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MORPHOLOGICAL AND FUNCTIONAL ISSUES IN THE DEVELOPMENT OF YOUNG MALE ATHLETES

MORFOLOŠKI IN FUNKCIONALNI VIDIKI RAZVOJA MLADIH ŠPORTNIKOV

ABSTRACT

There is a strong link between maturational development and growth and performance. Organising age groups according to the criteria of chronological age leads to a big difference in size, composition and performance, and adolescence is the period when these differences are more visible with the ages between 13 and 15 years appearing to be the most heterogeneous period. In the same age group, maturationally more advanced subjects are generally heavier and taller than their peers of the same chronological age from childhood to the end of their adolescence. However, adults do not usually reveal the same differences when the same comparison is made. This situation can be explained by the *catch up* phenomenon in late-maturing individuals.

The initial process for identifying promising athletes is multidimensional and the literature in the area shows that growth and maturation are two important concepts allowing a better understanding of the identification, selection and development processes of young athletes. Young soccer players tend to be above the mean for height and mass and tend to have an advanced biological maturity status with increasing age during adolescence and in elite development programmes. Worst results have been reported for body size and functional performance in young soccer players who were not selected to play in more demanding competitions or who had dropped out from sport. The same trend was visible in academy

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IZVLEČEK

Med zrelostnim razvojem, rastjo in uspešnostjo obstaja močna povezava. Oblikovanje starostnih skupin po merilu kronološke starosti vodi v velike razlike v velikosti, telesni zgradbi in uspešnosti, adolescenca pa je obdobje, ko so te razlike vidnejše, pri čemer je obdobje od 13 do 15 let najbolj heterogeno. V enaki starostni skupini so zrelejši člani od otroštva do konca adolescence na splošno težji in višji od svojih sovrstnikov enake kronološke starosti. Vendar se pri odraslih pri enaki primerjavi običajno ne pokažejo enake razlike. To je mogoče razložiti s pojavom *dohitevanja* pri pozneje zrelih posameznikih.

Začetek v postopku odkrivanja obetajočih športnikov je večdimenzionalen, literatura s tega področja pa kaže, da sta rast in zrelost dva pomembna koncepta za boljše razumevanje procesov identifikacije, selekcije in razvoja mladih športnikov. Običajno je višina in teža mladih igralcev nad povprečjem, glede na starost pa je njihova biološka zrelost višja v adolescenci ter pri programih za razvoj vrhunskih športnikov. Najslabše rezultate glede velikosti telesa in funkcionalne uspešnosti so poročali pri mladih nogometaših, ki niso bili izbrani za zahtevnejša tekmovanja ali so šport opustili. Enak trend je bil opazen pri igralcih iz športnih šol, ki jim niso bile ponujene profesionalne pogodbe. Kljub pomanjkanju dokazov, da antropometrične, zrelostne in telesne značilnosti na začetku procesa niso neposredno povezane z izjemno uspešnostjo v odraslosti, je dobro vedeti, da lahko ti kazalniki športnikom odprejo vrata športnih šol in drugih odličnih vadbenih centrov, ki promovirajo boljše pogoje in boljše treninge za izbrane igralce. Zadnje raziskave niso pokazale večjih razlik v vstopnem profilu nogometašev v klubski športni šoli. Ta ugotovitev nakazuje, da so se strategije za promocijo športa (nogometa) ohranile kljub vse večjim zahtevam po antropometričnih značilnostih profesionalnih players who were not offered a professional contract. Despite the lack of evidence that at the beginning of the process the anthropometrical, maturational and physical characteristics are not directly associated with an exceptional performance in adulthood, it is of interest to understand that these indicators may open the doors of academies and other training centres of excellence promoting better conditions and better coaching for select players. Recently, decennial differences were not found in the entrance profile of soccer players in a club academy. This finding suggests that the sport (soccer) promotional strategies are being maintained despite the increased demandingness of professional players' anthropometric characteristics and the demands of actual professional soccer competitions.

Key words: maturational development, growth, performance

igralcev in potrebah na dejanskih profesionalnih nogometnih tekmovanjih.

Ključne besede: zrelostni razvoj, rast, uspeh

INTRODUCTION

Organised sport provides adolescents with one of their most important opportunities for social participation. In spite of the urgency of the social alarm concerning the sedentary way of life and paediatric obesity, the statistics on sport participation continue to give information about the rising volume of people practising sport. Among the most popular sports, soccer is regarded as the dominant choice, boasting about 165 million players around the world with positive annual variations, and in all age groups. Meanwhile, investigations of youth sport equally show an abundant and growing production. Topics more studied in such investigations are based on problems such as talent and readiness and sport selection.

The growing popularisation of soccer and rising demand for long-term sport preparation is creating a need for answers to new problems related to the prognosis of sport performance, the adjustment of training and match contents to growth characteristics, maturation and young athletes' development, control of the incidence of sport injuries and the predictive variables of injuries and a description of players with different sport trajectories.

Talent identification and development is one of the emerging topics of research into sport sciences, partly due to the capacity to call on concepts and methodologies in domains as varied as sport medicine, genetics, sport psychology and other disciplines. The analysis of sport preparation programmes reveals a huge variation associated with the number of age groups, the duration of the age groups, the beginning of formal competitions and their organisation, and stages of sport selection. Different sports assume different models with the organisation of either the male and female sector providing an additional source of variation. However, in all cases chronological age constitutes the agglutinant element of long-term programmes for sport preparation. Some authors (Malina & Beunen, 1996, Malina *et al.*, 2005) detach the need to complement the organisation of a sports career based on information that considers the substantial biological variation that happens inside the same age group. This consideration has not been in conflict with other sport agents once the problem is located, above all, at the operational level. Even FIFA has been sensitive to the discussion of the problem.

Although just the concept of biological maturation exists, scientific and technological progress has made a group of somatic, sexual and skeletal indicators available, where each of them has different potential and limits with greater capacity for use in a sample with several participants and beyond the context of investigation. Determination of the stages of the secondary sexual characters promotes an invasion of the privacy of those observed. On the other hand, it has been shown that it is extremely difficult to use methods such as radiological exams on a massive scale. Alternatively, the percentage of predicted adult stature seems to be easy to utilise although a possible question remains about the validity of the formulas out of the original population.

THE CONCEPT OF GROWTH AND MATURATION

Children and youngsters experience the interaction of three distinct processes during the first two decades of life: they grow, mature and develop. However, these processes are frequently used as if they have the same meaning. Growth is a process that occurs throughout human life. Still, it is during the first two decades of life that it is most visible. Although there is no single definition of growth, it is common to define it in a quantitative way considering different dimensions because as a child grows there are changes in several tissues, shape and body composition and distribution. According to Malina *et al.* (2004), growth is an increment in the size of the body as a whole or of specific parts of it. Different parts of the body grow at different moments and paces with the necessary changes at the level of proportion. The same authors note that the changes allowed by growth are due to three essential cellular processes: i) an increase in the number of cells (hyperplasia); ii) an increase in the size of cells (hypertrophy); and iii) an increase in intracellular substances. These processes lead to a very similar pattern of growth in every individual, although there is great variability in the rate of growth at different ages and in the adult size attained. Maturation is different from growth since every subject reaches the same final state (the mature state). Following this, maturation may be defined as the moment and the cadence of a process that leads to the biological mature state. This is an individualised process because different people vary considerably in their maturation rates. Regulation of the growth and maturation processes is complex. Several interacting factors are involved from the moment of conception through to the mature state. The processes of growth and maturation assume huge plasticity as they are influenced by a large variety of factors.

PLASTICITY THE GROWTH PROCESS

An individual's growth cannot be explained solely by his genetic inheritance or by the surrounding environment. Some indicators may be urban/rural residency, social-economic status, family size, parents' educational level, maternal behaviour during pregnancy, presence of breast milk in the baby's feeding, hormonal influence, ethnical influence, nutrition and maturation.

By itself, physical activity, including sport practice, does not reveal any influence on the growing process. Malina et al. (2004) point out some errors in studies that associate growth in height with training: 1) most of these studies are not longitudinal; 2) they focus more on possible negative aspects of training than on its benefits; 3) the factor of sport selection is rarely controlled; and 4) they try to establish cause-effect connections based on correlative analysis.

VARIATION DURING THE PUBERTAL PERIOD

Puberty as a period of morphological and physiological changes affects both boys and girls. These transformations include almost every organ and structure but their timing, cadence and length do not follow a universal pattern. The main expressions of puberty are: a) the adolescent growth spurt – an increase followed by a decrease in growth of most skeletal measures and many internal organs; b) the development of the gonads; c) the development of secondary sexual characteristics; and d) changes in body composition – the amount of fat and skeletal and muscular development; and e) the development of circulatory and respiratory systems which leads to an increment in strength and endurance, especially in boys. There is no single factor that marks the beginning of puberty; instead, there is a gradual maturation of the hypothalamic-pituitary-gonadal axis during childhood. Puberty starts once there is an increase in the frequency and amplitude of secretion in the GnRH (gonadotropin releasing factor) leading to the maturation of the gonads and therefore to the development of secondary sexual characteristics (Stanhope, 1989).

The adolescent growth spurt is visible in the height growth velocity curve. This curve shows two moments that limit their occurrence: the *takeoff* and the peak height velocity (PHV). The first happens along with the start of the adolescent growth spurt and corresponds to a sudden increase in growth speed; the second corresponds to the maximum growth rate. After reaching the PHV, the increments become gradually smaller until they stop. The adolescent growth spurt is therefore the period that ranges from the *takeoff* to the peak height velocity. Malina *et al.* (2004) present a set of European and North American studies where it was possible to follow some trends for the adolescent growth spurt in general and for the PHV in stature in particular. The amplitude of the averages found for the age at *takeoff* is approximately 2 years and 1 year for the PHV. In *takeoff,* the average age for boys varies between 10.0 and 12.1 years. Data on the age where the PHV occurs in boys point to an amplitude ranging between 13.3 and 14.4 years. However, in 75% of the analysed studies (28 of 37) there is an amplitude of PHV occurrence between 13.8 and 14.1 years. Concerning the values of the PHV (cm/year), an amplitude with a discrepancy of approximately 2 cm per year was found among the different studies, presenting the boys with a variation of between 8.2 cm/year and 10.3 cm/year. In boys, the adolescent growth spurt begins around the age of 11/12 years and lasts for a period of about 2 years. However, the asynchronous adolescent growth spurt of other somatic measures with the corresponding differences in timing, intensity and length characterises the allometric growth.

The PHV for body mass usually happens about 0.4 years after the PHV for stature. This sudden increment in body mass brings some gains in bone tissue and muscular mass since fat mass is relatively stable at this time. The increments in stature depend on the increase of the trunk and the inferior limbs' proportions and these structures experience different paces of growth with the PHV of these two partial measures of stature happening at different moments. The PHV of stature is to be found between the PHV of the lower limbs and sitting height (trunk length), with the development of lower limbs occurring before the development of the trunk. Accordingly, rapid growth in the lower extremities marks the beginning of the adolescent growth spurt and the *takeoff* ages for lower limbs' length and sitting height differ by about 0.1 year while the age at PHV occurs with a difference of about 1 year. This confirmation suggests that the trunk length is subject to a longer growth process and, as a result, participates more strongly in the values observed for an individual's stature when compared to the length of the lower limbs.

The sitting height/height ratio (sitting height/stature x 100) establishes the extent of the trunk participation and, by subtraction, of the lower limbs, in the stature. Malina *et al.* (2004) describe the dynamics of the development of this index. The highest values appear during the first infancy (birth to 2 years of age) and decrease during the second infancy. The lowest level is attained during the pubertal period and then suffers a slight increase until the end of the second decade of life. Therefore, up until the halfway point of the adolescent growth spurt the lower limbs grow faster than the trunk, leading to a gradual decrease in the sitting height/height ratio. However, as the trunk reaches PHV after the lower limbs, a slight increase in the ratio is observed at the end of the adolescent growth spurt.

Considering body composition, it is possible to note the steadiness or slight increase of fat mass in males during the adolescent growth spurt. However, there is a big increase in fat-free body mass in this period because of the considerable increase in muscular and bone mass leading to an increase of all components but also to a proportional decrease in fat mass.

FUNCTIONAL CAPACITIES PUBERTY

Besides dimensional modifications, puberty is marked by important physiological transformations that hold immediate consequences for the training process of an adolescent athlete since it is natural that physiological changes happen along with dimensional ones as an organ's dimension is not irrelevant for its functional capacity.

Anaerobic performance (overall)

Technical and ethical constraints make it difficult to directly evaluate anaerobic energy-producing pathways in children and youngsters (through muscular biopsy). For this reason, many researchers have adopted the evaluation of mechanical work that depends on anaerobic ways (evaluation test performance) as a way of quantifying their aptitude.

The ability to perform anaerobic tasks increases during the growth process and this increment is detectable in short-, medium- and long-term anaerobic expressions and that the improvement in anaerobic performance in children and youngsters not only depends on quantitative factors (increment in body and muscular mass) but also on qualitative aspects of the muscle or of the activation of motor units (Armstrong & Welsman, 2000; Van Praagh, 2001; Malina *et al.,* 2004). Anaerobic *performance* depends on body size, especially on fat-free body mass and the transversal muscular section of the thigh. Other factors underpinning this type of performance are: the quality of the muscle (type of fibres, availability of substrates); muscle architecture (fibre alignment); muscle endurance (glycolytic enzymes, storage of creatine phosphate – CP); endurance to fatigue; muscle amount (muscle and cross section size); musculoskeletal structure (joint geometry); and neuromuscular activation (recruitment and coordination of motor units), and all these factors contribute to increments during the growth and maturation processes.

A minor capacity to use the glycolytic way is shown by pre-pubertal individuals. This is due to the small concentration of the enzyme phosphofrutokinase, which limits the glycolytic process and compromises activities that last between 10 and 60 seconds.

Velocity

Performance in this physical ability increases with ageing and develops in a linear way during the growth period. Even though the increments in this physical ability happen all through the second childhood, it is during the pubertal period that its development is more obvious.

There is a set of factors that are capable of acting favourably to improve this ability during growth: an increase in the length of the footstep; an improvement in the quality of strength production against the ground; an increment in muscular strength and neuronal influence. The ability to be fast depends largely on the glycolytic way but, paradoxically, the glycolytic ability of a youngster increases with growth and, at the same time, relative speed (per unit of body mass) decreases in the same period due to a disproportional increase in body mass.

Strength

Strength is an ability that shows increments throughout childhood and puberty, yet not all of the tasks that depend on the different expressions of this ability follow a similar development pattern (Rowland, 2004; Malina *et al.,* 2004).

There are strong and positive correlations between chronological age and measures of maximum voluntary strength in boys during childhood and puberty periods. These may be the result of a covariance in chronological age and other biological and somatic variables that may assume more importance in explaining the changes in strength that appear throughout the growing process. The gains in strength during childhood and puberty seem to have a deep connection with changes in somatic dimensionality, muscular size, neuromuscular and neuroendocrine development, as well as heredity and lifestyle (given by regular physical activity and sport participation).

Isometric maximum strength increases linearly from childhood until approximately 13–14 years of age when it is possible to see a clear adolescent growth spurt in this capacity. The association of isometric maximum strength with chronological age in boys reveals high and positive correlations and the intensity of those is higher between 10 and 16 years. Horizontal and vertical jumps are seen as indicators of muscular power of the lower limbs and, on average, the performance of males increases linearly until 18 years of age (Malina et al., 2004). Explosive extension or flexion of the knee joint, stature and body mass are indicated as performance predictors of explosive strength (De Ste Croix *et al.,* 2002).

During childhood and adolescence there are significant changes in the ability to produce strength due to the different conditions of growth and maturation, and (static and dynamic) maximal strength shows a stable increment with chronological age from childhood until 13–14 years of age and then there is an acceleration with the onset of the pubertal period.

Aerobic performance

A child's ability to do aerobically supported physical exercise increases with age. VO_2max increases all through the second childhood and up until 12 years of age there are no significant differences between the two sexes, although boys continually show higher values after the age of 5 years. In the adolescent growth spurt, this stops happening because girls reach a *plateau* and boys continue to have increasing values until they reach 18 years (Baxter-Jones & Helms, 1996). The pubertal changes that occur in the cardiorespiratory and cardiovascular systems, when the increase in the number of circulating red blood cells causes a rise in the concentration of haemoglobin, have positive effects on the extraction, fixation and transportation of oxygen as well as blood buffering (Armstrong & Welsman (2000).

There is a strong association between the maximum oxygen consumption and body size and, if growth has a direct influence on the maximum oxygen consumption, then it is essential to control the dimensional changes caused by the adolescent growth spurt. There seems to be a steadiness of VO_2max with ageing when expressed in body mass units ($ml.kg^{1}.min^{-1}$), which suggests proportional growth between maximum oxygen consumption and body size (Malina *et al.,* 2004). However, more than body mass, muscular mass plays a more important role in the manifestation of maximum oxygen consumption. Absolute VO_2max ($l.min^{-1}$) begins its adolescent growth spurt at around 12 years of age and reaches the peak height velocity approximately 1 year later. However, if we take the PHV for stature as a reference, we can verify that the highest growth rate for these two variables coincides in time (Geithner *et al.,* 2004).

The traditional analyses that use body mass as a scaling element to assess VO_2max have reported the steadiness of these values in boys from 8 to 16 years of age. However, use of allometric techniques that are more appropriate for removing the effect of body size proves that boys' VO_2max is not steady but suffers an increment with ageing (Armstrong & Welsman, 2000). Malina *et al.*

(2004) follow this opinion and reveal that the increment of VO_2max with age also depends on factors other than sex, body size and maturational status because even if we control the effect of these factors there is an improvement in performance during the growth process.

SKILLS

During the first decade of life, children acquire and become progressively more competent in performing the basic motor patterns that constitute the foundations of specific motor skills in different sports. The performance of those skills improves with age and depends on neuromuscular maturation, the quality of previous experiences, the opportunity for training, and teaching quality. Many theories have been proposed to explain how players learn their motor skills. Stratton *et al.* (2004) consider that the theory that has contributed the most was derived from cognitivist psychology that attributes the development of a generalised motor programme (scheme) for each specific skill to training. Hopper *et al.* (1991) consider that learning motor skills is a process that involves the central nervous system and happens continuously and, in some skills, it goes on for several years. Horn & Williams (2004) consider the period between 7 and 11 years as the transition between the basic motor patterns and the acquisition of specific soccer motor skills. These authors classify as phylogenetic skills those acquired in a specific sport context. The authors call the period from 7 to 11 of age the *context-specific period* in which coaches, parents and the cultural environment all play a part in the quality and rhythm of learning motor skills. Besides these factors, some functional constraints (endurance, strength, speed, coordination) and structural ones (stature and body mass) are presented that may influence participation in formal sport and thus reduce contact with specific sport-context experiences. Davids *et al.* (2000) define coordination as movements between segments of the same limb (intrasegmental coordination), between segments of different limbs (intersegmental coordination), or between a limb's segment and an object. Bompa (1995) consider that, along with strength, speed and endurance, coordination is one of the main motor skills, and that if the first ones represent the basis for physical fitness that supports sport performances, coordination must be regarded as a precondition for learning and perfecting motor skills.

Coordination development mostly happens during the pre-pubertal stage due to greater contact with a wide range of motor stimuli. In puberty, the time needed for certain readjustments caused by allometric growth leads to a reduction of coordinative ability and at the same time to a possible decrease in technical ability (Reilly *et al.*, 2000). This coordinative readjustment period has some repercussions even in age groups where the more mature elements must be more solicited through coordinative activities so that they can face segmental disorders.

CONCLUSION

Growth and maturation directly influence body size and functional development. The literature is more focused on adults and performance and still lacks an overall understanding of young athletes in their multifactorial dimensions. The huge biological variability that occurs during the entire growth process, but mainly in the pubertal years, gives an important advantage to those athletes who are more biologically developed (more advanced in maturation), particularly in sports where functional capacities and physical contact are present. This increased capacity to perform is usually misunderstood by coaches and/or club managers who do not consider this advantage as a transient manifestation of early development that will be caught up with in the near future by those who mature later. However, this lack of knowledge, or behavioral intention focused on immediate sport performance/success, may promote an increased drop-out rate for consecutive negative experiences in less developed counterparts, where the grouping of athletes by chronological age is one of the risk factors for this scenario.

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