant advantage to the player serving first in the match. In a similar way that two consecutive points are required to win a deuce game if scores are level at three points all, a set in Lawn Tennis would require a player to win two consecutive games if scores are level at five games all.

The introduction of the tiebreak game in 1970 was to reduce the length of matches and advantage sets are no longer played under the rules of the United States Tennis Association. However, advantage sets are still used in the final set in the Australian Open, French Open, Wimbledon and the Olympics. The US Open is the only Grand Slam to use a tiebreak in the final set. There was evidence to show that serving performance has increased in the last 30 years due to changes in racket technology (Haake et al. 2007). This has resulted in long matches in recent times from an advantage final set. More recently, the longest match in history was recorded at 11 hours and 5 minutes. From table 3, there was evidence to show that

long final advantage sets are a reasonable possibility in men's singles matches. From table 9 it can be observed that the 98% point of the cumulative distribution of the number of points for system 4 when p_a=0.77 and p_b=0.73 is 582 and when p_a=0.62 and p_b=0.58 is 395. In comparison from table 10, the 98% point of the cumulative distribution of the number of points for system 6 when p_a=0.77 and p_b=0.73 is 385 and when p_a=0.62 and p_b=0.58 is 383. Given that two 'strong' servers have led to long matches in men's tennis, it could be argued that system 6 is preferable to system 4 in men's singles and doubles matches.

From section 3, it was observed that a tiebreak set may be too long in a best-of-five set match, as a result of the amount of time to play a point (particularly on clay) and the 'lack' of dominance on serve leading to a relative 'large' number of points played in a game. Long matches played at the Australian and French Open was used to support this observation. One method to reduce the length of a tiebreak set is to use no-ad games as currently used in a range of doubles events. By comparing the characteristics of system 6 to system 10; the mean, standard deviation and the 98% point of the cumulative distribution of the number of points are reduced for system 10 for when p_a=0.77 and p_b=0.73, and for when p_a=0.62 and p_b=0.58. System 10 is also more efficient that system 6. The 50-40 game as outlined in Pollard and Noble (2004) is such that to win the game, the server requires four points and the receiver requires three points. When comparing system 10 to system 11; the mean, standard deviation and the 98% point of the cumulative distribution of the number of points are reduced for system 11 for when p_a=0.77 and p_b=0.73, and for when p_a=0.62 and p_b=0.58. System 11 is also more efficient that system 10. Based on the above, it could be argued that systems 11 and 10 are preferable to system 6 and system 11 is preferable to system 10. The characteristics are very similar when comparing system 11 to system 12, and demonstrates that an advantage final set is 'reasonable' in reducing the likelihood of long matches occurring by changing the game structure of a standard deuce game to a 50-40 game.

From section 2, in 2006 there was a change to the best-of-three sets scoring system used for doubles in a range of professional men's and women's tournaments (excludes grand slam events). The main objectives of the change would appear to have been to reduce somewhat the average length of a match, to play matches that have a more predictable duration, and to reduce the likelihood of 'long' matches. Pollard et al. (2007) compare five alternative scoring systems including the 50-40 game and conclude that on statistical grounds these systems would appear to be legitimate alternatives to the current system. By comparing the characteristics between system 9 and 13, it could be argued that system 13 is preferable to system 9.

It was shown in table 2 that the average percentage of points won on serve in mixed doubles at the 2011 Australian Open was 63.0%, which is higher than both men's singles (61.9%) and men's doubles (62.9%). For this reason, it could be argued that system 8 is preferable to system 5.

Based on the results and discussion, the following recommendations are obtained for men's and women's singles and doubles events and represented in table 12.

	Match	Set	Game
Men's singles (grand slam/Olympics)	5 sets	Final set advantage	50-40
Men's singles	3 sets	All tiebreak	Deuce
Men's doubles (grand slam/Olympics)	3 sets	All tiebreak	Deuce
Men's doubles	3 sets	Final set super tiebreak game	50-40
Women's singles (grand slam/Olympics)	3 sets	Final set advantage	Deuce
Women's singles	3 sets	All tiebreak	Deuce
Women's doubles (grand slam/Olympics)	3 sets	All tiebreak	Deuce
Women's doubles	3 sets	Final set super tiebreak game	50-40
Mixed doubles (grand slam)	3 sets	Final set super tiebreak game	Deuce

Table 12: Recommendations of scoring systems for men's and women's singles and doubles events

5. Conclusions

The history of tennis scoring systems, possible factors causing long matches, examples of long matches that have occurred in recent times and numerical results for characteristics of scoring systems are given in this paper. Based on this information, recommendations of scoring systems are given for men's and women's singles and doubles events that could be used for today. These recommendations show that men's and women's doubles matches (excluding grand slam events) could replace the current no-ad game with a 50-40 game and that men's singles grand slam and Olympic games matches could use a best-of-5 set match structure with a final set advantage by replacing the current deuce game with a 50-40 game.

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