Being a top swimmer during the early career is not a prerequisite for success: A study on sprinter strokes

ABSTRACT

Objectives

To quantify the junior-to-senior successful transition rate in swimming sprinting events in elite European performers.

Design

Retrospective analysis of publicly available competition data collected between 2004 and 2019.

Method

The yearly performance of 6631 European swimmers (females = 41.8% of the sample) competing in 50 and 100m freestyle, backstroke, breaststroke, and butterfly were included in the analysis. The junior-to-senior transition rate was determined as the number of elite junior athletes that maintained their elite status in adulthood. To investigate how the definition of elite may affect the calculation of the transition rate, we operationally defined elite athletes as those ranked in the all-time top 10, 25, 50, and 100 in their category. We also calculated the correlation between junior and senior performances.

Results

The average transition rates ranged, depending on age of reference, from 10 to 26% in males and from 23 to 33% in females. The transition rate for top 100 junior swimmers was greater than for top 10. In general, the 50m distance showed a slightly lower transition rate compared to the 100m distance. Depending on the age of reference, low-to-moderate correlations were observed between junior and senior peak performances.

Conclusions

Most elite junior athletes did not maintain the elite level in adulthood. Except for the last year of the junior category (18 yrs for males and 17 yrs for females), junior performances are poorly related to senior ones.

Keywords: transition rate; junior-to- senior; talent identification; career trajectories; development programs.

i. Introduction

Longitudinal assessments of athlete career trajectories may provide useful data for assisting athletes, coaches, and federations to determine realistic long-term performance goals and to inform talent development policies better.[1-4] For this purpose, different studies have provided information about the career development of swimmers focusing on relatively small samples.[1,2,5] Allen et al.[2] studied the career performances of 16 swimmers competing in the Beijing and London Olympic Games. They reported that men reached the peak performance later (~ 24 yrs) than women (~ 22 yrs) despite having a similar peak performance window (~ 3 years) and a similar performance improvement over eight yrs before reaching their peak performance (~ 9.5%). Similarly, Costa et al.[6] described the career of junior Portuguese male swimmers for short-course freestyle events reporting an overall performance improvement of about 14–19% between the age of 12 and 18 yrs. More recently, using a retrospective design, Post et al.,[1] showed that top-elite swimmers progressively outperformed swimmers of similar age with some considerable variabilities in the individual pathways and some marked between gender differences with females being early developers. The first appearance in the top-elite rank was widely distributed and changed depending on gender, being from 17 to 24 yrs for males and from 14 to 24 yrs for females. Female swimmers also reached earlier their peak performance [7] and top-level ranking compared to males.[1]

These initial attempts to describe and predict performance in the literature suggest that the transition phase from junior to senior competitions is not as predictable as expected.[1,8] For example, Costa et al.[6] noted that the ability to predict adult performance was not reasonably robust before the age of 16 years in their cohort. Staub et al.[8] demonstrated that only one-third of the top ranked 11 years old German swimmers were still ranked in the top 100 at 18 years of age. Sokolovas et al.[9] reported that only about a half of USA swimmers considered elite at age 17-18 had been elite when 15-16 years old. To provide further arguments for the inability of the swimmers to maintain a relative rank across a career, Yustres et al.[5] reported that only about 17% of swimming finalists in Junior Word Championship had achieved success in subsequent Senior Word Championship. The same group of researchers indicated that among those who participated in both Junior and Senior World Championship, the qualification for a final in the Junior Championships did not predict achieving success in the Federation

Internationale de Natation (FINA) World Championships.[5] Despite these findings, the importance of early junior performances on future senior success cannot and should not be ruled out.[1,5,10]

The reasons for the long-term instability of performances are manifold.[11] The low association between junior and senior performance is influenced by the age-related changes in three main domains: the task, the performer and the environment.[11] Regarding the task domain, for example, the relative influence of different predictors of task performance may vary with age. Regarding the performer domain, it is known that there is considerable inter-individual variability in the timing of biological maturation.[12] Lastly, regarding the environment domain, some coaching structures, experiences and training paradigms may be favorable for early success and detrimental for later success.[13] While it is challenging to determine the causes of long-term instability of performance without access to physiological, biological and training load-related data, the analysis and quantification of junior-to-senior transition rate informs about the prevalence of elite junior athletes that achieve an elite-level during the senior category. Quantifying the junior-to-senior transition rate would help to set realistic expectations about the chance of adult success of early-success junior athletes. It may also provide information about the efficacy of early talent-identification and talent-promotion programs and help coaches and parents in putting performances into a wider context. The junior-to-senior transition rate has been previously studied adopting a prospective design for swimmers participating in the Junior World Championship[5,14] or junior national Championship.[8,9] Nevertheless, we believe that adopting both prospective and retrospective design for the analysis of performance development should be necessary to assess the transition rate with an adequate level of confidence.[15] Moreover, the study of a broader sample of athletes would provide a more robust estimate and a more realistic analysis of the career development to better understand the importance of early age success on the senior career. With this approach, it is possible to consider not only the athletes who participated in the World Championships but also those unable to join because of selection policies of the national federation or because of injuries. Similar attempts have been recently suggested in track and field events,[15-17] but to date, to the best of our knowledge, no study investigated junior-to-senior transition rates in swimmers in such a way.

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Additionally, the definition of what determines an elite athlete is lacking, with descriptions ranging from Olympic gold medalists and World-record holders to regional level athletes.[18] The

84 definition of an elite athlete in a given discipline may affect the quantification of the transition rate, as
85 the level of competitiveness intrinsic in that definition may make the maintenance of that level
86 throughout the career either more accessible or more difficult. Nevertheless, to date, there is no clear
87 information on typical junior-to-senior transition in swimming when considering different criteria to
88 identify elite athletes. For this reason, we decided to explore how setting different criteria of level of
89 competitiveness (the top 10, 25, 50, or 100 swimmers) may impact in the transition rate estimation.
90 Considering the lack of analyses and the limited reports on transition rate in swimmers, we
91 focused on long course sprint events (i.e., 50m and 100m) including the four strokes (i.e., freestyle,
92 backstroke, breaststroke, and butterfly). Thus, our aim was to quantify the junior-to-senior successful
93 transition rate in swimming sprinting events in European performers considering 1) gender differences;
94 2) different criteria to identify top swimmers (i.e., considering the top 10, 25, 50, or 100 swimmers) and
95 3) reference age (i.e., from 14/15 to 17/18 yrs old) and 4) to investigate possible differences in transition
96 rates between strokes and distances. Furthermore, to avoid defining success only as a categorical
97 variable (e.g. ranked in top 50 vs ranked below the top 50), we also calculated the correlation between
98 junior and senior performances to quantify the extent to which individual differences in junior
99 performance predicted individual differences in senior peak performance.
100 **ii. Methods**
101 This study was conducted with available resources collected from the public site of
102 Swimrankings (https://www.swimrankings.net/) between the competition years 2004-2019. This site is
103 provided by the European Swimming Federation (LEN: Ligue Européenne de Natation) and contains
104 the annual ranking of swimming events. The annual ranking was provided both for the junior and senior
105 categories. Depending on gender, the junior category included the rank of the swimmers with ages up
106 to 17 yrs and up to 18 yrs in females and males, respectively. Differently, in the rank of senior category
107 it was possible to find swimmers aged upwards over 17 or 18 yrs according to gender. This age-related
108 difference in category cut-off arises from the FINA rule (http://www.fina.org/content/fina-rules) and
109 corresponds to the cut-off age from the transition to junior and senior competitions. Moreover, for each
110 swimmer the site provides an individual athlete profile with data on career progression (i.e., performance
111 time of the career). Since the data are based on public available resources, no informed consent was

obtained. All performance times in the database were registered in accordance with official FINA rules. The study was conducted according to the declaration of Helsinki and was approved by the local ethics committee of the University of Torino.

The names of swimmers ranked each year in the top 50 official lists in junior or senior categories competing in long course sprint events (i.e., 50m – 100m) were extracted for analysis. After screening the database for participants' duplication, the Seasonal Best Times (SBTs) during each swimmer's career were downloaded and included in the dataset. Owing to the uncertainty involved in forecasting when the best performance peak occurred in the younger swimmers and that consequently did not reach the senior career, a first screen excluded all swimmers that registered their best personal performance in the last 3 yrs of the calendar age (i.e. from 2017 to 2019).[7] Indeed, using this cut-off we are confident that most swimmers have achieved their individual career peak performance. Moreover, only swimmers that obtained a minimum of three SBT (also in non-consecutive years) were included in the analysis. The SBTs were collected from the age of 10 to 36 yrs, or at career termination, or on December 31, 2019 if the individual was still competing. This resulted in 6786 European swimmers (42% females) included in the data analysis with an average of 8.3±3.2 and 8.2±3.0 observations per male and female swimmers, respectively. Freestyle, backstroke, breaststroke, and butterfly competitions were included.

Statistical analysis

In order to compare junior-to-senior transition rate of swimmers of multiple generations also competing with different FINA rules (e.g., full-body polyurethane swimsuits), we normalized all SBT according to the best times of that relative year (BTY) using the following formula:[19,1]

$$\text{rSBT} = \left(\frac{SBT}{BTY}\right) \times 100$$

An rSBT value of 100 was corresponding to the best performance of that relative year. Subsequently, according to each competitive age an all-time ranking was calculated. According to the FINA rules, we calculated all-time ranking between age 15 and 18 yrs and between age 14 and 17 yrs in males and females respectively (i.e., junior category swimmers). Consequently, all-time ranking over 18 and 17 yrs, according to gender, was calculated to determine the senior category rank.

To address the first and the second aim of the study, we calculated how many top 10, 25, 50, and 100 ranked junior swimmers remained at the same top-level in the Senior category (>18 years old). To give a broad view of the transition rate, for this analysis, we merged the strokes and the distances. Separate analysis was performed for gender.

To address the third aim of the study, according to previous studies,[6,16,17] we defined the top 50 as the threshold reference. Thus, we calculated how many top 50 ranked swimmers during their junior career remained in the top 50 ranked in the senior category. To give a broad view, for this analysis, we merged data considering the whole transition rate from 15 to 18 yrs or 14 to 17 yrs. Separate analysis was performed for strokes, distances, and gender.

Finally, Pearson's product moment correlation coefficients between the Peak Senior Performance and Junior annual Peak Performance at each age of the junior career were determined to assess the stability of the data. The stability was considered to be high if $r \geq 0.60$, moderate if $0.30 \leq r < 0.60$, and low if $r < 0.30$.[6] The percentages of transition rate were calculated and reported with binomial Confidence Intervals (90% CI). The significance level for the Pearson's product moment correlation coefficients was set at $p < 0.05$. All data were analysed with custom-written software in MATLAB R2020b (Mathworks, Natick, Massachusetts) and the graphs were prepared with GraphPad Prism 8 (San Diego: CA, USA).

iii. Results

A total of 6786 European swimmers (female 42%) were included in the study. The results for junior-to-senior transition rate are presented in Figure 1. The transition rate was overall quite low; however, it was greater in females. Taking the top 50 swimmers as reference, on the average (merging junior ages and strokes) the transition rate was 21% and 25% for males and females, respectively. The transition rate increased according to the reference age, i.e., the greater was the reference age, the larger was the transition rate (see Figure 1). In males, the most competitive criterion to define top-level swimmers, i.e., top 10, showed the lowest transition rates (i.e., average merging junior age = 10%). The least competitive criteria (i.e., Top 100) ranged from 14 to 26%. In females, the transition rate was on average 23-33% irrespective of the criterion considered to define them (i.e., from Top 10 to Top 100).

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< Figure 1 about here>

Overall, the transition rates slightly varied across distances. In fact, except for male freestyle, the 50m distance showed a lower transition rate compared to the 100m distance. For more details see Figure 2.

<Figure 2 about here>

The results of correlation analysis and the relative 95% CI between Senior and Junior Peak Performances are reported in Table 1. The analysis indicates an increase of correlation coefficients as age increase. In general, moderate stability was observed only at the end of the junior career, i.e., at age 18 and 17 yrs in male and female, respectively. Specifically, 0 to 1% of male performances at senior level were explained by performance at 15 years, 0 to 4% by performance at 16 years, 1 to 10% by performance at 17 years, and 2 to 16% by performance at 18 years of age. In females, 0 to 6% were explained by performance at 14 years, 0 to 5% by performance at 15 years, 0 to 9% by performance at 16 years, and 6 to 19% by performance at 17 years of age.

<Table 1 about here>

iv. Discussion

The present study aimed to investigate junior-to-senior transition rates of European swimmers competing in sprint events. We operationally defined the junior-to-senior transition rate as the percentage of athletes ranked in the all-time top 50 both during youth and adult career. This approach has allowed us to determine a relevant measure of how much success at an early age can be predictive of later success. The main findings of this study were the following: 1) on average, ~21% and 25% of male and female top 50 swimmers managed to succeed both in the junior and the senior career; 2) generally, changing the criterion to define elite athletes slightly changed the transition rate in males but not in females; 3) the transition rate increased according to the reference age; 4) the differences in transition rate across strokes were only minor; 5) the correlations between junior and senior performances were poor to moderate.

Only 21-25% of top 50 junior swimmers maintained the same level of competitiveness later in their career. This finding together with the low to moderate correlations between junior and senior peak

performances in all strokes or distances confirm the notion that the early performances are not a reliable predictor for future careers.[6,8,20] The junior to senior transition rate observed in the present study was in line with previous national data[8,9] but larger if compared to studies on international swimmers[14] or track and field athletes.[15-17] Sokolovas et al.[9] reported that only about a half of national USA swimmers considered elite at the end of their junior career had been elite at the beginning of the same. A study on German swimmers showed that 23% of top athletes at age 11 maintained the top-level rank until 19 yrs, indicating that early age success is challenging to retain post adolescence. Also, Yusters et al.[14] observed that only 17% of swimmers were finalists in both Junior and Senior World Championships. Nevertheless, it is necessary to take into account that our transition rates are based on the all-time top rankings and not on annual top rankings like previous studies. On the other hand, our results suggested that more swimmers were able to reach and/or retain elite performances both in junior and senior stages of career compared to world-class track and field athletes (i.e. sprinters,[15] jumpers,[17] and throwers[16]). It is possible that the lower competitive level of our database (continental vs. World level) may explain this difference. In fact, to support this statement, if we focused on the transition rate in the top 10 swimmers only, the average transition rates in our sample were similar to previous studies (i.e., ~10% and 23% in males and females).

In general, female swimmers showed a greater junior-to-senior transition rate. This means that a higher number of young female swimmers was able to maintain a high level of performance also in adulthood. Considering that top-level Olympic female swimmers achieved peak performance ~2 years earlier in comparison with top-level Olympic male swimmers[7] and that most of the female top-elite swimmers achieved the top-elite level about 3 years earlier in comparison with male top-elite swimmers,[1] it is possible to speculate a shift forward of about 2-3 yrs in the prediction of the transition rate in male compared with female swimmers. Thus, the gender difference might diminish or completely disappear if gender peak performance difference is considered. Moreover, it is also possible to speculate that the early maturation of young females[12] at junior ages make them more physically similar to senior athletes, and this might increase their chances for a successful transition to seniors.

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performance progression.[6,8] In fact, the correlation between the performance recorded in the first year of the junior category and the peak performance reached at senior level did not exceed r=0.24 (Table 1). This means that individual performance differences through junior age are not predictive of senior performances. In fact, the transition rate calculated at the beginning the junior career was very low <10%. When performance in the last year of junior category was analysed, the transition rate was 35% and the correlation between junior and senior performance was moderate (up to r=0.43). This confirms that most elite senior swimmers outperformed the early-success swimmers after their junior career was over. Consequently, a talent identification and developmental programme should be wary of considering performance at a very young age and/or success as the main (or only) criterion for selection.[21] Previous work, focused on the prediction between performances from childhood to the beginning of senior career found a low relationship between performances at ages 12 and 18 (r=0.31 and r=−0.62 in 50m and 100m freestyles respectively) and the performance prediction was only robust at age 16 (r=0.75 and r=0.68 in 50m and 100m freestyles respectively).[6]

When increasing the level of competitiveness, by adopting criteria that identify fewer athletes as elite (e.g., top10), the transition rate slightly decreased compared to a lower level of competitiveness. The difference was of ~16% of difference in males and 10% in females. The higher level of competitiveness may increase the instability of performance across the career for many reasons. For example, at higher level of competitiveness the early-maturing athletes may be particularly advantaged in the junior career compared to the senior career. Moreover, exceptionally high senior performance may be only achieved with longer career duration, with a longer time gap between junior and senior peak performance.

The transition rates among disciplines are sparse and may differ among strokes. However, the general trend from the analysis of European data suggests that the transition rate was lower in 50 m competitions than in 100 m ones. Presumably, this pattern among distance and stokes may be explained by heterogeneity of performances and thereby their long-term differential stability. However, these are just speculations that have to be confirmed by future studies possibly with larger datasets. Nevertheless,

250 the 50m freestyle showed the lowest transition rate, possibly because speed abilities are strongly affected
251 by growth and maturation[22,23]and therefore early success may be linked to early maturation. Another
252 possible explanation is that the freestyle stroke is the only 50m event in the Olympic program. Therefore,
253 it is possible to speculate that a higher level of competitiveness may in part explain these results.
254 Summing up, our results suggested that the populations of successful juniors and of successful
255 seniors are not identical but are widely distinct populations. Indeed, many successful junior swimmers
256 (i.e., athletes ranked in the all-time top 50 during their youth career) did not reach the elite level in the
257 senior category. This evidence suggests that the most successful senior swimmers (i.e., athletes ranked
258 in the all-time top 50 during their senior career) were not successful when they were junior and therefore,
259 they were considered junior sub-elite swimmers. Moreover, data confirm that predicting senior
260 performance from youth performance may be problematic and prone to large errors and that talent
261 identification cannot consider only actual performance as the main parameter to select or de-select
262 swimmers. Different possible explanations may explain these results. Junior-to-senior transition is a
263 challenging process with diverse associated demands:[24] some athletes may cope well with them while
264 others may not. Many years of training and experience are necessary to compete at the international
265 arena's highest level.[2,25] To compete at a high level during the early phase of the career may provide
266 specific skill acquisition and experience that may improve success chances in later stages of an athlete's
267 career.[5,26] Nevertheless, even if some degrees of sports specialization are necessary to develop elite-
268 level skill development,[5,14] a large training volume in a single sport can be deleterious.[13] Rather, early
269 diversification seems to positively impact on performance improvement to optimize success, while
270 reducing overuse injury incidence, psychological stress, dropout and burnout.[27-29] In this regard, it has
271 been reported that many successful senior athletes did not only focus on their dominant sport but rather
272 on different other sports or disciplines during their early career, performing both training sessions and
273 competitions.[11,30,31] These athletes also entered age group rankings later.[30] The large turnover/dropout
274 may also be explained by maturity selection bias and relative age effect. Early maturing and relative
275 older athletes may be the advantage to reach early success at the early ages, but the effect tends to
276 disappear later in life.[11,32,33] In this regard, it was suggested that maturity status was able to predict both

swimmer's technical skill and the related performance[34] highlighting the need to account for maturation status in talent identification programmes.

With easier access to competition databases, it is becoming easier to study junior-to-senior transition rates of different sports. This initial attempt in swimming has the limitation of analysing sprint events and European athletes only. However, considering the sample size of more than 6000 swimmers, we expanded previous literature and provided a starting point to verify if similar patterns are evident in other continents and in other swimming events. Moreover, we tracked the career pattern considering the data available in one database only. Consequently, it is possible that some swimmers started their career before appearing in this database, possibly competing in lower-level national competitions. This may have partially affected our results.

v. Conclusion

The junior-to-senior transition rate in elite European sprinters swimmers was as low 21% and 25% in males and females, respectively. The present findings provide evidence that many successful juniors swimmers did not reach the elite level in the senior category and provide that, except for the last year of the junior category (18 yrs for males and 17 yrs for females), junior performances are poorly related to senior ones. Indeed, most elite junior athletes were not able to maintain the same level of competitiveness in their senior career. However, successful female junior swimmers had slightly more chances to become elite senior athletes. This is true independently of the level of competitiveness criteria used to define the elite level, ranging from the top 100 to the top 10 ranked athletes.

vi. Practical Implication

- Considering that approximately two-thirds of the elite senior swimmers did not reach elite level during their junior career but rather were considered sub-elite swimmers, it is possible to suggest that talent identification and development programmes dealing with young adolescents should consider alternatives to performance as the main selection criterion.

- Talent identification policies should put in place strategies to favour retention of athletes who may not be performing at the elite level in junior categories, possibly assessing growth and maturation and biological development status as part of a comprehensive evaluation.
- Federations can use the present findings to provide coaches, parents and athletes with realistic data on the long-term potential and challenges of early successful athletes and benchmark their policies and performance developments.

vii. Acknowledgements

The acknowledgements section has been uploaded as a separate file.

viii. References

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ix. Figure legend

Figure 1

The transition rates (merged across strokes and distances) at different criteria to define top-level and reference age. Panel shows how many swimmers top 10, 25, 50,100 ranked at 15, 16, 17, 18 in males and at 14, 15, 16, 17 yrs old preserve their status during senior career.

Figure 2

The transition rates of the top 50 ranked swimmers that during the whole youth career managed to become top 50 ranked during their senior career. Data are present separately for strokes, distance, and gender.