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Talent identification and promotion programmes of Olympic athletes

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Abstract
The start of a new Olympic cycle offers a fresh chance for individuals and nations to excel at the highest level in sport. Most countries attempt to develop systematic structures to identify gifted athletes and to promote their development in a certain sport. However, forecasting years in advance the next generation of sporting experts and stimulating their development remains problematic. In this article, we discuss issues related to the identification and preparation of Olympic athletes. We provide field-based data suggesting that an earlier onset and a higher volume of discipline-specific training and competition, and an extended involvement in institutional talent promotion programmes, during adolescence need not necessarily be associated with greater success in senior international elite sport. Next, we consider some of the promising methods that have been (recently) presented in the literature and applied in the field. Finally, implications for talent identification and promotion and directions for future research are highlighted.

Keywords: Practice, sport expertise, talent recycling

Introduction
Many youngsters show signs of expert sporting potential. However, only a minority of them will attain international sporting excellence. As Abernethy (2008, p. 1) claimed, "expertise in sport is so highly prized, and so difficult and time- and resource-consuming to attain, that any means that can be found to accelerate the acquisition of expertise and to make skill learning more efficient will be exceptionally valuable to athletes, coaches, officials, and administrators alike". Consequently, as early as the 1950s and 1960s, identifying and nurturing young individuals who might excel in sport in the future has been the preoccupation of national governing bodies, federations, clubs, and coaches (Régnier, Salmela, & Russell, 1993).

Talent identification programmes are designed to identify young athletes who possess extraordinary potential for success in senior elite sport, and to select and recruit them into talent promotion programmes. The purpose of talent promotion is to increase athletes’ potential by means of a variety of institutional measures designed to accelerate talent development (e.g. through additional competition and training opportunities, effective time management, high-profile coaching, scientific and medical intervention, individual funding, and counselling and welfare).

The power struggle between nations to win medals at major international competitions such as Olympics Games and World Championships has intensified. De Bosscher and colleagues (De Bosscher, De Knop, Van Bottenburg, & Shibli, 2006) stated that more countries are winning medals and that more are winning the market share of gold medals. Today, most countries worldwide are trying to develop structures to identify exceptionally gifted athletes at an early age so as to focus available resources on particularly promising individuals and to promote their development in a certain sport (Abernethy, 2008; Güllich et al., in press). This process has led to, among other initiatives, the foundation of specialized organizations like the Child and Youth Sport Schools in Eastern European countries, and other national talent search programmes such as the
Australian Institute of Sport, ASPIRE in Qatar, and the UK High Performance Talent Programme. Such institutions may be significant for tapping a large(r) proportion of potential talent. This process can be considered valuable in particular for sporting organizations in countries with a relatively small population that when compared with “giants” like China, the USA or Russia, can understandably only rely on a small pool of gifted individuals. Altogether, the efforts and resources invested in these programmes have escalated in recent decades. Hogan and Norton (2000) reported a linear relationship between money spent and total medals won at the Olympic Games. They calculated that, for the Australian Government, an Olympic medal corresponded to an expenditure of approximately A$37 million per gold and A$8 million per medal in general.

Although efforts in talent identification and talent promotion originate from the field, they have aroused much scientific interest in recent decades (for reviews, see Durand-Bush & Salmela, 2001; Régnier et al., 1993; Vaeyens, Lenoir, Williams, & Philippaerts, 2008). Researchers and practitioners have made progress in revealing some of the determinants underlying talent identification, talent promotion, and sporting excellence. Nevertheless, predicting and stimulating years in advance the next generation of sporting experts remains problematic.

In this article, we reflect on the theme of talent identification and talent promotion from a practical perspective with regard to the goal of (senior) success in Olympic sports. The focus is on institutionally organized talent identification and talent promotion programmes operated by national governing bodies and sport federations. We highlight some of the conditions during youth at the individual level (i.e. the athlete) that favour the long-term development for later success in senior elite sport. Also, we review institutional programmes designed to facilitate such conditions (talent promotion) and highlight the identification of talents for the corresponding promotion programmes (talent identification).

First, we consider the main principles underpinning talent identification and talent promotion programmes and discuss problems associated with the underlying assumptions. We present data that highlight the low to moderate success ratio of traditional models. In the next section, we highlight important features in youth athletes that are associated with a successful senior career as an Olympic athlete. We then address some of the promising techniques that have been (recently) presented in the literature and applied in the field. The focus will be on mature-age (i.e. post-puberty) talent identification and talent “recycling” models. Finally, implications for talent identification and talent promotion and directions for future research are discussed.

**Traditional talent identification and promotion programmes**

**Early recruitment based on current performance:**

**Economic motives**

In the academic literature in particular, there is limited detailed information on the features of national governing bodies’ Olympic talent identification and talent promotion systems. Few researchers have related contextual (e.g. socio-economic) or structural (e.g. target ages in recruiting, promotional system) characteristics of these programmes to national success in international elite sport (for recent exceptions, see Bernard & Busse, 2004; Güllich et al., in press; Johnson & Ali, 2004; Kuper & Sterken, 2003). An examination of former Soviet Union and East German (Riecken, Wallberg, & Senf, 1993) and present Eastern and Western European (Güllich et al., in press) talent identification systems reveals that practitioners were and are preoccupied with identifying and recruiting gifted athletes at fairly young ages (starting from 6 years or younger, but mostly between 8 and 12 years) to enable a long promotion period until the age expected to reach elite performance. Most models have therefore focused on applying current motor performance and/or competitive success as the main or only selection criterion (for reviews, see Güllich & Emrich, 2006a; Güllich et al., in press). This traditional approach is principally based on economic motives (time, finances).

The time-economic motives originate from the assumptions that: (a) international success in senior elite sport is the result of long-term “linear” careers in one sport discipline; (b) success increases with extended duration of training and competition practice in this sport; and (c) early training onset, early success, early participation, and continuation in promotion programmes will stimulate the development process and subsequently correlate positively with long-term success in senior elite sport (Güllich & Emrich, 2006a). Retrospective descriptive analyses of elite athletes’ practice history profiles across a variety of sports (e.g. field hockey, figure skating, soccer, and wrestling) revealed sizeable training volumes providing descriptive support for the deliberate practice framework (e.g. Ericsson, Krampe, & Tesch-Römer, 1993; Ford, Le Gall, Carling, & Williams, 2008; Helsen, Hodges, Van Winckel, & Starkes, 2000; Helsen, Starkes, & Hodges, 1998; Hodge & Deakin, 1998; Hodges & Starkes, 1996; Starkes, 2000; Starkes, Deakin, Allard, Hodges, & Hayes, 1996; Ward, Hodges, Williams, & Starkes, 2004). According to this theory, the level of attainment in any field is directly and monotonically related to the accumulated amount of deliberate practice in that field. Accordingly, a key
issue is – assuming equivalent “quality” of practice – to have accumulated more hours of deliberate practice than your competitors.

The plea for an early start to deliberate practice extends Simon and Chase’s (1973) 10-years rule. It has been advocated as a “rule of thumb” that a minimum of 10 years (~10,000 h) of deliberate practice is necessary to acquire the skills and experience required to achieve expertise in any domain (e.g. Kalinowski, 1985; MacMahon, Helsen, Starkes, & Weston, 2007; Monsaas, 1985). Ericsson et al. (1993) concluded that the start of target-oriented, purposeful training at an early age led to a higher accumulated training volume and performance advantage at any stage of life, making it difficult for those who started specific training later to reach the same level of attainment.

The time-economic approach aims to accelerate talent development processes by extension (additional training, provision of coaches and facilities, increment of load tolerance through medical and paramedical interventions, time management in cooperation with schools) and intensification of training time in the targeted sport discipline (increment of success gain per investment unit, for example, through high-profile coaching and sports science support). This is reflected in financial-economic motives enforcing the investment of limited resources on the development of only a select number of promising youngsters, enabling the processing of higher amounts of resources per capita.

However, several constraints question the authenticity of these economic motives and their relation to the effects of talent identification and talent promotion programmes. First, several researchers have shown that the age at onset of training and competition varied markedly among successful senior athletes in some sports (e.g. Carlson, 1997; Deakin & Cobley, 2003; Hill, McConnell, Forster, & Moore, 2002; Van Rossum, 2000). The Athens 2004 Olympic organizing committee collected data for its standardized athlete portraits. Güllich (2007) analysed the data of 4455 Olympians who reported their age at onset of training in their main sport. Some example data from sports with the highest numbers of participants are presented in Figure 1. Although athletes in sports such as swimming and field hockey reported a fairly young age at training onset, the data suggest that the initial age of discipline-specific practice varies markedly between and within many Olympic sports and that a considerable proportion of international athletes began training after the traditional “timing” of talent identification (i.e. 8–12 years), implying that for many Olympic sports specific training from an early age is not an indispensable precondition for later senior success.

Similarly, experiences from the Australian Institute of Sport highlight that the attainment of sporting excellence can occur in fewer years of discipline-specific practice than suggested by the 10 years “rule of thumb”. Gülbin and colleagues investigated the developmental rates and pathways of Australian high-performance athletes via a retrospective questionnaire (Gülbin, 2006; Oldenziel, Gagné, & Gülbin, 2004; Oldenziel, Gülbin, & Gagné, 2003). In total, 681 scholarship holders recalled events, experiences, and key catalysts that influenced their development at well-defined competition phases. For 459 respondents who had represented Australia at either junior (<23 years) or senior level, the average period of development from novice (i.e. first experience in scholarship sport) to expert (i.e. senior national representation) was 7.5 ± 4.1 years. While many athletes have practised their main sport over relatively long periods, a considerable number of athletes attained expertise in their current main sport within relatively short time frames (Table I). For each of the sport disciplines represented in Figure 1, the 2004 Olympic athletes’ age of training onset exhibited pronounced negative correlations with the time lag before making their international championship debut ($r = -0.63$ to $r = -0.83$, $P < 0.01$; shooting $r = -0.32$, $P < 0.05$).

Second, many international athletes have not progressed through “linear” sport careers exclusively within one discipline, but have practised multiple sports during childhood and adolescence (Baker, Côté, & Abernethy, 2003; Baker, Côté, & Deakin, 2005; Carlson, 1997; Côté, Baker, & Abernethy, 2003; Deakin & Cobley, 2003; Hill et al., 2002; Kutschke, 1988; Petlichkoff, 1994; Riecken et al., 1993). The aforementioned studies of Australian

Figure 1. Age at onset of training for main sport among athletes of the Olympic Games in 2004. Note: Numbers in brackets represent mean ± standard deviation (in years) and subsample size (n).

The road to Olympic success
Table I. Age at onset of training in current main sport and involvement in other sports by national-standard Australian athletes: Comparison of two groups with especially short (<4 years) and long (≥10 years) accumulated periods of specific practice in their main sport (data from Oldenziel et al., 2004).

<table>
<thead>
<tr>
<th></th>
<th>≤4 years (n = 72)</th>
<th>≥10 years (n = 78)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age when began main sport</td>
<td>17.1 ± 4.5</td>
<td>7.9 ± 2.5***</td>
</tr>
<tr>
<td>Number of sports</td>
<td>3.3 ± 1.6</td>
<td>0.9 ± 1.3***</td>
</tr>
<tr>
<td>before taking up main sport</td>
<td>0.2 ± 0.5</td>
<td>2.4 ± 1.8***</td>
</tr>
</tbody>
</table>

Significant group differences: ***P < 0.001.

athletes addressed the number of sports practised and its relation to the age of training initiation and total period of discipline-specific practice in the athlete’s current main sport (Gulbin, 2006; Oldenziel et al., 2003, 2004). While these data do not address a relationship between success achieved in one sport and practice in other sports, the authors observed that between two groups of athletes with particularly long and short accumulated periods of specific practice in their current main sport, the latter athletes had mostly started practice in this sport at a later age but had been involved in a greater number of sports before. These data are presented in Table I.

Third, traditional talent identification programmes seldom recognize the distinction between finding out what characterizes a champion and the qualities required to become a champion (Geron, 1978). The accuracy of the early identification of exceptionally gifted children is restrained by the influence of large inter-individual variations in practice history profiles and (biological) maturity on adolescent performance outcomes (e.g. Baxter-Jones, Goldstein, & Helms, 1993; Malina, 1994; Malina, Bouchard, & Bar-Or, 2004; Pearson, Naughton, & Torode, 2006). It is noteworthy that boys who are advanced in biological maturity status are often more successful in adolescent sport, whereas the opposite is the case for girls. In addition, children born early in the selection year presumably have an advantage in stature and/or performance over peers who are relatively younger. The former are also more likely to be selected for teams and promotion programmes. This phenomenon is labelled the “relative age effect” (i.e. the skewed birth date distribution favouring individuals born in the initial months of a selection year; see Musch & Grondin, 2001). It is also evident that different sports favour different types of athletes and that some form of implicit sport-specific selection occurs during childhood (Bass et al., 2000; Baxter-Jones, Helms, Baines-Preece, & Preece, 1994; Baxter-Jones, Helms, Maffulli, & Preece, 1995; Le Gall, Carling, Williams, & Reilly, 2008). Continued participation and/or success at youth level in a particular sport would then be related to a combination of sport-specific requirements and an athlete’s physical characteristics associated with maturity status and relative chronological age. However, inter-individual differences in biological maturity are reduced and eventually disappear when all individuals, including athletes, reach adulthood (i.e. maturity). Consequently, height and performance advantages associated with earlier or later maturation during adolescence are reduced and perhaps disappear at older adolescent ages and in young adulthood; maturity-associated variation in body mass, however, may persist (Malina et al., 2004).

Also, some of the relevant attributes for success in senior elite sport may not be apparent until late adolescence, essential conditions for successful performance of the next generation may still be unknown, while new training methodologies, evolving sport characteristics, modifications in competition rules, and innovative technologies may favour different types of athletes (Gulbin, 2008; Régnier et al., 1993; Williams & Franks, 1998; Williams, Lee, & Reilly, 1999). Bloom (1985) concluded that ultimate successful development into world-class athletes was not necessarily preceded by top performances at junior ages. Among the Athens 2004 Olympians (Güllich, 2007), only 44% reported to have made their international competition debut within discipline-specific youth or junior age categories (16.8 ± 2.5 years). The majority (56%) made their first international appearance in the senior age category (22.0 ± 3.1 years). In a study of cycling, 29.4% of elite athletes had participated in junior World Championships, whereas only 34% of the participants in junior World Championships participated in major elite competitions (Schumacher, Mroz, Mueller, Schmid, & Ruecker, 2006). Researchers have previously reported that exceptional success and performance by juvenile athletes appeared to be neither a necessary nor a sufficient prerequisite for later success (Carlson, 1997; De Koning, Bakker, de Groot, & van Ingen Schenau, 1994; Güllich & Emrich, 2006a; Hill et al., 2002).

Efficacy: No empirical evidence to support the traditional approach

A review of the academic literature reveals that few researchers have examined the effects of institutionalized programmes on the development of athletic performance and/or sporting success. Nevertheless, national sporting organizations have acquired analogous data over time (although these documents are mostly discussed and evaluated only internally). Table II represents a schematic overview of findings...
from German and Russian talent identification and talent promotion programmes. In summary, analyses of these systems’ efficacy revealed low to moderate success ratios (Gülich, 2007). These audits suggest that most of the early recruited and supported children never became successful senior elite athletes. Alternatively, many successful senior athletes have not been supported in institutional promotion programmes at a young age. For instance, among the German Olympians in the 2004 and 2006 Games, athletes who entered the promotion programmes of the elite sport schools at later ages were more likely to win a medal.

These findings appear to confirm the doubts previously expressed by other researchers who questioned the efficacy of traditional talent identification and talent promotion programmes in which children are recruited at an early age. There is a growing consensus that traditional models based on pre-pubertal cross-sectional talent identification are likely to exclude many, especially late-maturing, “promising” children from promotion programmes due to the dynamic and multidimensional nature of sport talent (e.g. Abbott & Collins, 2002, 2004; Martinshale, Collins, & Daubney, 2005; Vaeyens et al., 2008). However, it remains unclear to what extent the reported findings at the collective programme level are attributable to implementation inaccuracy and/or programme inaccuracy (inaccurate programme assumptions). Thus, this issue warrants further examination at the individual athlete level. In the next section, we discuss differences and commonalities between the sport participation histories of more and less successful senior athletes.

**Sport biographies of world-class athletes: The “other sports” may make the difference**

Gülich and Emrich (2006a, 2006b; Gülich, 2007) examined the practice history profiles of 1558 German athletes who were recruited for Olympic promotion programmes at some stage in their sport career. More specifically, they explored to what extent and how participation in youth sport and in talent promotion programmes was associated with senior sporting success in Olympic athletes. Methods and preliminary results have been published previously (Gülich & Emrich, 2006a, 2006b). They are summarized here in a condensed form and supplemented by new findings.

In a mixed-longitudinal retrospective design, two samples of 2000 and 2008 members of the national junior and senior squads in all Olympic sports were administered a standardized postal survey in 1999.

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### Table II. Indicators of low to moderate efficacy in talent identification programmes based on early age recruitment (data from national sporting organizations in Gülich, 2007).

<table>
<thead>
<tr>
<th>Reference</th>
<th>Sample and methods</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joch (1992)</td>
<td>FRG: 493 children (6 years) selected in a TID programme, 7-year longitudinal study</td>
<td>After 7 years, only 153 children were still part of the talent promotion programme</td>
</tr>
<tr>
<td>Rost et al. (1989)</td>
<td>FRG: 131 children (10 years) selected in a TID programme, 2-year longitudinal study</td>
<td>Within 2 years, the group was reduced to 32 members</td>
</tr>
<tr>
<td>Riecken et al. (1993)</td>
<td>GDR: 20,100 children (10–13 years) selected in child and youth sport schools, 1-year follow-up</td>
<td>25% of the recruited talents were relegated after their first year in a promotion programme</td>
</tr>
<tr>
<td>Riecken et al. (1993)</td>
<td>GDR: 48 Olympians (Seoul 1988) in 12 sports, retrospective research of former TID data</td>
<td>Only 20 athletes completed the selection criteria for admission to child and youth sport schools at age 9–10 years</td>
</tr>
<tr>
<td>Kupper &amp; Wallberg (1978)</td>
<td>GDR: 120 young wrestlers (13 years) selected in child and youth sport schools, 9-year follow-up</td>
<td>5 of the wrestlers recruited participated in national senior championships, 115 never did</td>
</tr>
<tr>
<td>Gülich et al. (2001), Emrich et al. (in press)</td>
<td>FRG: 4972 squad athletes, 7 Olympic sports, 7-year longitudinal study with recording of squad status and yearly level transitions</td>
<td>0.3% of the athletes selected in the youngest level of the federations’ squad system for Olympic preparation eventually became one of the 10 best international senior athletes</td>
</tr>
<tr>
<td>Ljach (1997)</td>
<td>RUS: Retrospective review on child and youth sport schools, 35,000 members</td>
<td>0.14% of the children involved achieved sporting excellence at senior level</td>
</tr>
<tr>
<td>Gülich et al. (2005)</td>
<td>FRG: 11,287 members of elite sport schools, 3-year longitudinal study</td>
<td>1.7% of former members of elite sport schools obtained a medal in an international senior championship</td>
</tr>
<tr>
<td>Gülich et al. (in press)</td>
<td>140 Olympians (2004 and 2006) from elite sport schools, retrospective study</td>
<td>Overall recruitment age in the elite sport schools is 11.2 ± 1.7 years compared with 13.9 ± 2.2 years for (later) Olympic athletes. Non-medallists were recruited at age 13.3 ± 1.9 years, the medallists at 15.4 ± 2.0 years. None of the Olympians recruited up to 12 years attained a medal, while 18% of those recruited at 13–15 years and 56% of those recruited later did</td>
</tr>
</tbody>
</table>
and in 2002. The return rate was 38.9%. Only senior athletes (above discipline-specific international junior age, \( n = 680 \)) were considered for the present report. Table III describes the sports proficiency of the sample.

The respondents provided information concerning their history profiles of the age-related location, volume, intensity, and specialization of their training, competition, success, and institutional support at youth level. While it is accepted that many elite athletes have (training) experience in multiple sports, the role of multi-sport practice for long-term senior success remains a contentious issue (e.g. Côté et al., 2003; Ward et al., 2004). In this regard, there is still a lack of comparison between more and less successful senior athletes across different sports in the literature. In the present study, all variables were measured for the current main sport and for other sports in which the athletes participated. Features of youth sports career were compared between world-class (top ten in Olympic Games and/or World Championships) and national-level senior athletes. The frequency distribution of current scholarship sport disciplines did not differ significantly between the two groups, which consequently had comparable age boundaries of the junior categories.

The analyses revealed five key findings (Table IV):

1. No systematic group differences were observed regarding the age at onset of overall training and competition or total juvenile training intensity.

2. The world-class athletes performed an adolescent training volume and intensity in their current scholarship sport that were comparable to those of the national-level athletes, but the former group’s development in this sport was relatively delayed. World-class athletes started training, competing, and participating in international championships significantly later than their less successful peers (with maximum national senior success). For instance, less senior world-class athletes had already competed before the age of 11 years (16.6% vs. 25.6%; \( \chi^2 = 5.23; P < 0.01 \)) and in the age category 11–14 years (57.8% vs. 72.0%; \( \chi^2 = 11.63; P < 0.01 \)).

3. A higher proportion of the world-class athletes trained (60.9% vs. 48.3%; \( \chi^2 = 8.17; P < 0.01 \)) and competed (47.2% vs. 37.2%; \( \chi^2 = 5.55; P < 0.01 \)) in other sports beyond their current individual main sport and they invested significantly more training time in other sports. They performed approximately every second training session up to 10 years of age and every third training session from 11 to 14 years in other sports, and the total training frequency accumulated during childhood and youth was over 50% larger than among national-level athletes (Table IV).

4. In line with their relatively delayed development in the main sport and their higher participation in other sports, world-class athletes were selected for sport federations’ talent promotion programmes at a significantly older age. The German federations’ talent promotion system involves five consecutive stages: Stages “D”, “DC”, and “C” represent subsequent stages within youth and junior age categories, while stages “B” and “A” are the senior squad categories. In addition to the federations’ discipline-specific support programmes, there are 20 Olympic Support Centres that provide multidisciplinary athlete services (e.g. medicine, physiotherapy, exercise science, biomechanics, psychology, nutrition, and career counselling) for the squad members. Only 46.4% were already selected at the initial “D”

Table III. Description of the sample of German senior squad athletes from all Olympic sports (\( n = 680 \)) by selected characteristics: age, current and juvenile age-specific training volume, and the distribution of current and juvenile age-specific success attained.

<table>
<thead>
<tr>
<th>Current age (years)</th>
<th>Current training volume (h - week(^{-1}))</th>
<th>Juvenile training volume (sessions - week(^{-1}))</th>
<th>Most success</th>
<th>No competition</th>
<th>(&lt;\text{finalist RC})</th>
<th>(&lt;\text{finalist NC})</th>
<th>\text{finalist IC}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>18.9 ± 7.6</td>
<td>( \leq 10) years</td>
<td>( 11-14) years</td>
<td>4.2 ± 2.8</td>
<td>6.6 ± 3.5</td>
<td>4th-10th IC</td>
<td>medal IC</td>
</tr>
<tr>
<td></td>
<td>2.0 ± 2.3</td>
<td>( 15-18) years</td>
<td>4.2 ± 2.8</td>
<td>38%</td>
<td>43%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6%</td>
<td>(&lt;\text{medal NC})</td>
<td>31%</td>
<td>21%</td>
<td>42%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( \text{Note. RC} = \text{regional championship, NC} = \text{national championship, IC} = \text{international championship (Olympic Games, World Championship; also European Junior Championships).} \)
stage (compared with 55.4% of national-level senior athletes; \( \chi^2 = 3.61; P < 0.05 \)). Compared with the national-level athletes (23.9%), a higher proportion of world-class athletes (34.5%) “side-entered” the squad system at the latest juvenile stage “C” \( (\chi^2 = 5.91; P < 0.01) \). For the latter group, the age of recruitment into the athlete service programmes of the Olympic Support Centres was also significantly higher \((19.8 \pm 4.8 \text{ vs. } 18.1 \pm 4.7 \text{ years}; t_{444} = 3.67, P < 0.01)\).

5. In line with Bloom’s (1985) findings, the present data imply that adolescent sporting success does not contribute significantly to explaining or predicting long-term success at senior level. Correlations between the highest success at senior level and the highest success achieved during youth were principally low and negative for the youngest age categories (≤10 years: \( r = -0.10, n = 447, P < 0.05 \); 11–14 years: \( r = -0.09, n = 421, P > 0.05 \)). Even in the 15–18 year age group, there was a low and non-significant correlation \((r = 0.07, n = 475, P > 0.05)\).

These findings (1–5) were supported by a longitudinal design (Gülich & Emrich, 2006b). In this panel study over 3 years involving 121 senior Olympic athletes, a higher training volume in other sports together with a lower volume of involvement in institutional support programmes in 1999 was associated with greater success in 2002. On the other hand, the absolute training volume in the athlete’s current main sport in 1999 did not contribute significantly to explaining differences in success in 2002, whereas a greater proportion of the total training career up until 1999 devoted exclusively to practice in the main sport correlated with less success in 2002.

In conclusion, the present results from German athletes suggest that most senior squad members have commenced practice during childhood, performed sizeable training volumes during childhood and adolescence, and have been included in talent promotion programmes at some stage of their career. However, for the present sample of Olympic athletes, there is no indication that (a) an earlier onset and a higher volume of discipline-specific training and competition or (b) an extended involvement in institutionalized promotion programmes during adolescence is associated with greater success in senior elite sport. Moreover, early participation in competitions and inclusion in talent identification and talent promotion programmes correlated negatively with

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**Table IV. Former juvenile training and competition characteristics of current senior world-class and national-level athletes in Olympic sports (from Gülich, 2007).**

<table>
<thead>
<tr>
<th></th>
<th>World-class</th>
<th>National-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internationally valid discipline-specific junior age limit</td>
<td>18.7 1.1 347</td>
<td>18.6 1.2 222</td>
</tr>
<tr>
<td><strong>Age of onset of . . . (years)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training in general</td>
<td>9.1 3.7 345</td>
<td>8.8 3.7 220</td>
</tr>
<tr>
<td>Competing in general</td>
<td>10.9 3.7 330</td>
<td>10.8 4.2 214</td>
</tr>
<tr>
<td>Training in individual main sport</td>
<td>11.4 4.6 344</td>
<td>10.2 4.1 219</td>
</tr>
<tr>
<td>Competing in main sport</td>
<td>13.1 4.3 326</td>
<td>12.0 4.2 212</td>
</tr>
<tr>
<td>International championship debut</td>
<td>18.0 3.6 337</td>
<td>17.0 3.8 190</td>
</tr>
<tr>
<td>Training in other sport(s)</td>
<td>9.6 5.5 184</td>
<td>8.8 4.7 91</td>
</tr>
<tr>
<td>Competing in other sport(s)</td>
<td>10.8 5.7 143</td>
<td>9.9 4.6 65</td>
</tr>
<tr>
<td><strong>Duration until junior age limit (years)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training in general</td>
<td>9.4 3.5 338</td>
<td>9.9 3.5 217</td>
</tr>
<tr>
<td>Training in individual main sport</td>
<td>7.4 3.9 338</td>
<td>8.6 3.7 217</td>
</tr>
<tr>
<td>Training in other sport(s)</td>
<td>4.5 5.9 309</td>
<td>3.3 4.9 197</td>
</tr>
<tr>
<td><strong>Training volume (number of sessions)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total until age 10 years</td>
<td>391 594 316</td>
<td>428 564 189</td>
</tr>
<tr>
<td>Total at age 11–14 years</td>
<td>832 630 325</td>
<td>785 553 195</td>
</tr>
<tr>
<td>Total at age 15–18 years</td>
<td>1419 833 332</td>
<td>1310 617 209</td>
</tr>
<tr>
<td>Individual main sport until age 10 years</td>
<td>235 685 330</td>
<td>252 358 207</td>
</tr>
<tr>
<td>Individual main sport at age 11–14 years</td>
<td>610 571 328</td>
<td>616 484 206</td>
</tr>
<tr>
<td>Individual main sport at age 15–18 years</td>
<td>1241 840 333</td>
<td>1186 632 213</td>
</tr>
<tr>
<td>Individual main sport until junior age limit</td>
<td>2369 1872 331</td>
<td>2329 1299 202</td>
</tr>
<tr>
<td>Other sport(s) until age 10 years</td>
<td>187 430 272</td>
<td>136 362 166</td>
</tr>
<tr>
<td>Other sport(s) at age 11–14 years</td>
<td>208 380 250</td>
<td>117 273 157</td>
</tr>
<tr>
<td>Other sport(s) at age 15–18 years</td>
<td>153 348 210</td>
<td>63 172 138</td>
</tr>
<tr>
<td>Other sport(s) until junior age limit</td>
<td>631 897 250</td>
<td>410 732 148</td>
</tr>
</tbody>
</table>

\*P < 0.05, **P < 0.01.
long-term senior success. Only the training volume in other sports (beyond the current main sport) displayed significant differentiating effects on later success in senior elite sport.

It is generally accepted that an “early specialization model” is apparent in some sports, such as figure skating, gymnastics, soccer, and swimming (e.g. Caine, Lewis, O’Connor, Howe, & Bass, 2001; Ford et al., 2008; Helsen et al., 1998, 2000; Kalinowski, 1985; Kjendlie, 2007; Starkes, 2000; Ward & Williams, 2003; Ward et al., 2004). For example, Ward et al. (2004) presented data indicating that more and less successful young soccer players differed in the amount of specific but not non-specific practice. However, the data presented here appear to reveal an alternative perspective on talent identification and talent promotion of elite athletes in most Olympic sports. This approach is not well presented in the literature and further effort is required for consolidation and scrutiny of the findings and of potential factors to account for the reported observations. Nevertheless, in the available literature there is support for diversified training in the early stages of development as a possible route to exceptional senior performance in some sports (Baker, 2003). Several researchers who examined the early stages of development in senior elite athletes revealed variable sport involvement during youth in baseball (Hill, 1993), rowing and tennis (Carlson, 1997; Côte, 1999), field and ice hockey, netball and basketball (Baker et al., 2003; Côté et al., 2003), and in studies involving multiple sports (Hill et al., 2002; Oldenziel et al., 2004; Petlichkoff, 1994). Consequently, these authors claimed that early sport specialization as a child does not appear to be a prerequisite for attaining expertise as an adult. The present comparative study extends these findings as the data suggest that among high-performance senior athletes in numerous Olympic sports, sport-spanning training experience is mostly associated with an enhancement of long-term potential.

It can be hypothesized that the German athletes’ cross-over sampling of various sports over a fairly long period: (1) may have increased the probability of matching an exceptional talent with the sport discipline he or she was most talented for (principles of multiple sampling and functional matching); (2) could facilitate the progress in the main sport based on more varied stimuli for motor development and on differential experience in training and competition; (3) may reduce the risk of premature staleness and emotional fatigue; (4) may be associated with a higher level of maturity and persistence in deciding to focus on one main sport at the individual level; and (5) may consequently create and/or maintain a larger total talent pool at the collective level.

New avenues in talent identification and talent promotion

We have offered some tentative, preliminary evidence that in some Olympic sports to be successful at senior level (1) it is not necessary to be included in talent identification/talent promotion programmes from an early age, and (2) it is possible to focus on or switch to a new target sport at a relatively late age and rapidly achieve sporting excellence. Indeed, there are currently a number of successful Olympic (Summer and Winter) “talent crossover” athletes who show that it is possible to make the transition from one sport into the elite level of another (Gulbin, 2008). For instance, former artistic gymnast Yelena Isinbaeva switched at the age of 15 years to pole vault and won a gold medal both at the 2004 and 2008 Olympic Games. There are a few athletes who managed to win Olympic medals in two different sport disciplines. After winning two bronze medals in cycling, Clara Hughes successfully re-oriented her sporting career in 2001 to win three additional medals (including a gold) in speed skating at the 2002 and 2006 Olympic Games. Athens 2004 silver medallist rower Rebecca Romero switched to the individual pursuit event in cycling at 25 years of age. Within 2 years, she became world champion and within 3 years Olympic Champion.

These perceptions have stimulated practitioners to explore alternative strategies to adequately identify and promote sporting experts. At a sport systems level, these observations would suggest the launch of (additional or alternative) institutionalized “mature-age talent identification” and “talent recycling” programmes at later ages. The question arises whether the individually self-organized transitions between sports that apparently underlie the aforementioned results can be systematically used, facilitated, and/or enhanced by virtue of organized programmes (i.e. collective level).

Mature-age talent identification and talent recycling in UK Sport

The structured “recycling” of talented athletes is an area that is under-researched. While the transition of athletes from disciplines attributed to represent “foundation” sports such as gymnastics to sports requiring perceived similar talent attributes like pole vaulting or diving (Malina & Geithner, 1993) is an accepted international practice (for instance, 10 of the 12 Athens 2004 Olympic finalists in female diving had started their sporting career in gymnastics), there appear not to be regularly organized attempts at athlete reassignment across national sport systems or sporting federations. This is surprising, since practitioners would argue that there
are sports that share talent characteristics (skill, physical, physiological, perceptual, cognitive) among their athletes and hence would appear well positioned to benefit from a more formal, organized partnership approach.

With the announcement of the 2012 Olympic Games in London, UK Sport implemented novel recruitment techniques to further enhance the Great Britain talent identification and talent promotion model. Most athletes who are expected to feature in time for London 2012 have been previously identified through more traditional sport-specific talent identification programmes and are known performers in the current world-class Olympic support programmes (Figure 2). However, an international “gap (to podium) analysis” revealed targeted opportunities for success. Through creative promotion programmes, UK Sport identified new (i.e. currently unknown to the high-performance system) gifted athletes who they believe have the potential to achieve international performance standards in time for London 2012 (UK Sport, 2008a). These initiatives represent non-traditional or “smart-track” injection programmes by which talent can enter the world-class system at any age or stage (Figure 2). Building on Australia’s experiences in the 1990s (e.g. Hoare & Warr, 2000), “talent recycling” and “mature-age talent identification” searches are two techniques that have recently been applied by UK Sport. Both focus on the systematic search for additional or re-assigned talents at a fairly late age.

One example is the Sporting Giants campaign, whereby UK Sport, in partnership with three sports, launched an advertising campaign seeking exceptionally “tall” athletic talent (UK Sport, 2008b). The aim was to attract mature-aged athletes into a nationally coordinated three-stage screening process, with a view to short-listing the top 1–2%, and to provide the opportunity to develop medal-winning success in the sports of rowing, handball or volleyball in 2012 and beyond. Prior experience in any of the targeted sports was not a prerequisite for participation in the screening programme. Table V presents a schematic overview of the different selection and promotion procedures.

An October 2008 audit revealed that 48 athletes have continued in the full-time training programme within their respective sports (reduction based on de-selection during multiple re-tests or in a few cases attrition). These represent 4% of the originally assessed cohort and 48% of the athletes recruited into the apprenticeship or “confirmation” phase. Three males were selected to compete at the Beach

Figure 2. Schematic representation of the Talent Identification and Talent Promotion programme structure of UK Sport for London 2012.

Table V. Overview of the selection and promotion procedures of UK Sport’s “Sporting Giants” programme.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Methods</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (February 2007)</td>
<td>Mass, nationwide scale public appeal using a variety of communication media to all athletes throughout the UK who fulfilled the basic criteria: minimum height of 1.9 m for men and 1.8 m for women, aged between 16 and 25 years, and having competed at a minimum regional standard in any sport</td>
<td>&gt;4000 applications of which 3010 met the initial criteria. The athletes’ mean age was 19.6 ± 2.9 years and they recounted to have practised 2.4 ± 1.2 different sports at minimum county competition standard</td>
</tr>
<tr>
<td>2 (May–August 2007)</td>
<td>1245 of the invited 2145 athletes attended the assessment events [i.e. a variety of generic and sport-specific skills and tactics (position-specific), physical and physiological capacities, functional movement and psycho-social analyses]</td>
<td>101 newly recruited athletes were selected into an 8-week apprenticeship programme in handball (15 of 131), rowing (69 of 1131), and volleyball (7 of 77), plus 10 athletes who were assigned to canoeing (fulfilling physiological criteria for rowing but not height)</td>
</tr>
<tr>
<td>3 (Summer–Autumn 2007)</td>
<td>Throughout an intensive apprenticeship phase, athletes were immersed into full-time training programmes while coaches and sports scientists tracked and benchmarked the responsiveness of athletes to these specified training interventions</td>
<td>48 athletes continued in the full-time training programme</td>
</tr>
</tbody>
</table>
success in senior elite sport. Alternative methods such as ‘talent recycling’ and ‘mature-age talent identification’, which have recently been employed in the field, seem to be successful in delivering additional world-class performers in certain sports.

Practice is undeniably paramount for achieving world-class success. However, no difference was observed in the total training volume of German senior national-level and world-class athletes. In this sample, a world-class (top ten in Olympic Games and/or World Championships) athlete’s practice history profile was mostly characterized by: (a) a longer period of “product” development and higher initial investments (later first success); (b) a higher individual contribution in the investments (later inclusion in the support system); (c) a more variable distribution of the individual capital in terms of buffering investment risks (sampling various sports); and (d) a reduced intensity in the main sport over longer periods (delayed training- and competition-related development). These findings are likely to support a more efficient and careful individual investment pattern associated with a longer delay of reward but higher returns in the long term. Consequently, these observations would suggest more attention for structures beyond federations’ talent promotion programmes (e.g. sport clubs, sport promotion) encouraging youngsters to sample various sports (cf. early diversification) and the launch of additional and/or the extension of existing (institutional) talent identification programmes towards the right on the age scale (cf. talent recycling and mature age talent identification).

Organized talent recycling approaches and the multidisciplinary and multi-stage assessment of post-pubertal athletes may have several advantages, both at the individual and collective level.

1. **Second-chance opportunities for athletes.** There may be many post-puberty athletes who do not achieve expertise or who leave their sport due to age, injury or de-selection, but still possess physiological capacities and skills that can be used in other sporting disciplines (Gulbin, 2008).

2. **Improved chance of success.** At a micro level, it is reasonable to assume that talent recycling is of particular interest to elite-level coaches when talent “gaps” in the existing performance “pipeline” are apparent. The presence of alternative entry points can enable a “fast injection” of talent into the promotion programme. At a macro level, talent recycling helps to retain a larger pool of promising athletic talent in the national elite sporting systems and increases the return on former investments that may have already been undertaken, albeit in another sport. “Cluster-sport” talent

**Practical implications and directions for future research**

The identification of athlete potential at an early age is commonly perceived to be advantageous. The belief is that if gifted youngsters are endowed with more and specialized coaching and training at an early stage, this would accelerate their development process and facilitate success in senior elite sport (cf. deliberate practice). However, in this paper we have presented tentative evidence to suggest that an earlier onset and a higher volume of discipline-specific training and competition and an extended involvement in institutional talent promotion programmes during adolescence are not by definition associated with greater success in senior elite sport. Alternative methods such...
identification recruitment drives can be an effective means of maximizing chances of assisting skilled athletes to find a sport of best fit. Talent recycling offers more opportunities for “swaps” over the development cycle and an extensive database of athletes that could potentially “plug talent gaps” in targeted sports.

3. Increased return on investment. As explained earlier, national governments invest substantial amounts of money in talent identification and promotion programmes. Although traditional talent identification and talent promotion is characterized by relatively large numbers of recruited athletes, high expenses over long periods, low success rates, and uncertain programme effects, mature-age talent identification and talent recycling programmes may be associated with fairly low numbers of promoted individuals, much shorter support periods, and apparently higher success rates. Furthermore, from a funding body’s perspective, a scholarship athlete who could not deliver the expected sporting success does not necessarily have to be labelled a “waste of money” if this athlete’s skills can be reallocated to another sport.

4. Reduction of uncertainty in talent identification. These evaluations are less influenced by maturational differences that are largely present among (pre-)pubertal athletes (Vaeyens et al., 2008). Also, adolescents who possess the required characteristics will not necessarily retain these attributes throughout maturation as a number of factors impact upon the development process (Abbott & Collins, 2002; Ackland & Bloomfield, 1996). Working with older athletes offers the opportunity to reduce the period over which success needs to be forecast and accordingly increases prediction accuracy (Vaeyens et al., 2008). If the time window for data extrapolation is reduced, this will reduce or eliminate the unawareness of the impact of determinants of an individual’s sporting potential such as motivation and/or other psychological and socio-cultural factors (Baker & Horton, 2004). This has proven a major shortcoming for traditional talent identification programmes.

In contrast, talent recycling programmes may involve certain restrictions. Subject to age structure, nature of the sport (e.g. maturity and early or late specialization), participant rates, and (inter)national competition depth, some sports are more likely to act as “donor” sports (the original sport an athlete used to practise in, such as artistic gymnastics, figure skating, swimming), while others tend to be “recipient” sports (the destination sport to which an athlete has transferred, such as biathlon, bob-sled, canoeing, rowing, skeleton) (Baker & Horton, 2004; Gulbin, 2008), which made Gulbin (2008) conclude that equal interchange between sports may not always be possible. Similarly, these factors may limit the likelihood of being a maturity age “recipient sport” in a discipline with extensive young-age participation and/or where an early specialization model is perceived to be essential, such as gymnastics or soccer.

A number of questions that have occupied scholars and practitioners over the last decades remain unanswered and new questions have emerged. For example, the question arises as to which mechanisms underlie beneficial long-term effects of athletes’ multi-sport involvement. Does multiple sampling and functional matching at the individual level lead to an enlargement and/or maintenance of a larger talent pool at the collective level? If so, are certain sports more susceptible to “recycled talents” than others? Can predestined “donor” and “recipient” sports be identified? To what extent are such selection effects related to the (culturally determined) popularity, participation rates, competition strength in depth, and/or rigidity and irreversibility of talent de-selection in a sport?

As currently no training concepts for an athlete’s mature-age introduction into a new sport and initial training regime are available, these are conducted mainly based on coaches’ intuition. The question arises as to which way current scientific knowledge and future research can add further value to this process.

While there is empirical evidence that certain skills can be transferred across sporting disciplines (e.g. Abermethy, Baker, & Côté, 2005; Smeeton, Ward, & Williams, 2004), a number of areas require further scrutiny. In future, researchers should examine to what extent the transition from one sport to another is accompanied by a transfer of skills and/or other features, including physiological capacities, cognitive, emotional, motivational competencies, and social support. What are the theoretical mechanisms underpinning potentially existing transfer effects? For instance, (how) are competencies acquired in sport A applied to sport B? Do these competencies facilitate processes or products? Possible scenarios are: (a) beneficial effects of results (e.g. acquired technical or cognitive skills, specific motor capacities, motivational features) from sport A on performance in sport B (product–product); (b) effects of results from practice in sport A on acquisition process in sport B (product–process); and (c) effects of acquisition process in sport A on acquisition process in sport B (process–process). Notwithstanding the existence of skill transfer (cf. scenarios a and b), this theory alone appears to be insufficient to explain the
finding that among many elite athletes spending time on other sports appeared to be more beneficial for success in the long term than investing this time in the main sport. This would suggest that future research should focus on scenario c.

In this context, the issue arises as to whether successful transition is applicable across all forms of sports or whether it is restricted to specific categories (i.e. are there certain combinations of “donor” and “recipient” sports that have more positive effects on performance/success development than other combinations)? In the latter case, to what extent are these restrictions related to the specific performance elements and/or early specialization? More generally, which commonalities and which particularities do different sport disciplines exhibit with regard to conditions during childhood and youth for later success in senior elite sport? How do we know that a gymnast has the potential to become a successful diver or if a sub-elite soccer player can successfully transfer to playing handball? Which criteria can be applied for identifying the athletes predestined for a successful reassignment?

In conclusion, continuing scientific scrutiny of the described questions and close cooperation with programmes operating in the field may be expected to expand scientific knowledge on talent identification and talent promotion and to add value to talent identification and talent promotion practice. As short-term effects of features of juvenile training, competition, and talent promotion can turn into their opposite in the long term (Gülich & Emrich, 2006a), longitudinal studies over fairly long periods (multiple years) will be particularly valuable in advancing our understanding.

Acknowledgements

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