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Late specialization: the key to success in centimeters, grams, or seconds (cgs) sports

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A controversial question within elite sports is whether young athletes need to specialize early, as suggested by Ericsson et al., or if it is more beneficial to follow the path of early diversification proposed by Côté et al., which includes sampling different sport experiences during childhood and specializing later on during adolescence. Based on a Danish sample of 148 elite and 95 near-elite athletes from cgs sports (sports measured in centimeters, grams, or seconds), the present study investigates group differences concerning accumulated practice hours during the early stages of the career, involvement in other sports, career development, as well as determining whether or not these variables predict membership in the elite group. The results clearly reveal that elite athletes specialized at a later age and trained less in childhood. However, elite athletes were shown to intensify their training regime during late adolescence more than their near-elite peers. The involvement in other sports neither differs between the groups nor predicts success. It can be concluded that factors related to the organization of practice during the mid-teens seem to be crucial for international success within cgs sports. Future research should adopt a longitudinal design with means of drawing causal inferences.

The question of how to achieve peak performance is central in elite sports. Researchers within all domains of sport sciences seek insight on which variables and processes lead to winning international medals. Within social sciences, and from a developmental perspective, one of the controversial questions concerns which career path leads to expert performance. Based on the ''Developmental Model of Sport Participation'' (Côté et al., 2007), two ways to reach elite performance are described. The path of *early specialization* focuses on early involvement in the main sport; normally occurring in early to middle childhood, with little or no involvement in other sports. Additionally, the importance of a high amount of deliberate practice is stressed during all ages (Ericsson et al., 1993). Originally, deliberate practice was defined as activities that are specially designed to improve performance, relevant to the particular domain, as well as effortful and not inherently enjoyable (Ericsson et al., 1993). However, Deakin and Cobley (2003) conclude that so far no practice activity in sports has been judged as highly relevant and effortful, while simultaneously scoring low on enjoyment. Moreover, many activities that constitute a normal practice regimen of an elite athlete may not improve performance per se, but rather aim at enhancing required levels in certain domains (e.g. physical training) which collectively leads to increased performance (Ward et al., 2004). Therefore, it is suggested to define deliberate practice in sport in a broader sense than initially suggested by Ericsson et al. (1993), which would include all activities that aim to increase the current performance level. In contrast, the path of *early diversification* postulates that the first years of sport participation should be characterized by the involvement in different sports as well as a high amount of play-like practice that focuses little on deliberate practice activities. After these sampling years, around age 12, the young athlete gradually reduces involvement in other sports and begins focus on the main sport, maturing to a highly deliberate practice regime around the age of 16 (Côté et al., 2007). The two paths will be described in more detail in the next sections.

Elite performance through early specialization

Emerging from Ericsson et al. (1993) theoretical framework, this path postulates that in order to achieve expertise, one must engage in 10 000 h of deliberate practice within the chosen domain. The theory is based on a well-documented, strong, and positive relationship between amount of practice hours and performance found in different domains (e.g. Ericsson et al., 1993). Ericsson et al. (1993) also argue that the accumulation of these practice hours must match sensitive stages of the biological and cognitive development during childhood and adoles-

cence. To optimally exploit these sensitive stages as well as prevent a delay compared with peers that started earlier, it can be hypothesized that an early onset in a given sport is required in order to reach expert performance and to be competitive with other athletes.

There is extensive scientific evidence from different sports that supports a positive relationship between practice hours and expertise level (e.g. Hodges & Starkes, 1996; Helsen et al., 1998; Hodges et al., 2004; Baker et al., 2005a, b; Law et al., 2007).

Although the relationship between practice and performance is one of the most robust in behavioral science (Baker et al., 2005b), criticism arose regarding Ericsson et al. (1993) approach. Firstly, even with many studies revealing that elite performers trained more than near-elite performers, the elite performer failed to accumulate the magic number of 10 000 practice hours (Van Rossum, 2000). Secondly, Baker and Côté (2006) indicate that reducing the development of expertise in sport solely to deliberate practice fails to acknowledge important developmental, psychosocial, and motivational factors of young athletes. Thirdly, there is no consensus that both, early onset and early specialization are required for the development of expertise (e.g. Carlson, 1988; Barynina & Vaitsekhovskii, 1992; Lidor & Lavyan, 2002). For example, the results of Vaeyens et al. (2009) reveal that there is no evidence that an early onset and a higher amount of sport-specific training are associated with greater success at a later stage.

Additionally, a body of research emerged that showed early specialization may lead to negative consequences for the athletes, such as attrition and negative health outcomes (e.g. Côté et al., 2007). Law et al. (2007) found that Olympic-level rhythmic gymnasts who had participated in significantly more training hours in their career rated their health as lower and their participation experiences as less fun, than their peers at the international level. Gould et al. (1996) study revealed that early specialization and highly structured training reduced intrinsic motivation as well as led to higher dropout and burnout among young athletes. Likewise, Wall and Côté (2007) found that ice hockey players who dropped out of sport had began off-ice training earlier than the athletes who continued their participation. This indicates that early-specialized training regimes deemed not inherently enjoyable, may have a detrimental effect on the long-term development of athletic expertise. These results strengthen the assumption that in order to become a highly motivated, self-determined, and committed adult athlete, it is crucial to build a solid foundation of intrinsic motivation at early stages (Deci & Ryan, 2000).

None involved in elite sports will negate deliberate practice as an important pillar for reaching expertise, and the prominence of practice is generally agreed upon in literature (Janelle & Hillman, 2003). However, the risks of an early and intense involvement in sports as well as the evidence for late specializing experts need to be acknowledged. Therefore, it has to be questioned whether or not early specialization is the exclusive path to expertise. It also needs to be investigated if different paths that involve lower risks for the individual can lead to the same outcome (Baker et al., 2005a).

Elite performance through early diversification

Based on the previously mentioned results, the notion emerged that in addition to early specialization, expertise can also be reached through early diversification (Côté et al., 2007).

Two underlying notions exist for that path. From a psycho-social point of view, it can be reasoned that engaging in a variety of different sports allows the young athlete to experience different physical, cognitive, affective, and psycho-social environments (Côté et al., 2009). It is hypothesized that this path promotes the development of intrinsic motivation (Côté et al., 2007), which again serves as the basis for a self-regulated involvement in elite sport at a later stage (Côté et al., 2009). From a performance point of view, it can be hypothesized that experiences in different sports provide the young athlete with important abilities. These abilities prove beneficial in the development of sport-specific skills required to reach elite performance in the main sport at a later stage in the career. There is a general assumption that talented athletes can benefit from such a transfer across sports (Williams & Ford, 2008). Baker, et al. (2003) support this view, stating that a transfer of learning occurs from one sport to another, including both cognitive and physical abilities. Current research further suggests that the effect of such a transfer is most pronounced during early stages of involvement (Schmidt & Wrisberg, 2000), corresponding with the timeframe of the sampling years in the ''Developmental Model of Sport Participation'' (Côté et al., 2007). Based on these considerations, it can be hypothesized that involvement in different sports, during at least the early stage of the career, may be beneficial for reaching elite performance in certain sports.

There is evidence that specializing later can be more beneficial for becoming an expert athlete. Carlson (1988) found that elite tennis players specialized later and practiced less than their near-elite peers between the ages of 13 and 15, but intensified their training considerably more after age 15. Likewise, Lidor, and Lavyan (2002) found that elite athletes from different sports began specializing later than near-elite athletes. Nevertheless, the elite

athletes had completed more training hours when they reached their peak performance, indicating that despite their late start, they managed to compile enough hours to perform at the top level. Barynina and Vaitsekhovskii (1992) found that swimmers who specialized early spent less time on the national team and ended their sport career earlier than athletes who specialized later. Güllich's (2007) results showed that early intensification in athletic development does not correlate with long-term success, but that in contrast, particularly successful careers are characterized by a deceleration of practice and competitive development.

Lidor, and Lavyan (2002) results confirms the idea of sampling, finding that 70% of the elite, compared with 58% of the near-elite athletes, performed more than one sport in their early years of involvement. Likewise, Emrich and Güllich (2005) report that both being active in another sport beside the main sport, and starting the sport career in another sport and then switching to the main sport at a later age, is significantly more prevalent in internationally competitive German athletes; this compared with their peers that competed only at a national level. Evidence suggests a beneficial effect of early diversification, not only on the performance level but also on other variables. Baker and Coté (2006) state that deliberate play, defined as sport activities that are intrinsically motivating and provide gratification and enjoyment, as well as sampling in the early years of sport participation may lead to more enjoyment and a lower frequency of dropout, which indirectly contribute to the attainment of a high level of performance in adult years. Moreover, they report that athletes that sample and diversify in their young years may be at less risk for injuries than their peers that specialized early.

However, doubts concerned sampling being inherently beneficial for all young athletes arose: several authors questioned whether or not early diversification is applicable to all sports (Baker, 2003; Williams & Ford, 2008), and Côté et al. (2009) conclude that early diversification is not beneficial for athletes in sports where peak performance occurs before full maturation, such as gymnastics. Emrich and Güllich's (2005) study also confirms this assumption.

Career development stages

In addition to the above-mentioned ''Developmental Model of Sport Participation'' (Côté et al., 2007), another approach to analyze athletes' career development exists and will supplement the theoretical background of this study. This approach takes into account the age at which athletes pass through different transitions. Based on Bloom's (1985) stages of talent development, Wylleman and Lavallee (2004) designed a model that focuses not only on the athletic but also on the psychological, psychosocial, and academic and vocational development of athletes. They describe three transitions that occur during a sport career: a transition into organized sport (entering initiation stage), a transition to a more intense level of training and competition (entering developmental stage), and a transition into the elite level (entering perfection stage). Along with suggesting time frames when athletes typically go through these transitions, Wylleman and Lavalee (2004) also stress the idea of sport-specific differences, which have to be taken into account when investigating career development.

Sport specificity in career development

Based on the results above, it is expected that sports with a focus on different capabilities (physical, technical, tactical) are unique in their career development and should therefore be analyzed separately. Emrich and Pitsch (1998) propose that sports sharing similar structural conditions will lead to similar career paths. Therefore, the present study's focus is solely on athletes involved in cgs sports (sports that are measured in centimeters, grams, or seconds; Güllich, 2007). Cgs sports have a high focus on physical capabilities, with lower requirements on technical and tactical factors. However, Anderson and Twist (2005) conclude that adaptations to aerobic training occur in childhood, but seem to be blunted when compared with the adaptions to the same training load in adolescence, making it irrelevant to enter and specialize at an early age in these sports.

Aim of the study

The aim of this study is to gather and compare data on the careers of elite and near-elite athletes in cgs sports. The first step will be to investigate if there are differences between elite and near-elite athletes concerning variables related to career development. The second step aims to detect variables that predict membership in the elite group.

Based on the above-mentioned reflections on the cgs sport category, the following hypotheses were formulated.

Hypothesis pertaining to group differences

Owing to the considerations concerning sport-specific requirements in cgs sports, the following hypotheses were formulated. Elite athletes specialize more intensely than near-elite athletes from adolescence onward, which is hypothesized to result in a higher amount of accumulated practice hours at age 18 (H1.1) and 21 (H1.2). Likewise, elite athletes are

younger than their near-elite peers when they enter the perfection stage (H1.3). Moreover, it is hypothesized that elite athletes spend more years on the senior national team (H1.4). The remaining investigated variables are not expected to differ in the current sample because of the requirements of cgs sports and the trainability of physical factors in young age.

Assumptions concerning predictive function of career variables

It is assumed that variables related to accumulated practice hours, engagement in other sports, initiation of different stages, first national and international competition, as well as junior and senior national team membership significantly predict the membership in the elite group.

Method

Design

Identifying the means to distinguish between elite and near-elite athletes based on exposure to practice activities, could help to gain information on how to reach high-level athletic performance (Williams & Ford, 2008). Many studies dealing with talent development and expertise have been conducted with a retrospective design, based on the seminal work of Bloom (1985). Even though this design bears methodological risks (e.g. recall bias, see Hodges et al., 2007), it can provide interesting and meaningful insights into the early experiences of elite and near-elite athletes when there are not enough resources for a longitudinal study. Based on the above considerations, the present study adopts a cross-sectional, retrospective design.

Procedure

A link to a web-based questionnaire was emailed to the target group. This design seemed most suitable for a sample with young persons. Web-based studies allow participants to individually choose when they want to answer and they are also a low-cost method for obtaining responses from participants living in different parts of the country (Shaugnessy et al., 2006). Before beginning the questionnaire, the athletes were informed about the content and the aim of the research project, as well as being told that all data would be treated with confidentiality and that participation was voluntary. After 6 weeks, a retest was sent to the participating athletes, with the goal of checking the validity of various variables. In order to enhance response rate, reminders were sent out by mail and/or SMS after both surveys. To further check the validity of the data, some of the participants who simultaneously took part in an interview study, were on that occasion asked the same questions again, offering the unique opportunity for an additional validity check 4 months after data collection.

Sample

All athletes that were registered in *Team Danmark's* (Team Danmark is the organization that handles overall planning of elite sports in Denmark through financial and instrumental support to sport-specific federations and athletes. Support is given to the sport federations, who in turn decide which athletes they want to support. This support is strategic, i.e. mainly based on the sport-federation's evaluation of the athlete's potential to win medals in international competitions.) database, and who were either supported in the year of the survey (2009) or had been supported within the last 6 years, were contacted.

Data of 243 Danish athletes from cgs sports could be sampled. The "elite" category ($n = 148$) was defined by placing top 10 at a championship at the world level (e.g. World Cup, Olympics) or by winning a medal at a championship at the European level (e.g. European Championship) on a senior level. In order to eliminate an age bias, athletes up to the age of 21, who had won a medal at the junior championship at the world level were categorized as elite. Athletes who failed to meet one of these criteria were labeled as near-elite athletes ($n = 95$). Table 1 displays the distribution of sport and success level in the sample. One hundred and sixty-one athletes were currently active at an elite/near-elite level in their main sport, while 82 athletes had retired before the survey being conducted. The mean age for the 96 female and 147 male athletes was 24.5 years ($SD = 7.5$), ranging from 13 to 51 years of age. The relatively high age of some the athletes is due to the sample including retired athletes, as well as there being some sports that have a relatively high age of peak performance (e.g. sailing).

Instruments

The questionnaire gathered information about the following topics (a copy of an English translation of the questionnaire can be requested from the first author):

1. *Biographical information*
2. *Practice hours in the main sport*: the athletes had to report how many hours they trained on average per week for every year in their main sport, starting with the actual year and then working backward (see Hodges et al., 2007). In order to best adhere to the definition of deliberate practice in sport, they were asked to include all forms of training (technical, physical, mental) in their main sport as well as competitions in this calculation. The accumulated amount of practice at age 9, 12, 15, 18, and 21 was calculated based on this question.
3. *Involvement in other sports*: the athletes were asked to state all additional sports they were involved in during their career; indicating which sport they were engaged in and how many months they practiced in for the respective sport.
4. *Career development*: the athletes reported the age at which they entered the "initiation stage," the "developmental stage," and the "perfection stage" (Wylleman & Lavallee, 2004); at what age they participated in their first national and

Table 1. Description of the sample

Sport	N_{total}	n_{elite}	$n_{near\text{-}elite}$
Canoeing/kayak	12	11	1
Cycling	34	28	6
Orienteering	17	6	11
Rowing	40	35	5
Sailing	39	23	16
Skiing	1	1	0
Swimming	55	24	31
Track and field	33	11	22
Triathlon	11	8	3
Weightlifting	1	1	0
Total	243	148	95

international competition, and how many years they were a member of the junior and senior national team.

5. *Weekly training schedule*: for data validation purposes, the athletes were asked to report their average training schedule for every weekday during the current year, or alternatively, for the last year they were involved in their main sport at an elite level.

6. *Athletic success*: the athletes were asked to state their results from different international competitions at junior and senior levels.

Data analyses

Missing data present a challenge in research (Tabachnick & Fidell, 2007). In the present study, due to the length of the question about the practice hours in the main sport, there was a relatively high amount of missing values from that question. Because this information was the heart of the project, it was decided to not estimate the missing data.

Outliers were detected and then adapted to a more appropriate value; this value was based on the *z*-value as well as through discussions within the author team, as suggested by Tabachnick and Fidell (2007). Fifteen participants had between one and three outliers, resulting in a total of 20 values that had to be adapted.

After gathering data from the main survey and the two re-tests, correlations were performed to analyze the validity of the data on practice hours in the main sport. Because data can be biased, and checking the data before analyzing seems indispensable, correlations were performed retrospectively.

In order to investigate differences between the elite and the near-elite sample in terms of the variables related to practice hours in the main sport, involvement in other sports, and data on career development, two-tailed *t*-tests were conducted with the significance level set at 0.05. Owing to well-known problems in testing the null hypothesis (Cohen, 1994), the confidence intervals of the means and the power will be added in order to gain a more detailed overview.

A logistic regression was performed to investigate whether or not practice hours in the main sport, involvement in other sports, and data on career development (IV's) predicted membership in the elite athlete group (DV). Because there were no hypotheses on the order of importance of predictor variables, the enter method was chosen. Assumptions regarding the distribution of the predictor variables are not required for logistic regressions (Tabachnick & Fidell, 2007).

Results

Owing to the equal distribution of males and females in the two groups ($\chi^2 = 0.44$, $df = 1$, $P = 0.51$), the main analyses were conducted with the whole sample.

Validation of the data

Data validation of the practice hours during the career occurred with three different measures. (1) A correlation was performed between two measures, given in separate sections of the questionnaire that aimed at gathering the same information (e.g. the amount of weekly training in the data on practice hour's history and the information about the average training amount per week from the same year). The correlation between these two measures was 0.70 ($N = 459$). (2) The average result of the written re-test (4 weeks after the data collection) over the seven different time points was 0.75 for the weekly training amount. (3) The results of the re-test gathered during the interview study with 16 athletes (4 months after the data collection) showed a correlation of 0.74 for the weekly training amount. All correlations can be categorized as strong (Brace et al., 2009). Additionally, analyses revealed that the correlations in the elite and the near-elite athletes (elite athletes: 0.76, near-elite athletes: 0.74) did not differ, indicating that the two groups have a similar level of recall.

Group differences

T-tests reveal significant differences between the elite and near-elite athletes in 11 of 20 variables (Table 2). Concerning the data on practice hours in the main sport, the results show that the near-elite athletes have accumulated significantly more training hours as early as age nine, and continue to complete more hours through early adolescence until age 15, with effect sizes that can be considered to be moderate ($0.45 \leq d \leq 0.50$; Cohen, 1969). At age 18, the accumulated amount of practice hours for the two groups is roughly the same. After age 18, the elite athletes complete more hours, showing a significant difference by age 21 from the near-elites, whose training increase has not developed that intensively. However, elite and near-elite athletes do not differ in involvement in additional sports. The following results can be found regarding different variables about career development. Elite athletes state that they pass important steps within their career (e.g. starting sport, participation at first competition, etc.) at a significant older age than the near-elite athletes ($0.40 \leq d \leq 0.63$). Moreover, the elite athletes spend significantly fewer years on the junior national team ($d = 0.27$), but more years on the senior national team ($d = 0.97$).

Prediction of group membership

In a first logistic regression, six variables (membership in junior national team, membership in senior national team, age, and training accumulated at age 12, 15, and 18) were significant and were thus re-entered in a second logistic regression. In this analysis, a total of 175 cases were analyzed and the full model significantly predicted membership in the elite group ($\chi^2 = 91.51$, $df = 6$, $P < 0.001$). The model accounts for between 40.7% and 54.6% of the variance of the membership in the elite group. Overall, 81.7% of group predictions are accurate. Table 3 illustrates coefficients, the Wald statistics, and the associated degrees of freedom, probability values, as well as confidence intervals for each predictor vari-

Table 2. Comparison between the elite and the near-elite group on data about practice hours, involvement in other sports and data on career development (Means, confidence intervals, mean differences, effect sizes and power)

Scale	Elite			Near-elite			*T*	*df*	*p*	|*d*|	*Power*
	n	*M*	*CI*	*n*	*M*	*CI*					
Accumulated amount of practice at age 9	99	113.98	61.57; 166.39	76	272.32	187.31; 357.32	3.11	129	<0.05	0.50	0.56
Accumulated amount of practice at age 12	99	584.61	410.15; 759.07	76	1063.41	832.29; 1294.53	3.31	173	<0.05	0.50	0.47
Accumulated amount of practice at age 15	99	1854.93	1481.53; 2228.33	76	2699.99	2278.57; 3121.41	2.94	173	<0.05	0.45	0.51
Accumulated amount of practice at age 18	99	4106.16	3507.46; 4704.86	76	4192.94	3664.33; 4721.55	0.21	173	0.83	0.03	0.49
Accumulated amount of practice at age 21	99	6334.81	5539.19; 7130.43	76	5204.71	4630.65; 5778.77	−2.26	167	<0.05	0.33	0.46
Months of involvement in other sports	148	62.97	47.65; 78.29	95	62.00	44.38; 79.62	−0.08	241	0.94	0.01	0.94
Number of other sports	148	1.57	1.30; 1.84	95	1.42	1.11: 1.73	−0.69	241	0.49	0.09	0.58
Entering Initiation stage	143	11.71	10.83; 12.59	94	8.55	7.65; 9.45	−4.74	235	<0.05	0.63	0.49
Entering Development stage	144	15.11	14.38; 15.84	95	12.87	12.03; 13.71	−3.88	237	<0.05	0.51	0.46
Entering Perfection stage	143	18.38	17.58; 19.18	87	16.30	15.38; 17.22	−3.28	228	<0.05	0.45	0.57
First national competition	148	14.53	13.71; 15.35	95	12.42	11.58; 13.26	−3.34	241	<0.05	0.44	0.51
First international competition	147	17.37	16.53; 18.21	87	15.43	14.59; 16.27	−3.21	215	<0.05	0.40	0.44
Years in junior national team	148	2.37	2.08; 2.66	95	2.93	2.46; 3.40	2.07	241	<0.05	0.27	0.50
Years in senior national team	148	4.54	4.01; 5.07	95	1.62	1.13; 2.11	−7.90	237	<0.05	0.97	0.98

Table 3. Results of the logistic regression with data on practice hours, involvement in other sports and career development as predictor and athletic success as dependent variable

Variable	Coefficient	SE	Wald	df	*P*	Exp(*B*)	Confidence interval	
							Low	High
Membership Junior National Team	−0.54	0.14	15.74	1	<0.001	0.59	0.45	0.76
Membership Senior National Team	0.44	0.11	16.04	1	<0.001	1.56	1.26	1.94
Age	−0.08	0.05	2.13	1	0.14	0.93	0.84	1.02
Training up to age 12	0.00	0.00	1.42	1	0.23	1.00	1.00	1.00
Training up to age 15	0.00	0.00	16.31	1	<0.001	1.00*	1.00[1]	1.00*
Training up to age 18	0.00	0.00	24.05	1	<0.001	1.00*	1.00[1]	1.00*

*These values have been rounded to 1.00, but do reflect a significant result and no confidence interval includes the exact number of 1.00.

able. The values of the coefficients reveal that a shorter membership on the junior national team, an additional year on the senior national team, less accumulated practice hours at age 15, as well as more accumulated practice hours at age 18 significantly predict international success.

Discussion

Investigating the career development of Danish elite and near-elite athletes in cgs sports has provided interesting results. A general trend can be seen that elite athletes in cgs sports specialize later in their career than near-elite athletes; contrary to hypothesis H1.3, the near-elite athletes pass through all three transitions at a significantly earlier age than the elite athletes. Moreover, the elite athletes have their first national and international competition at an older age. This finding is in line with the results of other studies investigating different sports: e.g. Emrich and Güllich, 2005; Vaeyens et al. 2009, who also report a relatively delayed development of the more successful athletes compared with their less successful peers. Similarly, the elite athletes spend fewer years on the junior national team, but according to hypothesis H1.4 they spend more years on the senior national team. As seen in the data on the accumulated practice amount, near-elite athletes spend more hours practicing at a young age. However, this trend seems to reverse itself in late adolescence: at age 18, elite and near-elite athletes have accumulated roughly the same amount of practice, thereby rejecting hypothesis H1.1. However, elite athletes intensify their training more after this time point, and report having accumulated more training hours at age 21, thereby confirming hypothesis H1.2. As assumed, there are no differences in the current sample regarding the amount and time spent in other sports. This finding contradicts previous results that revealed successful athletes to have had more experiences in additional sports (e.g. Vaeyens et al., 2009).

The results found in the group comparison were further strengthened by the logistic regression, where four variables significantly predict the membership in the elite group. Accumulating more training hours at age 15 and spending more years on the junior national team (both measures of early specialization) negatively predict membership in the elite group. On the other hand, variables that measure high involvement at a later career stage, namely, training hours at age 18 and years of membership in the senior national team, positively predict the membership in the elite group.

Even though the results found in the present study are comparable with results found elsewhere, it has to be kept in mind when making inferences that the sample of the present study consists of athletes from different sports. Because some sports consist of either more elite or more near-elite athletes, a sport-specific bias in the results cannot be excluded. Therefore, the present results should be considered as a general trend for sports that are measured in centimeters, grams, or seconds and sports that put the main focus on physical capabilities. If one wants to make inferences for a single sport, it is absolutely necessary to conclude sport-specific analyses, which could not be analyzed in the present study due to too small cell sizes.

The results of the present study confirm other studies investigating different sports, (e.g. Carlson, 1988; Emrich & Güllich, 2005; Güllich, 2007), which also report that elite athletes intensify their training regimes at an older age than their near-elite peers. Strengthening this approach of late specialization, a recent publication of Côté et al. (2009) postulates, among others, that late adolescents have developed the physical, cognitive, social, emotional, and motor skills needed to invest their effort in a highly specialized training regimen in one sport.

Considering the ''Developmental Model of Sport Participation'' (Côté et al., 2007), our results cannot fully confirm either of the two paths. Regarding the early specialization approach, the current results support the underlying assumption that elite athletes complete more practice hours than near-elite athletes. After age 18, the elite athletes report more practice hours than the near-elite, thus confirming the positive relationship between practice hours and performance level found in the literature (see introduction). In contrast, the assumption that late specialization can lead to a delay in athletic development that cannot be made up at a later stage cannot be supported. The current results clearly indicate that career planning with less training at early ages and specialization later seems more beneficial for young athletes in cgs sports. The findings of the study confirm the idea of late specialization of one sport, as suggested in the early diversification path postulated in the ''Developmental Model of Sport Participation'' (Côté et al., 2007). However, the results concerning involvement in different sports do not confirm the proposed advantage of sampling several sport experiences. The groups do not differ in the number of other sports, or in the number of months involved in other sports, and the two variables have no predictive value. Baker et al. (2005a) found a similar result in triathlon, a sport that can be classified as a cgs sport. The idea of sampling a wide variety of motor experiences at a young age does not seem to have a beneficial impact on athletes from cgs sports. It can be hypothesized that this has to do with the demands that are placed on athletes in these sports: cgs sports require great physical effort, but are not as complex as e.g. gymnastics or ice-skating, nor do they place the same demands on tactical or decision-making processes as team or racquet sports. It can be hypothesized that the skill transfer of physical capabilities does not have an important effect on the development of expertise, and therefore sampling different sport experiences does not seem to be crucial for athletes involved in cgs sports.

Limitations of the study

Even though interesting results emerged from the present study, the following limitations must be considered when making inferences.

(1) The use of retrospective data collection, which is commonly considered to be prone to recall inaccuracies (Hodges et al., 2007), could have led to distorted data. However, retrospective investigations will remain the main source of information about the acquisition of high elite performance as long as it is not possible to accurately foresee which athletes will succeed on their way to the top (Côté et al., 2005). Several steps to validate the data were taken to check for biases, revealing satisfying results that are comparable with those from other studies (Helsen et al., 1998; Hodges et al., 2004). Additionally, Côté et al. (2005, p. 16) concluded that ''athletes were able to accurately recall many aspects of their development even after decades had elapsed.'' It can be hypothesized that training activities played such an important part in the athletes' lives that they recall accurate numbers.

(2) It has to be considered that due to the cross-sectional design of the study, conclusions cannot be made about the causal effect of practice. To address this flaw, longitudinal studies need to be conducted in the future.

(3) In the current study, no information concerning the content of practice was gathered. Therefore, conclusions cannot be drawn about the importance of play-like training activities (e.g. deliberate play;

Côté et al., 2007), or about the importance of different forms of training activities (e.g. solitary vs. group practice; Ericsson, 2003). Therefore, it cannot be completely excluded that some athletes experienced a multifaceted training and had opportunities to sample different sport experiences during the practice hours in their main sport.

(4) Likewise, no information on the quality of training is available. Therefore, it cannot be assumed that the reported practice hours solely consist of what Ericsson et al. (1993) consider as deliberate practice; characterized as a highly structured activity that aims at further improving one's current performance level.

(5) When making conclusions, it has to be kept in mind that (even with trying to correct for an age bias) there exists a slight advantage for older athletes to be categorized as elite athletes. For future research, it is recommended to select participants within a more similar age range.

(6) Likewise and as mentioned earlier, it cannot be excluded that a sport-specific bias exists due to the heterogenous distribution of elite and near-elite athletes in the different sports. Further research may want to focus on a single sport, which would allow for sport-specific conclusions to be drawn.

Perspectives

The present study reveals that elite athletes specialize later than near-elite athletes, supporting numerous studies within the domain (e.g. Vaeyens et al., 2009). However, elite athletes start to intensify their engagement much more in late adolescence, resulting in a higher number of accumulated training hours in early adulthood. This confirms the idea of Ericsson et al. (1993) that experts sample more training hours during their career than their less successful peers. Another finding reveals that the involvement in other sports does not provide an advantage on the way to athletic expertise. Although this finding contradicts other studies (e.g. Lidor & Lavyan, 2002), it seems appealing considering the requirements that are placed on athletes in cgs sports with its high physical load, and its relatively low exigencies in the technical or tactical domain. From the current state of the art and the findings of the present study, it can be summarized that the optimal career path is not only a question of *amount* of training hours but also a question of *when* training regimes occur. The more recent adage ''perfect practice makes perfect'' (Janelle & Hillman, 2003, p. 28) might need to be changed to ''perfect training at the right time makes perfect''.

Key words: early vs. late specialization, career path, expertise.

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References

Anderson GS, Twist P. Trainability of children. IDEA Fitness J 2005: 2: 3.

Baker J. Early specialization in youth sport: a requirement for adult expertise? High Ability Stud 2003: 14: 85.

Baker J, Côté J. Shifting training requirements during athlete development: the relationship among deliberate practice, deliberate play and other involvement in the acquisition of sport expertise. In: Hackford D, Tenenbaum G, eds Essential processes for attaining peak performance. Aachen: Meyer and Meyer, 2006: 92–109.

Baker J, Côté J, Abernethy B. Sport-specific practice and the development of expert decision-making in team ball sports. J Appl Sport Psychol 2003: 15: 12–25.

Baker J, Côté J, Deakin J. Expertise in ultra-endurance triathletes early sport involvement, training structure, and the theory of deliberate practice. J Appl Sport Psychol 2005a: 17: 64–78.

Baker J, Deakin J, Côté J. On the utility of deliberate practice: predicting performance in ultra-endurance triathletes from training indices. Int J Sport Psychol 2005b: 36: 225–240.

Barynina II, Vaitsekhovskii SM. The aftermath of early sports specialization for highly qualified swimmers. Fitness Sports Rev Int 1992: 27: 132–133.

Bloom BS, ed. Developing talent in young people. New York: Ballantine Books, 1985.

Brace N, Kemp R, Sneglar R SPSS for Psychologists. New York: Palgrave Macmillan, 2009.

Carlson R. The socialization of elite tennis players in Sweden: an analysis of the players' backgrounds and development. Sociol Sport J 1988: 5: 241–256.

Cohen J. Statistical power analysis for the behavioral sciences. New York: Academic Press, 1969.

Cohen J. The Earth Is Round ($P < .05$). Am Psychol 1994: 49: 997–1003.

Côté J, Baker J, Abernethy B. Practice and play in the development of sport expertise. In: Eklund RC, Tenenbaum G, eds Handbook of sport psychology. New Jersey: John Wiley & Sons, 2007: 184–202.

Côté J, Ericsson KA, Law PA. Tracing the development of athletes using retrospective interview methods: a proposed interview and validation procedure for reported information. J Appl Sport Psychol 2005: 17: 1–19.

Côté J, Lidor R, Hackfort D. ISSP position stand: to sample or to specialize? Seven postulates about youth sport activities that lead to continued participation and elite performance. Int J Sports Exerc Psychol 2009: 9: 7–17.

Deakin JM, Cobley S. A search for deliberate practice. An examination of the practice environments in figure skating and volleyball. In: Starkes J, Ericsson KA, eds Expert Performance in Sports. Advances in Research on

Sport Expertise. Champaign, IL: Human Kinetics, 2003: 115–135.
Deci EL, Ryan RM. Intrinsic motivation and self-determination in human behavior. New York: Plenum Press, 2000.
Emrich E, Güllich A. Zur Evaluation des deutschen Fördersystems im Nachwuchsleistungssport. Leistungssport 2005: 35(3): 79–86.
Emrich E, Pitsch W. Die Qualitätserhöhung als entscheidende Grösse des modernen Nachwuchsleistungssports. Erste Ergebnisse einer empirischen Untersuchung von D-Kaderathleten in Rheinland-Pfalz und im Saarland. Leistungssport 1998: 28: 5–11.
Ericsson KA. Development of elite performance and deliberate practice: an update from the perspective of the expert performance approach. In: Starkes JL, Ericsson KA, eds Expert performance in sports. Advances in research on sport expertise. Champaign, IL: Human Kinetics, 2003: 49–83.
Ericsson KA, Krampe RT, Tesch-Römer C. The role of deliberate practice in the acquisition of expert performance. Psychol Rev 1993: 100: 363–406.
Gould D, Udry E, Tuffey S, Loehr J. Burnout in competitive junior tennis players: Pt. 1. A quantitative psychological assessment. Sport Psychol 1996: 10: 322–340.
Güllich A. Training – Support – Success: control-related assumptions and empirical findings. Saarbr ü cken: Universität des Saarlandes, 2007.
Helsen WF, Starkes JL, Hodges NJ. Team sports and the theory of deliberate practice. J Sport Exerc Psychol 1998: 20: 12–34.
Hodges NJ, Huys R, Starkes JL. Methodological review and evaluation of research in expert performance in sport. In: Eklund RC, Tenenbaum G, eds Handbook of sport psychology. New Jersey: John Wiley & Sons, 2007: 161–183.
Hodges NJ, Kerr T, Starkes JL, Weir P, Nananidou A. Predicting performance from deliberate practice hours for triathletes and swimmer: what, when and where is practice important? J Exp Psych-Appl 2004: 10: 219–237.
Hodges NJ, Starkes JL. Wrestling with the nature of expertise; a sport specific test of Ericsson, Krampe and Tesch-Römer's (1993) theory of deliberate practice. Int J Sport Psychol 1996: 27: 400–424.
Janelle CM, Hillman CH. Expert performance in sport: current perspectives and critical issues. In: Starkes JL, Ericsson KA, eds Expert performance in sports: Advances in research on sport expertise. Champaign, IL: Human Kinetics, 2003: 19–48.
Law MP, Côté J, Ericsson KA. Characteristics of expert development in rhythmic gymnastics: a retrospective study. Int J Sport Exerc Psychol 2007: 5: 82–103.
Lidor R, Lavyan Z. A retrospective picture of early sport experiences among elite and near-elite Israeli athletes: developmental and psychological perspectives. Int J Sport Psychol 2002: 33: 269–289.
Schmidt RA, Wrisberg CA Motor learning and performance: A problem based learning approach. Champaign, IL: Human Kinetics, 2000.
Shaugnessy JJ, Zechmeister EB, Zechmeister JS. Research Methods in Psychology. Boston: McGraw Hill, 2006.
Tabachnick BG, Fidell LS Using Multivariate statistics. Boston: Pearson, 2007.
Vaeyens R, Gullich A, Warr CR, Philippaerts R. Talent identification and promotion programmes of Olympic athletes. J Sports Sci 2009: 27: 1367–1380.
Van Rossum JHA. Deliberate practice and Dutch field hockey: an addendum to Starkes. I J Sport Psychol 2000: 31: 452–460.
Wall M, Côté J. Developmental activities that lead to dropout and investment in sport. Phys Educ Sport Pedagogy 2007: 12: 77–87.
Ward P, Hodges NJ, Williams AM, Starkes JL. Deliberate practice and expert performance. Defining the path to excellence. In: Williams AM, Hodges NJ, eds Skill acquisition in sport: research, theory and practice. London, New York: Routledge, 2004.
Williams AM, Ford PR. Expertise and expert performance in sport. Int Rev Sport Exerc Psychol 2008: 1: 4–18.
Wylleman P, Lavallee D. A Developmental Perspective on Transitions Faced by Athletes. In: Weiss M, ed Developmental Sport and Exercise Psychology: A Lifespan Perspective. Morgantown, WV: Fitness Information Technology, 2004: 507–527.