DEVELOPING YOUNG TALENT TO OLYMPIC CHAMPIONS IN ATHLETICS

UNDERSTANDING REALISTIC PROGRESSIONS

– Written by Marco Cardinale, Qatar

INTRODUCTION

Athletics is quite possibly the most ancient sport in the Olympic programme. It is a collection of sporting events that involve running, jumping, throwing and walking and it has been documented since the ancient Olympics. Athletics is in fact one of the only five sports that have been contested at every summer Olympic Games since 1896 with a current programme of 24 events contested in the Olympic programme. National and continental and World events are also contested at various age groups (youth and junior categories) as well as youth Olympic Games since their inception in 2010.

In this sport, young athletes compete in groups according to their birth year with specific age ranges for each category. They compete with peers up until the junior level before entering senior competitions (albeit recently some under-23 competitions were created to facilitate transition from junior to senior).

Various approaches have been used to detect, confirm and develop talent in the sport of athletics, however many are still strongly biased towards competition results, which is a typical issue in CGS (centimetres, grams and seconds) sport. Talent by definition is "*...an individual whose athletic performances are superior to his peer group and is capable of reaching or has achieved consisting performances at top level*[1]". Therefore, by proxy, individuals winning at youth or junior level in athletics competitions are often identified or referred to as "talents". While this may be semantically correct, the true manifestation of sporting talent occurs when elite level performance is reached at adult level and therefore, any assessment of transition from potential talent to champion should occur with the long-term view of identifying successful adult performers.

Running, jumping and throwing are the skills affected to a large extent by physical traits, influenced by genetic factors[2–4] and developed through life with training. Furthermore, the physical abilities underpinning performance in running/jumping/throwing events evolve and are affected by growth and maturation from childhood to adolescence to adulthood[5–8]. For this reason, predicting adult performances at a very young age is challenging and might not be the most appropriate approach. Also, since training and competition exposure combined with injury occurrence affect the development of talent and affect the

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chances of its manifesting at adult age, it is necessary to understand how we can assess athletic progression of what can be realistic expectations for the young athlete.

Such an approach would reduce the risks of identifying early maturers as potential adult talents, would reduce the risk of deselecting potential high performers at later stages in life and could contribute to the development of more appropriate expectations and evaluations of athletic development programmes.

GENDER DIFFERENCES IN DEVELOPMENT

Both male and female athletes benefit from training and competitive environments and improve performance during childhood in running, jumping and throwing events with men outperforming women to a larger extent near or after puberty[9,10]. A recent extensive review highlighted the importance of circulating testosterone as the main basis for gender differences in sport[11] indicating that puberty, which determines a surge in testosterone levels in male athletes, is the beginning of differentiation between male and female performers. Also, there is strong evidence that the sex differences in muscle mass and strength are sufficient to account for the increased strength and aerobic performance of men compared with women[12]. Improvements in physical abilities occur in both males and females and various studies in non-athletic populations have identified that boys perform substantially better than girls at each age group on tests assessing muscular strength, muscular power, muscular endurance, speed-agility and endurance capacity. The magnitude of the sex-specific differences in such tests has been shown to be increasing with age and accelerating from approximately 12 years of age[6,8]. Boys also develop at a faster rate than girls on these tests, especially during the teenage years, possibly due to the increase in testosterone levels. With that in mind, everybody involved in coaching or supporting youth athletes should be aware that improvements in performance from pre to end of adolescence, are expected mostly due to growth and maturation, with further improvements likely to come from improved mastery of technical aspects. Most of all, it is important to realise that progress is very individual and things change dramatically after puberty and when maturation occurs.

From a coaching standpoint, technical adjustments/differences in training paradigms might be similar for boys and girls until puberty and be differentiated and targeted once puberty starts to reduce the likelihood of injury, and to ensure that improvements in technical abilities and motor skills are aligned with the growing skeleton and neuromuscular system.

Athletic populations follow similar patterns of improvement in physical abilities and performance than the ones observed with cross sectional studies in physically active individuals. However, thanks to easily accessible online competition databases it has now been possible to analyse performance trends and develop performance funnels in various athletic events. The analysis of Norwegian competitors conducted by Tonnesen et al[13] showed that male athletes start to outperform females in jumping and running events after the age of 12 with jumping events results showing an accelerated improvement up to 14 years of age (in males). This is followed by a very slow improvement by the age of 18 in males and a plateau by the age of 16 in females. Overall, Tonnesen indicated that from the age of 11 to the age of 18 (during adolescence), Norwegian boys improve high jump and long jump performances by 41% and 48% respectively, and girls by 24% and 26% respectively. Our work analysing the Italian results database showed that the rate of performance improvement in jumping events is reduced in both boys and girls approaching 18 years of age to negligible amounts (less than 1% from age 16-19 in women's long jump). However, most importantly, the data indicated that, in jumping events, gender differences are evident in the rate

Personal best prediction (R^2)					
	Age	**M – High Jump**	**M – Long Jump**	**W – High Jump**	**W – Long Jump**
Performance + annual change	**14**	0.286	0.194	0.631	0.522
	15	0.540	0.526	0.685	0.536
	16	0.637	0.481	0.754	0.602
	17	0.794	0.668	0.807	0.714
	18	0.815	0.744	0.846	0.793
Personal best prediction (R^2)					
	Age	**M – High Jump**	**M – Long Jump**	**W – High Jump**	**W – Long Jump**
Performance only	**14**	0.207	0.152	0.410	0.290
	15	0.343	0.240	0.586	0.402
	16	0.536	0.428	0.622	0.527
	17	0.671	0.580	0.693	0.679
	18	0.791	0.664	0.752	0.720

Figure 1: Coefficient of determination of personal best prediction in jumping events using best performance and annual change in performance vs. best performance only using data from the Italian competitions database. (Data from Boccia et al, 2017).

of improvement year on year and not only in the absolute performance values. These data and previous work all point to an evolution of the gender difference in performance in running and jumping events from < 5% to 10–20% from age 11 to 18 years. This gap widens considerably during early adolescence before gradually stabilizing at later stages. Also, the gap of percentage improvement year on year seems to reduce post adolescence, possibly due to the complete maturation of the hormonal system. This evolution is practically identical for the running and jumping disciplines and it highlights the importance of and influence of growth and maturation on athletic development.

The studies so far conducted suggest that future performance prediction is unlikely to be accurate if only actual performance data at a given age are used. The suggestion is to include and assess the year on year rate of performance progression[14] in order to ascertain the extent of progression and to some extent the future potential. Our data have shown that elite performers at senior level had a greater rate of progression at a young age compared to athletes who did not reach elite performance as seniors. This strongly suggest a measure of early performance progression as most indicative of future potential (Figure 1).

TRANSITION FROM YOUTH TO SENIOR

In the sport of track and field, the International Association of Athletics Federations (IAAF) hold World Junior Championships (WJC) every two years for athletes under the age of 20 and used to hold World Youth Championships until 2017 for athletes under the age of 18. Participation and success at such events have been historically seen as a stepping stone for success at World Championships and Olympic Games as adults. Some authors have also supported the idea that success at junior level was a pre-requisite for success at senior level[15]. However, prospective analysis of the same dataset indicated that more than 60-70% of athletes medalling at the World Junior Championships don't achieve success at the senior level. The work from Piacentini et al[16] analysing throwing events showed a large dropout rate of World Junior Championships (WJC) participants from worlds' list in senior (Figure 2).

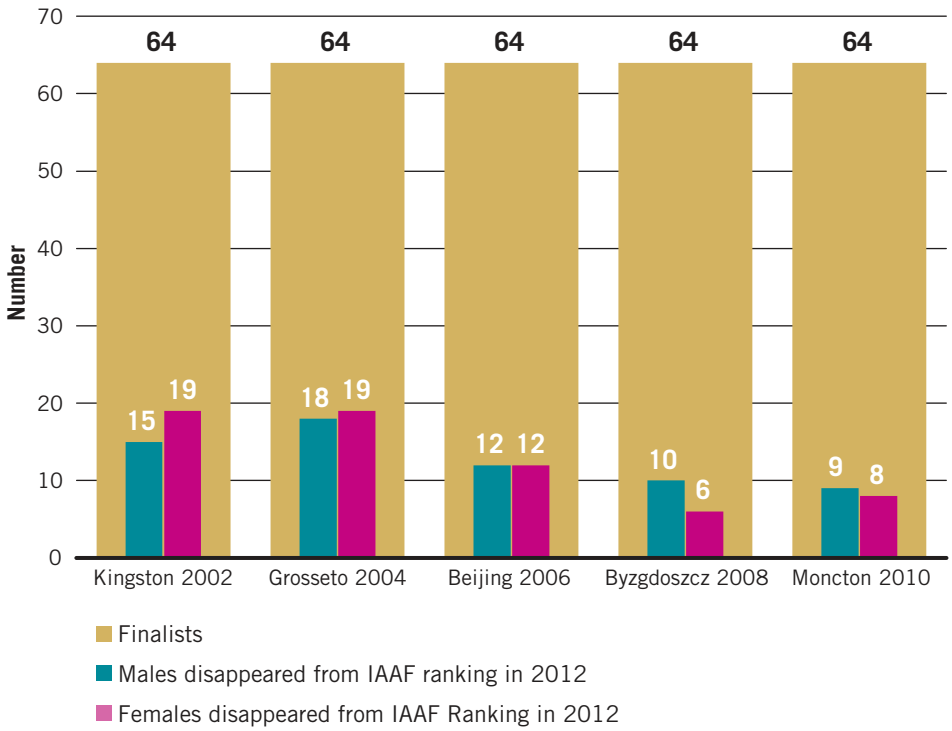

Figure 2: Junior to senior transition in throwing events. Data from Piacentini et al (2014).

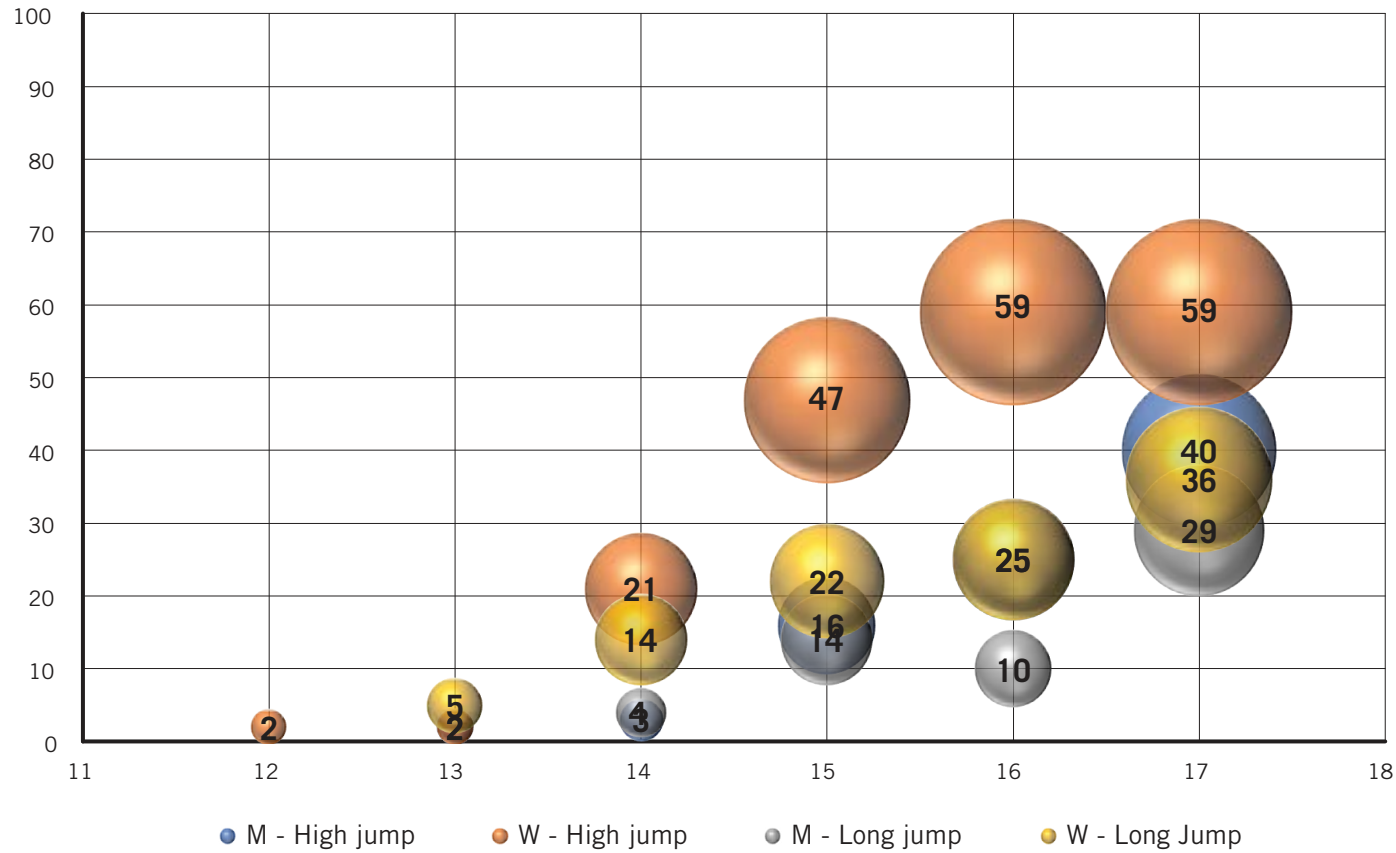

Figure 3: Percentage of top-level athletes which were elite at youth level in jumping events in the Italian results database. (Data from Boccia et al 2017).

Furthermore, only 8 athletes (2.5% of total athletes competing) of the finalists of 5 editions of WJC won a medal at the 2005, 2007, 2009 and 2011 World Championships and at the 2004, 2008 and 2012 Olympic Games. Data from the Italian athletic cohorts showed similar trends. In jumping events, a very limited number of athletes which reached elite performance levels as adults were performing at the top level as youth athletes (Figure 3).

A similar analysis conducted in sprints and throwing events confirmed this trend[17]. In fact, in this cohort, at best only 40% of the elite performers as adults were considered elite as youth in males (17 years of age, hurdles) and 50% in female discus throw. Only a small percentage (17-26%) of adult elite performers was considered elite in sprints, hurdles, discus throw and shot put between the age of 14-17 in the Italian cohort (Figure 4).

Authors from other countries have confirmed similar findings. Shibli and Barrett (2011) reported that only 12% of top 20 under-15 athletes in the United Kingdom retained their ranking when competing in the under-20 category. Kearney et al[18] analysed records of 134,313 performances (in the UK database, the power of 10 www.thepowerof10.info) by athletes aged between 12 and 35 years in sprinting, throwing, jumping and middle distance events. In this large cohort, only a minority (9% males; 13% females) of top 20 ranked senior athletes were also ranked in the top 20 when they were competing in the under-13 category. They also found that a very small number of athletes retained their top 20 ranking at subsequent age grades and by under-20, less than 30% of athletes who had been ranked in the top 20 at under-13, were still listed on the national rankings!

Transitions from junior to senior also don't seem to be straight forward. Data published in June 2019 by Foss et al[19] analysing finalists of WJC and Olympic Games in 2000, indicated that Olympic finalists achieved lifetime best performances at later ages than junior finalists and improved more from junior level performances. The most interesting finding was that, out of 130 junior finalists, 54 did not improve their performances after age 19, while only 19 of the 128 Olympic finalists showed no improvement in performance after age 19.

Overall, data so far seem to challenge the notion that achieving elite success as a junior athlete is a prerequisite for similar success at senior level. While the cause for lack of progression has not been researched, the number of dropouts/disappearances from top lists and the large number of athletes' performances not progressing might indicate injury, early specialisation as well as selection of early maturers as possible areas for further investigation.

> ***It is possible to succeed at senior level without early specialisation in most track and field events.***

The final consideration is on the progression of results. It is clear that improvements in year-on-year performance after age 19 are very small (in some disciplines less than 1%). Most athletes reach their lifetime best after age 25 with declining performances after that[20].

	Age			
Event	**14**	**15**	**16**	**17**
M – Sprint	0	10	7	22
W – Sprint	14	21	29	34
M – Hurdles	0	0	26	40
W – Hurdles	15	30	40	35
M – Discus Throw	2	23	23	38
W – Discus Throw	14	20	35	50
M – Shot Put	2	12	12	33
W – Shot Put	7	23	38	43

Figure 4: Percentage of top-level athletes which were elite at youth level in sprints and throwing events in the Italian results database. (Data from Boccia et al 2019).

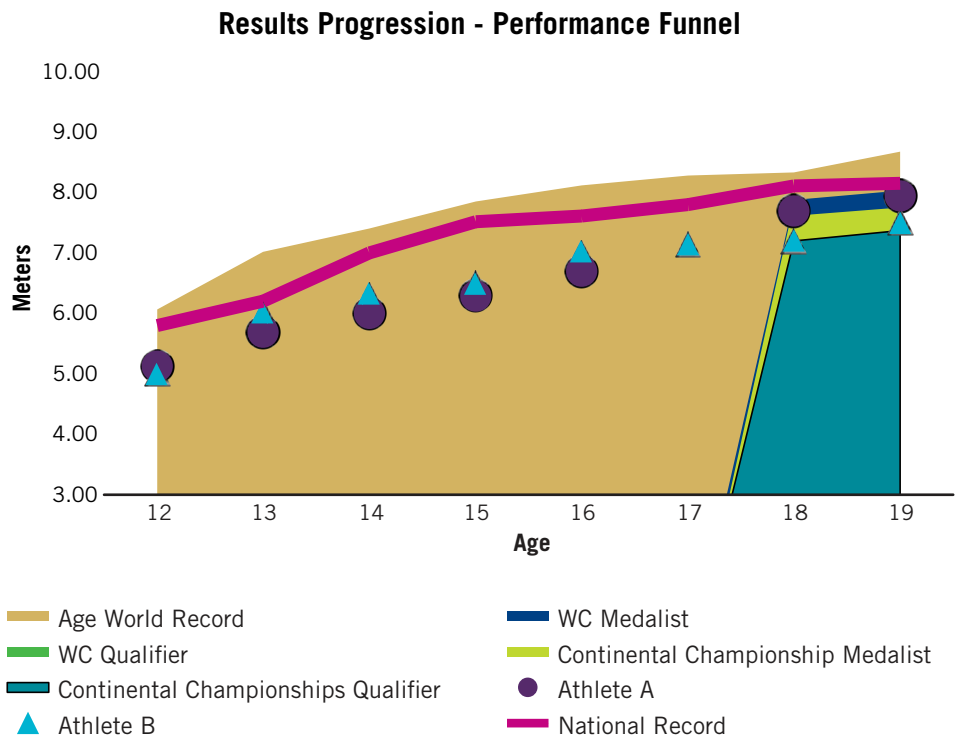

Figure 5: Example of a Performance Funnel tracking an athlete's progression according to typical progression curves.

EXCEPTIONS TO THE RULE

While current evidence seems to suggest that early success may not be a pre-requisite for success at senior level, it is important to also identify some exceptions to the rule. In fact, when analysing the careers of some exceptional athletes, it is clear that they performed consistently at a very high level and achieved significant progressions. In sprints, Usain Bolt is the first obvious example. He was World Junior Champion (while still in the youth category) in 2002, running the 200 m in 20.61 s. He was 200m World Youth Champion in 2003 (20.40 s), improved the world junior record in 2004 at age 17 (19.93 s) and continued to win 100m and 200m Olympic and World Championship titles in world record times. Recently, decathlete Kevin Mayer who won gold medals at youth and junior World Championships (in 2009 and 2010), won a gold medal at the World Championships in 2017 in London and a silver medal at the Olympics. He had 11 performances over 8000 points since 2012 and improved the world record in 2018. Heptathlete Carolina Kluft was an exceptional junior athlete setting the world junior record and winning gold at the WJC in 2002. She progressed to 3 World Championship gold medals and one Olympic gold medal.

These are examples of exceptional individuals with world class performances who, at a very early age, progressed to dominate their individual events as adult athletes – it is indeed possible! However, these are exceptional athletes; we still don't know why so many athletes fail to transition from junior to senior success.

CONCLUSIONS

Analyses of competition databases indicate that it is possible to succeed at senior level without early specialisation in most track and field events. Recent data suggest that most athletes reaching elite performance level as seniors were not elite performers as juniors. Furthermore, in some disciplines many junior medal-winning athletes do not repeat the same level of performance when they compete as adults.

All in all, it seems feasible to suggest that performance tracking and assessment of progression is necessary to determine if athletes' early career progress will result in high level adult performances. Some nations use performance funnels to describe and assess an athlete's progression. Results databases might identify performance trends in different events and to a certain extent predict the likelihood (and minimum requirements) of reaching adult medal potential in major events. While performance data might help to determine how athletes develop from youth to senior competitors, more needs to be done to identify key contributing factors (including training methods) necessary to increase the chances of transforming youth potential into adult success.

Running, jumping and throwing are the skills affected to a large extent by physical traits, influenced by genetic factors and developed through life with training.

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Marco Cardinale Ph.D.
Head of Sports Physiology & Research
Aspire Academy
Doha, Qatar

Contact: marco.cardinale@aspire.qa