Improving the Australian Open Extreme Heat Policy

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Introduction

One of the characteristics of tennis is that you do not know when the match is going to finish, and a "long" match is a real possibility. Very recently, the longest match in tennis history occurred in the first round of Wimbledon between John Isner and Nicholas Mahut. A total of 183 games were played and the match lasted for 11 hours and 5 minutes (and was played over 3 days).

It is well known that the match duration depends on the scoring system used. For example, the Australian Open, French Open and Wimbledon singles events have an advantage final set, whereas the tiebreak set is used for the final set at the US Open. Clearly, "long" fifth sets are less likely to occur at the US Open. Secondly, match duration also depends on the court surface. The average time taken to play a point is greater on the clay courts of the French Open than at the other grand slam events of Wimbledon (grass) and the Australian and US Opens (hard court) (Croucher, 1998). Thirdly, average match duration depends on gender. On average men win a higher proportion of points on serve than do women (Barnett and Pollard, 2007). Thus, an advantage final set has a greater expected duration in a men's match than in a women's match. Further, women's matches use best-of-three sets scoring, whereas men's matches can use the best-of-five sets structure as in the grand slam singles tournaments. Clearly, men's singles grand slam matches would be expected to last longer than women's singles matches.

The Australian Open is played in Melbourne in the hottest time of the year, where temperatures can reach 40 degrees. Players sometimes comment on the extreme temperatures. A heat rule policy for the Australian Open was introduced by Tennis Australia in 1998 and modified a number of times over the years since, primarily changing from one based on normal air temperature to one based on the Wet Bulb Globe Temperature and one which changed from a requirement to completely finish a match in progress to one which stops plays at the end of a set in progress. The most recent policy as of 2008 states: "*The Australian Open Extreme Heat Policy (EHP) will be applied at the Referee's discretion and may be altered at any time. At the Referee's discretion, when the Wet Bulb Globe Temperature only (WBGT) is equal to or above the pre-determined threshold, the Referee may suspend the commencement of any further matches on outside courts. Any matches currently in progress will continue until the end of the current set. At the completion of the set, play will be suspended. Where play in any match commences outdoors (or with a roof open) at the Referee's Discretion, the match will continue until the completion of the set. At the end of the set, a decision may be made by the Referee to close the roof for the remainder of the match and the following matches, when the EHP is still in effect. The roof will only be closed because of extreme heat if a decision has been made by the Referee to suspend the completion or commencement of matches on the outdoor courts. Supplement for women's singles and junior singles only; to allow a 10 minute break between the second and third sets when a WBGT reading of 28 has*

been recorded prior to the calling of the match by Tournament Control. Readings are continually made throughout the day. The 10 minute break will not apply between the second and third sets, if play had previously been suspended after the first set due to the EHP".

It could be argued that this policy may have a few problems. Firstly, the suspension of play could favour one of the players through the disruption of concentration (Young, 2005). Also, the policy does not appear to take into account the likely match duration for the particular match under consideration. A match lasting for five sets would appear to be affected more by extreme temperatures than a match that was over in three straight sets. This article aims to provide insights as to how the Australian Open Extreme Heat Policy could be modified by accounting for the possible match duration.

Model

By assigning constant probabilities to player A and player B for winning a point on serve throughout a match, exact calculations can be obtained for the probabilities of winning a game, set and match; the probabilities of reaching a point score within a game, a game score within a set and a set score within a match; and the mean number of points in a game, a set and a match with the associated variances (Brown et al, 2008a). The mean and variance are two measures of the distribution of the number of points played in the match. The coefficients of skewness and kurtosis are two other commonly used measures of a distribution, and the four measures have been applied to tennis using the Normal Power (NP) approximation formula to estimate the probability distribution of the number of points played in a match (Barnett et al, 2006). For example, the probability of a match going beyond 300 points could be obtained using the NP formula. Simulation methods have also been applied to tennis to estimate the probability distribution of the number points played in a match (Brown et al ,2008b).

Although other combinations of distributional characteristics could be used to interpret the length of a match, we have identified two characteristics that are sufficient for our purposes (to apply to the EHP). These are the probability of reaching a final set (relates to expected duration and standard deviation) and the probability of a set reaching 6 games-all (relates to coefficients of skewness and excess kurtosis). Table 1 gives the probabilities of reaching 1 set-all in a best-of-3 set match, 2 sets-all in a best-of-5 set match and 6 games-all in a set, for different values of player A and player B winning a point on serve. The probability of reaching 1 set-all in a best-of-3 set match is greatest when the probabilities of player A and player B winning a point on serve are each equal to 0.5. As the difference in these two serving probabilities increase, the probability of reaching 1 set-all decreases. Similar results apply for the probability of reaching 2 sets-all in a best-of-5-sets match. The probability of reaching 6 games-all in a set clearly depends on the values of player A and player B winning a point on serve. "Large" serving values for both players will lead to a relatively high probability of reaching 6 games-all. However "large" serving values can lead to a relatively low or high probability of reaching 1 set-all in a best-of-3 set match and 2 sets-all in a best-of-5 set match, as can be seen in table 1.

Player A Point on Serve	Player B Point on serve	3 set match 1 set-all	5 set match 2 sets-all	Set 6 games-all
0.50	0.50	0.500	0.375	0.123
0.50	0.55	0.440	0.291	0.115
0.50	0.60	0.305	0.139	0.094
0.60	0.60	0.500	0.375	0.174
0.60	0.65	0.447	0.299	0.190
0.60	0.70	0.326	0.160	0.190
0.70	0.70	0.500	0.375	0.381
0.70	0.75	0.457	0.313	0.452
0.70	0.80	0.357	0.191	0.498

Table 1: Probabilities of reaching 1 set-all in a best-of-3 set match, 2 sets-all in a best-of-5 set match and 6 games-all in a set, for different values of player A and player B winning a point on serve.

Predictions

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 hours. The night session with this long match required the following match to start at 1 am. Barnett and Clarke (2005) gave a detailed analysis of this match and concluded that whenever two players with dominant serves but relatively poor returns of serve meet, there is 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 at the 2003 Australian Open.

Table 2 gives some predicted statistics for the match between Roddick and El Aynaoui. The mean number of games in a set and the associated standard deviation are calculated for each player serving first in the set. Roddick was expected to win 72.3% of points on serve and El Aynaoui was expected to win 68.0% of points on serve. Roddick was expected to win 92.6% of games on serve and El Aynaoui 87.5%. In comparison the ATP average percentage of points won on serve was 62.0%, which equates to a 77.6% chance of winning a game on serve. Clearly it was going to be difficult for either player to break serve and if the match did reach 6 games all in the advantage fifth set, there was a possibility it would go on for a long time. There was a 32.6% chance of the match reaching a fifth set and a 37.2% chance that the final set would reach 6 games all. Therefore there was a 0.326 * 0.372 = 12.1% chance that the match (starting from 0-0 in the first set) would reach 6-6 in the fifth set.

Table 3 gives the chances of an advantage set reaching various score lines starting from 6 games all. Conditional on the set reaching 6 games all, there is a 0.926 × 0.875 + 0.074 × 0.125 or 81.9% chance it will reach 7–7, $(0.926\times0.875+0.074\times0.125)^2$ or 67.1% chance of reaching 8–8 and so on (where 0.926 and 0.875 are the probabilities of Roddick and El Aynaoui winning games on serve, respectively). Klaassen and Magnus (1998) show that while the chance of a player winning is dependent on the difference in serving probabilities of both players, the expected length of the match is, from a practical viewpoint, dependent on just the sum of serving probabilities of the two players. The Roddick–El Aynaoui match had the highest predicted total for the combined percentages of points won on serve,

given as 72.3% + 68.0% or 140.3%., and so this match had the highest expected number of games for an advantage set (14.6–14.7) along with the highest standard deviation of the number of games played in an advantage set (8.9–9.0). For these reasons it would have been clear that if there was going to be a long fifth set played at the 2003 Australian Open men's singles, it would most likely have come from this match. In the actual match both players actually served slightly better than predicted, with Roddick winning 75.8% and El Aynaoui 70.6% of points on serves. This total of (146.4%) was the highest total for the probabilities of points won on serve from all the men's singles matches played at the 2003 Australian Open, and easily exceeded the average of 123.2%.

Note that even though it would be unlikely that the predicted longest match actually turns out to be the longest match (given there were 127 men's singles matches at the 2003 Australian Open), estimating match duration could still be useful when applied to the EHP. For example, a best-of-five set match would be of greater duration than a best-of-three set match for any two given players. Also, a match with a deciding advantage set would be expected to last longer than a match with a deciding tiebreak set for two given players. Further, it is quite likely that a match between two players with dominant serves but relatively poor return of serves would be of greater duration than a match between the number one ranked player and a qualifier.

Parameter	Scoring unit	Roddick	El Aynaoui
Probability of winning	Point on serve	72.3%	68.0%
	Game on serve	92.6%	87.5%
	Tie-breaker game	57.5%	42.5%
	Tie-breaker set	63.1%	36.9%
	Advantage set	65.5%	34.5%
	Tie-breaker match	73.4%	26.6%
	Advantage match	74.2%	25.8%
Mean number of games	Tie-breaker set	10.8	10.9
	Advantage set	14.6	14.7
	Tie-breaker match	43.8	43.8
	Advantage match	45.0	45.0
Standard deviation of number of games	Tie-breaker set	1.9	1.8
	Advantage set	9.0	8.9

Table 2: Pre-match predicted parameters for the Roddick–El Aynaoui match played at the 2003 Australian Open

Score line	Chances (%)
6-6	100.0
7-7	81.9
8-8	67.1
9-9	55.0
10-10	45.1
11-11	36.9
12-12	30.3
13-13	24.8
14-14	20.3
15-15	16.7
16-16	13.7
17-17	11.2
18-18	9.1
19-19	7.5

Table 3: Chances of reaching a score line from 6 games all in an advantage set for the Roddick–El Aynaoui match

Extreme heat policy

As given in the introduction for the EHP:
At the Referee's discretion, when the Wet Bulb Globe Temperature only (WBGT) is equal to or above the pre-determined threshold, the Referee may suspend the commencement of any further matches on outside courts.

As given by Wikipedia (http://en.wikipedia.org/wiki/Wet_Bulb_Globe_Temperature):
WBGT is a composite temperature used to estimate the effect of temperature, humidity, wind speed (wind chill) and solar radiation on humans. It is used by industrial hygienists, athletes, and the military to determine appropriate exposure levels to high temperatures. It is derived from the following formula:

$WBGT = 0.7T_w + 0.2T_g + 0.1T_d$

Where

- T_w = Natural wet-bulb temperature (humidity indicator)
- T_g = Globe thermometer temperature (solar radiation indicator)
- T_d = Dry-bulb temperature (normal air temperature)

To illustrate how the EHP could be modified by accounting for anticipated match duration we will assume a maximum threshold value of 28, and decrease this value as the probabilities of either reaching 2 sets-all in the match increase or reaching 6 games-all in the fifth set increase. Threshold values are given as an example in tables 4 and 5 for a best-of-5 set match i.e. men's singles. Prior to commencing a

specified match, the threshold value corresponding to the probability of reaching 2 sets-all is obtained from table 4 and the threshold value corresponding to the probability of reaching 6 games-all in the fifth set is obtained. The minimum of these two values is then used as an indicator for whether the match should commence or postponed to a later time. For example, if the probability of a match reaching a deciding fifth set is within 0.1 and 0.2 (threshold value of 27) and the probability of a match reaching 6 games-all in a set is within 0.1 and 0.2 (threshold value of 26.5), then the Referee may suspend the commencement of this match, if the WBGT is equal to or above a threshold value of 26.5.

Probability Reaching 2 sets-all	Threshold value
$0 < x \leq 0.1$	28
$0.1 < x \leq 0.2$	27
$0.2 < x \leq 0.3$	26
$x>0.3$	25

Table 4: Example threshold values corresponding to the probability of reaching 2 sets-all in a match

Probability Reaching 6 games-all	Threshold value
$0 < y \leq 0.1$	28
$0.1 < y \leq 0.2$	26.5
$0.2 < y \leq 0.3$	25
$y>0.3$	23.5

Table 5: Example threshold values corresponding to the probability of reaching 6 games-all in a set

Conclusions

Given the extreme temperatures (40+) that can occur at the Australian Open and the best-of-five-set matches with deciding advantage sets that occur in men's singles events, it has been considered necessary to have an Extreme Heat Policy in place. A policy was introduced in 1998, and was modified a number of times over the years since, with the most recent policy in place since 2008. The present policy does not take into consideration the likely duration of a given match. It is known that some matches are likely to be longer than others, and that each match length can to a certain degree be predicted. An example has been given to show that the Roddick-El Aynaoui match could have been predicted to be longer than any other men's singles match played at the 2003 Australian Open. This article has suggested how the Extreme Heat Policy might be modified by taking into account the likely match duration.

Whilst the focus of the article has been on the Australian Open, the approach could also be applied to other grand slam events and tournaments. It is worth noting that the time duration of a match depends on the amount of time to play a point and well as the number of points in a match. Given that the average time to play a point at the French Open on clay is significantly greatly than at the other grand slam events, the Extreme Heat Policy could be modified accordingly.

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