An examination of the importance of performances in youth and junior competition as an indicator of later success in tennis

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ABSTRACT

Talent identification at a young age is deemed essential for many national sporting organisations to increase the chances of success for their players on the international stage. Talent identification methods can be imprecise and national tennis associations and coaches often identify talent based on performances at youth tournaments and junior rankings. However, not much is known about the relationship between the international competition performances of young tennis players and later success. This relationship is explored in this study using comparisons based on: (a) the results of 3521 players at U14 youth tournaments; (b) the rankings of 377 junior players (U18) by the International Tennis Federation; (c) the rankings of 727 professional male players by the Association of Tennis Professionals; and (d) the rankings of 779 professional players by the Women's Tennis Association. Junior performances (U18) and performances at youth tournaments (U14) appear to have a low success rate in predicting later success. No distinct age was found at which players should start to perform in order to be successful at the professional level. It is concluded that even though good performances at young ages increase athletes' chances to become elite players, they are not a precondition for achieving later success. Therefore, this study informs talent scouts, sport development officers, coaches and high performance managers of the role that performances at international youth competitions may play in talent identification in tennis.

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1. Introduction

Over the two past decades developments in elite sport have meant that if nations want to succeed at the international level, they need to adopt a strategic approach to elite athlete development (De Bosscher, Bingham, Shibli, Van Bottenburg, & De Knop, 2008). As a result, national sporting organisations (NSOs, sometimes called sports federations), invest more in the systematic identification of young talented athletes because a relaxed approach is no longer sustainable in an increasingly competitive environment (De Bosscher et al., 2008). This has resulted in talent identification at younger ages and in athletic careers becoming longer (Van Bottenburg, Elling, Hoekman, & Van den Dool, 2009). This has implications for the management of talented athletes and the player development policies of NSOs. Talent identification has become a key characteristic of national elite sport development systems (e.g., Bloyce & Smith, 2010; De Bosscher, De Knop, Van Bottenburg, & Shibli, 2006; Green & Oakley, 2001; Houlihan & Green, 2008; Lyle, 1997).

Various researchers have tried to identify the indicators which predict success at the elite level and this area of research has attracted a great deal of attention (e.g., Abbott & Collins, 2004; Hoare & Warr, 2000; Reilly, Williams, Nevill, & Franks, 2000; Vaeyens, Lenoir, Williams, & Philippaerts, 2008). Some studies have focused on the development, identification and selection of athletes based on physiological, biomechanical, psychological and sociological factors (e.g., Abbott & Collins, 2004; Mohamed et al., 2009). Other studies have examined the technical and scientific aspects of talent identification and the development process such as coaching techniques, sports sciences and technological advancements (e.g., Balyi & Hamilton, 2004; Bloom, 1985; Côté, Baker, & Abernethy, 2003; Côté & Fraser-Thomas, 2007). Some studies have considered the socio-cultural dimensions of athlete development such as unequal economic opportunities (e.g., Maguire & Pearton, 2000), or the birthplace of athletes (e.g., Côté, Macdonald, Baker, & Abernethy, 2006). All these studies refer to the complexity of talent identification and the difficulty of measuring talent and recognising talented athletes. Despite the plethora of studies in the area of talent identification, there is little agreement on what criteria should be used (Bloyce & Smith, 2010), and talent identification methods can be imprecise (Fahlström, Glemne, Hageskog, & Linnér, 2009).

The situation in tennis, just as it is in other sports (De Bosscher, Schaillé, & Truyens, 2009), is that in the absence of any other widely agreed-on measurable and objective criteria, high-performance managers, coaches and talent scouts identify young talent based on youth tournament results and junior rankings which are seen to be measurable and objective criteria (Unierzyski, 2005). Although these criteria are seen to be objective and even equitable, they mask a host of less objective criteria (e.g., the affordability of travel to tournaments, previous investment by national tennis associations (NTAs), physical maturation rates, and other types of support systems). For example, Tennis Australia uses athlete development criteria that are based on the ranking progressions of successful tennis players as entry requirements for the national academies and for the Australian Institute of Sport (AIS) Pro Tour Program (Tennis Australia, 2010). For each birth year, Tennis Australia has clearly defined ranking requirements. For example, to be eligible for a full scholarship a 14-year-old male player has to be in the top four of the U14 Australian rankings and in the top 240 of the U14 ranking of the International Tennis Federation (ITF). In addition, the player must have reached a semifinal in a Tennis Europe event. The Flemish Tennis Federation (Belgium) uses a combination of players' national rankings and their performances at international U14 youth tournaments to select players for a special program that combines school and tennis at the age of 13 and 14 years old. After the age of 14, the Flemish Tennis Federation uses ITF rankings and rankings by the Association for Tennis Professionals (ATP) and the Women's Tennis Association (WTA) as criteria to select players for the program (Vlaamse Tennis Vereniging, 2010).

Result-based talent identification can be problematic because high performance managers may over-estimate the potential of the early high achievers, and fail to notice athletes who may not be the best performers at the moment of identification, but who have the potential to perform well in the future (Elferink-Gemser, Jordet, Coelho-E-Silva, & Visscher, 2011). Additionally, talent identification based on results forces athletes to specialise in their sports at younger ages (De Bosscher et al., 2009). Anecdotal evidence from tennis experts suggests that on-court results should not be used as the sole predictor of later success, especially before puberty (MacCurdy, 2006; Unierzyski, 2003, 2006). This assertion has not been empirically tested and competition results and rankings at young ages appear to remain decisive in the talent identification processes of NTAs. Therefore, research on the extent to which performances at a young age are related to later success is required to inform high performance managers, coaches and talent scouts. While we recognise that there is a range of factors that need to be considered to accurately identify talented athletes, the focus of this study is on tournament results and rankings – the main criteria that NTAs use.

The aim of this research is to examine the importance of performances in youth and junior competition as indicators of later success in tennis. This paper contributes to the germane sport development literature and sport managers' understanding of the role that youth (U14) and junior (U18) competitions may play in the identification of athletes for talent development programs. The analysis of the relationship between international competition performances at young ages and later success in tennis is based on comparisons between U14 youth tournament results, U18 ITF rankings and senior rankings by the ATP and WTA.

2. Competitive performance-based talent identification

Competitive performance by itself is an inadequate criterion for talent identification because it can be affected by a number of other factors that are obscured when only performances at competitions are taken into account. As this section will show, these factors include the support for athletes when transitioning from one level to another, the moment at which athletes specialised into tennis, and the age at which competition results are used as an indicator for talent identification.

2.1. Athlete transitions

Successful sport development processes compel sports to attract, retain, transition and nurture athletes (Green, 2005; Shilbury, Sotiriadou, & Green, 2008; Sotiriadou, Shilbury, & Quick, 2008). NSOs identify talented athletes for their programs and allocate available resources to the development of a small number of talented athletes to ensure returns on their financial investment (Unierzyski, 2006; Vaeyens et al., 2008). In a lot of talent development studies the main goals are to find ways to speed up the progress of young athletes and to increase athletes' abilities to perform at a peak level on numerous occasions (Starkes, Helsen, & Jack, 2001). It can be seen, therefore, that the main role of the talent development process is to facilitate athlete transition from regional competitions to national and international competitions and from junior to senior

level when athletes' skills and conditioning improve (Green, 2005). To facilitate athlete transition, NSOs implement policies including player development programs and competitions that help train athletes with the aim of taking the most talented ones through to the highest levels of the sport. However, Sotiriadou et al. (2008) and Green (2005) indicated a lack of linkages among organisations at each level of sport and a lack of support for athletes when making a transition from one level of sport to the next. There have been many attempts to outline the different phases and transitions of athlete development (e.g., Balyi & Hamilton, 2004; Bloom, 1985; Côté, 1999; Côté & Fraser-Thomas, 2007; Wylleman & Lavallee, 2004). Only one tennis-specific transition model was found: the long-term performance model of Grosser and Schönborn (2002). Appendix A gives a detailed overview of the most influential athlete development and transition models which informed this study. None of these models was tested in this study.

2.2. Specialisation

A concept that features strongly in each of the development models is specialisation. In the transition model of Bloom (1985), in Côté's development model of sport participation (Côté, 1999), and in the elite performance through sampling pathway (Côté & Fraser-Thomas, 2007), it is recommended that specialisation does not take place until the age of 12. During the specialisation phase (also known as the specialising years), athletes focus on one sport and there is an increase in: (a) the quantity and specialisation of training; (b) the amount of activity designed to improve the current level of performance, also known as deliberate practice (Ericsson, Krampe, & Tesch-Römer, 1993); and (c) the role of competition. The early identification of talented players and elite performances at ever-young ages leads to the often discussed concept of "early specialisation". Early specialisation in sport is understood to mean "identifying talent at an early age and subjecting young people to intensive performance programs in a single sport" (Enoch, 2010, p. 47). In contrast to early specialisation, diversification (also known as late specialisation) is the participation in a variety of sports and activities through which an athlete develops multilateral physical, social and psychological skills (Wiersma, 2000). There is little consensus in the literature on whether early specialisation or diversification is preferable. According to Côté, Horton, MacDonald, and Wilkes (2009) both approaches can be successful under optimal conditions.

In relation to tennis, Carlson (1988) found that players who were involved in more than one sport before the age of 14 years were more successful at a later age than those who only played tennis. Hence, he concludes that all-round sport engagement and physical activities designed to maximise enjoyment, defined as deliberate play (Côté, 1999), are more important than 'professional-like training' before adolescence (p. 252). In their tennis-specific long-term performance model, Grosser and Schönborn (2002) emphasise the importance of diverse, non-specific and varied ways of playing between the age of four and seven years. They suggest that tennis-specific training should only start after the age of seven and then gradually increase. However, they were not clear on when players should specialise in tennis. Other authors (e.g., Balyi & Hamilton, 2004; Rowland, 1997; Wiersma, 2000) argue that sports such as gymnastics, figure skating, swimming and tennis require early specialisation and a focus from a young age on one sport. Regardless of early or late specialisation of athletes, after the age of 16 all talent development models recommend an investment, or perfection phase, which includes high levels of deliberate practice and a focus on one sport.

It is generally accepted that athletes who specialise early will have more training hours compared to athletes who specialise at a later age, and therefore early specialisers will start to succeed earlier at international level (Ericsson et al., 1993). Similarly, players with more international tournament experience increase their chances of winning compared to athletes with less experience at a young age (Unierzyski, 2003). However, studies (e.g., Unierzyski, 1994, 2003) have shown that the advantage of having more training hours and tournament experience at a young age disappears after puberty and does not have a significant influence on results at a professional level because as age increases the determinants and indicators of talent shift towards motor abilities, tennis-specific skills, body structure and psychological characteristics. Additionally, tennis players who specialise early miss out on the development of generic motor skills and expose themselves to the risks associated with early specialisation (Wiersma, 2000). These risks may include injuries caused by overload (Dalton, 1992) and an increased risk of physical and psychological burnout and dropout (Weiss & Petlichkoff, 1989). Moreover, early specialisation exposes athletes to the risk of physical, psychological and social damage (Hecimovich, 2004).

In reality many young athletes are identified as talented based on their current performance levels and not on their potential to perform well in the future (Unierzyski, 2005). As a consequence the players who join the talent development programs of NSOs are often players who have matured early, players who specialised early or players with tournament experience. It is therefore likely that many selections may be inappropriate and that players with future potential may not be identified (Elferink-Gemser et al., 2011).

2.3. Age of talent identification

Competitions at various stages of athlete development are an important contributor to achieving peak performance as they provide opportunities for players to further develop their skills and gain international playing and travel experience. Competitions are a platform that delivers the path to higher levels of performance and prepares participants for more prestigious and challenging competition (Sotiriadou & Shilbury, 2009). Several authors indicate that during the perfection phase, competitions are essential for helping players adjust to the mental pressures of international tournaments and for helping them to become acquainted with other opponents and their ways of playing (Balyi & Hamilton, 2004;

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Grosser & Schönborn, 2002). Hence, a sensible program in which the number and standard of tournaments gradually increases, with realistic goals, is recommended to avoid burnout (Grosser & Schönborn, 2002). Similarly, studies in tennis have shown the importance of competitions offered by national and international tennis organisations in the development of tennis players (Crespo & Miley, 1998; MacCurdy, 1999). Tournament development features prominently in NTAs' policies which aim at increasing their countries' representation in the world rankings (Reid, Crespo, Atienza, & Dimmock, 2007).

An issue related to talent identification based on performances is the age of the players when they are identified. There is widespread debate amongst researchers on the best age to identify talent and thus the question in this study rises on the moment where performances in youth competitions are an important indicator of later success in tennis. MacCurdy (2006) argues that 12 years of age is too early to identify talent in tennis as at this age playing experience, technical skills, and biological maturity are the key factors in determining success. Unierzyski (2003) analysed the characteristics (anthropometry, motor ability, competition results) that successful senior players had when they were 12- and 13-year-olds and found that these players were not the best players at that age. He maintains that tournament results for players at the age of 14 would be better predictors of future success. Based on this argument the present study included an examination of the relationship between performances at U14 youth tournaments and later success in tennis.

As the accuracy of predictions of later success increases when those predictions are made closer to the time of peak performance (Vaeyens et al., 2008), this study examines the relationship between junior (U18) rankings and professional rankings in addition to examining the relationship between U14 and senior level performances. The importance of examining performances at junior level (U18) is stressed by Crespo and Miley (1998) who found that the ages between 15 and 18 years are crucial for player development in tennis because athletes build their physical prowess and tactical awareness at this time.

A few authors have examined the relationship between junior rankings and senior rankings in tennis. For example, Miley and Nesbitt (1995) analysed the performances of junior top 10 players at senior level and concluded that junior top 10 players have a 50% chance of achieving a professional top 100 ranking. However, their study might be outdated in a rapidly changing tennis landscape. More recently, Reid, Crespo, Santilli, Miley, and Dimmock (2007b) investigated the importance of the junior boys' circuit of the ITF in the development of professional tennis players and found that the achievement of a junior top 20 ranking is a significant predictor of future professional rankings. However, Reid et al.'s (2007b) study does not specify what professional rankings these players reached (e.g., top 1000, 200, 100). In both studies (Miley & Nesbitt, 1995; Reid et al., 2007b) a bottom-up approach was used to analyse how successful junior players performed at senior level.

No studies are currently available that analyse how successful senior players performed when young. This approach is defined as a top-down analysis and would provide an insight into the number of successful senior players that were not successful at younger ages. Additionally, a top-down approach would provide details on the pathways that successful senior players followed (e.g., the age at which they reached different milestones). This study is the first to combine the results from bottom-up and top-down analyses.

3. Method

This study examines the relationship between: (a) performances at youth tournaments (U14) and at the professional level (Fig. 1, comparisons 1 and 2); and (b) performances at the junior level (U18) and at the professional level (Fig. 1, comparisons 3 and 4).

Using a bottom-up approach, comparisons 1 and 3 (Fig. 1) helped to determine the extent to which performances at young ages (U14) and at junior level (U18) respectively influence success at the professional level. In contrast, the top-down
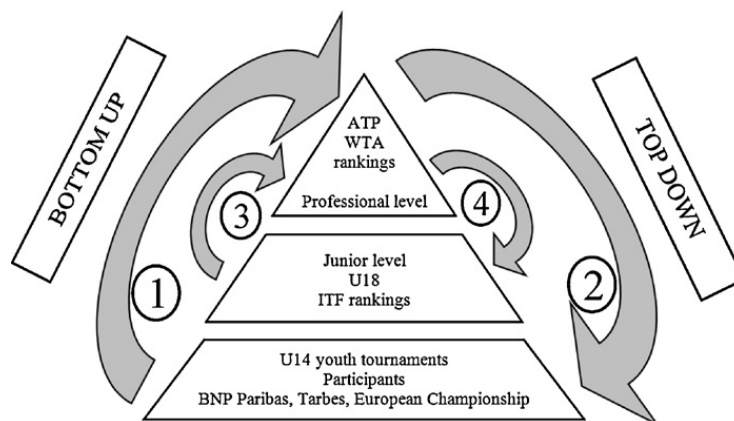

Fig. 1. Top-down and bottom-up comparisons.

approach used in comparisons 2 and 4 (Fig. 1) helped to determine the extent to which senior professional tennis players performed when they were U14 and U18 respectively.

The bottom-up analyses provided answers to the following research questions:

- How did players who participated at U14 international youth tournaments perform at a later age at senior level in ATP and WTA rankings? (Fig. 1, comparison 1)
- How did players who reached the junior top 20 perform at a later age at senior level in WTA and ATP rankings? (Fig. 1, comparison 3)

The top-down analyses provided answers to the following research questions:

- How did senior ATP and WTA top 200 and top 20 players perform at U14 youth tournaments when they were young? (Fig. 1, comparison 2)
- How did senior ATP and WTA top 20 players perform in U18 junior rankings when they were young? (Fig. 1, comparison 4)

The use of both types of analysis (bottom-up and top-down) was chosen as the preferred approach to compare data in this study is to complement existing studies that so far have only used bottom-up analyses (e.g., how did successful juniors perform at senior level? how many players made the transition from junior to senior?). The benefit of a bottom-up approach is that it provides information on the number of successful youth players who make it to the top. However, a bottom-up analysis alone does not provide information on how many successful senior players did not perform at a young age. The latter is provided by the top-down analysis which also provides detail on the pathway which successful senior players followed when they were young. The weakness of only using a top-down approach is that it looks at successful senior players only. Thus, information about players who were successful at a young age, but who did not make it to the top at the senior level, is omitted. Additionally, Grosser and Schönborn (2002) suggest that a number of successful senior players followed a rather unusual pathway and are exceptions that should not be seen as a model for others. This study included both bottom-up and top-down comparisons to provide a more complete and detailed examination of the relationship between performances at a young age and later success.

A database was developed based on data on the past performances of male and female tennis players. Four types of data were collected:

- U14 tournament results
- U18 junior rankings from the International Tennis Federations (ITF)
- professional rankings from the Women's Tennis Association (WTA) for female players
- professional rankings from the Association of Tennis Professionals (ATP) for male players.

For each comparison (i.e., comparisons 1, 2, 3 and 4) Table 1 illustrates the set of data (e.g., U14 youth tournament players), the performance indicators used (e.g., tournament results), the time period of data collection (e.g., 1990–2006), the sample size (e.g., 1,897 male players) and age of the sample (e.g., 10–14 years old). Additionally, Table 1 illustrates what this data set was compared with, including performance indicator 2 (e.g., ATP/WTA rankings) and time period 2 (e.g., 1992–2008).

3.1. Youth tournament results (U14s)

Les Petits As (Tarbes), the French Open and the European championship were selected following consultations with tennis experts from national and international tennis organisations (Belgium, United Kingdom, Tennis Europe) as the most representative and important tournaments for U14 players. The European championship is the most prestigious tournament and is attended by one or two of the best players of each Tennis Europe member country. The experts we consulted indicated that Les Petits As was the most important worldwide indoor tournament for U14 players and the French Open was the most important worldwide outdoor tournament.

The results from the three selected tournaments were entered into a database. At the time of data collection, results from 1990 to 2006 for 1897 male players, and from 1990 to 2005 for 1624 female players were available. Tournament results were used as performance indicators for this age category as they give a more reliable indication of performances than rankings. Performance indicators are the index points that the European Tennis Federation, allocated to players at each tournament based on the performance at the tournament and the significance of each tournament (Tennis Europe, 2007).

The number of tournaments a player participated in was taken into account in order to eliminate a bias towards players who participated in more tournaments. Therefore, the performance of a player is the sum of the index points earned at each tournament divided by the number of tournaments they participated in. The data from U14 youth tournaments allowed the examination of performances of youth tournament players at the professional level (bottom-up) and the examination of performances of professional top 20 players in youth tournaments (top-down) (Table 1, nos. 1 and 2).

Table 1
Overview of different comparisons and samples.

No.	Type of comparison	Relationship analysed	Set of data	Performance indicator	Time period	Sample size	Age of sample	Comparison Fig. 1	Performance indicator 2	Time period 2
1	Bottom-up	Performance of youth tournament players at professional level (top 200)	U14 Youth tournament players	Tournament results from 3 international U14 youth tournaments	1990–2006 (male), 1990–2005 (female)	1897 male 1624 female	10–14 years old	①	ATP/WTA rankings	1992–2008 (male), 1992–2007 (female)
2	Top-down	Performance of professional top 200 and top 20 players in youth tournaments	Professional top 200 and top 20 players	ATP/WTA rankings	2000–2008 (male), 1999–2007 (female)	TOP 200 281 male 323 female TOP 20 68 male 60 female	14 years old – Open	②	Tournament results from 3 international U14 youth tournaments	1990–2006 (male), 1990–2005 (female)
3	Bottom-up	Performance of junior top 20 players at professional level (top 200)	Junior (U18) top 20 players	ITF rankings	1988–1999 (male), 1988–1998 (female)	202 male 175 female	13–18 years old	③	ATP/WTA rankings	1992–2008 (male), 1992–2007 (female)
4	Top-down	Performance of professional top 20 players at junior level (top 200)	Professional top 20 players	ATP/WTA rankings	2000–2008 (male), 1999–2007 (female)	68 male 60 female	14 years old – Open	④	ITF rankings	1988–2007 (male), 1988–2007 (female)

3.2. Junior rankings (U18s)

Junior rankings for players between 13 and 18 years old, issued at the end of each calendar year, were used to measure junior performances. First, the rankings of junior top 20 players from 1988 to 1999 for 202 male players and from 1988 to 1998 for 175 female players were entered into the database. As professional rankings were available until 2008 (male) and 2007 (female) at the moment of data collection (see further), junior rankings for each year as far back as 1999 (male) and 1998 (female) were taken into account so that both male and female players had nine years after performing at junior level to reach the top 200 at professional level. These data allowed the examination of performances of junior top 20 players at professional level (bottom up) (Table 1, comparison no. 3).

Second, the junior rankings of players ranked in the ATP/WTA top 20 from 2000 to 2008 for 68 male players (ATP rankings) and from 1999 to 2007 for 60 female players (WTA rankings) were entered into the database. These data made it possible to examine how professional top 20 players performed when they were juniors (top-down) (Table 1, no. 4).

3.3. Professional rankings

To calculate the professional level of players, the year end ATP rankings from 1992 to 2008 for 727 male top 200 players (aged 14 and above) and the year end WTA rankings from 1992 to 2007 for 779 female top 200 players (aged 14 and above) were entered in the database. Professional rankings made it possible to examine the performances at professional level of youth tournament players and junior players (bottom-up), and to examine the records of professional top 20 players in youth tournaments (U14) and at junior level (top-down).

3.4. Statistical analysis

First, descriptive statistics were used to calculate the percentages of U14 tournament players and U18 players that reached a certain professional level, and the percentage of successful senior players who performed in U14 youth tournaments and at junior level. Second, SPSS (Statistical Package for the Social Sciences) software was used to examine the correlation between performances at youth tournaments and at professional level. The Spearman rank correlation coefficient was used as the data (i.e., index points at youth tournaments and rankings) were at ordinal level. In order to examine differences between the best players and those that did not reach the top level, the players were divided into groups (e.g., youth tournament winners or runners-up, or junior top 20 and top 100 players, or players who reached milestones at different ages). To determine if the differences between groups were significant the Mann–Whitney U test was used for ordinal level data (e.g., rankings). To examine whether younger junior top 20 players reached a significantly higher senior ranking than older junior top 20 players, the Kruskal–Wallis non-parametric analysis of variance was used. Results were considered statistically significant when $p < .05$.

4. Results

The results are divided into two sections. The first section discusses the relationship between performances at U14 youth tournaments and professional rankings. The second section discusses the relationship between U18 junior rankings and professional rankings.

4.1. Relationship between U14 performance and professional ranking

The relationship between U14 performance and professional ranking was examined using (a) a correlation between U14 tournament results and professional rankings, (b) a bottom-up analysis examining the performances of youth tournament players at professional level, and (c) a top-down analysis examining the performances of successful senior players in youth tournaments.

4.1.1. Correlation

The correlation between the highest index points players gained at selected youth tournaments and the best ATP or WTA professional ranking these players achieved was examined using the Spearman rank correlation. All the youth tournament participants (U14) were included in the correlation using their index points as an indicator of youth performance. The performances at professional level were taken to be the players' rankings in the ATP or WTA top 200. Youth tournament players who did not reach the top 200 were considered to hold a ranking of 201. The correlation between the highest index points that players gained at a youth tournament and their best professional ranking was significant for male and female players at an alpha level of 0.01. However, both correlations were low ($r_{s\ male} = .208$ and $r_{s\ female} = .296$). The low determination coefficients ($R^2 = .043$ for male and .088 for female players) indicate that the reliability of players' youth tournament results as a predictor of success at the professional level is low. The results showed that the predictability was twice as high for female players than for male players.

4.1.2. Bottom-up analysis

Frequencies of youth tournament players who reached the senior top 200 revealed that 6.2% ($n = 117$) of the male youth tournament players and 9.1% ($n = 147$) of the female youth tournament players reached the top 200 at the professional level. Of youth tournament players in the sample, 1.3% ($n = 25$) of males and 1% ($n = 18$) of females reached the ATP or WTA top 20.

In the next stage of the analysis, professional rankings of winners, runners-up and semifinalists of the youth tournaments were compared. The senior-level performances of the group of players with good youth tournament results were compared with those of the group that was less successful. For both male and female players, the percentage of the group with good youth tournament results that reached the ATP or WTA top 200 was higher than the percentage of the less successful group that reached the top 200. Table 2 shows that 43.2% of male and 60% of female youth tournament winners reached the ATP or WTA top 200 compared to 28.6% of male and 39% of female youth tournament runners-up and 13.3% of male and 29.5% of female semifinalists. A similar trend was found for players reaching the top 100 and top 20.

Table 2

Performance at youth tournaments (winners, runners-up and semifinalists) and professional ranking (ATP/WTA).

	MALE				FEMALE			
	Winners	Runners-up	Semifinalists	All youth tournament players	Winners	Runners-up	Semifinalists	All youth tournament players
	(n = 44)	(n = 42)	(n = 83)	(n = 1,897)	(n = 40)	(n = 41)	(n = 78)	(n = 1,624)
	%	%	%	%	%	%	%	%
ATP/WTA top 200	43.2	28.6	13.3	6.2	60.0	39.0	29.5	9.2
ATP/WTA top 100	36.4	19.0	8.4	4.1	47.5	29.3	17.9	5.6
ATP/WTA top 20	18.2	9.5	4.8	1.3	22.5	9.8	1.3	1.1

The Mann–Whitney U test revealed that winners and runners-up ($Mdn_{male} = 27$, $Mdn_{female} = 43$) of the selected youth tournaments attained a significantly better professional ranking compared to players who did not reach the finals ($Mdn_{male} = 83$, $Mdn_{female} = 84$) ($U_{male} = 608.5$, $p < .05$ and $U_{female} = 1056.0$, $p < .05$). The professional performances of 1329 male and 1113 female U14 players who lost in the first rounds of tournaments (referred to here as the "early-exit players") were also analysed to see how successful these players were at the professional level. Early-exit players were defined as those who earned 20 index points or less on average at the three youth tournaments examined in this study. A small percentage of early-exit tournament players (3.2% male and 4.1% female players) reached a top 200 place at the professional level. These percentages are lower than the percentages of youth tournament players as a whole who reached the ATP or WTA top 200 (6.2% male and 9.1% female). No female players and only four (0.3%) of the male early-exit players reached a top 20 ranking at the professional level.

4.1.3. Top-down analysis

In examining how ATP and WTA top 200 players (between the year 2000 and 2008 for male players and between 1999 and 2007 for female players) performed at youth tournaments, it was found that 32% male ($n = 90$) and 32.5% female ($n = 105$) top 200 players participated in one of the selected youth tournaments. Table 3 reveals that 42.6% of male top 20 players and 28.3% female top 20 players participated in one of the selected U14 tournaments.

Table 3

Performance of professional top 20 players at youth tournaments.

	Male		Female	
Performance	N	%	N	%
Number of ATP/WTA top 20 players since 2000	68	100	60	100
Participation tournament (Tarbes, European Championship, BNP Paribas)	29	42.6	17	28.3
"Early-exit" players	15	22.1	5	8.3
Semi-and quarterfinalists	4	5.9	4	6.7
Winners & runners-up	10	14.7	8	13.3

In their early careers, 14.7% of male ATP top 20 players and 13.3% of female WTA top 20 players had reached a final in one of the selected youth tournaments.

4.2. Relationship between U18 performance and professional ranking

The relationship between U18 performance and professional ranking was examined using (a) a bottom-up analysis examining the performances of U18 junior players at professional level and (b) a top-down analysis examining the performance of successful senior players at junior level.

4.2.1. Bottom-up analysis

Fig. 2 shows that 16.8% of male and 11.4% of female junior top 20 players reached the ATP or WTA top 20 at a later age. Also, 65.8% of male junior top 20 players and 64.4% of female junior top 20 players reached the professional top 200.

The age at which players reached the junior top 20 was taken into account to examine whether younger junior top 20 players had a greater chance than older players to become successful at the professional level. Fig. 3 shows that male players who reached the junior top 20 at the age of 16 or younger were more likely to reach the ATP top 200, top 100 and top 20 compared to 17- or 18-year-old junior top 20 players. More specifically, the percentages of 16-year-old or younger male junior top 20 players that reached the ATP top 200 (84.6%), top 100 (67.5%) and top 20 (62.5%) were higher than those of the 17- and 18-year-old junior top 20 players.
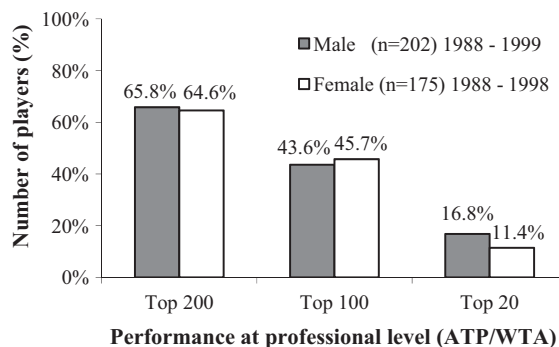

Fig. 2. Performances of junior top 20 players at professional level (n_{male} = 202, n_{female} = 175).

Even though Fig. 3 suggests that male players who reached the junior top 20 at the age of 16 or younger were more likely to reach the senior top 200, top 100 and top 20 compared to players who reached the junior top 20 at the age of 17 or 18, the Kruskal–Wallis test indicated that the youngest age group did not reach significantly higher senior rankings compared to the older age groups ($X^2(2, n = 202) = 4.564, p = 0.102$). Fig. 4 shows a similar analysis for female players.

The percentage of 15-year-old or younger female junior top 20 players who reached the WTA top 20 (32.1%) was three times higher than the percentage of 16-, 17- and 18-year-old players who reached the senior top 20. We also compared the senior achievements of female players who became junior top 20 players when 15 or younger with the achievements of
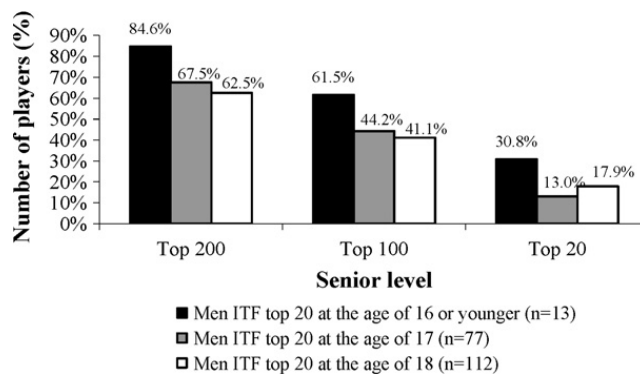

Fig. 3. Age at which players reached the junior top 20 and their performances at the professional level (ATP).
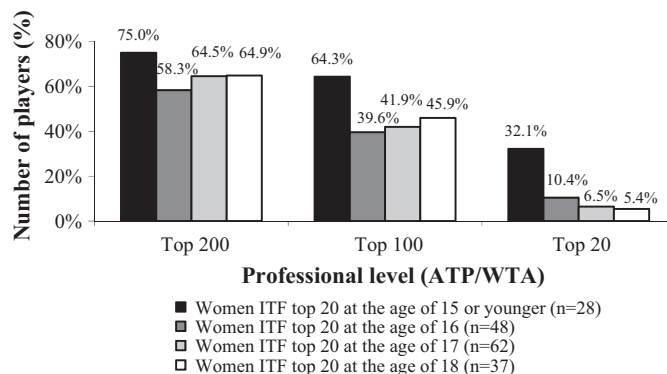

Fig. 4. Age at which players reached the junior top 20 and their performances at the professional level (WTA).

those who reached the junior top 20 when they were older than 15. We found that higher percentages of the young achievers reached the WTA top 200 and top 100. Like male players, the Kruskal–Wallis test indicated no significant difference for females in the senior rankings between the different age groups (X^2(3, n = 175) = 7.077, p = 0.069). These results indicate that male players who reached the junior top 20 at 16 or younger, and female players who reached the junior top 20 at 15 or younger, did not achieve significantly better rankings than players who were older when they reached the junior top 20.

4.2.2. Top-down analysis

More than three-quarters of professional top 20 players (76.5% male and 81.6% female players) reached a junior top 200 ranking. Almost half of the professional top 20 players (44.1% male and 40.0% female players) reached the junior top 20 (see Fig. 5).
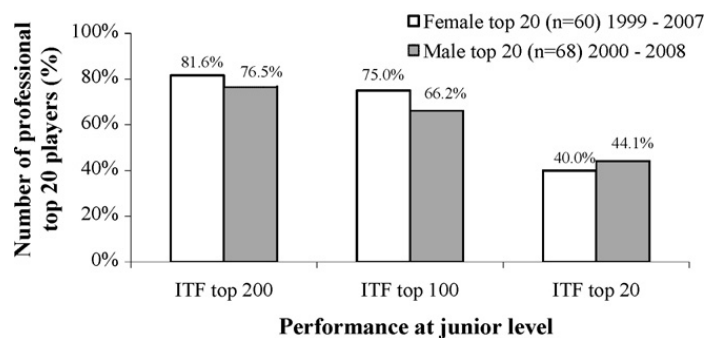

Fig. 5. Performance of professional top 20 players at the junior level.

An analysis of the ages at which professional top 20 players reached different milestones in their careers (e.g., the junior top 200 and the professional top 200, top 100, top 50 and top 20) revealed divergent results. Table 4 shows a difference of eight years between the youngest and oldest players who reached the professional top 200. The youngest male player to reach the senior top 200 was 16 and the youngest female player was 14 while the oldest male player was 24 and the oldest female player was 22. Male ATP top 20 players reached the professional top 200 at the average age of 19.5 years (SD = 1.7). The average age at which males reached the top 20 was 23.0 (SD = 2.8) with the youngest entering the top 20 at 19 and the oldest entering the top 20 at 32. The average age at which female junior top 20 players reached the WTA top 200 was 18.0 (SD = 2.4). The average age at which females reached the WTA top 20 was 20.6 years (SD = 3.0) with a difference of 12 years between the youngest player (aged 15 years) and the oldest player (aged 27 years) to reach the WTA top 200.

Table 4
Age at which ATP and WTA top 20 players reached the junior top 200 and senior top 200, top 100, top 50 and top 20.

	Milestone	Age ($M \pm$ SD)	Minimum age	Maximum age	Range
ATP top 20 players (male)	ITF top 200	16.4 ± 1.0	14	18	4
	ATP top 200	19.5 ± 1.7	16	24	8
	ATP top 100	20.3 ± 1.9	16	24	8
	ATP top 20	23.0 ± 2.8	19	32	13
WTA top 20 players (female)	ITF top 200	15.3 ± 1.0	14	18	4
	WTA top 200	18.0 ± 2.4	14	22	8
	WTA top 100	18.6 ± 2.5	15	27	12
	WTA top 20	20.6 ± 3.0	15	27	12

5. Discussion and conclusions

This study examined the extent to which performances at young ages can be used as an indicator for later success in tennis. It aimed to inform high performance managers, coaches and talent scouts on the importance of youth competition results and junior rankings for later success in tennis as these are often used by NTAs as criteria to identify talented athletes. This section starts with an overview of the study's most important results and their implications for sport managers. The importance of research on the combined contribution of other factors and indicators of later success is then highlighted. This is followed by a discussion of the limitations of the study and of the generalisablity of the results across other sports.

Based on the results of this study it could be concluded that for the great majority of tennis players performances at young ages are not associated with later success. The study showed that there is no clearly identifiable age at which all players should start to perform in order to be successful at the professional level and that it is difficult to identify an age at which performances could be used as a reliable talent selection indicator for later success. MacCurdy (2006) argues that the age of 12 is too young to identify talent in tennis and Unierzyski (2003) maintains that the reliability of tournaments results as a predictor is higher at the age of 14 than at 12. This study showed that it is difficult to predict later success based on

tournaments results at the age of 14. The ages at which senior top 20 players reach different milestones in their career vary considerably. For example, the difference between the age of the youngest and oldest player who reached the professional top 200 is eight years for both male and female players. Results of the bottom-up analysis showed that players who reached the junior top 20 at a very young age did not reach a significantly better senior ranking than players who reached the junior top 20 at an older age. These results imply that it is nearly impossible for NTAs to set milestones or rankings that players should reach at certain ages. Therefore, this study questions the reliability of the ranking criteria that NTAs use to identify players for talent development programs.

Although literature suggests that competitions play an important role in the athlete skilling and transition processes (e.g., Sotiriadou & Shilbury, 2009), the findings of this study collectively suggest that even though good performances at youth competitions (U14) increase players' chances of becoming an elite tennis player, they are not a precondition or a guarantee for later success. This is suggested by the low but significant correlations of 0.208 for male players and 0.296 for female players between youth tournament performance and professional senior ranking. Additionally, the analysis showed that only 43.2% of male U14 tournament winners and 60% of female U14 tournament winners were able to reach the professional top 200. Similarly, only 28.6% of male U14 and 39% of female runners-up reached the professional top 200 ranking. These low correlations and low percentages suggest that when NTAs use U14 tournament results to identify promising tennis players, they may be investing their resources in players who may not make it to the top. By implication sport managers, coaches, talent scouts and high performance managers should take into account the low importance of U14 competition results as indicators for future success. One of the reasons why not all successful young players make it to the top in the senior ranking can be attributed to the lack of support for players when they transition from one level to another. Therefore, linkages between the different levels must be impeccably articulated (Green, 2005). Based on the studies of Green (2005) and Sotiriadou et al. (2008) we recommend the provision of sequential levels for advancement and active assistance for athletes to make the transition from one level to the next. Another reason for failure in the transition to higher levels can be to the occurrence of non-normative transitions (Wylleman & Lavallee, 2004). Non-normative transitions are unpredictable events such as burnout, athlete dropout or overuse injuries that can occur as a consequence of early specialisation (Dalton, 1992; Weiss & Petlichkoff, 1989).

Junior rankings appear to be better indicators of later success than U14 results but they are also no guarantee of later success. The top-down comparisons showed that less than 50% of the senior top 20 players had reached the junior top 20. This suggests that half of the senior top 20 players were not very successful at the junior level and that a top 20 junior ranking is not a precondition for later success. More importantly, the results of the bottom-up comparison showed that less than 20% of the junior top 20 players reached the senior top 20 and less than 50% reached the senior top 100. These low percentages contrast with Reid, Crespo, Santilli, et al.'s (2007) results which suggest that the attainment of a top 20 junior ranking is a significant predictor of future professional ranking for male players as 91% of all top 20 juniors from 1992 to 1998 went on to achieve a professional men's ranking. Professional rankings however include more than 1500 players. Hence, the likelihood of achieving a professional ranking is much higher than the likelihood of achieving a senior top 200 ranking, which was the criterion that was used in this study.

Results of the study indicated that players who do not perform well at youth tournaments (U14) may still have a small chance of becoming successful senior players. The top-down comparisons showed that only 14.7% of male senior top 20 players and 13.3% of female senior top 20 players reached the final of a youth tournament. Additionally, it was shown that 23.5% of male top 20 players and 18.4% of female senior top 20 players never reached a junior top 200 ranking, indicating that performing well at junior level is not a precondition for reaching the senior top 20. Therefore, it is recommended that NTAs do not exclude players who do not achieve good competition results or rankings at young ages from talent development programs. Even though sports federations may not be able to provide the same resources and access to coaches and facilities for all athletes, we recommend that they provide more training and competition opportunities to a larger number of players. These opportunities will help develop a larger pool of players for future rankings and will support nations in their efforts to adopt more strategic approaches to elite athlete development (De Bosscher et al., 2008).

Some studies (e.g., Helsen, Hodges, Van Winckel, & Starkes, 2000; Unierzyski, 2003) suggest that the moment of specialisation, tournament experience and the maturity status of players influence tournament performances at young ages but have a minimal impact on senior performances. Due to the findings of this study which suggest minimal importance of performances at young ages for later success, we suggest that high performance managers and coaches take factors such as the moment of specialisation, tournament experience and the maturity status into account when analysing youth competition results. Also, managers and coaches need to remember that performances are just one of many indicators of later athletic success. For example, research has shown that physical skills, psychological preparation and social support should also be taken into account when analysing youth performances (Abbott & Collins, 2004; Hoare & Warr, 2000; Reilly et al., 2000).

Undoubtedly, there is a need for more research into the combined contribution of the factors and indicators of later success so that more informed talent selection decisions can be made. It is also essential for NTAs to have a tool (or test battery) in place for talent identification that uses a combination of criteria. This tool would have to be developed for different age groups and would need to include various criteria such as physical, mental and tactical skills, and would need to take account of players' ages and development levels. Even though there are examples of NTAs that utilise a combination of competition results and a test battery (e.g., the Flemish tennis federation), they are only used for players under 12 years old. Considering that it is only after the age of 12 that international performances are an important factor for talent selection (Vlaamse Tennis Vereniging, 2010), this study argues for the extended use of test batteries in combination with tournament results until the age of 18 years.

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The similarity of players across the three data sets may be a limitation in this study. The junior rankings and senior rankings are based on tournaments organised by international tennis federations (the ITF, the ATP and the WTA), while the three selected U14 youth tournaments are organised by Tennis Europe. Les Petits As and the French Open accept players from countries that are not members of Tennis Europe. The European championship is the only tournament that only allows players from Tennis Europe member countries. Therefore, it is likely that the sample of U14 youth tournament players might include more European players than would be found in an even distribution of players from all other continents. This is however consistent with general trends that show an imbalance between player representations from each continent in the worldwide junior and senior rankings. For example, MacCurdy (2008) found that in 2008, 80% of the ATP and WTA top 100 players were European. Further research needs to consider variations in talent development and talent selection systems outside Europe.

Another possible limitation in this study might be the range of the years for which data were collected. For example, the selection of male players in the first bottom-up analysis took into account tournament results between 1990 and 2006 and senior rankings between 1992 and 2008 because it takes a minimum of two years after playing a youth tournament to reach the senior top 200. However, most of the 14-year-old players who participated in an U14 youth tournament in 2006 would not have reached a senior top 200 ranking at the age of 16 in 2008.

The findings of this study cannot be generalised across all sports and situations. However, it is likely that the analysis which compares the reliability of U14 and U18 competition results as indicators for later success may be relevant to sports in which athletes specialise at a similar age and which have a similar age of peak performance. More specifically, in sports where the ages for specialisation and peak performance are lower than those in tennis (e.g., swimming, figure skating and gymnastics), it is likely that competition results at U14 and U18 level are better indicators of later success than in tennis. Consequently, it may be appropriate to attach more importance to junior competition results in the talent identification processes for these sports. In contrast, for late specialisation sports and sports where peak performance is delivered at an older age than in tennis, such as judo and cycling, U14 and U18 competition results might have a lower prediction value for later success. Therefore, talent scouts and high performance managers of these late specialisation and late peak performance sports should develop and use talent selection tools such as test batteries.

Each sport has its own physical requirements, and its own competition structures and formats. It is therefore recommended that the importance of youth competition results be examined at a sport-specific level. This sport-specific examination will allow sport directors to determine how important competitions should be in the talent selection process of that particular sport. Similar research in other sports may also allow for comparisons with this study and help further explain the role of competition results as a criterion for predicting later success.

Acknowledgements

Appendix A. Overview of athlete development models

Age markers (left axis): 6 · 10 · 12 · 16 · 18 · 28 (A G E)

Transition model – Bloom (1985)

- **Early Years / Initiation**
  - Introduction to activities
  - Talent identification
- **Middle Years / Development phase**
  - Quantity of training ↑
  - Level of specialisation ↑
- **Later years / Perfection phase**
  - Full-time engagement in the activity
  - Living as a professional performer
- **Maintainance / Mastery / Performance**

Development model of sport participation – Côté (1999, 2003)

- **Sampling years (age 6-12)**
  - Involvement in several sports
  - Intrinsically motivation
  - Self-efficacy
  - General physical and cognitive skills
- **Specialising years (age 12-15)**
  - Involvement in 1 sport↑
  - Balance of deliberate practice and play
- **Investment years (after age of 16)**
  - Focus on 1 activity
  - Sport specific deliberate practice

Development Model of Sport Participation – Côté & Fraser-Thomas (2007) — Entry into sport (age 6)

- **Sampling years (age 6-12)**
  - Recreational participation through sampling
  - Elite performance through sampling
    - Deliberate play ↑
    - Deliberate practice ↓
    - Involvement in several sports
- **Early Specialisation (age 6-18)** — Elite performance through early specialisation
  - Deliberate practice ↑
  - Deliberate play ↓
  - Focus on 1 sport
- **Specialising years (age 12-15)**
  - Deliberate play and practice balanced
  - Reduce involvement in several sports
- **Recreational years (age 12-18)**
  - Activities that focus on fitness and health
  - Deliberate play ↑
  - Deliberate practice ↓
- **Investment Years (age 15-18)**
  - Deliberate practice ↑
  - Deliberate play ↓
  - Focus 1 sport
- Recreational participation – Physical health ↑ – Enjoyment ↑
- Elite performance – Physical health ↑ – Enjoyment ↑
- Elite performance – Physical health ↓ – Enjoyment ↓

LTAD – Balyi (2001)

Late specialisation:
- **FUNdamental (age 6 - ♂9 - ♀8)**
  - Fun and participation
  - Agility, Balance, Coordination speed
- **Learning to train (age ♂9-12 - ♀8-11)**
  - Fundamental sport skills
- **Training to train (age ♂12-16 - ♀11-15)**
  - Gen. physical condition
  - FUNdamental technical skills
- **Training to compete (age ♂16-18 - ♀15-17)**
  - Sport & individual specific physical conditioning
  - Tactical preparation
  - Specialisation
  - Competitive conditions
- **Training to win (age ♂ +18 - ♀ +17)**
  - Maintenance/improvement of physical capacities
  - High performance
- **Retirement**

Early specialisation:
- Each early specialisation sport should develop a sport-specific model
- Training to train
- Training to compete
- Training to win
- Retirement

Long-Term Performance Development in Tennis – Grosser & Schonborn (2002)

- **Versatile basic training (age 4-6/7)**
  - non specific – varied –play
- **Basic training (age 6/7-9/10)**
  - Basic + tennis training
  - Mini tennis tournaments
- **Development training 1 (age 9/10-11/13)**
  - Technique - coordination
  - Limited tournaments
- **Development training 2 (Age 11-/13-14/15)**
  - Technique and tactics
  - International tournaments
- **Connecting training (age 14/15-16/18)**
  - Optimise techniques
  - Competitive training
  - Frequent tournament play
  - Junior + men/women
- **Top Class training (age 16 - 19)**
  - Shorter training periods
  - Tournament participation ↑
  - Grand Slams
  - Professional tournaments
  - Match stimulated training

Development model on transitions – Wylleman & Lavallee (2003)

Athletic level	Psychological Level	Psycho-social Level	Academic / Vocational Level
Initiation	Childhood	Parents, Siblings, Peers	Primary education
Development	Adolescence	Peers, Coach, Parents	Secondary Education
Mastery	Adulthood	Partner, Coach	Higher Education
Discontinuation		Family (Coach)	Vocational training / Professional occupation

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