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Estimating is not measuring: the use of non-invasive estimations of somatic maturity in youth football

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Introduction

Biological maturation refers to the progression to the adult state. It is continuous throughout childhood and adolescence, and its effects on sport performance might mask or be greater than the effects associated with exposure to training (Baxter-Jones et al. 2005). The underlying mechanisms of biological maturation can be observed or measured (Malina et al., 2015). For example, measures such as skeletal age, dental age, age at menarche, the development of secondary sex characteristics and somatic maturity, can provide an indication of the timing, tempo or sequence of maturational events.

Differential growth and maturation contribute to variations in body size and performance in adolescent male and female footballers. As such, the timing of maturational events, such as the somatic assessment of the adolescent growth spurt [Peak Height Velocity (PHV)] has received considerable interest in the study and practice of talent identification and development for several decades. In this issue of Science and Medicine in Football alone, there are three manuscripts addressing maturational issues: (i) the effects of maturity on talent identification and selection (Toum et al. 2021); (ii) sustained attention and tactical behaviours (Gonçalves et al., 2021); and (iii) physical and psychological indicators of talent (Towlson et al., 2021). The interest in growth and maturation studies in youth sport is unsurprising, given the wealth of youth athlete development and talent frameworks that recognise the confounding influence of growth and maturation in talent identification and development (e.g. Bennett et al., 2019).

With the confounding influence of maturation now at the forefront of a proportion of the talent identification and development research, sport scientists have increasingly expanded their repertoire for measuring or estimating maturity.

A paradox of choice

A wealth of non-invasive estimations of maturity are now available to researchers and practitioners, which often replace more traditional and robust, but less user-friendly methods such as estimating skeletal age using wrist and hand bone X-rays, the (self) assessment of secondary sex characteristics or longitudinal observations of height. While the use of estimations of somatic maturity based on anthropometric measures has clear advantages in the context of youth talent development (i.e. they are more suitable to large samples, less time consuming, less invasive, do not require technical equipment and are suitable to be used in cross-sectional studies), their use in the context of talent identification and development research is often ill-considered.

Non-invasive estimation of somatic maturity uses a linear (e.g. Mirwald et al., 2002; Khamis-Roche; 1994; Moore et al., 2015) or non-linear (e.g. Fransen et al., 2018) combination of anthropometric and descriptive variables such as height, body mass, leg length, chronological age and/or mid-parental height. It is used to estimate how many years an individual is removed from attaining, or having attained PHV; or the percentage of adult height achieved by an individual (i.e. at PHV individuals are at around 90% of their adult height [Sanders et al., 2017]). However, before using these estimations, one should consider the reference samples from which they were obtained to understand their applicability to a sporting context. In the case of the Mirwald et al. (2002) maturity offset and Fransen et al. (2018) maturity ratio methods, the reference sample consists of a mixed-longitudinal, mainly white Canadian children who were between four years pre-, and three years post-PHV. The Khamis-Roche (1994) method to predicted adult stature used sample data from the Fels longitudinal study, consisting only of white, relatively well-off children whose anthropometry was assessed between 3-18 years. These reference samples are distinctly different from the multi-ethnic populations observed in youth football today across many parts of the world. Therefore, the application of these estimations in samples other than those consisting of Caucasian participants, should be considered carefully.

Estimating is not measuring

Non-invasive estimations of maturity suffer the same disadvantages as many other estimations. They are most accurate around the event that is to be estimated (i.e. APHV or attainment of adult stature), and they come with significant measurement errors. In their original publication, Khamis and Roche (1994) reported that generally the estimating error (at the 90% error bound) is 5.3 ± 1.4 cm in males, and 4.3 ± 1.6 cm in females. Mirwald et al. (2002) reported that maturity offset could be estimated within an error of one year, 95% of the time. Estimating errors using other methods in similar samples are likely comparable. However, the estimating error could be much greater in samples that do not resemble the original reference data, such as samples with diverse ethnic backgrounds.

Finally, the validity of predicting maturity from anthropometrics in football samples is questionable when compared to criterion measures. For example, Teunissen et al. (2020) showed that estimated age at PHV did not correspond with longitudinally observed age at PHV in a single player among 17 high performance footballers, regardless of the estimating equation used. These findings echo concerns about the limited validity of the Khamis-Roche predicted adult stature method when compared with estimations of skeletal age (Malina et al., 2007).

Practical advice for researchers and practitioners

Researchers and practitioners working with youth athletes should develop an in-depth knowledge of how and when children and adolescents grow and mature. This will allow them to better understand and appreciate the large variability in timing and tempo of maturational events within and between the sexes. When practitioners and researchers use non-invasive estimations of somatic maturity such as those obtained from the maturity offset or percentage of predicted adult stature methods, they should carefully consider their shortcomings, such as the reference sample in which they were developed, the fact that estimations are generally poorer when youths are far removed from what is to be estimated, the significant estimating errors, or the general absence of criterion validity.

Finally, the most appropriate method used to assess the timing, tempo and/or sequence of maturational events is context dependent. In a clinical situation the gold standard method of using hand and wrist radiographs is commonplace. When x-rays are not available, measured height and the observation of secondary sexual characteristics can be used by comparing it to references standard charts. When working with groups outside of a clinical context, the recommended method is to use an estimation of the occurrence of PHV either by percentage of estimated adult height or an estimation of the attainment of PHV. While researchers and practitioners should carefully contemplate these estimations, they are sufficiently sensitive to assign players into categories (i.e. pre, circum or post puberty), which can, alongside players' chronological age, offer valuable insights to researchers and practitioners concerned with football players' growth and development.

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