World-Class Sprinters' Careers: Early Success Does Not Guarantee Success at Adult Age

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(Article begins on next page)

Sprinting to success at early age does not guarantee success ad adult age

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Abstract

Purpose. This study aimed to quantify how many of the top 50 Under-18 (U18) sprinters in the world managed to become top 50 ranked as adult competitors. We also described the career trajectory of athletes ranked in the top 50 during either U18 or senior category.

Methods. The performance progression of 4924 male and female athletes competing in sprint races and ranked in the IAAF lists (now World Athletics) in any of the seasons between the 2000 and 2018 were included in the study. Then, the athletes ranked in the top 50 positions of all-time lists during U18, senior or both categories were analysed.

Results. Only 17% of the male and 21% of the female top 50 ranked U18 managed to become top 50 ranked senior athletes. The top 50 ranked senior athletes consistently produced yearly larger improvements during late adolescence and early adulthood compared to those who ranked in the top 50 at U18. Furthermore, top 50 ranked senior athletes reached their peak performance later compared to the top 50 ranked only in U18.

Conclusions. This study confirms that early success in track and field is not a good predictor of success at senior level in sprinting events. The yearly performance improvements and its tracking provide the most suitable approach to identify athletes more likely to succeed as elite performers in adulthood. We hope that the results of this study can provide useful comparative data and reference criteria for talent identification and development programs.

Keywords:

Performance progression, career trajectories, talent identification, youth training, track and field.

Introduction

There is debate over whether junior success is prerequisite for success as a senior athlete. The path that leads a young athlete to become an adult champion is not linear and is characterized by a conspicuous amount of uncertainty.[1,2] Previous studies attempting to describe the extent of the transition from successful junior to successful senior performer showed inconsistent results, probably because the conclusions largely depends on how the data are analyzed.[3] In fact, there are two main approaches to analyze the athletes' performance progression: a prospective or a retrospective viewpoint.[3,4]

Prospective approaches are based on the possibility to track the career of young athletes participating, for example, at World Junior Championships up to the end of their career.[5] These studies allow quantifying the successful transition rate (or conversion rate) which represents the chance for an elite junior athlete to become an elite senior athlete. Previous studies found a transition rate of 21% for track and field medalist in World junior championships[4] and of 17% for participants at swimming junior World Championship.[6] However, there are some limitations with such prospective approach, since it is mostly focused on a small selected group of athletes, (e.g. only those participating at one specific World Junior Championship). Furthermore, the possibility to participate at a World Junior Championship is based not only on the performance level, but sometimes (e.g. in the case of swimming) on selection policies of the national federations, on the athletes' fitness in the months before the competitions, and may be strongly influenced by injuries occurring just before or at the championship. For all these reasons, reconstructing careers and success rate as seniors from analysis of individual championships is based on datasets that can be considered somewhat incomplete.

Retrospective analysis on individual careers allows to track back the performances of senior elite athletes (e.g. the World champions), providing useful information about the performance progression of those who succeed at senior level.[7,8] They can illustrate the developmental experiences of those who achieve elite performances as senior athletes.[9] They may also present anecdotal experience of successful case studies.[10] However, findings from this kind of studies may not be useful to explain and describe the differences between individuals attaining success at senior level from the individuals unable to progress. The developmental stages addressed by a small group of elite champions may not be considered as a rigid benchmark, in particular since a certain amount of variability for the path to success is indisputable.[1,2] Taken together, these arguments suggest that the adoption of both retrospective and prospective approaches are necessary to thoroughly characterize the developmental phases of those who achieve and do not achieve senior elite performances.[3,4,11]

In track and field, few studies tracked the career trajectories of large samples of athletes, including both junior and senior elite performers[12-14] but these research efforts were confined to national level athletes and thus the conclusions might not apply to world-class performers. In particular, despite its popularity, sprinting events seem to be the least analysed. Sprinting races are cornerstone events of the Olympic Games and World championships and attract considerable attention. Because of this, the training and development of elite sprinters are gaining consideration in the literature.[15] Since an overall view of career trajectories of best performers are lacking, it is still difficult to understand what determines the transition of a talented junior athlete to a World-class adult performer. Despite this gap in the literature, some studies focused on the second part of the athletes' career providing plausible arguments on the importance of performance progression during the transition from elite junior to senior phase.[16,17] For example, the improvement in performance from 18 years of age to the peak performance was about 8% for world-class sprinters and only 1.4% for national-level athletes (Norwegian athletes).[17] Furthermore, Haugen et al.[8] provided an in-depth analysis of performance progressions in the five years before the peak performance of world-class athletes and revealed that the annual improvements in world-class sprinters (range 0.1-0.2%) was greater in the top 10 athletes than the ones observed in athletes ranked from 11 to 100 . Despite this, the authors did not include the analysis of the junior to senior transition phases. In general, we can state that a more comprehensive understanding of the relationship between young and senior performances of world-class track and field athletes is lacking. To fill this gap, we tracked the career performances of a large sample of world-class sprinters and we investigated the transition rate of elite U18 sprinters to elite senior level. Since the definition of elite performers remains elusive, we operationally defined being "elite" as those athletes in the top 50 ranking in their category. Thus, the first experimental question was to quantify how many top 50 ranked U18 managed to become top 50 ranked as seniors. Secondly, we aimed to describe the performance progression of athletes classified in the top 50 ranking in U18 and senior categories.

Methods

The sample of this study involved the sprinters competing in 100m, 200m, and 400m races. The names of males and females' athletes ranked in the top 100 official lists of the International Association of Athletics Federations (IAAF – now called World Athletics; https://www.iaaf.org/home) in each season from 2000 to 2018 and the athletes who participated in the IAAF World U18 Championships (from 1998 to 2014; https://www.iaaf.org/competitions/iaaf-world-u18-championships) and IAAF World U20 Championship (from 1999 to 2015;

https://www.iaaf.org/competitions/iaaf-world-u20-championships) were collected from the publicly available results database. The dataset of names coming from these lists were merged and, after duplication removal, the IAAF database was used to download the career performance progression of each athlete included in the dataset. Athletes disqualified for doping offences were excluded from the analysis. IAAF database provides athletes' career progression, which consists in the best results for each competitive year from the beginning to the end of the athletes' career or until December 31, 2018 if he/she was still in activity. According to IAAF rules, only results with regular wind readings were considered.

Statistical analysis

Data were separately analyzed for gender and discipline. Records were included only if the individuals were present in the dataset for a minimum of three years, also non-consecutively. Longitudinal data of each athlete were extrapolated by custom-written software in MATLAB R2018b (Mathworks, Natick, Massachusetts).

As previously suggested,[8] individual trends were generated by fitting a quadratic curve separately to each athlete's performance and age. From the quadratic curve, the following outcome variables characterizing the career of athletes were calculated: 1) age of first appearance in the IAAF database; 2) age of last appearance in the IAAF database; 3) personal peak performance; 4) age of peak performance; 5) improvement from the age of 17 to peak performance; performance at 6) 16 years of age; 7) 17 years of age; (8) 18 years of age; (9) 19 years of age; 10) 20 years of age; annual performance improvement (%) between 11) 16-17 years; 12) 17-18 years; 13) 18-19 years; 14) 19-20 years.

To answer the first experimental question, we created two all-time rankings, respectively for the performances in U18 (16 and 17 years of age) and senior categories (≥ 18 years of age). Subsequently, we quantified how many top 50 ranked U18 managed later to become top 50 ranked as seniors. We also quantified how many top 50 ranked as seniors were top 50 ranked as U18. To do this, athletes were categorized in four subgroups: (1) *only U18*, i.e. those who were top 50 ranked in U18 but not in senior category; (2) *U18 and senior* i.e. those who were top 50 ranked both in U18 and senior categories (3) *only senior* i.e. those who were top 50 ranked in senior but not in U18 category; (4) *others*, i.e. those who never appeared in the top 50 ranked. The frequency of athlete in each category was calculated. We selected the threshold of the top 50 athletes because this is approximately the common sample size for participants in Olympic Games in sprinting events. However, we also tried to assess the threshold to the top 100 athletes in a preliminary analysis.

Since the overall finding of the study did not differ, for conciseness here we reported and discussed the results for the threshold posed at the top 50 only.

To answer to the second experimental question and to compare the four subgroups of performers, a series of one-way analyses of variance (ANOVA) was carried out for each outcome variables. When the homogeneity of variances was violated, as assessed by Levene's Test of Homogeneity of Variance (all P values < .05), the Welch's *F* test was used. When necessary, Bonferroni and Games-Howell post hoc analysis was used to identify differences between subgroup.

The relationships between the personal peak performance and age of first appearance in the IAAF database, performance at 17 years of age (i.e. the last year of U18) and age of peak performance were analysed using Pearson’s correlation. A series of multiple regressions was run to predict the personal peak performance in each sprint event (i.e., dependent factor) from age of first appearance in the IAAF database and performance at 17 years of age (i.e., independent factors).

Results

A total of 58 men and 60 women were removed from the database because they were disqualified for doping. After error and duplication removals, a total of 4924 (females: n = 2865, 58.2%) sprinters were included in the study. The sample size of each subgroup is reported in Table 1. On average, only 17% (90%CI from 12 to 23) of the male athletes and 21% (90% CI from 16 to 28) of the female athletes were in the top 50 rankings both in U18 and in the senior category (*U18 and senior* subgroup).

Descriptive statistics of the performances of subgroups: *only U18, U18 and senior*, *only senior* are reported in Figure 1. Table 2 reports the descriptive statistics and post hoc comparisons of age of first and last appearance in the IAAF database personal best performance, age of peak performance. The one-way ANOVA outcomes are reported in Supplementary Table 1. In general, the *only U18* subgroup reached their personal peak performance, made their first and last appearance in the IAAF database earlier than the *U18 and senior* and *only senior* subgroups (Table 2). The *only senior* subgroup made their first appearance in the IAAF database later than *U18 and senior* subgroup and reached the personal peak performance later than the *U18 and senior* subgroups (Table 2).

Figure 2 shows the relative annual change of the subgroups of performers over the course of their career. The detailed descriptive statistics of performances and relative annual changes from 16 to 20 years of age are reported in Supplementary material 2. The *only senior* subgroup consistently showed greater annual improvement prior to age of peak performance from 16 to 19 years of age compared to the *only U18* subgroup. Furthermore, the *only U18* athletes did not show any significant improvement in performance from 19/20 years of age onwards, while the *only senior* group improved their performances up to 26/27 years of age (Figure 2 and Supplementary Table 2).

The results of the correlations analysis are reported in Table 3. Briefly, small to moderate correlations were identified between the performance at 17 years of age and the personal peak performance depending on gender and discipline. Women tend to show larger correlations (*r* values from 0.49 to 0.55) than men (*r* values from 0.16 to 40). The age of first appearance in the IAAF database showed large correlation with the age of personal peak performance (all r values greater than 0.51). Furthermore, the personal peak performance showed moderate to large correlation with the age of personal peak performance (all r values from -0.44 to -0.60).

Table 4 presents the summary of the multiple regression analyses to predict the personal peak performance using as independent variables the age of first appearance in the IAAF database and performance at 17 years of age. In all disciplines and gender, the age of first appearance in the IAAF database had trivial negative effect on the personal peak performances in senior category, i.e. later age of first appearance in the IAAF database were trivially but significantly related to an improvement of peak performance. The performance at 17 years of age positively, despite weakly, influenced the personal peak performance: on average the variance explained by the models were 29% in females and lower than 15% in males (Table 4).

Discussion

We tracked the career performance trajectories of a large set of world-class sprinters from the first to the last appearance in the IAAF database. We compared key features of career progressions between the top 50 ranked U18 and senior sprinters. This gave us the possibility to present the details of a realistic successful transition rate with an unprecedented robustness. Around 20% of the top 50 ranked U18 managed later to become top 50 ranked as seniors. Those who were among the top 50 senior athletes first appeared in the IAAF database, reached their personal peak performance, and last appeared in IAAF database later than those who were top 50 ranked only in U18. The top 50 senior athletes also showed a greater annual change of improvement from 16 to 19 years of age compared to those who were among the top 50 only when competing in the U18 category.

Being an elite young athlete does not guarantee a transition to an elite adult athlete. Indeed, when removing from the analysis athletes disqualified for doping, only 17% of male and 21% of female top 50 ranked athletes successfully transitioned to be among the top 50 as senior athletes. Consequently, an attrition rate of 79-83% highlights that it is quite rare for an elite young sprinter to become an elite adult sprinter. This is in line with previous evidence presented on track and field athletes.[4] The reasons for such a high attrition rate are manifold and are likely include early maturation,[18] early specialization,[19,20] relative age effect,[3,21,22] injuries,[16,23] drop-out,[24] and dual career barriers.[16,25] Even more importantly, most elite senior athletes were not considered as such when they were young. Indeed 79-83% of top 50 senior athletes were not present in the top 50 ranking when they were U18. Consequently, being an elite young sprinter is not a prerequisite to become an elite senior athlete. This confirms previous observations in national level populations[12-14]. Taken together, these findings constitute a solid base to affirm that success in young categories is not strongly related to success in the adulthood.

Assuming success at adult level solely based on performance at U18 level can be misleading. Indeed, the correlation between the personal peak performance and the performance at 17 years of age in this cohort of world-class athletes is small in men and moderate in women (Table 3). Even when including the age of first appearance in the IAAF database in the regression model, the performance at 17 years of age may explain only up to about 26% of the variance in personal peak performance in males, and up to about 31% in females (Table 4). This finding confirms that performances during adolescence do constitute a predictor of success in the adulthood. A certain association between the performance at young ages and the personal best performance is expected and somewhat obvious,[7,13,26] but care should be applied when using U18 performances to predict adult success.

Entering competitions early does not constitute an advantage for reaching elite performance in sprinting events. The age of first appearance in IAAF database (which can be associated to the age of entering competition) was around 17-18 years for the *only senior* subgroup, while less than 16 years for the *only U18* subgroup. Furthermore, age of first appearance in the IAAF database was positively correlated to the performances at 17 years of age, but negatively correlated to the personal peak performance (see Table 3). This means that early competition may increase the chance of being considered elite at 17 years but may blunt the chance to become an elite adult athlete. Taken together, these findings suggest that entering competition too early does not represent an advantage, and may, at some extent, be considered as a detrimental factor for future performance.

The annual rate of improvement was one of the most evident characteristics distinguishing the career trajectory of successful compared to non-successful athletes. Those who were among the top 50 athletes only in U18 plateaued at an earlier age compared to the other athlete subgroups (Figure 2, supplementary Table 3). The improvement of performance of *only senior* subgroup across the 16-20 years of age was larger than all other subgroups, suggesting that continue progression,[8] instead of early success, may characterize those who reach the elite level in the world.

The age of peak performance has been widely investigated in track and field studies.[3,8,27] Here we expand previous findings showing that the age of peak performance is positively correlated to the age of first appearance in the IAAF database (see Table 3). This means that those who started the competitions later reached the peak performance later compared to those who started the competitions at an early age. Furthermore, the *only senior* subgroup reached their personal best approximately 1-3 years later than the *U18 and senior* subgroup. Taken together, these findings reinforce the opinion that more time to reach the peak performance should be given to those who started the competition at a later age.[12]

The top 50 U18 athletes that did not become top 50 senior athletes showed a peculiar pattern of performance trajectory. Indeed, they appeared in the IAAF database, reached their peak performance,[3] and last appeared in database (retired from competitions) earlier than those who managed to become top 50 ranked in the senior category (Table 2). They also showed blunted annual rate of improvement across the young ages compared to top 50 ranked in the senior category. All these features may be explained in the following way: a young athlete that starts its sport specific activity early, may have more chance to be an elite U18 athlete but also has less room for improvement and consequently may reach the personal peak performance early probably due to intense specialized training. The successive levelling of performance may increase the chance of drop out and thus may induce to conclude the career early.[24] However, since details of reasons to stop careers are lacking, this can only be considered speculation.

On average, the relationship between U18 performance and adult performance was stronger in women than in men, in all disciplines. Indeed, women showed larger correlations between performances at 17 years of age and in the senior category (Table 3 and Table 4). This is in line with previous observations on national athletes[12-14] and may be explained by the fact that young females are more biologically mature at 17 years compared to their male counterparts.[18,28] This makes young female athletes closer (from a biological standpoint) to the adult women athletes, hence decreasing the gap between young and adult performances.

Some limitations should be highlighted when interpreting the current data. We describe the career trajectory using the IAAF database. However, it is possible that many athletes started their career before being appearing in the IAAF database possibly competing in lower-level national competitions. Despite this, it is reasonable to assume that the abovementioned issues/problems are similar across all the athlete subgroups. From the data available, it is impossible to know if these

U18 athletes were already specialized in sprinting and/or if they were involved in other competitive/sporting activities or performing and training for different events.

Practical applications

This study provides a robust estimation of transition rate (or conversion rate) for world-class sprinters: from our analysis, 17% of male and 21% of female top 50 U18 sprinters managed to become top 50 adult athletes, thus informing the coaches and governing bodies about the realistic possibility to infer future success from young performances. This poses important concerns about the recent emphasis posed on world level competitions like youth Olympics which may push athletes to early specialization pathways. Therefore, a more cautious approach to athletic development is required as suggested by a recent IOC consensus statement.[26] The present study also suggests that beyond the absolute performance in U18 category, the age of entering competition and the annual change of performance represent the best approach for talent identification and development tracking in sprint disciplines.

Conclusions

According to our analysis of the performance trajectories of the best sprinters in the world, being an elite young athlete is not a prerequisite to become an elite adult sprinter. Indeed, most elite adult sprinters were not considered as such when they were young, but they showed a more rapid and durable improvement of performances during the young ages, compared to their early success counterparts. For this reason, performance progression rather than only performance *per-se* should be considered when determining chances of success at a later stage in the athletic career.

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Captions

Figure 1

Performance progressions (mean, 90%CI), from the first to the last appearance in IAAF database, are reported for each subgroup of athletes: 1) *only U18* (black circle), i.e. those who were among the top 50 ranked only at U18 but not in the adulthood; 2) *U18 and senior* (empty circle), i.e. those who were top 50 ranked both at U18 and in the adulthood; 3) *only senior* (gray circle), i.e. those who were top 50 ranked only in the adulthood.

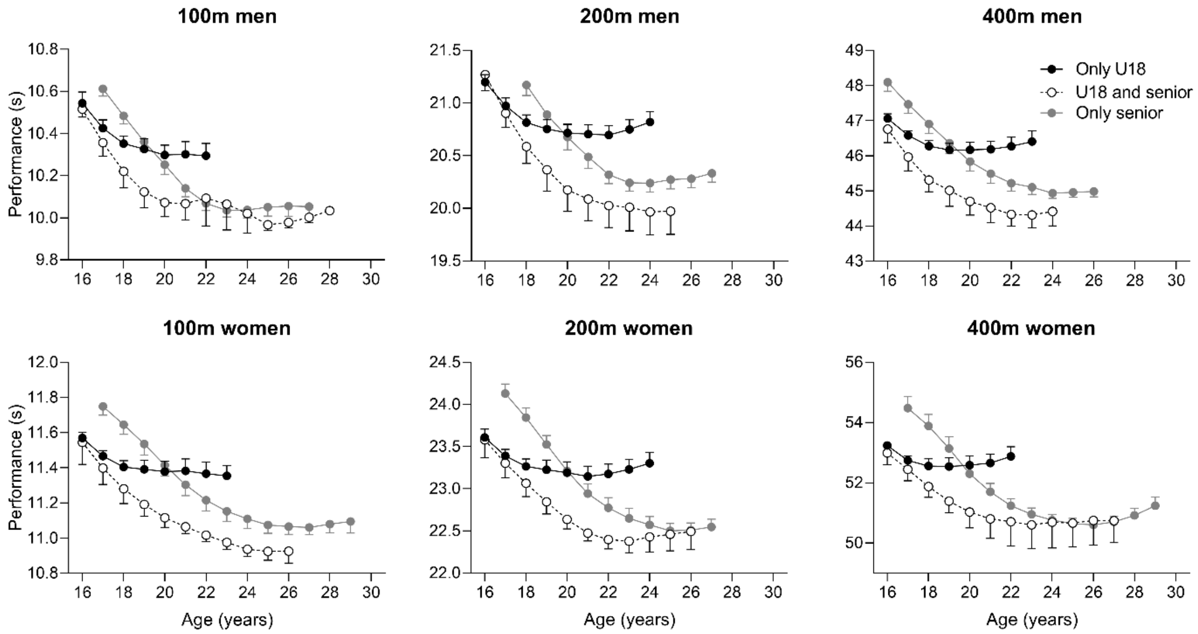

Figure 2

Percentage of yearly performance changes (mean, 90%CI), from the first to the last appearance in IAAF database, are reported for each subgroup of athletes: 1) *only U18* (black circle), i.e. those who were among the top 50 ranked only at U18 but not in the adulthood; 2) *U18 and senior* (empty circle), i.e. those who were top 50 ranked both at U18 and in the adulthood; 3) *only senior* (grey circle), i.e. those who were top 50 ranked only in the adulthood.