DIFFERENTIATING TOP-RANKED MALE TENNIS PLAYERS FROM LOWER-RANKED PLAYERS USING HAWK-EYE DATA: AN INVESTIGATION OF THE 2012–2014 AUSTRALIAN OPEN TOURNAMENTS

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The purpose of this study was to differentiate top- and lower-ranked professional tennis players, using Hawk-Eye derived performance metrics. Eighty players competing at the 2012–2014 Australian Open tournaments were assigned to either a top-ranked (n=40) or lower ranked (n=40) group, based on their ATP ranking. Hawk-Eye data from one of each player's matches were obtained for analysis and compared between groups. Top-ranked players achieved more success on serve (with respect to aces, accuracy and points won) and possessed a faster first serve return, compared with lower-ranked players. Top-ranked players also played more groundstrokes from behind the baseline, delivered the ball deeper into their opponent's court, and covered a greater distance during matches. Coaches may be able to use these findings to develop playing style and match tactics.

KEY WORDS: analytics, tactics, biomechanics, conditioning.

INTRODUCTION: During the 2015 ATP season, prize money on the men's tennis tour will exceed US$100 million for the first time. Ostensibly, this bodes well for the 2184 players who obtained professional ranking points during the 2014 ATP season. However, a recent review of professional men's tennis revealed that 60% of the total prize money available is won by the top 1% (i.e., top 50) of players (ITF, 2015). Moreover, it was estimated that only players ranked higher than 336 earned enough to cover their basic playing expenses, suggesting that profits for those outside the top 1% are rather modest. For lower-ranked players, these findings highlight the importance of closing the performance gap between themselves and the world's top players.

Tennis is a multifaceted sport, with elite players required to possess expert stroke production abilities and physical capacities. Although research has been valuable for improving stroke biomechanics (Elliott, 2006) and conditioning programs (Reid & Schneiker, 2008), those factors that differentiate top-ranked tennis players remain somewhat unclear. Further, most objective data pertaining to elite tennis matchplay have emanated from controlled laboratory experiments involving restricted cohorts, thus limiting their application to professional tennis. However, the introduction of computer-assisted adjudication has redefined the possibilities for performance analysis in tennis. In equipped venues, Hawk-Eye tracks three-dimensional ball trajectories and player locations using cameras mounted in the stadium. Consequently, performance measurement is no longer restricted to a laboratory, and obtaining large datasets of top-level players has become a reality. Plausibly, these data could be used to supplement extant performance research in tennis and provide a direct insight into the professional game that coaches could use to improve player development.

Identifying the performance metrics that are unique to top-level tennis players may help coaches to develop players' ability and/or match strategies. The purpose of this study was to utilize Hawk-Eye data obtained during the 2012–2014 Australian Open tournaments to compare the performance of top-ranked players to that of lower-ranked players. It was hypothesised that top-ranked players would display superior serving, return of serve, groundstroke and movement abilities to their lower-ranked counterparts.

METHODS: During the 2012, 2013 and 2014 Australian Open tournaments, a total of 118 male players completed at least one match on a Hawk-Eye equipped court at Melbourne Park and were initially identified for inclusion in this study. During each of the analysed matches, the Hawk-Eye system recorded ball and player movement data. At the conclusion of each match, a summary report was generated based on the recorded data. The report contained a total of twenty-eight performance metrics pertaining to serving, returning serve, groundstrokes and on-court movement that were analysed in this study.

One match, per player, was selected for analysis in this study. Where a player had completed more than one match on a Hawk-Eye court, only one was randomly selected for analysis. Each player's ATP ranking, at the time of their match was obtained manually from the ATP website. The players were then sorted according to their ranking and, using the ⅓ split technique (Murphy, Duffield, Kellett & Reid, In Press), the 38 players around the median removed, leaving two heterogeneous groups. The top 40 players were assigned to the "top-ranked" group, while the bottom 40 players were assigned to the "lower-ranked" group.

Given that the data were not normally distributed, nonparametric procedures were employed to compare performance metrics between the two groups. Significant differences between the groups were ascertained using Mann-Whitney U tests. With multiple comparisons being undertaken, significance was adjusted to the more conservative level of $P < 0.005$ and Cohen's d effect sizes were computed to aid interpretation. Conservatively, only effect sizes > 0.4 were considered meaningful, and were classified as either moderate ($0.4 < d < 0.5$), moderate-to-large ($0.5 > d > 0.8$) or large ($d > 0.8$).

RESULTS: The ATP ranking of the top-ranked group (≤ 53) was significantly better than those in the lower-ranked (≥ 73) (Table 1).

In the serve, top-ranked players hit significantly more aces, and won significantly more points on their first serve than lower-ranked players. A moderate-to-large effect size was associated with top-ranked players winning a greater percentage of points on their first serve, while moderate effect sizes were associated with top-ranked players winning a greater percentage of points on their second serve and also possessing greater maximum first serve speed.

Both groups returned first serves from similar locations; the same was true for second serves. The percentage of first serves returned and second serves returned also exhibited no significant difference between groups. Average first serve return speed was significantly greater in top-ranked players, but second serve return speed comparable in both groups.

Top-ranked players played a greater percentage of groundstrokes from behind the baseline and delivered a greater percentage of these shots to locations beyond the service line (both moderate effects). However, when considering groundstrokes, rally length, ball contact height, net clearance and average shot speed did not differ between the groups.

With respect to on-court movement, top-ranked players covered significantly greater distances during matches than lower ranked players. Similarly, top-ranked players covered greater distances during receiving points than lower-ranked players. Average speed and maximum speed did not differ between groups.

DISCUSSION: Several between-group differences suggested that the serve was superior in top-ranked players. Additionally, top-ranked players returned first serves with greater speed and were able to deliver groundstrokes deeper into their opponent's court from locations further behind the baseline. Top-ranked players also covered a greater distance during matches than their lower-ranked counterparts. Coaches may be able to use these findings to refine players' training programs and/or on-court strategies.

The data imply that players aiming to infiltrate the top 50 in professional tennis should posses a proficient serve. Top-ranked players achieved more aces (d = 0.60), which may relate to their capability of achieving faster maximal serve speeds (d = 0.43). Accuracy was also foremost in top-ranked players, who possessed a greater first serve percentage (d = 0.51). These factors might explain why top-ranked players won a greater percentage of points on their first (d = 0.62) and second serve (d = 0.41) and underlines the importance of being able to win points on serve in professional tennis. Interestingly, however, average serve speed did not differ between the groups and implies that velocity generation was similar in this cohort of professionals. This generally conforms to traditional serve speed "records", which are

Table 1
Statistical Comparison of Hawk-Eye Derived Performance Metrics Between the Two Groups.

Variable	Top-Ranked Mean ± SD	Lower-Ranked Mean ± SD	*P*	*d*
Ranking	20.2 ± 11.9	157.0 ± 90.2	<0.001*	1.46
Serve				
Aces	12.3 ± 8.0	7.8 ± 6.4	0.004*	0.60†
1st Serve (%)	64.6 ± 6.8	61.2 ± 6.0	0.031	0.51†
Points Won on 1st Serve (%)	65.7 ± 7.9	60.3 ± 8.8	0.003*	0.62†
Serves Unreturned (%)	34.3 ± 10.6	30.3 ± 10.5	0.093	0.38
Fastest Serve Speed (km/h)	201.2 ± 9.3	196.5 ± 11.6	0.065	0.43‡
Avg. 1st Serve Speed (km/h)	175.0 ± 9.9	171.9 ± 8.7	0.095	0.34
Double Faults	3.9 ± 3.7	4.6 ± 3.0	0.112	0.21
Points Won on 2nd Serve (%)	53.7 ± 11.3	49.7 ± 7.7	0.025	0.41‡
Serves Unreturned (%)	17.1 ± 7.9	15.9 ± 9.3	0.438	0.14
Avg. 2nd Serve Speed (km/h)	145.7 ± 9.3	144.4 ± 10.3	0.623	0.13
Serve Return				
Avg. 1st Serve Return Location# (m)	–0.95 ± 0.8	–0.92 ± 0.7	0.751	0.05
Avg. 2nd Serve Return Location# (m)	0.01 ± 1.09	0.16 ± 1.03	0.603	0.15
1st Serve Returns Made (%)	65.7 ± 10.6	69.3 ± 10.4	0.143	0.34
2nd Serve Returns Made (%)	82.9 ± 7.9	84.3 ± 9.0	0.355	0.17
Avg. 1st Serve Return Speed (km/h)	76.2 ± 13.3	67.5 ± 9.9	0.003*	0.70†
Avg. 2nd Serve Return Speed (km/h)	104.7 ± 8.9	101.4 ± 9.5	0.073	0.35
Groundstrokes				
Shots Inside Baseline (%)	30.7 ± 7.9	34.0 ± 7.7	0.039	0.42‡
Avg. Rally Length on 1st Serve	3.7 ± 1.0	4.0 ± 1.2	0.240	0.28
Avg. Rally Length on 2nd Serve	5.5 ± 1.2	5.2 ± 1.1	0.165	0.24
Avg. Ball Contact Height (m)	1.05 ± 0.09	1.07 ± 0.10	0.087	0.28
Avg. Net Clearance (m)	0.36 ± 0.02	0.37 ± 0.02	0.545	0.14
Avg. Shot Speed (km/h)	95.6 ± 6.6	94.3 ± 6.3	0.209	0.20
Shots Deep of Service Line (%)	64.7 ± 16.7	59.6 ± 5.6	0.019	0.40‡
Movement				
Match Distance (m)	3082 ± 1075	2498 ± 898	0.002*	0.57†
Avg. Speed (m/s)	1.3 ± 0.2	1.2 ± 0.2	0.491	0.12
Maximum Speed (m/s)	6.1 ± 2.5	6.5 ± 3.7	0.777	0.15
Avg. Distance Serving Points (m)	9.8 ± 2.8	9.5 ± 2.6	0.375	0.11
Avg. Distance Receiving Points (m)	8.7 ± 2.1	7.5 ± 2.1	0.003*	0.58†

#Relative to baseline (–ve = behind baseline); *P* = Significance; *d* = Cohen's *d* effect size; *Significant at P<0.005 level. †Moderate-to-Large effect size; ‡Moderate effect size.

typically not limited to top-ranked players. For this reason—and based on the first serve percentage data in this study—developing serve accuracy and/or direction should be at the forefront of coaches' intentions. It follows that future research in this area should appraise the dispersion of serve locations to identify patterns unique to top-ranked players.

All players returned first serves while standing 0.9–1.0 m behind the baseline, returned second serves fractionally inside the baseline, and were equally good at returning these balls into play. The primary difference in the return of serve—and largest effect size noted in this study (*d* = 0.70)—was the average speed of first serve return strokes (which was 8.7 km/h faster in the top-ranked group). Plausibly, a faster serve return may counteract the abovementioned advantage that is presented by a proficient first serve and better equip these players to break their opponents' serve. Although these data imply that serve return speed is unrelated to the player's location on court, future research should explore other factors that might influence speed of the first serve return such as gaze, anticipation, movement time, and stroke mechanics. Such explorations would help coaches to develop what appears to be a critical component of elite tennis players' on-court strategies.

Although players stood in similar locations when returning serve, the same cannot be said for the ensuing groundstrokes. Top-ranked players executed a greater number of shots from behind the baseline (*d* = 0.42), which is consistent with a counter-punching strategy where the player aims to return as many balls into play as possible (standing deeper permits greater court coverage). Top-ranked players also delivered 5% more of these groundstrokes to a deeper location in their opponent's court (*d* = 0.40). This speaks to their offensive ability, as deeper balls are generally considered more difficult to play since they arrive faster, and may afford top-ranked players an advantage during rallies. Logically, these findings imply that practice drills should afford players ample opportunities to develop their stroke play from behind the baseline. However, it should be noted that average groundstroke speed, shot flatness (i.e., net clearance) and contact height did not significantly differentiate groups. Thus, for groundstrokes—as appeared to be the case with the serve—accuracy may be more a pivotal in differentiator of top- and lower-ranked players than speed.

Interestingly, top-ranked players covered greater distances during: (1) entire matches (*d* = 0.57), and; (2) points where they were receiving (*d* = 0.58). This is seemingly consistent with the counter-punching strategy noted previously, but could also indicate that top-ranked players: (1) recovered to centre court after each shot, and/or; (2) took extra steps to execute strokes from more favourable positions. Obviously further research is necessary, but these data underline the importance of movement and endurance capacities in professional men's tennis. In contrast, average and maximum movement speed data did not differentiate top- and lower-ranked players and—when considered alongside the stroke speed findings—presents the possibility that explosiveness is not a critical discriminator of ATP ranking.

This study was limited by the fact that only one match of data were analysed, per player. With Hawk-Eye in its infancy as an analytic tool, this was unavoidable and it follows that this study should be repeated and expanded as more data become available for analysis. These data also only pertain to professional male players at the Australian Open in recent years, thus restricting the generalizability of the findings.

CONCLUSION: This exploratory study identified a selection of match play parameters that differentiated top- and lower-ranked professional male tennis players. Top-ranked players appeared more successful on serve (with respect to aces, accuracy and points won) and possessed a faster first serve return, compared with lower-ranked players. Top-ranked players also played more groundstrokes from behind the baseline and delivered them deeper into their opponent's court, while covering a greater distance during matches. Consequently, it appears prudent for coaches to focus on developing these characteristics during practice. With average serve, groundstroke and movement speeds similar among all players, breaking into the top 50 may be more reliant on refining non-explosive capacities (e.g., accuracy, endurance and strategy) rather than velocity generation and explosiveness. Future research should utilize the growing volume of Hawk-eye data to further probe this question and advance the applications of tennis analytics.

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