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Abstract

This study analysed the competition scheduling of future top 100 and 250 ranked tennis players from international tournament profiles at ages 13-18y. Retrospective tournament data was analysed for 165 future top 100 (T100) and top 250 (T250) males during their junior international tournament eligibility. Tournament/match volumes, days between tournaments and consecutive tournaments (<8 days between) were quantified for junior and professional events. A two-way (age x ranking) analysis of variance determined the effects of age and ranking group on tournament profiles. Significant interactions were observed for tournament volumes across junior and professional categories, with T100 players competing in professional tournaments earlier (p<0.05). No significant interactions were observed for volumes of junior or professional matches played (p>0.05). No significant interactions were observed for days between tournaments or consecutive tournaments played (p>0.05). Significant main effects were observed for age on tournament volume, with junior and professional volume increasing at age 15 and 17, respectively (p<0.05). Higher match volumes were observed for T100 players compared to T100-S players (p<0.05). Competition schedules intensify at age 15 compared with ages 13-14y through increased tournament and match volumes. Future T100 players transition to professional tournaments earlier, alongside greater engagement in higher quality junior tournaments.

Key Words: racquet sports, junior development, athlete planning, player pathways

Introduction

Competition engagement through tournament play dictates the periodisation of tennis players' yearly calendars (Roetert, Reid & Crespo 2005). In turn, the accumulation of ranking points from tournaments provides the desired prestige and financial rewards for progression on the tour (Reid et al. 2014). This landscape is capricious due to the knockout structure of tournaments and irregularity of competition scheduling (Roetert, Reid & Crespo 2005). As a result, traditional periodisation strategies based on known or predictable durations of training and competition cycles are not easily designed or implemented in tennis (Roetert & Ellenbecker 2009). Accordingly, many aspiring players prioritise competition over training, which can compromise the time available for dedicated sport-specific skill development that has been reported as being so central to the future success of elite athletes (Elferink-Gemser et al. 2011; Martens & Maes 2005; Reid et al. 2009; Rumpf et al. 2014; Unierzyski 2005). Tennis coaches working with talented junior players attempt to navigate these issues through strategic scheduling of competitions to balance the desire for short term ranking improvements and long-term development (Unierzyski 2003). Given the anecdotal nature of current literature on competition engagement, a data-driven understanding of typical competition engagement patterns of future successful players might better inform training and athlete development recommendations.

Currently, most player development strategies in tennis define success at the individual player level as future attainment of a top 100 or top 250 professional ranking as these ranking milestones provide entry into Grand Slam events, which offer the game's most lucrative prizemoney (Bane, Reid & Morgan 2014; Brouwers, Sotiriadou & De Bosscher 2015; Reid & Morris 2013). With that in mind, athlete selection into national development programs is often based on a player's ranking status. Between the ages of 16-18 y, distinctive trajectories for

future top 50 players exist, though rankings in early adulthood are more indicative of a player's future top 100 or top 250 status (Reid et al. 2014). Further, Li and colleagues (2020) have shown the poor predictive ability of professional ranking in adolescence to predict those players achieving a future ranking from 51-100. Ironically, as rankings are the product of competition results, it stands to reason that two players could achieve similar rankings in their developmental years through quite different engagements in competition scheduling and may represent a limitation of solely relying upon ranking for selection decisions. This understanding of the role of tournaments and therefore the organisation of aspiring professional players' competitive calendars is an obvious omission from previous work in tennis, and inadvertently contributes to the conjecture regarding the importance of performance at young ages (Brouwers, De Bosscher & Sotiriadou 2012; Unierzyski, Wielinski & Zhanel 2003).

Information describing competition volumes and distributions to strategically plan players' schedules in tennis are limited to relatively crude accounts. Indeed, total international tournament volume at age 17 (11 ± 8 events) and 18 (15 ± 5 events) among future top 10 male players has been reported (Reid et al. 2009), with expert opinion pointing to lower volumes at 13-14 y as players prioritise sport-specific and physical skill development (Unierzyski 2003, 2005). Coaching anecdotes suggest competition exposures in early adolescence should be managed so that players do not compete in any more than three consecutive tournaments (Unierzyski 2005). Clearly, these types of time-honoured maxims are untested, meaning that guidelines for competition organisation/scheduling and long-term athlete development in tennis lack the necessary sophistication for effective implementation (Gerdin et al. 2020). Consequently, the aim of this study was to describe and compare the frequency and distribution of tournament-play across the junior pathway (13-18 y) of future top 100 and top 250

professionally ranked tennis players, while also outlining the practical implications for the modern coach and player.

Materials and Methods

Participants

This retrospective study focused on international tournament engagement characteristics of future top 100 and 250 professionally ranked Association of Tennis Professionals (ATP) players between 13 and 18 years of age. Individual player data was analysed during their International Tennis Federation (ITF) junior tour eligibility (i.e. the day of 13th birthday to the end of 18th birth year) and further detailed according to the player's peak ATP ranking based on the available dataset. The initial sample of players obtained from the ITF included all players who competed in the main or qualifying draw at a junior or professional event from January 1st, 2000 through to December 31st, 2015. The earliest birth year possible for included players was the year 1987 to ensure that players tournament activity between 13-18y could be captured. Player tournament and ranking data was obtained from publicly available domains including the official websites of the ITF and ATP. The ranking milestones for each player included the dates of their peak junior ranking, first professional ranking and entries into the top 100 (T100) and top 250 (T250). This study was approved by the University Human Research Ethics Committee (ETH19-3951).

Eligible players were those who achieved peak professional singles rankings inside the top 100 or from 101-250 during the aforementioned dates. With past research showing four years to be the average transition time from first professional ranking point to the top 100 (Kovacs et al. 2015; Reid & Morris 2013), players were further categorised into the following groups for analysis;

- T100-fast (T100-F). T100 players achieving their ranking ≤4 years from first professional ranking point (n = 42),
- T100-slow (T100-S). T100 players achieving their ranking >4 years from first professional ranking point (n = 55),
- T250 (T250). Players achieving a T250 rank and meeting at least one of the following criteria (n = 68):
    - Are ≤8 y removed from first professional ranking and have been in T250 for >4 y
    - Are >8 y removed from first professional ranking and have been in T250 for >4 y
    - Are >8 y removed from first professional ranking and have been in T250 for ≤4 y

Data Collation

Junior and professional international tournaments were categorised according to the possible ranking points earned and thus used to represent tournament quality. For the junior tour, Grade A and Grade 1 junior ITF events represented Category 1 tournaments, Category 2 tournaments included Grade 2 and Grade 3 junior ITF events, while Category 3 included Grade 4 and Grade 5 junior ITF events. For the professional tour, Category 1 tournaments were the four Grand Slams, Category 2 were ATP World Tour tournaments, Category 3 were ATP Challenger events and Category 4 included ITF Futures/Satellites. Local tournaments administered by the respective national tennis federations were not considered.

Annual competition engagement was described through total matches played, total junior matches played, total professional matches played, days between tournaments and number of consecutive tournaments. For total matches only, further analysis was undertaken which

detailed total matches played per month based on a count per calendar month. Consecutive tournaments were defined as any tournament, regardless of tour or category, that started <8 days from the player's previous tournament ending. This definition was determined from the reporting of dates in the dataset. Walkovers were noted and excluded from the match analysis. Matches played were inclusive of both singles and doubles matches. To account for instances where eligible players did not play tournaments in a given year, tournament and match volumes were reflected as '0'.

Statistical Analysis

All statistical analysis was performed in the R language (RStudio, 1.1.463, RStudio, Inc.). The mean and standard deviation were reported for all tournament and match variables and reported annually, and for each birth year. Data normality was assessed via a Shapiro-Wilk test and revealed all variables were not normally distributed. Data was then log-transformed prior to analysis. A two-way (age x ranking group) analysis of variance (ANOVA) determined the effects of respective age and ranking groups on competition engagement metrics. Tukey's post-hoc test was used with a Bonferroni correction to reduce risk of Type I error. Significance was set at 0.05.

Results

Annual Junior Tournaments Played

Figure 1 shows the annual junior tournaments played across ages for the three pre-defined junior tournament categories. Significant interaction effects were observed for age and ranking group in junior category 1 ($p<0.01$; Figure 1A). Significant main effects were observed for age ($p<0.01$), with post-hoc analyses showing significant increases in tournaments at age 16 and 17 ($p<0.01$), followed by a trend towards reduced tournament volume at age 18 ($p=0.06$). A

significant main effect was observed for ranking group in junior category 1 tournaments played (p<0.01). Category 1 tournaments played by T100-F players were significantly greater than T100-S players (p<0.01).

For junior tournaments in category 2, no significant interaction effects were observed (p=0.06). Significant main effects were observed for age (p<0.01), whereby ages 15 and 16 showed a significant increase in junior category 2 tournaments played (p<0.01). A significant reduction in tournaments played was observed at age 18 compared to age 17 (p<0.01). No significant main effects were observed for ranking group (p=0.17).

Significant interaction effects were observed for age and ranking group for category 3 junior tournaments (p=0.04; Figure 1C). Significant main effects were found for age (p<0.01); with post-hoc tests revealing a significant increase in tournaments played at age 15 from earlier ages (p<0.01), with an ensuing decrease in tournaments played at age 17 and 18 (p<0.01 and p<0.01, respectively). No significant main effects were observed for ranking group on tournaments played in this category (p=0.47).

*****FIGURE 1 NEAR HERE*****

Annual Professional Tournaments Played

Figure 2 shows the annual tournaments played across ages for all four professional tournament levels. For Grand Slam competitions (professional category 1), significant interaction effects were observed for age and ranking group (p<0.01; Figure 2A). Significant main effects for age were evident (p<0.01), with a significant increase in Grand Slams played at age 18 compared with previous ages (p<0.01). Significant main effects were observed for ranking group

(p<0.01), with an increase in category 1 tournaments for T100-F players compared with100-S and T250 players (p<0.01).

Figure 2B shows significant interaction effects observed for age and group on tournaments played in category 2 (p<0.01). Significant main effects existed for age (p<0.01), with post-hoc analyses revealing an increase at age 18 (p<0.01). Additionally, significant main effects were observed for ranking group (p<0.01), where category 2 tournaments were played more by those in T100-F (p<0.01).

Significant interaction effects for age and group on tournaments played in professional category 3 were evident (p<0.01; Figure 2C). Significant main effects for age revealed an increase in tournaments played at ages 17 and 18, compared to younger ages (p<0.01). For ranking group, significant main effects were also observed (p<0.01), with tournament volume by T100-F players significantly higher (p<0.01).

Significant interaction effects for age and group were found across professional tournaments played in category 4 (p<0.01; Figure 2D). Significant main effects were found for age (p<0.01) and revealed a significant increase in tournaments played at age 16, 17 and 18 (p<0.01). Significant main effects were found for ranking groups on category 4 tournaments played (p<0.01) and, post-hoc analyses, revealed an increase in tournaments for T100-F players compared with T100-S (p<0.01).

*****FIGURE 2 NEAR HERE*****

Annual Match and Tournament Distribution Variables

There were no significant interaction effects for the total volume of matches played (p=0.50; Table 1). Significant main effects were observed for age (p<0.01), with increases in matches played at ages 16 and 17 (p<0.01). Significant main effects were observed for ranking group (p<0.01), with total matches significantly greater in T100-F compared to T100-S (p<0.05). Figure 3 shows the distribution of matches played per month for players grouped via future T100 and T250 status across ages 13 to 18 y. The figure depicts an apparent peak increase in density of matches played per month occurring at ages 16-18 y.

No significant interaction effects were observed for age and group on junior matches played (p=0.44). Main effects were observed for age (p<0.01), and post-hoc analyses revealed that junior matches increased at ages 16 (p<0.01) with a subsequent reduction at age 18 (p<0.01). No significant main effects were observed for ranking group (p>0.05).

No significant interaction effects were observed (p=0.89) for professional matches played. Significant main effects were found for age (p<0.01), with professional matches played increasing at ages 17 and 18 (p<0.01). No significant main effects for group were observed (p=0.08).

For days between tournaments, no significant interaction effects were observed for age and ranking group (p=0.85). Significant main effects were observed for age (p<0.01), with post-hoc tests showing increased tournament density at ages 15 and 17 compared to other ages (p<0.01). No significant main effects were observed for ranking group (p=0.15).

*****TABLE 1 NEAR HERE*****

*****FIGURE 3 NEAR HERE*****

For consecutive tournaments played, no significant interaction effects for age and group were observed (p=0.67; Table 2). Significant main effects for age were found (p<0.01) with post-hoc tests revealing an increase in consecutive tournaments played at age 16, 17 and 18 (p<0.01). No significant main effect was observed for ranking group (p=0.15).

*****TABLE 2 NEAR HERE*****

Discussion

The aim of this study was to describe and compare the frequency and distribution of tournament-play across the junior pathway (13-18 y) of future top 100 and top 250 professionally ranked tennis players. Tournament volumes increased from age 15, with late adolescence characterised by an increased number of professional tournaments played by future T100 players. Whilst match volumes progressively increased from age 16, the lack of interaction effect suggests similar overall match-play engagement. This is instructive as it highlights that the degree of future success is not simply a function of having greater access to international competition volumes when young; a point previously made by Brouwers and colleagues (2012), who highlighted that competitive junior performances had only limited effect on a player's chances of future professional success. The tournament profiles of T100-F players did reveal however that earlier engagement in higher quality tournaments may be associated with a greater degree of future success, supporting previous suggestions from Li and colleagues (2018; 2020). These insights of the competition scheduling patterns of successful professional players are needed to support the previously anecdotal long-term athlete

development (LTAD) recommendations in tennis. Whilst it is acknowledged that development pathways of individual athletes are unique, these findings appear to show general competition engagement metrics for players to strive, and national federations to steer recommendations, towards.

The 18 and under competition profiles appear to illustrate how priorities and foci change throughout adolescence. At ages 13-14 y, it has previously been suggested that tournament exposures are tightly controlled (i.e. ≤9 ITF tournaments annually) to allow optimal time for development of skill and physical capacities (Unierzyski 2003, 2005). This appears to be true of the players in this sample as junior tournament volumes were comparable between ages 13-14 and across ranking categories. This reduced international tournament play would infer players at this age dedicate greater time to training and sport-specific development, as has been observed in other sports (Hujigen et al. 2013). Indeed, capitalising on the training opportunities in early adolescence are critical in accumulating the sport-specific training needed to develop expertise and enhance chances of success in later adolescence (Monsaas 1985), thus the observed lower emphasis on international competitions. Furthermore, this accumulation of training time in early adolescence may assist players in developing the skills necessary to facilitate their transition to senior competitions, which was associated with future success in combat sport (i.e. taekwondo, wrestling and boxing) athletes (Li et al. 2018). Alternatively, it could be that early adolescence typically involves the concurrent sampling of multiple sports (Baker et al. 2003; Cote 1999), which might also account for the lower tournament volumes observed during this development period. More realistically though, historical perspectives in tennis suggests that players will have sourced domestic or regional events (not analysed in this study) to complement their international exposure (Monsaas 1985) and that these lighter

309 international schedules may even be a function of the sport's international age eligibility
310 restrictions (ITF 2016).
311
312 With international tournament volume clearly increasing from age 15 onwards in future T100
313 and T250 players, it suggests that players at these ages begin to prioritise international tennis
314 competition over other commitments. Using T100 players in their 16th BY as an example, ~14
315 weeks of the year involve international competition. Current recommendations from Tennis
316 Australia suggest 15-17y players compete in relatively conservative 8-17 international
317 tournaments per annum. Increasing tournament volumes impacts the available training time
318 during a key development period and previous analysis of elite Australian athletes has revealed
319 that the average individual sport athlete enters the highest level of junior competition at age 16
320 ±2y and experience a ≈4 h increase in training duration per week (Gulbin et al. 2010). It is
321 unclear whether similar increases in training volume are evident in tennis players and
322 represents a limitation of the current dataset in that the training profiles of players were not
323 captured. Inclusions of such profiles would provide a deeper understanding of competition and
324 training engagement to inform LTAD guidelines in tennis. Further benefits of such data relates
325 to the appropriate timing of training stimuli (physical and skill) around such condensed periods
326 of competition.
327
328 Experts opine that a maximum of three consecutive tournaments should feature in annual plans
329 (Unierzyski 2005), yet our results show that ≈5-10 consecutive tournaments are regularly
330 played throughout late adolescence. This amalgam of consecutive tournaments likely
331 compromises a player's physical conditioning due to a lack of appropriate training stimulus
332 (Murphy et al. 2015) and clearly presents as a programmatic challenge for players and coaches.
333 Outlined visually in Figure 3, 7-9 matches per month are consistently played throughout the

year from age 16 and, combined with the nature of consecutive tournaments, further challenges the planning processes of physical preparation staff. This may be necessary though as, given the future success achieved by players in the current sample, it is possible that the increased density of monthly matches results from reaching the latter rounds of tournaments, though this remains speculative.

Longitudinal accounts of match volumes have not been reported in the literature; however, leaders in Belgian tennis have documented that top 100 junior ranked girls (16.2 y) played between 43-74 matches per annum with a yearly average of 55 matches (Martens & Maes 2005). The current study found similar average annual match volumes played at age 16, with a range of 44-61/year. Indeed, match-play volumes followed a similar pattern to overall tournament engagement, with significant increases noted at age 15 through to 17 y. This is to be expected given guidelines from federations suggest stepped increases in match-play volume from age 15+, culminating in 80-100 singles matches at the age of 17y. Whilst the average matches at ages 17 and 18 in the present study are towards the lower end of these recommendations, it is likely a result of local domestic competitions not being captured. These final stages of adolescence were further characterised by increasing engagement on the professional circuits, which is consistent with what is commonly reported.

Previous surveys of elite athlete pathways have highlighted the practical relevance of competition milestones, with future elite-level athletes entering professional competitions as teenagers (Gulbin et al. 2010). Further emphasising this point, Li et al. (2018) reported higher success rates of future senior combat sport athletes (in particular taekwondo) when succeeding at senior events in their junior years. Our results appear similar, where future T100 players competed in a higher number of ATP Tour events at ages 17 and 18, and likely influenced their

eventual professional status. This is to be expected given the previously observed distinctiveness of ranking trajectories for future top 50 players at ages 16-18 (Reid et al. 2014) likely resulting from an earlier engagement in ATP level events (Li, De Bosscher & Weissensteiner 2018), and appears to highlight the emergence of precocious talent in tennis. Although future 51-100 and 101-175 ranked players did not have distinctive ranking signatures at these ages (Li et al. 2020; Reid et al. 2014), the present study showed T100 players did engage earlier in more professional competitions compared to future T250 players in late adolescence. This suggests that current selection or LTAD guidelines, anchored alone in adolescent ranking data, may oversimplify the current performance and future ranking trajectory of players. This may also suggest future selection guidelines aim to consider the quality of tournaments played leading to a player's resultant ranking status.

Limitations

Whilst the strength of this study is the novel reporting of competition engagement in future successful tennis players, limitations exist in the metrics reported. Firstly, the inclusion of doubles matches may be seen as a limitation of true ranking progression in singles; however, was reported in order to provide an overall understanding of competitive load. This study also reports exclusively on international competitions without consideration to domestically sanctioned tournaments. Thus, it is likely that the tournament and match volumes are underestimated for players, especially those under the age of 17 where age eligibility limits international tournament engagement (ITF 2016). Similarly, the assumption that when players were not competing in these tournaments, they were in periods of focused training or recovery is likely imperfect. Maturation status of players was also not considered in this regard to provide greater context to participation, or lack thereof, during adolescence. This study does also not account for other reasons for non-participation in tournaments at a given age (i.e.,

injury) and, as a result, is only able to provide limited context to explain the speed of a player's transition to the T100. Further, the groupings of players may have masked more subtle differences among smaller groups of ranked players (i.e.., top 10 players versus top 50-100 players). With regards to classifications of tournament qualities, it is acknowledged that the groupings used are imperfect given changes in ranking point allocations over the years in question. Lastly, it should be noted that the introduction of the ITF World Tour in 2019 changed the landscape of entry-level professional events and may impact the generalisability of the present findings.

Conclusion

This study has outlined the international tournament scheduling characteristics of future T100 and T250 male players throughout their junior tournament eligibility (13-18 y). For aspiring male players, international competition schedules intensify in their volume and distribution from age 15. However, whilst this intensification is consistent amongst future T100 and T250 players, the quality of tournaments played throughout this period appears to be a key factor in distinguishing the degrees of success achieved. The present study suggests that coaches and national federations are aware of the intensification of international tournament volumes at age 15 and that recommendations from federations in the formative adolescent years provide players with guidelines to manage this increased competitive load. Given the competing interests that appear to exist in order to maximise competitive opportunities whilst continuing to develop sport-specific skills and physical capacities, further research is needed to analyse the training patterns of future successful players throughout this critical period of development.

Declaration of Interest

No conflict of interest is declared.

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