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A stitch in time saves nine: the importance of biological maturation for talented athlete development

Jamie Salter, David Johnson and Dr Chris Towlson outline the importance of individualising training prescription to minimise injury risk and optimise talent development in youth sport environments

Introduction

The individualisation of training is universally accepted to optimise performance, reduce injury risk and promote talent development. Tailoring the prescription of training stimulates desired physical and physiological adaptations, accelerates recovery and helps to maintain psychologically healthy athletes. By manipulating scientific principles, practitioners can periodise training prescription based on sporting demands, seasonal-cycle, athlete characteristics and coach leadership styles. At elite levels, advances in technology and data processing have enabled quick and sophisticated monitoring of both internal (e.g., heart rate and perceived exertion) and external metrics (e.g., training volume, GPS metrics) to inform decision-making. The recent proliferation of research exploring associations between training load, injury and performance would suggest this is now 'standard practice', rather than 'best practice' and that interpreting and applying data to inform training is a preconceived notion; unless you work with adolescent athletes (12-16 years).

Despite the large volume of contemporary training prescription research, a small proportion of this has been conducted in adolescent athletes with respect to the non-linear variations in biological maturation. These biological changes occur asynchronously to chronological age, which may confound traditional age-specified approaches to talent development. Logistical, resource and environmental (i.e., school) constraints associated with working within adolescent environments may in part explain the relative lack of empirical research in this area. That said, evidence would suggest there is a sincere need for considered individualisation of training prescription and dose-response management in adolescent athletes to adequately develop talent (Bergeron et al., 2015). This article aims to explore the importance of biological maturation in youth sport and give guidance on how the information can inform an individualised approach to talent identification, development and injury risk reduction for more positive long-term outcomes.

Biological maturation

Biological maturation is the ongoing progression towards adulthood that involves significant developmental processes that change anthropometric, physiological and psychological standing. Although the type and sequential order of biological development is well understood, the timing and tempo of these changes vary significantly between individuals making understanding and management of this period complex. Maturation varies substantially within chronological age-groups, with variations in male body mass (~50%), stature (~17%), fat free mass (~21%) and predicted adult height (10-15%) not uncommon (Hannon et al., 2020). This is primarily influenced by variations in maturity timing, meaning that the onset of key maturational processes (i.e., peak height velocity; PHV) can differ by 3-4 years between individuals of the same age. Typically, PHV occurs earlier in females (~11.9 years) than males (~13.8 years) with rates in growth typically approximating ~8 cm and ~10 cm per year, respectively. The magnitude of change in such a short period can significantly impact the coordination, stability and general movement competency of athletes, thus making identification and development of talent difficult.

Several methods to monitor growth and maturation exist, each with important practical considerations. Invasive methods such as skeletal age (e.g., hand-wrist x-ray) requires both time and resources to conduct, whilst secondary sex characteristics (e.g., breast and pubic hair development) may be psychologically invasive

and potentially considered unethical. Somatic estimates of maturation are simple and accessible at all levels of sport and usually require accurate readings of basic anthropometric measures (i.e., stature, body-mass, sitting stature) accompanied with both birth parent stature (if available). Maturity-offset is one somatic method that predicts the individuals time (in years) from the onset of PHV offering an estimation of maturity timing, which can then be used to classify individuals into status groups (i.e., pre-, mid- and post-PHV). Alternatively, measures of estimated adult stature (EAS), and the progress towards this (EAS%) can be used to infer maturity timing (and status) based on PHV occurring between 88-93% EAS (Bergeron et al., 2015). Both somatic methods are widely utilised in both research and practice, with recent studies indicating greater accuracy when adopting EAS% versus maturity offset methods.

Reducing injury

As a profession 'we' scrutinise the daily activities of adult athletes to optimise loads, yet we are happy to group age determined cohorts together expecting biologically diverse individuals to all 'cope' with the planned session equally—yet injury evidence suggests this is just not the case. Injury rates are elevated in adolescent athletes in comparison to their pre-pubescent and adult peers, with a high proportion of injuries (46-72%) being non-contact in nature and 17% insidious onset (Towlson et al., 2020). It is common for athletes to experience 'growth-related' inflammatory-based conditions during this period, such as Severs or Osgood Schlatter disease. It is proposed that this heightened incidence and inflammatory symptoms are largely caused by frequent, high-intensity activities imposed on 'skeletally fragile' and rapidly developing individuals with palpable imbalances between soft and hard tissue development. For example, adolescent stature increases are initiated by long bone growth, with soft tissue (i.e., tendon and muscle mass) developing after adapting to the altered levels of mechanical stress. During this lag period, it is common for individuals to adopt modified movement kinematics (termed 'adolescent awkwardness') and mechanical load-response pathways, potentially reducing their resilience to injury.

By utilising the accessible somatic maturation methods previously outlined, practitioners can adopt a proactive approach to reducing injury risk in adolescent populations. Monitoring maturation over time can allow practitioners to classify 'at risk' players and intervene early (through structured activity management) and reduce (not stop) exposures to mechanically demanding activities. By utilising regular maturity categorised (i.e., bio-banded) training sessions, practitioners can more adequately 'manage' the exposures of their athletes, by prescribing activities to facilitate development whilst preventing unwanted mechanical stress. For example, grouping 'mid-PHV' individuals together and focussing on technical proficiency of movement for one session each week may innately reduce the repetitive, high-stress mechanical loads associated with rapid decelerations and changes of direction. These reductions in repetitive stress act as 'a stitch in time' to prevent negative long-term consequences of injury and potentially burnout and or drop-out. Maintaining player availability is a key performance outcome for performance staff in adult populations, but higher availability in adolescent cohorts will ultimately enhance time to identify and develop talent.

Talent identification & development

Actively considering maturation within talent identification and development processes is crucial to inform decision making. The maturity-selection bias proposes that individuals of advanced biological maturity are physically advantaged over less mature peers, resulting in positive appraisal from coaches/scouts and subsequently exposed to higher quality training environments. Physical advantages manifest themselves in the form of enhanced speed, strength, power and overall size which reduces the relative intensity and demand of match-play and augments performance. However, the bias suggests that less mature individuals that can 'cope' with the academy system, often possess superior technical, tactical and psychological ability when they catch up physically (~16 years), termed the 'underdog hypothesis'. Without considering biological maturation

into selection discussions, practitioners may misjudge 'talent' for physical advantage. Various strategies such as bio-banding and age-ordered shirt numbering have been used to reduce this bias, with growing frequency and success. Exposing players to biologically categorised training and competition environments has been well-received by players and coaches with clear positive impact on the psychological and sociological development of participants (Cumming et al., 2018). These events aim to reduce the physical disparity between players of varied biological maturity and offer a more technical/tactical emphasis to allow players to showcase their ability more holistically.

The collection, presentation and communication of data and information involving adolescent players needs to be considered carefully. For example, speed, power and aerobic endurance data is commonly assessed and ranked within chronological age-groups. This may place biologically diverse athletes 'competing' against each other on tests one is more predisposed to succeed in, drawing similarities to Einstein's analogy that if you judge a fish on its ability to climb a tree, it will always consider itself as stupid. Therefore, these data should be analysed and presented with maturation and/or biological age clearly signified to allow stakeholders to appropriately appraise the data within the context they exist. Additionally, maturation data should then be communicated to parents, specialist support staff and coaches to ensure that the developmental environment specially focuses on the needs of the individual, which may also reduce anxiety, stress and expectations of the support network as they will understand the differentiated practices well.

The future

Evidence to support and guide practitioners with catering for individuals during maturation is developing. However, there is an urgent need for large scale, multi-centre studies to: a) identify the most accurate somatic maturation method, to facilitate comparisons across research and practice; and subsequently b) generate robust guidelines for practitioners responsible for developing adolescent athletes. Although frameworks exist around the focus of athletic development activities, these are limited when offering guidelines on the maturity-specific dose-responses which are crucial to the individualisation of development pathways. Therefore, to generate better long-term outcomes for young athletes, we must prioritise establishing a uniformed set of best practice, maturity-specific guidelines for talent and athletic development.

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