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# Predictability of physiological testing and the role of maturation in talent identification for adolescent team sports

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**KEYWORDS**
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**Summary** Entrepreneurial marketing of sport increases demands on sport development officers to identify talented individuals for specialist development at the youngest possible age. Talent identification results in the streamlining of resources to produce optimal returns from a sports investment. However, the process of talent identification for team sports is complex and success prediction is imperfect. The aim of this review is to describe existing practices in physiological tests used for talent identification in team sports and discuss the impact of maturity-related differences on the long term outcomes particularly for male participants.

Maturation is a major confounding variable in talent identification during adolescence. A myriad of hormonal changes during puberty results in physical and physiological characteristics important for sporting performance. Significant changes during puberty make the prediction of adult performance difficult from adolescent data. Furthermore, for talent identification programs to succeed, valid and reliable testing procedures must be accepted and implemented in a range of performance-related categories. Limited success in scientifically based talent identification is evident in a range of team sports. Genetic advances challenge the ethics of talent identification in adolescent sport. However, the environment remains a significant component of success prediction in sport. Considerations for supporting talented young male athletes are discussed.


## Introduction

A plethora of talent identification issues can be found within the sub-disciplines of exercise science including motor learning,[1,2] sports psychology[3,4] and sociology.[5] The sub-discipline selected for this review is physiological testing. Despite the trend for multidimensional analyses, most testing batteries devised for talent identification for males continue

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to include physiological testing. The aim of this review is to describe existing practices in physiological tests used for talent identification in team sports and discuss the impact of maturity-related differences on the long-term outcomes for male participants.

A basic definition of talent identification lies within the recognition of a natural endowment or ability of a superior quality. But identifying a talented athlete within sport is multifaceted and complex. Talent in sport is identified by characteristics that are at least partially genetically determined, affected by numerous environmental conditions and difficult to determine accurately.[6] Furthermore, talent in adolescents is recognised within an interaction of innate abilities, demonstrations of mature play patterns at an early age and demonstrations of highly sports-specific skills.[7]

National sporting associations frequently seek to identify young athletes who have the highest likelihood of success. If talent identification offers young athletes resources to achieve sporting greatness, the additional support may inspire sustained participation and passion for sport. Alternatively, critics of elitism in sport in young populations contend that existing models for talent identification in sports are poor predictors of success and simply serve to discourage or divide young participants by non-selection and/or stratification processes.

## General talent identification in adolescent sports

Talent identification is a serious component of many sports, and a scientific systematic approach continues to elude recruitment officers. Scientific methods of talent identification were initially developed in a number of Eastern European countries and involved government-sponsored, systematic and large-scale testing of youth.[8] The goal of wide-ranging talent identification programs was to streamline talented individuals into sports in which they would be most suited. Talent identification campaigns are not exclusive to the communist countries in which they originated during the 1960s and 1970s. Australia also conducted a similarly ambitious program.[9] Students aged between 14 and 16 years were invited to perform a battery of eight physiological tests. The results of the tests created pathways for students with sports-specific attributes to develop skills in sports they had not previously experienced.[8]

Ambitious general talent identification programs appeal to some organisations' egalitarian sentiments. However, extensive talent search programs are costly and have arguably resulted in minimal success, particularly in team sports. Subsequently, large-scale testing for talent identification has been replaced by more sports-specific methods.[10]

## Specific talent identification in adolescent team sports

More recently, specific talent identification programs are targeting individuals already in competition who demonstrate an existing commitment to doing well. The challenge is to develop valid and reliable specific talent identification programs to determine young athletes' current suitability for a given sport with some predictive value of future performance. But before valid and reliable tests can be developed, the needs of the sport must be recognised.

Defining the components of elite performance in the sport involves assessing attributes of top level competitors in addition to describing the characteristics of the sport (i.e., movement patterns). Subsequent goals of pursing specific valid and reliable testing are complicated by a number of factors. Because most talent identification programs are conducted during adolescence, the effect of growth and maturation can confound prediction of future performance. Additionally, differences in the rate of response to training stimulus can account for large discrepancies in performance between two athletes who appear similar during initial testing. Thus, growth during adolescence and trainability dictate that talent identification programs in young athletes need to be thoroughly scrutinised, monitored more than once and carefully implemented before success can be claimed.

# Methods

To explore the influence of maturation on results from physiological tests used for talent identification in team sports we searched for peer-reviewed articles in the past 10 years. Language was restricted to English and cross-sectional, longitudinal and review articles were retrieved. Databases included Medline, SportsDiscus, Web of Science and Human Kinetics. Keywords entered were talent, identification, gifted, excellence, success, youth, adolescence and adolescents. The generic term of sport was entered first and then the names of specific team sports were included in the search. The websites of national institutes of sport were useful in providing historical overviews of talent identification programs.

## Results

### Effect of maturation on performance parameters used in talent identification

Adolescence is a period of dynamic change in physiological capabilities, physical parameters, sexual characteristics and social interaction. Puberty is identified by the development of secondary sex characteristics and the accelerated growth of physical size and stature. Pubertal development is mediated by changes in hormone availability and function and is associated most noticeably in boys with serum testosterone and growth hormone increases. The appearance of secondary sex characteristics in males is accepted as the beginning of puberty and commences at approximately 12 years, with 97% of males at least starting development by 15 years.[11] Most sporting organisations begin talent identification programs between the onset and completion of puberty.[12] The effect of growth and maturity-related changes in puberty needs to be considered within the testing and outcomes of talent identification programs.

### Physical parameters

#### Height

The importance of height is sport-dependent and individual changes in the tempo and magnitude of growth during puberty (17—18% of adult height) result in problems with the use of current height during adolescence for talent identification purposes.[12] Height gain is primarily attributed to altered hormone activity during puberty. Therefore, during adolescence, height is strongly linked to pubertal status. Early maturing males may be taller than average or late maturing males, during all stages of adolescence (13—18 years).[14] However, reports of longitudinal height patterns from the Leuven Growth Study suggest that when height remeasurement occurred at 30 years, early maturing males have no height advantage over their peers.[15] Adolescent height is therefore unreliable for talent identification because of the large variation in growth potential during and following puberty.

Because most participants in team sports do not participate in elite level competition until at least 20 years, a prediction of adult height is desirable for talent identification. A number of well-documented methods are available for predicting adult height.[16] Height prediction methods have widely acknowledged errors and large standard deviations but predictors of adult height continue to be an integral component of talent identification programs for many team sports.

#### Weight

Substantial weight gain occurs during adolescence, with approximately 40% of adult weight gained in males between the ages of 13 and 18 years. The links between weight gain and hormonal processes associated with puberty result in early maturing males being heavier than age-matched peers.[14] Weight differences between early and late maturing adolescents are most evident towards the end of adolescence but again, become insignificant during adulthood.

#### Body composition

*Muscular development*. Increases in muscle mass account for a large proportion of growth during adolescence in males. Measures of muscularity show early maturing males have significantly greater muscle mass than late maturing males.[14] However, advanced muscularity does not continue into adulthood, with early maturing adolescents losing the previous ''muscular'' advantage over others in adulthood.[15]

*Body fat*. Subcutaneous fat steadily rises during childhood in males, with a marked decrease at approximately 14—16 years.[11] Decreased subcutaneous fat deposition corresponds with peak height velocity.[11] A marked characteristic of male puberty is a decrease in fat at the extremities that coincides with a slow increase in truncated subcutaneous fat.[17] Fat deposition during puberty is the result of a complex interaction between genetics and hormone activity but is modifiable through behavioural factors such as changes in habitual activity and nutrition.

The recommendation from the current understanding of the role of maturation on body composition would be to minimise the importance of performance measures where growth related variables are confounders. Concurrently, it is incumbent on talent identification officials to maximise their understanding of the potential for young bodies to change.

### Physiological capacity

#### Aerobic capacity

Longitudinal studies in males show absolute peak oxygen consumption ($L\,min^{-1}$) increases steadily between 8 and 16 years.[17] The greatest improvement in aerobic capacity occurs between the ages of 11 and 15 years. Generally, peak improvement coincides with peak height and weight velocities.[13] Increases in aerobic power are related to a number of factors including increases in fat free mass (FFM), development of the physical and functional size of the cardiovascular system and increased haemoglobin content. Longitudinal studies suggest that relative $VO_2$ peak ($mL\,kg^{-1}\,min^{-1}$) in young males tends to reach a maximum around 8 years, then marginally declines into early adolescence before levelling off during the remainder of the maturation process.[18] The concurrent increases in absolute $VO_2$ and body mass result in the relatively stable scores reported for $VO_2$ when expressed per kilogram of body mass in large studies of adolescent males. Compared with the insensitivity of relative $VO_2$ peak results in adolescent males, unequivocal improvement can occur in field-based endurance tests.[19]

### Anaerobic power

In contrast to relative aerobic power results, a steady increase in anaerobic power of males occurs during childhood, with an increased rate of improvement at the onset of puberty.[20] Sprint speed and jumping ability improve dramatically during adolescence, with the highest rate of improvement occurring between the ages of 14 and 15 years.[18] Notably, anaerobic power production in adolescence is closely related to body mass, with up to 92% of variance in peak power performance during a Wingate test explained by a combination of an athlete's physical dimensions (such as height, leg length, weight, lean body mass, leg volume and total muscle mass).[18,21] The effect of body size parameters on anaerobic power performance are therefore strongly linked to maturation status. The non-linear anaerobic improvement during adolescence, the marked trainability of muscle power during adolescence and young adulthood and the established relationship between body size and anaerobic power make extrapolations of results from young adolescent athletes to adult athletic performance problematic.

### Strength

The production of human strength incorporates neural control of contracting muscle, muscle cross-sectional area and length and arrangement of fibres for optimal force production. Similar to anaerobic power performance, muscle strength is not an entire body characteristic but is dependent on the ability and trainability of specific body segments to perform the desired movement. Most longitudinal research on adolescent strength development reports results from grip strength testing but the test may not relate to sport-specific contexts. However, tests of elbow and knee flexor and extensor strength show similar patterns of development to grip strength, leading to the assumption that, during adolescence, increase in strength is influenced by hormonal factors acting throughout the body.[14]

In males, a steady increase in strength occurs during childhood, followed by a larger, more dramatic improvement during adolescence that peaks between the ages of 14 and 16 years.[22] Strength development closely relates to body size and serum testosterone concentration, which again links strength development to maturation status.[23] Gains in muscle strength are more strongly associated with increased serum testosterone than nervous system development.[24]

Strength is related to factors including serum testosterone and body size and is largely modifiable through well-implemented training interventions. Results from adolescent strength testing are therefore problematic predictors of adulthood performance.

Strength, aerobic and anaerobic power have unambiguous potential to respond to training during adolescence, particularly in males who are well supported by anabolic hormones at this time. Pre-training values in strength, aerobic and anaerobic power are unlikely to be predictive of the potential to improve through the synergy of growth and training.

## Motor performance tests

### Skill

Schmidt and Lee[25] define skills as ''movements that are dependent on practice and experience for their execution, as opposed to being genetically defined''. The learning of skilled movement patterns, such as in team sports, is also dependent on the many factors including the amount and quality of practice or experience, which result in relatively permanent changes in a skilled behaviour.[26] The extent to which practice improves skilled performance also relies on a multitude of factors, including the attention and memory capabilities of the learner and the physical ability to perform the required task.[27] With adequate teaching and practice, refinement of motor skills can continue in males through adolescence.[26]

Additionally, if progressive improvement occurs in motor skills, performance in complex motor tasks associated with team sports, may be less complicated because of previous practice and experience. Improvement may also result from increased physical and cognitive aptitude for the performance of physical tasks and is therefore possibly linked to holistic maturity. Therefore, testing for more abstract, complex skills of adolescents in talent identification programs will lack the power to predict adult performance.

### Agility

Results of agility tests through adolescence are difficult to interpret for a number of reasons. Difficulties include a lack of standardisation of testing procedures, limited longitudinal data and a relatively high cognitive burden on participants who may have to learn new complex testing procedure regardless of any capacity to move and change directions. Longitudinal improvements in agility tests may also be attributed to improved lever length and gait efficiency concomitant with growth. Results from the *President's Council on Physical Fitness and Sports* (1985) showed a steady increase in performance of the agility run test between the ages of 6 and 18 years.[28] However, the dearth of research on maturation and agility prohibit definitive statements on this relationship.

Like physiological attributes, motor skills and agility have the potential to advance markedly during adolescence. The contribution of physical and cognitive maturation in skills and agility remains poorly researched.

## Summary of sports related changes during puberty

Table 1 provides a summary of the effects of maturation on physical and physiological parameters used in talent identification programs. Considerable improvement in most physiological characteristics is possible during adolescence in males and most characteristics have links to hormonal mediation. Additionally, the trainability of most physical and sporting characteristics makes prediction of adult performance difficult during adolescent years.

## Measurement of physiological parameters in adolescents participating in team sports

The limitation of poor predictability of adult physiological performance should be acknowledged whenever talent identification programs occur. Within this context, test selection should be based on specificity, reliability, validity and ease of testing. Table 2 describes commonly used measures of basic physiological capabilities among active adolescent populations. Each test has advantages and disadvantages.

### Aerobic capacity testing methods

The use of $VO_2$ peak testing is inviting because of its frequent usage and accepted precision, but financial and practical restrictions preclude the uses of $VO_2$ peak tests for talent identification in most major team sports.

The elimination of direct $VO_2$ peak testing dictates that the next best option is based on the closeness of the relationship of other tests with $VO_2$ peak, the tests' specificity to performance and the ease of testing for a large subject population.

Endurance runs for time or distance are frequently used in adolescent populations. Tests are easily conducted and permit testing of large groups of young athletes. Endurance running tests can be scored in time or distance and demonstrate acceptable validity in the prediction of $VO_2$ peak.[29] However, endurance runs have limitations that include requirements for participants to self-pace their performance which can result in a sub-maximal exertion (underestimation of $VO_2$ peak).[30] Limitations to environmental and motivational conditions can also preclude comparison of results within the same and other populations. Additionally, improvement in these tests may result from growth, improved running economy and better pacing ability, rather than an increase in aerobic capacity.[30]

Problems of self-pacing during maximal field tests are decreased in the 20-m shuttle run test (20 MSRT). The 20 MSRT provides results that can be converted to $VO_2$ peak scores and is considered easy to conduct, reliable and valid for use with athletic adolescent populations.[31]

In summary, despite limitations, when aerobic testing is required for large groups who are not supported by funds for laboratory tests, field-based tests for aerobic testing appear to be acceptable. Results from longitudinal field-based tests for aerobic capacity in young populations are likely to be confounded by factors such as growth, and skill and cognitive improvement.

### Anaerobic power testing methods

Most team sports require participants to perform periods of play at high velocity. Sprint performance is therefore an integral component and should be included in talent identification testing. Speed tests should be conducted over a sports-specific distance (for example 10—40 m) recording both acceleration and total sprint time. Accuracy and relevance of assessment may increase with the use of timing lights and repeated sprint performances within sports-specific timeframes (Tables 2 and 3).

Jumping is a secondary skill often demanded in team sports. Explosive leg power can be accurately

**Table 1** The effect of puberty on physical and physiological parameters commonly tested in talent identification programs

| Characteristic | Effect of puberty | Approximate change during puberty | Age at greatest increase (years) | Trainability | Hormone mediated |
|---|---|---|---|---|---|
| Height | Increase in height | ↑ 17–18% | 13.5 | No | Yes |
| Weight | Increase in total body mass | ↑ 40% | 13.5 | Yes | Yes |
| Muscular development | Increase in muscle mass | ↑ 20% | 13.5 | Yes | Yes |
| Body fat | Increase of total fat (small decrease in % body fat at age 14–16 years) | ↑ 50% (%body fat) | Steady increase | Yes | Yes |
| $VO_2$ peak ($L\,min^{-1}$) | Steady increase throughout adolescence related to increased FFM and improved cardiovascular system | ↑ 70% | 12–13 | Yes | Yes |
| $VO_2$ peak ($mL\,kg^{-1}\,min^{-1}$) | Small decrease during early adolescence, but remaining steady during later adolescence | Steady | NA | Yes | No |
| Anaerobic power | Steady increase in childhood, with a rapid increase during puberty | ↑ 50% | 14–16 | Yes | Mostly |
| Anaerobic capacity | Steady increase throughout adolescence | ↑ 200% | Unknown | Yes | Yes |
| Strength | Dramatic increase associated with body size | ↑ 150% | 14–16 | Yes | Yes |
| Skill | Increase during adolescence related to practice and possibly increased physical ability | Dependant on type of skill | Unknown | Yes | Partially |
| Agility | Possible increase during adolescence | ↑ 20% | Unknown | Probably | Partially |

**Table 2** Examples of tests used in talent identification with young athletes

| Measures | Examples of projects incorporating tests |
|---|---|
| Aerobic capacity | |
| Maximal oxygen uptake | Male soccer players (Czech Republic 2001)[47] |
| Maximum power output | Junior national basketball team (Greece, 2004)[48] |
| 20 m shuttle run test | Talent search program (Australia, 2003)[49] |
| Anaerobic power | |
| Vertical jump | Junior rugby league players (Australia, 2002)[33] |
| Stand long jump | Young team handball players (Israel, 2005)[38] |
| Anaerobic capacity | |
| Repeated sprints | Female field hockey (New Zealand, 2003)[35] |
| Running velocity | Gymnasts (Australia 2004)[50] |
| Wingate anaerobic tests | Swimmers, tennis and team handball players, gymnasts (Denmark 2002)[51] |
| Strength | |
| Isometric | Female field hockey (New Zealand, 2003)[35] |
| Agility runs | |
| 505 test | Female soccer (Australia 2000)[52] |
| Illinois agility run | Female field hockey (New Zealand, 2003)[35] |
| Sports-specific motor skill | |
| Slalom dribbling | Team handball players (Israel, 2005)[387] |
| Water polo dribbling | Water polo (Israel, 2004)[2] |
| Soccer dribbling | Female soccer (Australia 2000)[52] |
| Game intelligence | |
| | Water polo (Israel, 2004)[2] |

measured using jump tests. Results from jump tests are positively related to sprint performance with correlation values between the two tests ranging from 0.42 to 0.72.[32]

Jump and sprint performance testing for talent identification have two additional benefits. Both tests are easy to conduct with large groups and familiarisation with the test procedure is straightforward for young athletes. In addition, extensive availability of databases on field- and laboratory-based jump tests permit comparison within and between age groups and young sporting populations.[33]

**Anaerobic capacity testing methods**

The Wingate test is the most commonly used research tool for anaerobic power and fatigue, and has a strong reproducibility in adolescent populations. However, the use of Wingate tests in large talent identification programs is limited because of practical constraints of equipment and staff, and questionable specificity for most team sports. For sports requiring running-specific anaerobic power, limited research is available for 400-m performances of adolescent team sport participants. However, the use of a 400-m trial may be attractive for talent identification in team sports because it could replicate a most extreme sporting demand in a team sport, is easily conducted and high performance comparisons can be ascertained through track and field results from the same age group.

**Strength testing methods**

Strength requirements for team sports are complex and varied in playing situations. Intuitively, it is desirable to develop a battery of strength tests replicating sports-specific movement patterns. Isotonic strength measurement can be used to assess important ranges of movement in team sports.[34] Isometric testing via a hand grip was recently considered useful in tests on young female field hockey players,[35] but may lack relevance for other sports.

**Agility and skill testing methods**

A number of agility tests are available for use in talent identification. Again, the specificity of the test should be considered and tests need to replicate movement in team sports. Most agility tests have acceptable and replicable results in adolescent populations. Sport-specific skills are increasingly included as strong correlates of talent identification in team sports such as basketball,[1,36] rugby,[37] handball[38] and football.[39] Although Table 3 includes several studies with girls as well as boys, some new directions in sport-specific talent testing are evident. Recent investigations into talent identification for water polo have advanced the possibility of using game intelligence in predicting future success of adolescents.[2] In contrast to physiological parameters, physical size and maturity appear to contribute minimally to motor skill performance.[40] However, it is possible for adolescents with no sports-specific skills to be successfully identified through physiological and anthropometric attributes for recruitment to new sports. Subse-

**Table 3** Examples of talent identification programs in team sports

| Sport | Country and year | Selected test items | Major results |
|---|---|---|---|
| Youth field hockey[53] | The Nether-lands, 2004 | Anthropometric, physiological, technical (dribbling), tactical and psychological tests | Differences between elite and sub-elite<br>Technical, tactical qualities and motivation |
| Young female field hockey players[35] | New Zealand, 2003 | Anthropometric, physiological and sport-specific skills | Differences between regional and local teams<br>Relative percent body fat<br>Speed and agility<br>Dribbling speed and accuracy<br>Aerobic and muscle power |
| Gymnastics team handball, tennis and swimming [51] | Denmark, 2002 | Muscle strength, anaerobic power and maturation. | Gymnasts best jumpers |
| Female soccer[52] | Australia, 2000 | Anthropometric, physiological and skill tests | 17 with highly ranked scores selected for 12 months' talent development — 10 players in state teams following one season |
| Youth basketball[36] | Australia, 2000 | Anthropometrics, speed, agility, coach's rating | Coach's rating related to good results for speed, agility and anthropometrics |
| Water polo[2] | Israel, 2004 | Distance swims, dribbling and throwing skills in water, game intelligence | Three repeated tests in 2 years<br>Baseline results accounted for 67% of results 2 years later |
| Team handball[37] | Israel, 2005 | Anthropometrics, single and repeated sprints, standing long jump, medicine ball throw, sprint dribbling | Only slalom dribbling predictive of national success 2—3 years later. |
| Junior rugby league[32] | Australia, 2002 | Body mass, vertical jump, sprint and agility runs, multi-stage shuttle run tests | Age and experience were related to results for<br>Body mass, vertical jump, speed, agility and aerobic power |

quently, an argument may be presented by sports officials that motor skills are more important in talent development once talent identification has occurred.

### Repeated sprint tests

Single performances provide a broad index of the suitability for sports performance but the ability of a young athlete to repeatedly perform high intensity intermittent activity under increasingly fatiguing conditions in team sports may not be initially evident. Repeated sprint tests are more specific than traditional physiological variable testing and are designed to replicate specific movement patterns in team sports that involve high-intensity work periods interspersed with rest periods.[41] Results are interpreted in two ways: first the performance score relating to the time taken to complete the test, and second, a measure of the amount of fatigue or recovery that can be demonstrated.

A number of different protocols exist for repeated sprint ability. However, extensive time demands decrease wide spread use. Repeated sprint tests are more frequently emerging in talent identification programs.[35,38] Once again some of these examples include results from studies on girls,[35] but the general trend is not expected to be different between sexes. Sprint results provide access to insightful information about the suitability of young athletes for a team sport and could also set salient benchmarks for improvement in development programs.

## Genetic influences on talent identification processes for adolescents in team sports

### Measures of heritability

The contribution of genetics to physical performance has generated substantial interest in recent years.[42] The growth of gene therapy appears to exceed acceptable and ethical debate on its application. Questions about confidentiality of results and consequences of genetic identification testing on aspiring young athletes are also a concern to leaders in genetics and performance research.[43]

Understanding the complexities of genes and performance requires the development of models that incorporate phenotypic variance, from identification of the genetic source of variance, as well as the environmental component (training, lifestyle).[44] These models involve family comparisons, either between parent and child or siblings. In practice, there is often a large variability in inheritance coefficients reported in different studies.[43] Variability can be attributed to differences in age and gender of the studied population, selected methods and standardisation and deficiencies in design and analyses.[44] Thus the magnitude of genetic variability is large for many characteristics and often difficult to quantify with precision.[45]

### Genetic contribution to training response

Genetic contribution to performance is not limited to measures of physical or physiological performance characteristics, but includes the genetic contribution to training response. Large variability in responses to the same exercise program implicates a genetic component of the response to aerobic training.[45] Results from studies of monozygotic twins suggest approximately six to nine times more variability in improvement in $VO_2$ max after training between twins than within each pair.[46]

The genetic contribution to trainability of anaerobic characteristics has also been studied using monozygotic twins performing a 15-week high-intensity intermittent training program.[46] Results showed that the training response for short term anaerobic performance (10 s work output) had a minimal genetic component, whereas trainability of long-term anaerobic performance (90 s work output) was strongly genetically mediated. The genetic component of trainability for a 90 s work output was estimated at 70%.[46]

The seemingly strong influence of genotype on trainability of anaerobic, aerobic and skill performance should be considered in talent identification processes. The benefit does not lie in using genetic testing methods to determine young athletes' trainability, because currently genetic talent has questionable ethics and precision issues. However, coaches and selectors should be educated that athletes responding slowly to training may possess as much or more ability as their peers who respond more rapidly to training programs. Selection should ideally be based on long-term rather than short-term performance assessment.

## Conclusions

Limited evidence suggests scientifically based testing protocols can be used in physiological testing for talent identification in team sports. Frequently, physiological tests report acceptable reliability but few have proven predictability in talent identification. The effect of maturation on physiological testing makes prediction of adult performance from adolescent data difficult. A more perfect model is likely to account for maturity and include multidimensional aspects of performance such as game intelligence and psychosocial attributes in addition to physical performance and growth-related measures. A useful outcome may emerge if results from multidimensional tests can be used to nurture players' strengths and improve areas of weakness rather than for exclusion purposes. The limitations inherent in physiologically based performance tests in talent identification highlight the importance of alternative strategies to include late developers and slower responders to training.

## Practical implications

- The unpredictability of growth and critical environmental factors confound the accuracy of most physiological tests used in talent identification for males in team sports.
- Traditional physiological testing continues despite poor predictability and limited specificity.
- Trainability differs among individuals. Therefore ''once only'' testing during adolescence may be misguided.

- Genetics may have a salient role in talent identification but ethical issues and recognition of a positive training and life environment remain significant.

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