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MOVEMENT PROFICIENCY AND TALENT DEVELOPMENT IN SPORT*

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Abstract

The development of proficiency in movement skills is a major development task from childhood through adolescence. Proficiency in movement skills is also central to play behavior, to informal and formal games, and to sport-specific skills and functional capacities (power, speed, agility, strength, aerobic capacity, etc.). The teaching and refinement of sport-related skills is an objective of youth sport programs in general and of talent programs for specific sports. The development of movement proficiency is discussed in general and then in the context of talent development models and specifically the Long Term Athlete Development model. Four features of the talent development need to be recognized: (1) it is a dynamic and highly individualized process; (2) the process is superimposed upon a constantly changing base – the demands of physical growth, biological maturation and behavioral development, and their interactions; (3) the process is selective and exclusionary; and (4) fourth, although talent models view the process as long term, *paths to elite status are highly variable* among individuals.

Introduction

Movement proficiency – competence in movement or motor skills, is a primary developmental task during infancy and childhood, although the process continues through adolescence into adulthood. Movement proficiency is central to learning, to play behaviors, to informal and formal activities, games and sports, to sport-specific skills and functional capacities, and to sport talent development programs. Movement is also the basis of physical activity, "…any bodily movement produced by skeletal muscles that results in energy expenditure" [1, p. 126].

The development of movement proficiency from infancy through adolescence is a long term process that is superimposed on the demands of physical growth, biological maturation and behavioral development, and of the interactions among these processes which are often overlooked. Although the development of movement proficiency is largely dependent upon neuromuscular maturation and associated changes, movements are behaviors which occur in specific cultural contexts and as such are influenced by cultural demands and pressures.

This paper reviews general concepts related to the development of movement proficiency in childhood and adolescence and several societal trends that may influence demands placed upon movement development and proficiency. It then focuses on movement proficiency in the context of sport talent development programs.

Movement Proficiency: Process and Product

The development of movement proficiency involves two general aspects: first, the development and refinement of basic movement patterns (often labeled fundamental motor skills), and second, the integration of these

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patterns into more complex and specialized movement patterns and skills. The former is more general concept that focuses on the general features of a specific movement and on the process through which children progress from initial efforts in a specific movement task to the mature pattern (mastery). The latter, in contrast, focuses on the product (outcome) of specific movements more so than on the process. Improvement in the product of performance implies greater efficiency of movement (skill).

The movement patterns comprising nine fundamental movement skills have been described in a developmental context for children the mixed-longitudinal Motor Performance Study at Michigan State University [2, 3]. The approach was largely qualitative and focused on the ages at which the criteria for specific developmental stages for each movement pattern were attained by boys and girls. Boys tended to attain each stage of overhand throwing and kicking earlier than girls, whereas girls tended to attain each stage of hopping and skipping earlier than boys, which may be related to perceptions of the cultural appropriateness of activities that involve these movement patterns. The attainment of early stages for running, jumping, catching and striking showed considerable similarity between boys and girls, but there was more variation between boys and girls in ages at which the final or mature stages were attained. Mature patterns of most fundamental movements were attained by 6 or 7 years in 60% of the children in the Motor Performance Study, although some were not attained until later, e.g., standing long jump in both sexes, overhand throw in girls. Note, however, 40% of the children had not attained the mature levels by these ages, i.e., many 6 to 9 year old boys and girls had not developed sufficient movement control to successfully accomplish the mature patterns of the fundamental skills. Given the observed variability, there is a need to address the influence of outdoor play, parent-child and sibling interactions and modeling, specific instruction and practice, and/or early entry into a sport on progress through specific movement patterns and their integration into more complex movement sequences?

Currently used tests of fundamental motor skills [4–6] in surveys of children and adolescents are largely qualitative. Emphasis is on the specific components which define mature movement patterns (mastery) for several locomotor (run, jump, gallop, skip, etc.) and object-control (throw, catch, kick, etc.) skills. A variable number of criteria describe the mature pattern (mastery) for each skill. Performances are rated in terms of the presence or absence of the specific criteria. The tests have a major subjective component. Performances of children are evaluated and rated by trained observers, though inter- and intra-observer variability is not ordinarily reported.

The tests are used primarily to evaluate status and also to screen for movement problems. Status reflects level of proficiency at the time of observation, and as such reflects the outcome of the interactions among neuromuscular maturation, growth, and the environments of children. Percentages of Australian children attaining mastery or near mastery of fundamental movement skills (described as possessing advanced skills) tended to increase with age from 6 through 15 years of age [5, 7], although there was considerable variation by skill. Nevertheless, many youth, girls more so than boys, 9 through 15 years of age, did not show near mastery or mastery of six fundamental movement skills – run, vertical jump, throw, catch, strike, kick [7].

The results beg several important questions: What are the characteristics (growth, maturation, physical activity and other behaviors) of those who have and have not reached mastery in fundamental movement skills? What type(s) of intervention can enhance the fundamental movement skills of youth at these ages? What is the relationship between level of mastery subjectively assessed and performances (outcomes) in corresponding motor tests?

Motor performances on standardized tests of running (dashes, shuttle runs), jumping (standing long and vertical jumps), and throwing (ball throw for distance or velocity) improve, on average, through childhood into adolescence. Sex differences are minor in childhood except for the ball throw, but are magnified during adolescence. Performances of boys continue to improve, on average, through adolescence while those of girls tend to reach a plateau [8]. Performance data for standardized tests of striking, catching, skipping, etc. for the general population of youth are limited.

Movement Proficiency: Maturation Effects

Relationships among body size and maturity status (skeletal age) on one hand and movement proficiency on the other hand have received attention. Earlier studies were limited to correlational analyses, whereas more recent approaches attempted to control for interactions among age, maturation and body size. For example, skeletal age per se and in combination with chronological age, stature or body mass were not significant predictors of the standing long jump, vertical jump and shuttle run among girls among girls 6–16 years [9], but accounted for 6% to 13% of the variance in the vertical jump in boys 13–17 years and for only 1% to 3% of the variance in a shuttle run in boys 12–16 years [10]. Standardized residuals of skeletal age (note, skeletal age and chronological age are correlated) independently or interacting with stature and mass explained limited amounts of the variance in three motor performances (dash, standing

long jump, distance throw) of children 7–12 years, 4% to 30% in boys and 7% to 27% in girls [11]. On the other hand, standardized residuals of the regression of skeletal age on chronological age alone or interacting with body size were not strongly related to six locomotor and six object-control skills [4] and the four tests comprising of a motor coordination battery [12] in boys and girls 7–10 years; total variances explained ranged from 0 to 9% [13]. The available evidence, though limited, suggests that skeletal maturation as reflected in skeletal age, alone or interacting with stature and mass had a relatively limited influence on fundamental movement skills, motor coordination and motor performances of children and adolescents.

At the extremes of biological maturation among adolescent boys of the same chronological age, however, early maturers show better motor performances than late maturers; corresponding maturity-related trends are not clearly apparent in adolescent girls of the same age [8]. Variation in the timing and tempo of the adolescent growth spurt as a factor affecting motor performance has received limited attention. In a longitudinal sample of Belgian boys 12–18 years, running speed and speed of upper limb movement had adolescent spurts which occurred prior to peak height velocity (maximum rate of growth in height during the adolescent spurt), while the vertical jump had a spurt that occurred after peak height velocity [14, 15]. Results of a short term longitudinal study of Spanish boys and girls were consistent for the standing long jump, but not for running speed [16]. Static strength also had an adolescent spurt that occurred, on average, after peak height velocity in both sexes [15].

There is a need to identify and study other factors which influence the development of movement proficiency, motor skills and motor performances during childhood and adolescence. Several early reviews noted associations among parental attitudes, parent-child interactions and specific fundamental motor skills (standing long jump, overhand throw), and sibling interactions in eliciting selected object-oriented and locomotor activities [17–19]. Low motor proficiency was associated with low socioeconomic status (girls) and non-English speaking cultural backgrounds (boys) in Australian elementary and high school youth [20]. Low proficiency was also associated with reduced levels of physical activity and cardiorespiratory fitness. Overweight/obesity (BMI) was associated with low proficiency in locomotor skills, but was not consistently associated with proficiency in object control skills. Other factors, cultural, behavioral, familial and social, and their interactions with growth and maturity status which may influence the development of fundamental movement skills and motor performances need study.

Societal Conditions and Activities of Youth

Although limited to the United States, observations on changes in the daily activities of children and adolescents provide insights into societal factors which may have influenced physical activity and participation in sport, and by inference movement proficiency [21–24]. Across surveys in 1981, 1997 and 2003, time in school increased to 1997 but was then stable, while time in physical play (including sport) was replaced by organized sport, other organized activities (arts, academic, social) and non-physical play/leisure time (computer games, media in general). Time in sport declined from 1997 to 2003 among children 6–12 years (30–32). More recently, statistics from the Sports and Fitness Industry Association indicated 2.6 million fewer participants 6–12 years of age in several sports (basketball, soccer, football, baseball, softball, track and field) between 2008 and 2013 [25].

The time use surveys of children and adolescents between 1981 and 2003 were motivated by interest in the influence of family circumstances per se, of changes in family characteristics over time, and subsequently of several political and societal changes on the daily activities of children and adolescents. Persistence of the trends has been emphasized more recently [25]: continued increase in the number of single parent and dual-working parent families; cultural pressures to raise high achieving children - the "professionalization of parenthood"; persistence of state mandates for standardized testing which has contributed to an increase in after school classes/tutoring sessions and reductions in school recess and free play; and a parental focus on resumé building for their child/children.

The trends suggest an "over-organization of childhood" which has implications for the development of motor proficiency. This is especially apparent in the increased prevalence of organized after-school activities among children and adolescents [26–28]. Emphasis on organized activities impacts discretionary time and specifically opportunities for free play, and may also contribute to early specialization in arts, sport and other activities. Superimposed upon the preceding is the ever-increasing presence of the media in the daily lives of youth and by inference increased opportunities for physical inactivity [29].

One consequence of increased time in organized activities is a reduction in time for free play, specifically outdoor play. Free play is unstructured; children created their own structure or structures while they play – real or imagine. Free play is also free of adult involvement and organization. In contrast, organized activities are likely to involve structured play which is structured by adults and directed towards specific activities and goals.

Free play of course can include a variety of activities. Of relevance to the present discussion are "street games" based on sports, so-called informal sports – stickball and punchball (variants of baseball which include throwing, catching, striking), inner city basketball, street soccer, ice hockey played on a frozen pond or roller hockey on the street – played under conditions free of adult supervision. Such informal activities represent what is now labeled deliberate play [30]. These and related activities/games have major implications for movement proficiency. They involve frequent repetitions (not under the eye of a coach), trial and error, experimentation and repetition, variable settings, and exposure to different conditions, skills and rules. Movement skills in general and sport-related skills are learned without awareness or explicit knowledge of the skills. Acquisition of skills under such circumstances represents informal or implicit learning [31]. Skills learned informally may be adaptable to variety of circumstances. It is also postulated that skills learned under informal are influenced less by stress and fatigue [32]. Research on implicit learning in sport is in its infancy but is expanding. Nevertheless, it is reasonable to assume that youth with a variety of experiences in informal, free play and street game activities are exposed to different situations and skill demands in which they attempt, practice and learn a variety of movement skills. It is also likely that such informally learned movement skills (and probably social skills) transfer relatively easily to other play, game and sport situations.

Sport Talent Development Models

The identification of potentially talented youth athletes is central to sport programs. Given the money involved in sport nationally and internationally, the search for and the development of sport talent are perhaps more structured at present than in the past. The process takes a variety of forms, including formal talent identification programs, sport-specific schools, clubs and academies, select teams in youth leagues, the quest for sport scholarships, commercial enterprises such as the IMG academy [see Note 1], and probably others.

Although the approach varies by sport, the general pattern of talent development includes initial evaluation of physical characteristics (anthropometric), movement skills and perhaps behavioral characteristics beginning at relatively young ages. Each sport, of course, has its own template, timetable and approach. Protocols were rather systematic in the sport systems of the former Soviet Union and several Eastern European countries [33–38], which were extended and modified to Western countries, including the United States, Canada and Australia [39, 40]. The programs generally focused on individual sports or sport disciplines in contrast to team sports, perhaps because of the greater number of Olympic medals in the former. The structured approaches of the former Eastern European countries are to some extent still visible in artistic gymnastics, tennis, figure skating, swimming and perhaps other sports. Presently, these sports are largely operated by private clubs or organizations which are fee based.

Protocols for talent development in team sports are seemingly less structured on the surface. The general template includes physical, skill (general and sport-specific), physiological (functional), perceptual and cognitive, and psychological (behavioral) characteristics [41]. Application of the template in the development of talent is quite variable.

Most youth sports programs emphasize mass participation at relatively young ages and are largely community based. Programs become more specialized and competitive with increasing age during childhood and into adolescence. Focus on talented youngsters also increases at these ages. The search for talent occurs both informally, e.g., observing youth in game situations, noting those who are more skilled and inviting them for a specific team, and formally, e.g., regular tryouts for select or advanced teams, scholarships for elite school programs and perhaps others.

Special programs for talented young athletes in the United States are often labeled select or travel teams. Such programs emerge at about 10–12 years of age or so in basketball, baseball (boys), softball (girls), soccer, ice hockey and perhaps others. Talented youth are recruited from a local area and sometimes from adjacent areas for the purpose of participating at a higher competitive level. The programs operate independently of highly organized interschool sport programs (see below) and often encourage youth to participate in a single sport year round. In some sports where qualified coaches in schools may be limited (e.g., soccer), select or travel teams are often preferred by parents and sport organizations. Select programs vary in cost, most of which is borne by parents.

The focus on talented youth athletes in the United States is nationally apparent in many interscholastic sport programs in public and private schools [see Note 2]. High school sport programs are, in many ways, a feeder system for intercollegiate sport programs. There is also an increase of elite foreign athletes in high school programs, particularly basketball, and an increase in recruiting players from other school districts and states, and from public to private schools [42–44]. However, the number of high school players who make it to the collegiate level is quite small [45] and the number receiving a scholarship support is markedly smaller [46, 47].

Approaches to identifying skilled or talented youth in team sports are especially apparent for European football or soccer where many professional clubs have developmental and academy programs. Soccer is largely a sport

of the lower socioeconomic strata throughout most of the world. Competitions among youth at this level are routinely monitored by clubs looking for talented players. Once identified, talented youngsters are enrolled in the developmental program of a club at a relatively young age. Enrollment in a developmental club program is also aimed at retaining the talented youngster in the sport and also at keeping him away from other sports. Similar to soccer, youth baseball in the Caribbean region is also largely a sport of the lower social strata. It is characterized by many informal games and local programs, and by more formal programs run by professional baseball clubs locally and internationally. The primary purpose of the formal programs in both sports is to develop talented players for the professional market.

General Scheme of Talent Programs

Allowing for variation within specific models to identifying potentially talented youth athletes, several generalizations are apparent: early emphasis on general movement skills in early and middle childhood; a shift to sport-specific skills and functional capacities (power, speed, aerobic, anaerobic, etc.) often during the transition into puberty and adolescence; and eventual specialization which occurred relatively late. Exceptions were the so-called "early entry sports", specifically artistic gymnastics, figure skating, diving, and more recently table tennis.

Two "windows of opportunity" during which responsiveness to training is presumably enhanced are implicit in the various talent development models. The first is responsiveness to motor skill instruction and practice during childhood and especially in "early entry sports", and the second is responsiveness to more intensive sport-specific training demands during adolescence. Although documentation of the influence of early instruction and practice in sport-specific movement skills has not been systematically reported, successful instructional programs for motor skills among children 4-5 years and older include guided instruction by specialists and/or qualified coaches, appropriate motor sequences, adequate time for practice, and constructive guidance and feedback [48, 49]. Adolescence is perceived as an interval of enhanced responsiveness to sport training and has received more attention. Adolescence is often viewed as a period of increased sensitivity of the muscular and cardiovascular systems to training, specifically in association with the hormonal changes of puberty [50].

The Long Term Athlete Development Model

The Long Term Athlete Development (LTAD) model [51, 52] is perhaps the most recent reiteration or modification of the formal East European models noted above. The LTAD model is really two models, an early specialization model and a late specialization model. The former includes artistic and rhythmic gymnastics, figure skating, diving and table tennis, and the authors propose that each sport develop a model suited to the specific demands unique to each. Proficiency in a diverse array of gross and fine motor and perceptual-motor skills is central to the early entry sports which often begin at 4–5 years of age. Except for table tennis which has its own unique perceptual-motor demands [53], the demands of gymnastics, figure skating and diving highlight unique movement skills and bodily control which highlight orientation in space, optical and acoustic reactions, balance, rhythmic sensitivity, among other factors. An adaptation of the model to diving has been developed [54, 55].

The late specialization model emphasizes four "stages" or "windows" in childhood through adolescence [51]:

1. FUNdamental stage – 6–8 years in girls and 6–9 years in boys, emphasizes the development of fundamental movement skills;
2. Learning to Train stage – 8–11 years in girls and 9–12 years in boys, emphasizes continued development and refinement of fundamental motor skills and the development of overall sport skills. This second phase is described as the "window of adaptation to the development of motor coordination" [51, p. 4].
3. Training to Train Stage – 11–15 years in girls and 12–16 years in boys, emphasizes the development of aerobic and strength capacities and of sport specific skills, described as "build the 'engine' and consolidate sport-specific skills" [51, p. 4]. Biological maturation is central to the third phase; the protocol calls for emphasis on the age at peak height velocity and identifying youth of contrasting maturity status (early, average, late).
4. Training to Compete phase – 15–17 years in girls and 15–18 years in boys, is focused largely on preparations for competition.

The late specialization model includes two further stages that extend from late adolescence through adulthood and that are beyond the scope of this discussion. It should be noted that an earlier iteration of the model combined the first two phases into a Fundamental Stage (6–10 years in both sexes), and had different age ranges for the Training to Train stage, 10–13 years in girls and 10–14 years in boys, and Training to Compete stage, 13–17 years in girls and 14–18 years in boys [56].

Two concepts are central to the late specialization model: the "10 year" rule derived from the expertise model in sport psychology and age at peak height velocity. Accordingly,

> "Scientific research has concluded that it takes eight-to-twelve years of training for a talented player/athlete to reach

elite levels. This is called the ten-year rule or 10,000 hour rule, which translates to slightly more than three hours of practice daily for ten years [51, p. 1],

and,

"One practical solution is to use the onset of Peak Height Velocity (PHV) as a reference point for the design of optimal individual programs with relation to 'critical' or 'sensitive' periods of trainability during the maturation process" [51, p. 1].

The theoretical framework of expert performance [57, 58], with a focus on deliberate practice over an extended period, emphasizes quality of instruction and practice and as well as ability of the individual to organize the specific knowledge. The accumulation of experience is ultimately represented in the motor and cognitive neural substrates. In contrast, evidence from elite athletes in a variety of sports indicates participation in several sports prior to specializing, variable trajectories to elite levels, and attainment of sport success at national and international levels without 10 years or 10,000 hours of deliberate training [59–61].

Use of PHV as a reference to individualize and optimize training programs is beset with problems. Age at PHV is an estimate of the chronological age (i.e., timing) at which the maximal rate of growth in height occurs during the adolescent spurt. The spurt begins when the rate of growth in height reaches its minimum in late childhood (age at take-off), followed by acceleration (increased rate) to a maximum rate (PHV), and then decelerates until growth in height terminates in the late teens or early twenties. Estimates of age at PHV require longitudinal data for individuals that span the adolescent years [8,62]. Inter-individual variation in age at take-off (TO) of the spurt and in age at PHV is considerable as highlighted in longitudinal data from the Wrocław Growth Study [63,64]:

Girls (n = 198)	
Age at	8.9 ± 1.1 years, range 6.3 to 12.0 years
Age at PHV	11.9 ± 1.0 years, range 9.0 to 14.8 years
Boys (n = 193)	
Age at TO	10.5 ± 1.1 years, range 7.0 to 14.1 years
Age at PHV	14.1 ± 1.1 years, range 11.5 to 17.3 years

Quarterly measurements of height and calculating and plotting of velocities to monitor the shape of the velocity curve for height are recommended in the LTAD: "By plotting the velocity curves it will be possible to clearly distinguish the rate of growth from one point in time to another. The velocity curve will immediately show distinctive growth points (… the onset of the acceleration in the curve, the peak in the curve and the deceleration in the curve)" [65, p. 15].

Increments calculated over short intervals are influenced by technical errors of measurement, seasonal variation, and time of measurement (diurnal variation). Also, height measurements taken after a period of physical activity (running, jumping, etc.) are likely less than those taken after a period of rest. Measurements are not always taken at the prescribed intervals or dates; as such, derivation of increments needs to be adjusted for the interval between measurements and the prescribed interval, i.e., quarterly as suggested [65]. Given the preceding, short term increments have major limitations. Similar adjustments are also necessary if measurements are taken semi-annually or annually.

Although principles of the late specialization LTAD model are being used in a variety of sports and sport programs, several concerns should be noted. The underlying tenets of the model have been questioned due lack of data and questionable assumptions [66], while evidence addressing the responses of adolescent youth to aerobic-, strength-, and speed-specific training is not consistent with a "maturation threshold" [67]. Limitations of maturity classifications with established methods of assessment – skeletal age and pubertal stages [8, 62, 68], as well as maturity-related gradients among youth athletes in many sports sports [62, 69] have implications for tailoring sport-specific training programs to individuals.

The LTAD indicates differential timing of windows of responsiveness to training of different functional capacities during the interval of PHV [51, 52, 65]. However, the fact that body weight, lean tissue mass, bone mineral content, sitting height and estimated leg length (both sexes), static strength, power, speed and flexibility (limited to boys) and aerobic capacity (both sexes) have their own adolescent growth spurts that vary, on average, relative to the timing of PHV is seemingly overlooked [8, 14, 15, 70].

The preceding observations are based on means derived from longitudinal studies. Intra-individual variation in functional performances during the adolescent spurt needs more attention. For example, in the longitudinal study of Belgian boys, performances of some boys declined during the interval of PHV (vertical jump, bent arm hang, leg lifts, plate tapping-speed of arm movement, shuttle run). Interestingly, boys whose performances declined during the spurt had better performances in respective functional tests at the beginning of the interval of PHV than boys whose performances improved during the spurt [15].

Behavioral changes during childhood and adolescence are mentioned in discussions of the LTAD as well as other talent development models, but are not considered in depth. Sport does not occur in a social vacuum. There is a need to consider how youngsters adapt to sport-specific instructional and training programs, to the

associated social and emotional demands, to the adults who direct the programs, and of course to the competitive arena. The skills and bodies of young athletes hold important social stimulus value which impacts self-perceptions and self-evaluations, especially during adolescence, and also influence the nature and quality of interactions with peers, parents and adults involved with sport. Interactions among athletic peers, between coaches and athletes, as well as sport administrators, parents and athletes likely influence progress or lack thereof in talent development programs and obviously need systematic study. In contrast to athletes in talent development programs, relatively little is known about the physical, behavioral and performance characteristics of youth who voluntarily withdraw or who are systematically excluded from a sport. Detailed study of youth who discontinue participation in a sport may serve to inform the process of athlete development and retention, progression in a sport, and the re-orientation of excluded skilled athletes to other sports where they may attain success.

Predicted Age at PHV

Although not incorporated into the LTAD, sex-specific equations for predicting time before PHV (called maturity offset) from chronological age and anthropometric dimensions (height, weight, sitting height, estimated leg length) have been developed [71]. Predicted age at PHV (years) is calculated as the difference between chronological age and predicted maturity offset. The equations are often discussed in the context of talent development models [72, 73] and are increasingly used in studies of youth athletes, often classifying them as pre- or post-PHV, or in terms of time before or after PHV [63, 64].

Validation studies applying the maturity offset equations to longitudinal samples of Polish – Wrocław Growth Study [63, 64] and American – Fels Longitudinal Study [74] youth followed from 8 to 18 years indicated several limitations. First, predicted maturity offset and age at PHV were dependent upon chronological age at prediction, including age per se and associated variation in body size. Second, predicted ages at PHV had reduced ranges of variation (SDs $\leq$ 0.5 year). Third, predictions were affected by individual differences in actual ages at PHV (also age at menarche); among early maturing boys and girls, predicted ages at PHV were consistently later than actual age at PHV, while among late maturing youth of both sexes, predicted ages at PHV were earlier than actual ages at PHV. And fourth, intra-individual variation in predicted ages at PHV associated with chronological age at prediction was considerable. The original maturity offset prediction equations have been simplified and calibrated with external samples [75], but the new equations await validation in independent longitudinal samples.

The LTAD calls for identifying youth of contrasting maturity status, i.e., early, average or late maturing, though does not specify the method for doing so. The maturity offset prediction equation has been used by several English professional sport clubs to categorize players as early, on time or late maturing. Several club representatives noted that >90% of players were classified as average using a plus/minus one year criterion to define early, average and late maturing youth, (Sean P. Cumming, University of Bath, personal communication). This reflected the reduced range of variation in predicted ages at PHV. The observation was also consistent with data for Portuguese youth soccer players. Using a predicted age at PHV within plus/minus one standard deviation of the mean age at PHV for the three samples upon which the prediction equations were developed (13.8 $\pm$ 0.9, 12.9–14.7 years) as the indicator of average maturity status among 180 soccer players 11-14 years, 89% were classified as average [76].

Summary

The development of overall movement skills and sport-specific skills is the primary priority of sport talent programs. The development of functional capacities (power, speed, aerobic, and so on), which are largely based on motor performances, occurs largely during adolescence. Inter-individual variation is characteristic of the age at onset of the adolescent spurt and also of age at peak height velocity. Similar variation is also characteristic of the adolescent spurts in body mass and composition, and in functional capacities which vary relative to the timing of the spurt in height.

Programs aimed at developing talented young athletes need to recognize several important features. First, talent development is a highly individualized and dynamic process. Second, the process is superimposed upon a *constantly changing base*, specifically the demands of physical growth, biological maturation and behavioral development, and their interactions, as children pass from childhood into and through puberty and adolescence, and into adulthood. Third, the process is *exclusive*; focus is often on the "most talented" individuals for a given sport or sport discipline/position, whereas many others are systematically excluded and/or voluntarily withdraw from the sport. And fourth, although some talent models view the developmental process as long term, *paths to elite status are highly variable* among individuals.

Notes

1. IMG Academy was formerly the International Management Group that operated a boarding school for tennis players. The IMG Academy is a school that

now offers academics as well as programs in baseball, basketball, American football, golf, lacrosse, soccer, tennis, track and field, and general athletic development (https://www.imgacademy.com/about-img-academy).

2. In the 2014-2015 school year, the ten most popular sports (participants) among boys were American football, outdoor track and field, basketball, baseball, soccer, wrestling, cross-country, tennis, golf and swimming and diving; the corresponding sports among girls were outdoor track and field, volleyball, basketball, soccer, softball (fast pitch), cross-country, tennis, swimming and diving, competitive spirit squads, and lacrosse (National Federation of State High School Associations, http://www.nfhs.org/ParticipationStatics/ParticipationStatics.aspx/).

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