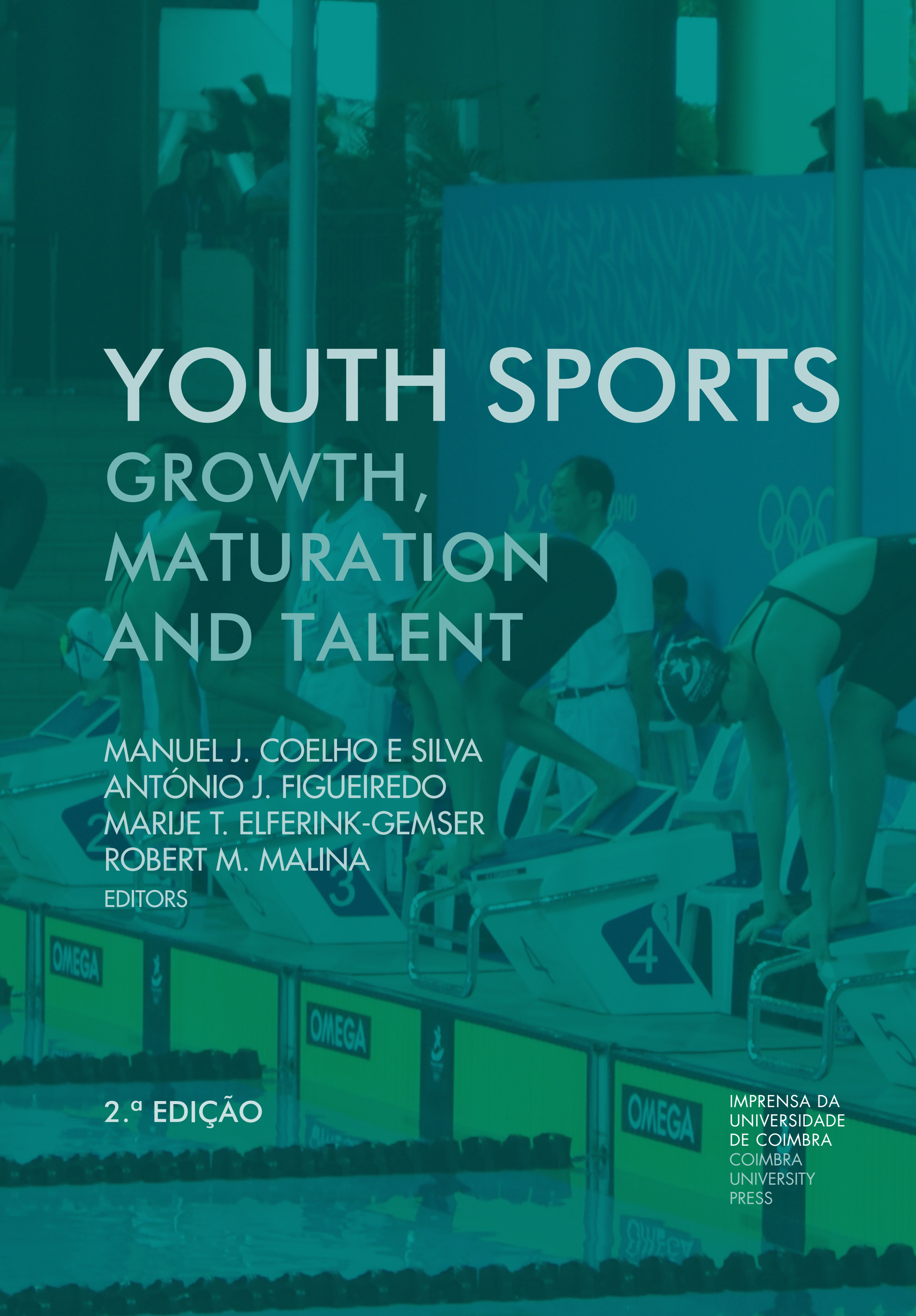


YOUTH SPORTS

GROWTH, MATURATION AND TALENT

MANUEL J. COELHO E SILVA
ANTÓNIO J. FIGUEIREDO
MARIJE T. ELFERINK-GEMSER
ROBERT M. MALINA
EDITORS

2.ª EDIÇÃO

IMPRENSA DA UNIVERSIDADE DE COIMBRA
COIMBRA UNIVERSITY PRESS

A preparação a longo prazo de jovens atletas para o alto rendimento pode ser incompatível com opções de curto prazo centradas na obtenção imediata de resultados desportivos. Só o conhecimento do essencial dos processos de crescimento e maturação pode confluir na máxima expressão das capacidades individuais e, por outro lado, evitar o esgotamento precoce dos sistemas biológicos e psicológicos de que depende o rendimento desportivo. Outro imperativo à qualidade do processo de treino com crianças e jovens decorre da gestão das exigências da participação desportiva em termos familiares e escolares, na observância de princípios essenciais para o desenvolvimento pessoal e social. O presente livro e os seus autores oferecem uma colecção de capítulos devidamente organizados, cobrindo tópicos fundamentais ao treinador e às organizações que enquadram a formação desportiva. Em resumo, a investigação presta um valioso contributo ao desenvolvimento do treino desportivo.

Agostinho Oliveira
Nascido a 5 de Fevereiro de 1947, iniciou a sua carreira como jogador de futebol em 1957, jogou pela Associação Académica de Coimbra por um período de três anos, tendo-se licenciado em Filosofia. Esteve ao serviço de Federação Portuguesa de Futebo como seleccionador e coordenador das selecções, tendo vários títulos conquistados: (1) Campeão do Mundo Sub-20 em 1991, como treinador adjunto; (2) Campeão da Europa Sub-18, 1994; (3) Campeão da Europa Sub-18, 1999; (4) Campeão da Europa Sub-16, 1996; (5) Campeão da Europa Sub-16, 2000. Em 2004, recebeu o título de Comendador da Ordem do Infante.

I N V E S T I G A Ç Ã O

IMPRENSA DA UNIVERSIDADE DE COIMBRA
COIMBRA UNIVERSITY PRESS

EDIÇÃO
Imprensa da Universidade de Coimbra
Email: imprensa@uc.pt
URL: http://www.uc.pt/imprensa_uc
Vendas online: http://livrariadaimprensa.uc.pt

CONCEPÇÃO GRÁFICA
António Barros

INFOGRAFIA DA CAPA
Carlos Costa

EXECUÇÃO GRÁFICA
Simões & Linhares, Lda

ISBN
978-989-26-1168-6

ISBN Digital
978-989-26-1169-3

DOI
http://dx.doi.org/10.14195/978-989-26-1169-3

DEPÓSITO LEGAL
406811/16

YOUTH SPORTS
GROWTH, MATURATION AND TALENT

MANUEL J. COELHO E SILVA
ANTÓNIO J. FIGUEIREDO
MARIJE T. ELFERINK-GEMSER
ROBERT M. MALINA
EDITORS

2.ª EDIÇÃO

IMPRENSA DA UNIVERSIDADE DE COIMBRA
COIMBRA UNIVERSITY PRESS

Página deixada propositadamente em branco.

LIST OF CONTRIBUTORS

Ad Roskam. *Dutch Olympic Committee NOC*NSF, The Netherlands* [Ad.Roskam@noc-nsf.nl]

Adriaan J Helmantel, *BSc. Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands [adriaan@helmantel.nl]*

Albrecht L Claessens, *PhD. Research Center for Exercise and Health, Department of Biomedical Kinesiology, Faculty of Kinesiology and Rehabilitation Sciences, Katholieke Universiteit Leuven, Belgium. BELGIUM [albrecht.claessens@faber.kuleuven.be]*

Anthony P Kontos, *PhD. Humboldt State University, Arcata, California, United States [apk10@humboldt.edu]*

António J Figueiredo, *PhD. Faculty of Sport Science and Physical Education, University of Coimbra, Portugal [afigueiredo@fcdef.uc.pt].*

António Marques, *PhD. Faculty of Sport. University of Oporto. Portugal [amarques@fade.up.pt].*

Astrogildo Oliveira Junior, *PhD. Institute of Physical Education and Sport. Rio de Janeiro State University, Brazil [avojr@uerj.br]*

Barbara C H Huijgen, *MSc. Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands [b.c.h.huijgen@med.umcg.nl]*

Carlos Gonçalves, *PhD. Faculty of Sport Science and Physical Education, University of Coimbra, Portugal [carlosgoncalves@fcdef.uc.pt]*

Casper H Jorna, *MSc. Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands [chjorna@gmail.com].*

Chris Visscher, *PhD. Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands [c.visscher@rug.nl].*

Eyra E Cardenas Barahona, *PhD. Escuela Nacional de Antropologia e Historia, Mexico City, DF, Mexico [†].*

Filipe Simões, *Msc-candidate. Faculty of Sport Science and Physical Education, University of Coimbra, Portugal [perryces@hotmail.com]*

Filomena Vieira, *PhD. Technical University of Lisbon, Portugal [fvieira@fmh.utl.pt].*

Francisco Sobral, *PhD. Emeritus Professor, University of Coimbra, Portugal [e-mail not available].*

Greg J Welk, *PhD. Iowa State University, Ames, Iowa, United States [gwelk@iastate.edu]*

Isabel Fragoso, *PhD. Technical University of Lisbon, Portugal [ifragoso@fmh.utl.pt]*

Jim L Lyons, *PhD. Department of Kinesiology, McMaster University Hamilton, Ontario, Canada [lyonsjl@univmail.cis.mcmaster.ca].*

João Valente dos Santos, *Msc, PhD-candidate. Faculty of Sport Science and Physical Education, University of Coimbra, Portugal [valente_hp_cdef@hotmail.com]*

Jodee A Schaben, *PhD. Iowa State University, Ames, Iowa, United States [jschaben@iastate.edu]*

Joey C Eisenman, *PhD. Department of Kinesiology and Pediatrics and Human Development,. Michigan State University, East Lansing, Michigan, United States [jce@msu.edu]*

José Oliveira, *PhD. Faculty of Sport. University of Oporto, Portugal [joliveira@fade.up.pt]*

Koen A P M Lemmink, *PhD. Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands [k.a.p.m.lemmink@rug.nl].*

Laura Jonker, MSc. Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands [l.jonker@med.umcg.nl]

Luísa Canto e Castro, PhD. Faculty of Science, University of Lisbon, Portugal [luisa.loura@fc.ul.pt].

Manuel J Coelho e Silva, PhD. Faculty of Sport Science and Physical Education, University of Coimbra, Portugal [mjcesilva@fcdef.uc.pt]

Maria E Peña Reyes, PhD. Escuela Nacional de Antropologia e Historia, Mexico City, DF, Mexico [eugeniapere@prodigy.net.mx]

Marije T Elferink-Gemser, PhD. Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands [m.t.elferink-gemser@rug.nl].

Martin J Lee, PhD. Faculty Fellow, Chelsea School Research Centre. University of Brighton, Brighton, United Kingdom [†]

Martyn Standage, PhD. School for Health, University of Bath, Bath, United Kingdom [m.standage@bath.ac.uk]

Mathijs van Ark, MSc. Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands [mathijsvanark@gmail.com].

Megan L Babkes, PhD. Department of Kinesiology and Physical Education. University of Northern Colorado, Greeley, Colorado, United States [e-mail not available]

Rianne Kannekens, MSc. Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands [r.kannekens@med.umcg.nl]

Robert M Malina, PhD, FACSM. Professor Emeritus, Department of Kinesiology and Health Education, University of Texas at Austin and Research Professor, Tarleton State University, Stephenville, Texas, United States [rmalina@skyconnect.com]

Rui A Gomes, PhD. Faculty of Sport Science and Physical Education. University of Coimbra, Portugal [ramgomes@gmail.com]

Sean P Cumming, *PhD. School for Health. University of Bath. UK [sc325@bath.ac.uk, s.cumming@bath.ac.uk]*

Shannon R Siegel, *PhD. California State University, Santa Barbara, California, United States [ssiegel@csusb.edu]*

Tamara Kramer, *BSc. Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands [tamarakramer87@hotmail.com].*

Thomas Reilly, *PhD. Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, United Kingdom [†]*

Tynke T Toering, *MSc. Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands [t.t.toering@med.umcg.nl]*

Vaclav Bunc, *PhD. Sport Research Laboratory, Faculty of Physical Education and Sports, Charles University, Prague, Czech Republic [bunc@ftvs.cuni.cz]*

Vasco Vaz, *Msc. Faculty of Sport Science and Physical Education, University of Coimbra, Portugal [vascovaz@fcdef.uc.pt]*

Yvonne Tromp, *MSc. Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands [e.j.y.tromp@med.umcg.nl]*

TABLE OF CONTENTS

PART 2: TALENT

PART 3: TRAINING

Página deixada propositadamente em branco.

NOTE FROM THE EDITORS

Participation in sports is a major feature of daily living for children and adolescents in many countries of the world. Structures of organized programs vary within and among countries. Likewise, sport offerings and values attached to these sports vary with cultural context. Sport is also important in the primary demands that face all children and adolescents, i.e., the business of growing, maturing and developing. Sport is also a primary source of physical activity for many children and adolescents, and is an arena in which personal and inter-personal values and behaviors are developed and nurtured. Key players in these important functions of sport are peers, coaches and parents.

The volume is aimed primarily for students of Physical Education and Sport Sciences, coaches, trainers, parents and others involved in youth sport programs and in the preparation of young athletes. The contents have application to a variety of cultural contexts given the near universality of sport for youth throughout the world. Focus is on the youth sport participant or the young athlete as a child and adolescent with the needs of a child and adolescent. The demands of sport are superimposed on the biological and behavioral demands placed upon children and adolescents. All too often this is overlooked, especially at the more elite levels of youth sport, where the young talented athlete is often viewed as a commodity. The editors hope that the contributions which comprise this volume will serve to enhance the sport experiences of youth, minimize potential risks, and maximize potential benefits by educating adults who work with them in the context of sport.

The second edition of Youth Sports is divided into two volumes. Volume 1 includes chapters in two parts. The first focuses on Participation – statistics, benefits and risks, motivation, coaching values, and parents. The second part focuses on Trainability, Readiness and Injuries – the effects of training on growth, responsiveness to training for sport, physiological dimensions of training, and risk factors for injury. Volume 2 includes chapters in three parts. The first focuses on growth and maturation - young athletes in general, young athletes participating in soccer, swimming and artistic gymnastics. The second focuses on Talent – specifically talented young athletes in tennis and soccer and physiological characteristics of elite adolescent athletes in several sport. The third part focuses on Training – quality of training experiences, tactical training and talent coaches. The two volumes bring together research-based knowledge and understanding from the perspectives of the biomedical (human biology), social and sport sciences. Readers are thus provided with a wide spectrum of contemporary insights relating to the participation of children and youth in sports, on one hand, and sport developmental processes, on the other. We believe that the compilation of chapters presents a reasonably comprehensive overview of topics and issues in contemporary youth sports research.

The chapters comprising the two volumes were prepared by senior researchers many of whom were working with their young colleagues, often beginning professors and students working on advanced degrees. Contributors come from nine different countries in Europe (Belgium, Czech Republic, Portugal, The Netherlands, United Kingdom) and the Americas (Brazil, Canada, Mexico, United States). We are sad to announce the deaths of three individuals who contributed to the first edition, Eyra E Cardenas Barahona from Escuela Nacional de Antropologia e Historia in Mexico City; Martin J Lee from the Chelsea School Research Centre of the University of Brighton in the United Kingdom; and Thomas Reilly from the Research Institute for Sport and Exercise Sciences of Liverpool John Moores University in the United Kingdom. Eyra was a physical anthropologist with a genuine interest in the study of sport while Martin and Tom were students of the sports sciences. All three will be dearly missed as friends and as scholars.

Manuel J Coelho e Silva
António J Figueiredo
Marije T Elferink-Gemser
Robert M Malina

Part 1:

GROWTH AND MATURATION

Página deixada propositadamente em branco.

http://dx.doi.org/10.14195/978-989-26-1169-3_1

CHAPTER 1: BASIC PRINCIPLES OF GROWTH AND MATURATION

Robert M Malina

INTRODUCTION

The interval between birth and adulthood is commonly divided into age periods. The first year after birth (birth to the first birthday) is labeled infancy, which is followed by childhood. Childhood is usually subdivided into two phases, early and middle. The former approximates the "preschool" years, about 1 through 5 years of age. The latter approximates the "elementary school" years, about 5-6 through 10-11 years. The upper limit of middle childhood is arbitrary because it is followed by adolescence, which is variable in when it starts. Some fourth grade girls, for example, who are about 9-10 years of age, have already entered the early stages of adolescence. The termination of adolescence is also quite variable so that it is also difficult to specify when adulthood begins. Biologically, some girls are sexually mature by 12 years of age and some boys are sexually mature by 14 years of age; i.e., they are biologically adult. Yet, they are adolescents in the eyes of society. Adulthood is a socially defined concept, usually in the context of completing high school, and in some instances, completing college.

This chapter has several objectives:

- What are the basic principles of growth, maturation, and development?

- How do they interact during childhood and adolescence?

- What is the pattern of age changes and sex differences in growth, maturation, and development from childhood through adolescence?

- What is the pattern of change in the performance motor, strength and aerobic tasks from childhood through adolescence?

GROWTH, MATURATION, AND DEVELOPMENT

Children and adolescents experience three interacting processes: they grow, mature and develop (Table 1). These terms are often treated as having the same meaning. They are, however, three distinct tasks in the daily lives of children and adolescents for approximately the first two decades of life.

Growth

Growth refers to the increase in the size of the body as a whole and of its parts. Thus, as children grow, they become taller and heavier, they increase in lean and fat tissues, their organs increase in size, and so on. Heart volume and mass, for example, follow a growth pattern like that for body weight, while the lungs and lung functions grow proportionally to height. Different parts of the body grow at different rates and different times. This results in changes in body proportions - relationship of one part of the body to another. The legs, for example, grow faster than the trunk during childhood; hence, the child becomes relatively longer-legged for his or her height.

Table 1. Universal tasks of childhood and adolescence.

GROWTH:	MATURATION:	DEVELOPMENT:
Size	Skeletal	Cognitive
Proportions	Sexual	Emotional
Physique	Somatic	Social
Composition	Neuroendocrine	Motor
Systemic	Neuromuscular	Moral
	SELF-ESTEEM BODY IMAGE PERCEIVED COMPETENCE	

Adapted from Malina *et al.* (2004)

Maturation

Maturation refers to progress towards maturity or the biologically mature state. It is an operational concept because the mature state varies with body system. All tissues, organs, and systems of the body mature. Maturation is process which should be viewed in two contexts - timing and tempo. Timing refers to when specific maturational events occur, e.g., age at the beginning of breast development in girls, the age at the appearance of pubic hair in boys and girls, or the age at maximum growth during the adolescent growth spurt. Tempo refers to the rate at which maturation progresses, e.g., how quickly or slowly the youngster passes through the adolescent growth spurt. Timing and tempo vary considerably among individuals.

Development

Development refers to the acquisition of behavioral competence - the learning of appropriate behaviors expected by society. As children experience life at home, school, church, sports, recreation, and other community activities, they develop cognitively, socially, emotionally, morally, and so on. They are learning to behave in a culturally appropriate manner.

The three processes, growth, maturation and development, occur at the same time and interact. They interact to influence the child's self-concept, self-esteem, body image, and perceived competence. Teachers and coaches (note, coaching is teaching) should be aware of these interactions. A mismatch between the demands of a sport and those of normal growth and maturation may be a source of stress among young athletes. How a youngster is coping with his/her sexual maturation or adolescent growth spurt, for example, may influence his/her behaviors, including sport-related behaviors and performance.

GROWTH IN BODY SIZE AND COMPOSITION

Height and weight are the two body dimensions most commonly used to monitor the growth of children and adolescents. With age, children are expected to become taller and heavier. Size attained at a given age (status) and rate of growth (progress) are usually monitored relative to growth charts. These charts are a reference for comparison for monitoring the growth status (size attained) of individuals or samples of children and adolescents. Revised charts height, weight and the body mass index (BMI, see below) for American children from birth to 20 years of age were recently made available (Kuczmarski *et al*., 2000). These are based on a nationally representative samples of American children and adolescents, and replace the earlier charts which were used internationally (Hamill *et al*., 1979). The charts include several curves which indicate the distribution of heights and weights (percentiles) at a given age. For example, a child at the 25th percentile for height is taller than 25%, and is shorter than 75% of the children of the same age and sex.

Height and weight increase gradually during childhood. By about 9-10 years in girls and 11-12 years in boys, the rate of growth in height begins to increase. This marks the beginning of the adolescent growth spurt, a period of rapid growth that is highly variable among individuals. The rate of growth increases until it reaches a peak, which is called peak height velocity (PHV) or maximum growth in height during the adolescent spurt. Then it gradually decreases and growth in height eventually stops. Girls, on average, start their growth spurts, reach PHV, and stop growing about two years earlier than boys. Nevertheless, when the growth spurt starts, when PHV is reached, and when growth stops are very variable among individuals. Most other body dimensions follow a growth pattern similar to that for height and weight.

The growth spurt in body weight begins slightly later than that of height. Body weight is a composite measure of many body tissues, but it is often viewed in terms of its lean (fat-free) and fat components. Thus, body weight = fat-free mass (FFM) + fat mass (FM). Major components of FFM are skeletal muscle and bone mineral. FFM has a growth pattern like that for body weight and experiences a clear adolescent spurt. FM increases more gradually during childhood and adolescence. General guidelines for expected changes in height, weight, and body composition are summarized in Table 2.

Height and weight are frequently used in the form of the body mass index (BMI) – weight divided by height squared (kg/m^2). After an increase in infancy, the BMI declines through early childhood. It reaches its lowest point at about 5-6 years of age, and then increases with age through childhood and adolescence, and into adulthood. Sex differences in the BMI are small during childhood, arise during adolescence, and persist into adulthood. The rise in the BMI after the low point at about 5-6 years of age has been labeled the "adiposity rebound". It is suggested that children who have an early "rebound" have an increased probability of being overweight in late adolescence and young adulthood. This hypothesis, however, needs further confirmation.

An elevated BMI is generally accepted as an indicator of adiposity or fatness in public health and nutritional surveys. An international reference for the definition of overweight and obesity during childhood and adolescence has been recently developed (Cole *et al*., 2000). These internatinally recommended age- and sex-specific cut-off points of the BMI for overweight and obesity between 2 and 18 years of age are based on pooled data from six nationally representative cross-sectional growth surveys – Brazil, Great Britain, Hong Kong, the Netherlands, Singapore, and the United States. In establishing the cut-off points, a BMI of 25.0 kg/m^2 at 18 years of age was considered overweight and a BMI of 30.0 kg/m^2 at 18 years of age was considered obese. Curves were then mathematically fit to the pooled BMI data from 2 years of age on so that they passed through a BMI of 25 kg/m^2 and 30 kg/m^2 at 18 years of age (retro-fitting). The values at each half year from 2 to 18 years of age are the respective cut-off points for overweight and obesity.

The interpretation of the BMI in childhood, adolescence and young adulthood as an indicator of fatness needs care. An elevated BMI is not necessarily indicative of fatness during childhood and adolescence. The BMI is reasonably well correlated with total body fat and percentage fat in heterogeneous samples, but has limitations. Associations between BMI and fatness indicate a wide range of variability so that children with the same BMI can differ considerably in percentage fat and total fat mass, which emphasizes the need for care and sensitivity in the use and interpretation of the BMI as an indicator of fatness in individual children and adolescents.

Table 2. Guidelines for expected changes in height, weight, and body composition.

Pre-Adolescence or Pre-Puberty (about 6-10 years of age)

Children are expected to grow, i.e., increase in weight and height. Although there is much variation among individuals, children gain, on average, about 5-8 cm (2 to 3 inches) per year and about 2-3 kg (5 to 7 pounds) per year between 6 and 10 years of age. As adolescence and puberty begin, growth rates increase, first in height and then in weight.

Adolescence and Puberty

Adolescence is characterized by the growth spurt and sexual maturation. It is a time of considerable variation in when events occur and the rate at which children pass through them.

The following highlights general trends that characterize the growth spurt:

GIRLS
- begins around 9-10 years
- reaches maximum around 12 years
- rate slows after 12 years, but growth continues to about 16-18 years

BOYS
- begins around 11-12 years
- reaches maximum around 14 years
- rate slows after 14 years, but growth continues to about 18-20 years

Growth in height continues into the early 20s in some girls and boys. There is considerable variation among individuals in TIMING (when the adolescent spurt occurs) and TEMPO (rate of progress through the spurt).

Body weight, FFM, and muscle mass also show adolescent spurts; they occur, on average, several months after the maximum rate of growth in height.

During the interval of maximum growth in height (about 11-13 years in girls and 13-15 years in boys), girls gain about 7 kg (15 pounds) in FFM while boys gain double this value, 14 kg (31 pounds); girls gain a bit more FM than boys during the interval of the growth spurt, 3 kg (6 pounds) versus 1.5 kg (3 pounds).

In a sense, during the growth spurt, "First you stretch them and then you fill them out!"

Adapted from Malina *et al*. (2004).

BIOLOGICAL MATURATION

The maturity status and progress of children and adolescents are ordinarily viewed two ways: skeletally and sexually. The timing of PHV is also an excellent maturity indicator, but longitudinal data are required to derive it. Maturation of the skeleton focuses on the bones of the hand and wrist, which generally reflect the remainder of the skeleton. An x-ray of the hand and wrist is needed to assess skeletal maturation. As such, the method has limited utility outside of a clinical setting. It is, however, a valuable method that is useful throughout childhood and adolescence, and is also used along with height at a given age to predict adult height.

Sexual maturation is based on the development of the breasts and pubic hair in girls and the testes and pubic hair in boys. Assessment of sexual maturation is ordinarily done at clinical examination by a physician. Age at menarche, the first menstrual period, is the most commonly used indicator of sexual maturity in girls.

The two most obvious features of biological maturation during adolescence are puberty or sexual maturation, and the growth spurt (see above). The first physically apparent sign of sexual maturation in girls is usually the initial development of the breasts, followed by the appearance of pubic hair. The first overt sign of sexual maturation in boys, on average, is the initial enlargment of the testes, followed by the appearance of pubic hair. Each of these secondary sex characteristics goes through a series of changes as the individual passes through puberty to maturity. They are usually assessed by a physician at a clinical examination. Their assessment requires invasion of the youngster's privacy at a time of life when he/she is learning to cope with the physiological changes that are occurring during puberty. Monitoring of these characteristics requires utmost care and sensitivity to the youngster involved. Guidelines for normal variation in sexual maturation are outlined in Table 3.

Age at menarche is limited to girls since male puberty has no corresponding physiological event. Menarcheal status (i.e., has menarche occurred or not occurred) and age at menarche in individual girls can be obtained with a careful and sensitive interview. The average age at menarche in American girls is 12.8 years, although normal variation ranges from 9 through 17 years of age.

It is important that teachers and coaches are aware of such variation among individuals as well as the significance of sexual maturation for growth and behavioral development. Sexual maturation in boys is accompanied with marked gains in muscle mass and strength, and broadening of the shoulders relative to the hips. In girls, it is accompanied by smaller gains in muscle mass and strength, by a widening of the hips relative to the shoulders, and by gains in fatness. The net result is sex differences in strength, body build, and body composition in late adolescence and young adulthood. Sexual maturation also influences behavioral development, for example, increased self-consciousness, concern with weight gain in girls, relationships with the opposite sex, and so on.

Table 3. Guidelines for normal variation in sexual maturation.

GIRLS

- The first physically apparent sign of sexual maturation in girls is the initial enlargement of the breasts. It occurs, on average, at about 10 years of age, but may occur before 9 years in about 10% of girls and not until after 12 years in another 10%.
- Mature breast development occurs, on average, between 14 and 15 years of age. However, maturity may occur as early as 12 years in some girls and not until 16 or 17 years in others.
- Progress from initial to mature breast development is highly variable among girls. Some girls may pass through the process in 2 years, while others may take 5 or more years.
- Menarche, the first menstrual period, is a rather late maturational event of puberty. It ordinarily occurs after maximum growth in height (peak height velocity). The average age at menarche for American girls is 12.8 years.

BOYS

- Initial enlargement of the genitals (testes and penis) marks the first physically apparent sign of sexual maturation in boys. It occurs, on average, about 11 years of age, but may occur around 9 years in about 10% of the boys and not until after 13 years in another 10% of the boys.
- Mature genital development occurs, on average, at about 15 years of age. However, maturity may occur as early as 13 years and after 18 years.
- Progress from initial to mature genital development is highly variable among boys. Some boys may pass through the process in 2 years, while others may take about 5 or more years.

Adapted from Malina *et al*. (2004).

BEHAVIORAL DEVELOPMENT

Development of behavioral competence proceeds simultaneously in several domains - cognitive, social, emotional, moral, and motor. Motor development, i.e., the acquisition of motor competence, and motor performance are considered in a separate section.

Middle Childhood

The period between the preschool years and adolescence is often called middle childhood. It approximately spans entrance into school (first grade) to the onset of puberty (which, as indicated above, is variable in timing).

Competence gradually develops in many behavioral domains during middle childhood. However, two features are especially significant. First, the child gradually refines his/her self-concept: Who am I?, How do I feel about myself?, Where do I fit in?, and so on. Second, the child learns many skills, including cognitive skills - reading, writing, number manipulation and others, and interpersonal behaviors and relationships that underlie social, emotional and moral competence - sharing, cooperation, honesty, sensitivity to others, and so on. In the development of behavioral competence, the child often evaluates himself or herself. They very often ask questions about their identity and how others perceive them. Two primary sources of feedback in this self-evaluative process are adults, specifically parents, teachers and coaches, and peers (playmates and teammates). It is essential that adults who work with children be aware of their developing sense of self and the ongoing process of self-evaluation. Guidelines for the development of cognitive and social competence during middle childhood are summarized in Table 4.

Table 4a. Guidelines for the development of cognitive and social competence during middle childhood (5-8 years).

Cognitive Competence

- Cognitive skills become elaborated as children show longer attention spans and increased problem solving ability.
- Children are able to handle multiple pieces of information; however, they have difficulty handling abstract or hypothetical questions.
- A major factor limiting the cognitive competence of young children is their lack of knowledge and experience using their developing skills.

Social Competence

- Children are expanding their understanding of self, i.e., self-concept formation.
- Children are interested in others, and often use other children as a reference of comparison in making self-evaluations and in defining themselves in terms of groups to which they belong.
- The peer group emerges as an important influence on children's behaviors. They are generally same-sex groups. Children have a strong sense of security in the group and in organized group activities.
- Given this sense of the group, children can learn a good deal from each other, which emphasizes the potential importance of cooperative learning environments.

Table 4b. Guidelines for the development of cognitive and social competence during late childhood and early adolescence (9-12 years).

Cognitive Competence

- Cognitive skills become more elaborated as children show longer attention spans and increased problem solving ability, and are able to handle multiple pieces of information.
- Logical thinking skills and hypothetico-deductive reasoning, and the ability to think about abstract concepts emerge during early adolescence.

Social Competence

- The strength of the peer group increases. The group is focal and is a means of establishing independence from adults.
- Individual differences in the onset of the growth spurt and puberty influence relationships with others and definition of the social self.
- A major social developmental task that emerges at this time is the formation of personal identity, i.e., accepting the self as worthy and different from others.
- There is a gradual shift from identifying with same sex peers to learning roles in heterosexual situations.

Adapted from Sproufe *et al*. (1992).

It is during middle childhood that the peer group emerges as a source of support, criticism, and comparison in handling the many challenges associated with an emerging sense of behavioral competence. Peer group activities occur in many settings and children have multiple peer groups, both formal as in school, church and organized sport, and informal as in neighborhoods and playgrounds. The significance and strength of peer groups increase with age during middle childhood.

The organized sport setting is a major source of peer group experiences for many children. In highly individual sports such as gymnastics, swimming, diving, figure skating and wrestling, coaches need to be especially sensitive to the child's need for group affiliation and the need to develop a sense of the group.

Table 5. Guidelines for the development of cognitive and social competence during adolescent years

---

Cognitive Competence

- Progress in logical thinking, hypothetico-deductive reasoning, and handling of abstract concepts continues.
- Enhanced abstract thinking is the basis for the ability for introspection. It is also the basis for emerging relationships between cognition and emotions.
- These cognitive skills expand the adolescent's ability to reason about moral and ethical issues.

Social Competence

- The formation of personal identity becomes crystallized, which contributes to establishing independence, i.e., the self as an independent person.
- The older adolescent's sense of self becomes more integrated, which contributes to better understanding of the uniqueness of each individual and to the ability to reconcile personal inconsistencies.
- Social relationships become more important. These contribute to self-evaluation and identify formation. Relationships with the opposite sex are especially important.
- There is increased acceptance of an adult role in different groups.

Adapted from Sproufe *et al*. (1992).

Adolescence

Adolescence, the transition from childhood to adulthood, is a period of major changes physically and behaviorally. The developmental tasks of adolescence are many, but three stand out. First, it is a period of physiological learning as the youngster copes with the physical and physiological changes associated with the growth spurt and sexual maturation. The youngster must learn to understand and accept the changes, to accept his/her body, and to adapt to masculine and feminine roles. A major concern of adolescents is their physical appearance. Second, it is a period of new relationships with age peers. During middle childhood, peer groups were largely same sex. During adolescence, youngsters develop relationships with age peers of both sexes, so that they have a major concern for social acceptance. And, third, it is a period of striving for independence. The youngsters strive for emotional independence from parents and other adults as they prepare for adult roles. Hence, it is a time of emotional peaks and valleys, of self-doubt, of changes in self-esteem, and of changing interests. Many youngsters experience a decline in self-esteem as they go through the developmental tasks of adolescence. It is no surprise that many youngsters drop out of sport between 12 and 14 years of age. The demands of normal adolescence may play a role in this decision.

Guidelines for the development of cognitive and social competence during adolescence are outlined in Table 5.

Adolescence appears to be a drawn out process in some cultures, for example, the United States. It appears to be a time of confusion and insecurity for many youth as they strive for independence and adulthood.

PERFORMANCE

The development of proficiency in a variety of movement skills is a major developmental task of childhood and adolescence. Skillful performance, of course, is an important component of sports. During the preschool years and extending into middle childhood, children develop basic competence in fundamental movement patterns such as running, jumping, skipping, and so on. These movements are the foundation for other skills and sport-specific skills, and for physical activity in general.

Children commonly enter school or organized youth sports programs at 5 or 6 years of age, when many are still developing the basic movement patterns. One of the objectives of physical education and youth sports programs is to teach skills. Teachers and coaches of children entering school or a sport should have an understanding of the development of movement patterns and knowledge of how to provide an environment in which these patterns can be nurtured and improved. A primary responsibility of teachers and coaches is to guide the skill development process from basic patterns to skillful performance.

As basic movement patterns are refined through appropriate instruction and practice, performance quality improves and the basic patterns are integrated into more complex movement sequences and skills required for specific games and sports. The transition from basic movement patterns to more complex sports skills depends upon individual differences in neuromuscular maturation, earlier experiences and opportunity for movement, and the quality of instruction and practice. A proficiency barrier may exist for some children who do not have such opportunities for instruction and practice. A key person in this process is the teacher or coach, who should be able to meet the developmental needs of young children or sport participants though appropriate instructional sequences and guided practice opportunities. It is important for teachers and coaches to know how to observe the movements of a child. All too often, individuals tend to focus on the end product of a movement, e.g., whether the ball was struck or how far a ball was kicked. A teacher or coach should be able to analyze a movement to determine what are the important elements to observe. As a corrollary, the teacher or coach should have a sound knowledge of activities and experiences that will help the young athlete to progress in the development of a basic skill or a more specialized skill sequence. This way they will be able to know the process of what the child is doing rather than the result of what the child is doing. Knowing the process of performance is important to being able to provide corrective, positive instructional feedback to help improve performance.

The development of proficiency in basic movement patterns is accompanied by improved levels of performance which can usually be quantified. These are outcomes of the performance of tasks, e.g., the distance or height jumped (power), the distance and accuracy a ball is thrown (power and coordination), the time elapsed in completing a 30-yard dash (speed). Performances on such standardized tasks improve with age during childhood, and boys perform, on average, better than girls. There is considerable overlap between the sexes during early and middle childhood. With the onset of adolescence, the performances of boys show an acceleration whereas those of girls improve to about 13-15 years of age and then improve only slightly.

Tests of performance include anaerobic and aerobic components. Anaerobic power is the maximal ability to perform short-term (usually less than 30 seconds), high intensity bouts of exercise as in the vertical jump or a sprint. As such, anaerobic power follows a pattern of growth like that for sprints and jumps. Aerobic power is the maximal ability to uptake, deliver, and utilize oxygen to produce energy under aerobic conditions. It is an important determinant of endurance events. Absolute maximal aerobic power (expressed as liters of oxygen per minute) increases in boys and girls with age, and shows a clear adolescent spurt as do other performance tasks. When maximal aerobic power is adjusted for body weight, it shows little change with age in boys but declines with age in girls.

Performance during adolescence is influenced in part by individual differences in the timing of the adolescent growth spurt. Performances in a variety of tasks show well-defined adolescent spurts. Measures of strength tend show peak gains after the time of maximum growth in height (peak height velocity) in boys and girls. However, the magnitude of the growth spurt in strength is only about one-half of the maximum gain in boys. The same trend is apparent for power (vertical jump) in boys, but corresponding data are not available for girls. The trends for measures of strength and power are similar in timing to those for body mass and muscle mass, both of which experience their maximum growth after peak height velocity. Maximal aerobic power shows an adolescent spurt that occurs very close in time to that for height in boys and girls. When motor performances of girls are related to the time before and after menarche, there are no consistent trends. Menarche is a late maturational event during puberty, and major gains in growth and performance have already occurred.

The overall pattern of age- and sex-associated changes in a variety of performance tasks during childhood and adolescence is summarized in Table 6. The trends are based on group averages. Some girls, especially those active in sport, improve their performances through adolescence.

Table 6. Guidelines for the development of motor competence during childhood and adolescence.

5-8 years

- By these ages, the majority of children have developed the basic movement patterns. Note, however, that some children have not yet mastered the basic movement patterns at theses ages and would benefit from systematic instruction and practice under the supervision of qualified teachers/coaches.
- Performance in a variety of strength, speed, and power tasks improves more or less proportionally to gains in body size. Balance and coordination tasks also improve.

9-12 years - transition into adolescence

- Performances in motor (many are anaerobic), strength and endurance (aerobic) tasks, on average, improve with age.
- Individual differences in the timing and tempo of the growth spurt and sexual maturation exaggerate differences among children in performance. This is especially apparent among children of the same age who differ in maturity status.

13+ years -adolescence

- Performance in motor, strength, and aerobic tasks continues to improve, on average, in boys.
- On average, the performances of girls tend to reach a plateau at these ages or improve only slightly. In young female athletes who are systematically training for a sport, performances improve into late adolescence.

Adapted from Malina *et al*. (2004).

OVERVIEW AND IMPLICATIONS FOR TEACHING AND COACHING

For the sake of convenience, the preceding discussion arbitrarily partitioned childhood and adolescence into three periods that approximate childhood (5-8 years), the transition into puberty (9-13 years) and later adolescence (14-18 years). The first period represents the ages when the majority of children enter organized sports programs. The second period highlights the transition from childhood into adolescence which has major physical, physiological, and behavioral changes. It is also a period during which many youth drop out of sport programs, either by choice or by the more selective nature of many programs. The third period approximates the high school years, when sport programs are more selective and demanding.

It is important to note that the age ranges are arbitrary, especially between the second and third periods. These ages span the transition from childhood into adolescence, and the timing and tempo of the transition is variable within and among individuals. Thus, many of the cognitive and social developmental issues in the high school years are reworked in the context of those in the transitional period.

Variation within and between individuals in growth, maturation, and development is considerable. The marked changes in body composition are of specific concern, especially to adolescent girls and to many coaches. Motor performance may be influenced by an especially rapid growth spurt in both sexes. Relationships between peers may influence social behaviors and in turn relationships with coaches.

A teacher or coach should be able to apply these general concepts of growth, maturation and development to fit the needs of the young athletes in his/her program. Several suggestions for coaches in dealing with the physical, behavioral, and motor changes associated with the transition into and during the adolescent growth spurt and sexual maturation follow:

- **Be aware of individual differences.** As youth enter adolescence and during adolescence, they needs reassurance that they are "normal", i.e., not different from their peers. This need most often occurs in youngsters who are extremely early or extremely late in maturation. Above all, coaches should not make fun of them; peers often do, especially in locker rooms. The young adolescent is very sensitive to the growth and maturational changes that are occurring, and must learn to adjust to them. Adolescence is a period of physiological learning. The adolescent needs the support of understanding adults to transcend these changes with a positive view of self.

- Adolescents are very sensitive about their body weight and shape. Given changes that occur in body composition during later childhood and adolescence, **teachers and coaches should avoid comments about body weight**, especially in girls who in many cultures are being taught that "thin is in." Adolescent girls are very sensitive to weight changes associated with growth and maturation, and do not need to be reminded of them.

- **Coaches should be careful in using body size as cut-points in sports.** This especially affects late maturing youngsters who need to be given the opportunity to participate and to keep working at improving skills, and who need to be reassured that they will eventually grow and mature.

- **Coaches should pay attention to the child's eating behaviors and diet.** A well-balanced diet is essential to support the needs of growth and maturation, in addition to those specific to physical activity and regular training for sport. Megavitamins are not a replacement for a well-balanced meal. Be aware of the use of antihistamines to suppress diet and of other ergogenic aids.

- **Teachers and coaches should be aware of expected developmental** changes and should also be aware of how developmental changes may influence performance. Some examples:

    - Since growth in height occurs before growth in body mass and strength, there may be temporary periods during which a boy or girl may appear to "outgrow his/her strength". The youngster needs reassurance that his/her strength will eventually catch-up.

    - There may be intervals during which a skill may temporarily decline compared to performances prior to the growth spurt, or there may be intervals during which skills may not improve as quickly. These may be associated with rapid changes in body proportions during the adolescent growth spurt, or changes in body composition associated with sexual maturation. The legs, for example, experience their grow spurt before the trunk does, which temporarily alters the position of the center of gravity.

    - Changes in body composition and development of the hips, particularly in girls, also may influence performance. The adolescent girl needs to be nurtured through these changes in a positive manner with appropriate instruction and practice in movement and sport-specific skills.

REFERENCES

Beunen G, Malina RM (1988) Growth and physical performance relative to the timing of the adolescent spurt. *Exercise and Sports Science Reviews* 16:503-540.

Clapp JF, Little KD (1995) The interaction between regular exercise and selected aspects of women's health. *American Journal of Obstetrics and Gynecology* 173:2-9.

Cole TJ, Bellizzi MC, Flegal KM, Dietz WH (2000) Establishing a standard definition for child overweight and obesity worldwide: International survey. *British Medical Journal* 320:1240-1243.

Hamill PV, Drizd TA, Johnson CL, Reed RB, Roche AF, Moore WM (1979) Physical growth: National Center for Health Statistics percentiles. *American Journal of Clinical Nutrition* 32:607-629.

Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R, Mei Z, Curtin LR, Roche AF, Johnson CL (2000): *CDC growth charts: United States. Advance Data from Vital and Health Statistics*, no 314. Hyattsville, MD: National Center for Health Statistics.

Levine MD (1983) Middle childhood. In MD Levine, WB Carey, AC Crocker, RT Gross (Eds). *Developmental Pediatrics*. Philadelphia: Saunders, pp 108-132.

Loucks AB, Vaitukaitis J, Cameron JL, Rogol AD, Skrinar G, Warren MP, Kendrick J, Limacher MC (1992) The reproductive system and exercise in women. *Medicine and Science in Sports and Exercise* 24:S288-293.

Malina RM (1994) Physical growth and biological maturation of young athletes. *Exercise and Sport Sciences Reviews* 22:389-433.

Malina RM (1996) The young athlete: Biological growth and maturation in a biocultural context. In FL Smoll, RE Smith (Eds). *Children and Youth in Sport: A Biopsychosocial Perspective*. Dubuque, IA: Brown and Benchmark, pp 161-186.

Malina RM (1998) Growth and maturation of young athletes: Is training for sport a factor. In KM Chang, L Micheli (Eds): *Sports and Children*. Hong Kong: Williams and Wilkins, pp 133-161.

Malina RM, Beunen G (1996) Monitoring of growth and maturation. In O Bar-Or (Ed): *The Child and Adolescent Athlete*. Oxford: Blackwell Science, pp 647-672.

Malina RM, Bouchard C (1991) *Growth, Maturation, and Physical Activity*. Champaign, IL: Human Kinetics.

Malina RM, Bouchard C, Bar-Or O (2004) *Growth, Maturation, and Physical Activity*, 2nd edition. Champaign, IL: Human Kinetics.

Sroufe LA, Cooper RG, DeHart GB, Marshall ME (1992) Ch*ild Development: Its Nature and Course*. New York: McGraw-Hill.

http://dx.doi.org/10.14195/978-989-26-1169-3_2

CHAPTER 2: ASSESSMENT OF BIOLOGICAL MATURATION IN ADOLESCENT ATHLETES – application of different methods with soccer and hockey players

Manuel J Coelho e Silva
Filipe Simões
João Valente dos Santos
Vasco Vaz
António J Figueiredo
Maria E. Peña Reyes
Robert M Malina

INTRODUCTION

Biological maturation is the process that marks progress toward maturity or adulthood. The process varies in tempo, i.e., rate, and timing, i.e., when certain events occur. Inter-individual differences in the tempo and timing of maturation are considerable. Differences among methods for assessing maturation are also apparent and can be considerable. Maturation of the skeleton spans the entire interval from the prenatal state to a fully ossified or mature skeletal. Sexual maturation refers to the secondary sex characteristics which become initially apparent in late childhood and progress towards the mature state during the adolescent years. As used in growth studies, somatic maturation refers to either the percentage of mature height attained at a given age or the timing of maximum growth in height during the adolescent spurt. When a youngster is observed at a single point in time, indicators of skeletal or sexual maturation provide a record of his/her maturity status. Longitudinal observations that span adolescence are needed to obtain an estimate of somatic maturation (Malina et al., 2004). Protocols for the estimation or mature or adult height have a long tradition in growth studies, but prediction equations required an estimate of skeletal age. More recently, equations for the prediction mature height that do not require an estimate of skeletal age and for the prediction of age at maximum growth in height (peak height velocity) have been developed (Roche et al., 1983; Khamis & Roche, 1994; Mirwald et al., 2002). Skeletal, sexual and somatic maturation are reasonably well-related during adolescence (Nicolson & Hanley, 1953; Bielicki et al., 1984; Bayer and Bayley, 1959; Malina et al., 2004); however, studies incorporating estimates of somatic maturation based on the more recently developed prediction protocols are not available.

The impact of individual differences in the timing of biological maturation among boys body size and functional capacities is well documented (Malina et al., 2004). Boys who are advanced in maturity status are not only taller and heavier but also tend to perform better in tasks requiring strength, power and speed compared with age peers who are average ("on time") or late in maturation. This translates to youth sports since adolescent male athletes in several sports, for example, baseball, American football, ice hockey, soccer and track and field, tend to be, on average, advanced in biological maturation compared to peers (Malina, 1994; Malina et al., 2004). As such, it is important to be able to monitor the maturity status of youth involved in sport.

Methods of assessing maturity status vary as do their application. Progress in development of methods of assessment has drawn attention to the need for systematic evaluation of the concordance among methods. In other words, do different methods provide the same indication of maturity status? The answer, in general, is yes (Malina et al., 2004).

This chapter summarizes three studies dealing with the concordance ofdifferent maturity assessments in Portuguese male adolescent athletes. The first addresses the concordance between clinical examination and self-assessment of sexual maturity status in soccer players 11-14 years of age (Coelho e Silva et al., 2005a). The second examines the concordance of classifications of maturity status based on two methods of skeletal age assessment in soccer players 13-15 years (Coelho e Silva et al., 2009). And the third examines the validity of predicted adult height without skeletal age in roller hockey players 14.8-16.5 years of age (Coelho e Silva et al., 2008).

PUBIC HAIR SELF-ASSESSMENT IN SOCCER PLAYERS

The assessment of sexual maturity in boys is based on secondary sex characteristics - genitalia and and pubic hair. The most commonly used criteria are those described by Tanner (1962). Applications to young athletes have more often used stages of pubic hair (PH) development. Stage 1 indicates the absence of pigmented PH, the prepubertal state; stage 2 the initial development of pigmented PH; stages 3 and 4 mark changes in the texture and distribution of PH and indicate early and late puberty; and stage 5 indicates the mature texture and distribution of PH. Given the difficulty in direct assessment of sexual maturation status in non-medical settings, self-assessments are increasingly used in studies requiring a maturity marker (Malina et al., 2004). This study evaluated the concordance between physician and self-assessments of PH development in youth soccer players.

Methods

The sample included 159 male soccer players 11-14 years (12.9±1.3 years). Pubic hair development was assessed by an experience observer using the criteria described by Tanner (1962). For self-evaluation, line drawings taken from photgraphs of standards published by Tanner were provided individually to each boy who was instructed to indicate on the charts the stage that most closely matched his level of sexual maturation. Identical drawings were published by Taylor et al. (2001). Stature and weight were also measured. Concordance between self-assessment and physician examination was assessed for players in two competitive age groups, 11-12 and 13-14 years, and also in the total sample. The effect of self- and clinically-assessed stage of PH on body size was then evaluated.

Results

Distribution of stages of PH by age group is given in Table 1. Concordance between self- and clinical-assessment was lower for players 11-12 years (47%) than for players 13-14 years (76%), and was 60% for the total sample. Concordance for specific stages varied by stage as follows: PH1, 23%; PH2, 90%; PH3, 80%; PH4, 59%. No players were self -assessed in PH5.

Table 1. Cross-tabulation between self- and clinical-assessments of stage of pubic hair development by age group.

	Clinical assessment	Self-assessment					-TOTAL
		1	2	3	4	5	
11-12 yr (n=87)	1	11	36				47
	2	2	25	3			30
	3		5	5			10
	4						-
	5						-
	Total	13	66	8	-	-	
13-14 yr (n=72)	1						-
	2		13				13
	3		2	23			25
	4			13	19		32
	5				2		2
	Total	-	15	36	21	-	
Total sample 11-14 yrs (n=159)	1	11	36				47
	2	2	38	3			43
	3		7	28			35
	4			13	19		32
	5				2		2
	Total	13	81	44	21	-	159

The influence of stage of puberty on body size by age group is given in Tables 2 and 3. The effect of pubertal status on stature and weight was significant using either clinical- or self-assessed status, and differences in stature and weight were relatively small in players in the two age groups. Regardless of clinical- or self-assessment, the gradient for mean stature and body mass is PH1<PH2<PH3<PH4<PH5.

Table 2. Results of ANCOVA (chronological age as covariate) of stature (cm) and weight (kg) of players 11-12 years (n=87) by stage of PH development based on clinical- and self-assessment.

	Clinical assessment				Self-assessment			
	PH1 (n=47)	PH2 (n=30)	PH3 (n=10)	F	PH1 (n=13)	PH2 (n=66)	PH3 (n=8)	F
Stature	140.9	147.5	153.7	30.795 **	140.9	144.5	152.1	8.374 **
Weight	34.5	41.6	44.2	26.049 **	35.1	37.9	44.2	5.736 **

(*) p≤.05, (**) p≤.01

Table 3. Results of ANCOVA (chronological age as covariate) of stature (cm) and weight (kg) of players 13-14 years (n=72) by stage of PH development based on clinical- and self-assessment.

	Clinical assessment					Self-assessment			
	PH2 (n=13)	PH3 (n=25)	PH4 (n=32)	PH5 (n=2)	F	PH2 (n=15)	PH3 (n=36)	PH4 (n=21)	F
Stature	153.6	162.2	168.2	169.4	13.075 **	154.8	164.4	168.3	14.696 **
Weight	43.2	52.0	59.5	61.6	11.618 **	44.7	55.0	59.0	11.334 **

(*) p≤.05, (**) p≤.01

Discussion

Results suggest that self-assessment of sexual maturity based on charts with illustrations of stage of PH development is moderately concordant with clinical assessments. Previous research performed by Taylor et al. (2001) noted 49% agreement between self and clinical assessments using the same protocol in youth 12-16 years of age. Quadratically weighted Kappa statistics for PH distributions assessed by self and by the physician was 0.67 [95% CI 0.49-0.87]. Matsudo & Matsudo (1994) also studied the concordance of self-assessment and physician evaluation of sexual maturity status (genitals and pubic hair in boys) in 178 males aged 6-26 years. The results showed that concordance between self and physician assessments range from 94% at stage PH1 to 37% at stage PH2. Percentages were 62%, 86%, 79%, respectively at stages PH3, PH4, PH5. In addition, better concordance was found for pubic hair (70% overall concordance) than for the genitals (60%) and, consequentely, the authors concluded that pubic hair determination was somewhat less subjective than evaluation of the genitals. Regarding self-assessment and physican examination

In the current study as well as that of Matsudo and Matsudo (1994), the magnitude of deviation between self- and clinical-assessments were relatively small and did not exceed one stage. On the other hand, observations of Taylor et al. (2001) on a sample of children attending a paediatric endocrinology outpatient clinic noted a difference of two or more stages between self- and physician-assessment in 12% of children. Leone & Comtois (2007) after assessing 24 male elite athletes aged 12 to 17 years, estimated a kappa coefficient of 0.79.

Observations in the youth soccer players were generally consistent with previously reported results (Schlossberger et al., 1992; Bonat et al., 2002) showing that boys tended to overestimate PH stage at earlier stages of development. Nevertheless, it is possible that self perception of sexual maturity status may be influenced by a tendency to view one's self as average, i.e., in the mid-range of the distribution, rather than at either extreme of the scale. In addition, physician assessment is not free of error, although this is not ordinarily reported. In the study of Matsudo & Matsudo (1994), reproducibility of two physician examinations (performed 3 days apart) was 0.89 using spearman rank-order correlation.

Given the relative simplicity and respect for individual privacy, self-assessment is an informative alternative to traditional clinical examination of pubertal status. Nevertheless, self-assessment should be applied in a private in contrast to a group setting. This functions to eliminate comparisons among youth and also to reduce potential embarrassment.

FELS AND TW3 SKELETAL AGES IN ADOLESCENT SOCCER PLAYERS

Three methods for assessming skeletal maturation are commonly used, the Greulich-Pyle (GP), Tanner-Whitehouse (TW) and Fels methods (see Malina et al., 2004; Beunen et al., 2006). The methods differ in the samples upon which they were based and in criteria. The GP method involves matching specific bones to sex-specific standard plates representing different skeletal ages. The TW and Fels methods use specific verbal criteria for individual bones, though the two methods differ in bones used and in statistical basis for assigning skeletal ages. The Fels method also uses ratios of linear measurements of metaphyseal and epiphyseal widths. All three methods result in the assignment of a skeletal age (SA); however, the SAs are not equivalent. Two issues of relevance deal with variation in SAs within specific chronological age (CA) groups and in classification of youth as early, average (on time) or late in skeletal maturity status. These issues are considered in a sample of adolescent soccer players using SAs based on the Fels method and the most recent version of the TW method (TW3).

Methods

The sample included 72 soccer players 13.3-15.3 years. CA was calculated the difference between date of examination and date of birth as recorded on official birth certificates. Posterior-anterior hand-wrist radiographs of the left hand were taken on all players following a standard protocol. SA was assessed with the Fels (Roche *et al*., 1988) and the most recent edition of the Tanner-Whitehouse (TW3, Tanner *et al*., 2001) methods. Players were also classified as late, average (on time) or early on the basis of the difference between SA and CA: Late - SA behind CA by more than 1.0 year; Average (on time) – SA within plus/minus 1.0 year of CA; Early – SA in advance of CA by more than 1.0 year. In addition to descriptive statistics, concordance between maturity groups based on the two methods was tested with the Kappa statistic.

Results

Although CAs ranged from 13.3 to 15.3 years, SAs ranged from 12.0-17.7 years with the Fels method and from 11.5-16.4 years with the TW3 method. Variation in SA was almost three times the variation in CA. Mean FELS SA was also greater than mean TW3 SA and the mean SA-CA difference with the FELS method was greater than mean difference with the TW3 method.

Skeletal age with each method of assessment is plotted relative to CA for individual athletes in Figures 1 and 2. Note that the maximum SA with the TW3 method is 16.4 years which is substantially less than the maximum value determined based on the FELS method.

Table 4. Chronological and skeletal ages (years) in adolescent male soccer players.

Method of Assessment	Variable	Minimum	Maximum	Mean	Standard deviation
	Chronological age	13.3	15.3	14.1	0.6
Fels method	Skeletal age	12.01	17.67	14.65	1.16
	SA – CA	-1.76	2.82	0.51	1.07
TW3 method	Skeletal age	11.05	16.42	14.34	1.31
	SA – CA	-2.65	2.39	0.20	1.19

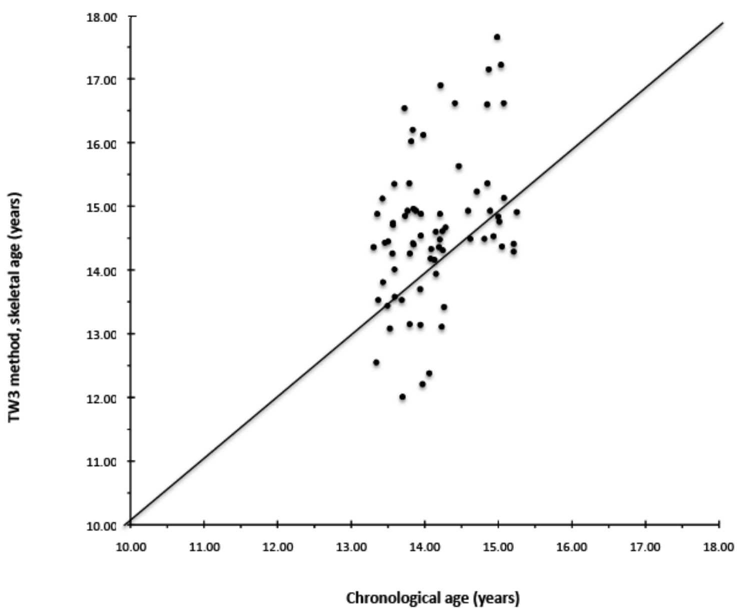


Figure 1. TW3 skeletal ages (SA) of individual soccer players plotted relative to their chronological ages (CA). The diagonal line is the line of identity (SA=CA).

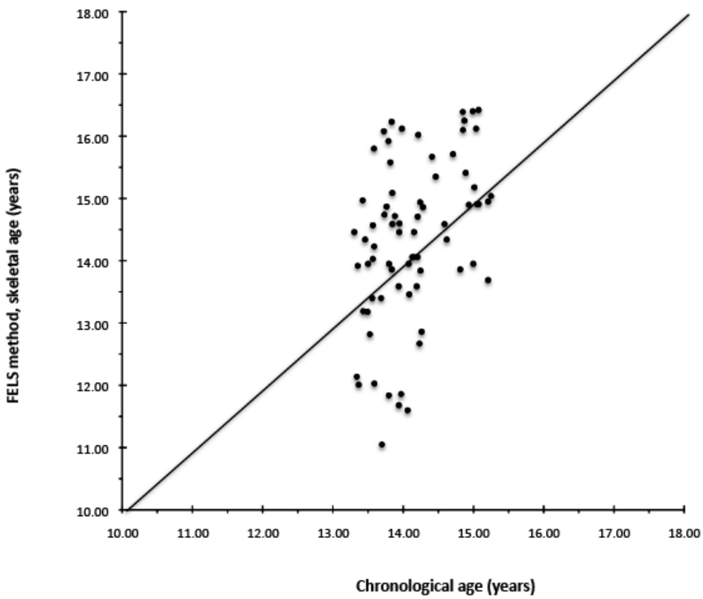


Figure 2. Fels skeletal ages (SA) of individual soccer players plotted relative to their chronological ages (CA). The diagonal line is the line of identity (SA=CA).

Classification of players by maturity status also varied with method of SA assessment: With the TW3 method, the distribution of players by maturity status was as follows: Late, 17%, On time, 57%, Early, 26%. The corresponding distribution with the FELS method was as follows: Late, 5%, On time, 63%, Early, 32%. Concordance between maturity classifications was 81% (Kappa=0.65±0.08, $p<0.001$). Figure 3 shows FELS SAs plotted relative to TW3 SAs and Figure 4 shows individual age disparities between methods versus average skeletal age of both assessments.

Table 5. Cross-tabulation between skeletal maturity status based on the Fels and TW3 methods of assessment.

		TW3			
		Late	Average	Early	Total
FELS	Late	4	-	-	4
	Average	8	36	1	45
	Early	-	5	18	23
	Total	12	41	19	72

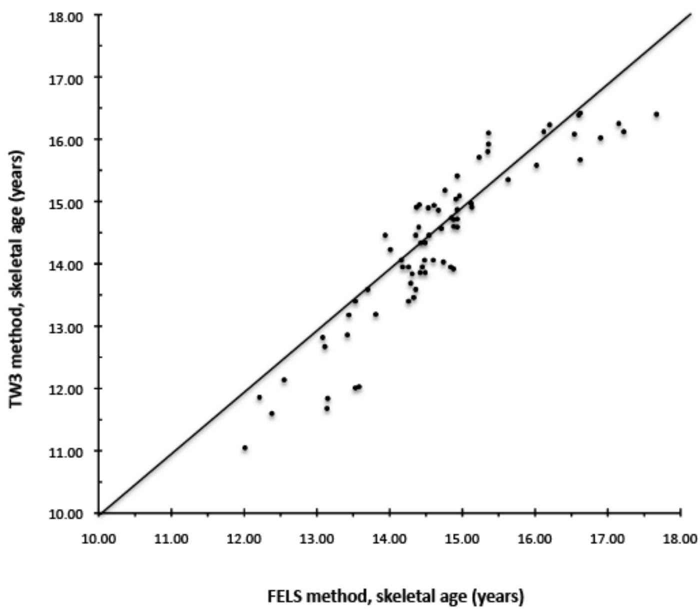


Figure 3. TW3 SAs of individual soccer players plotted relative to their Fels SAs.

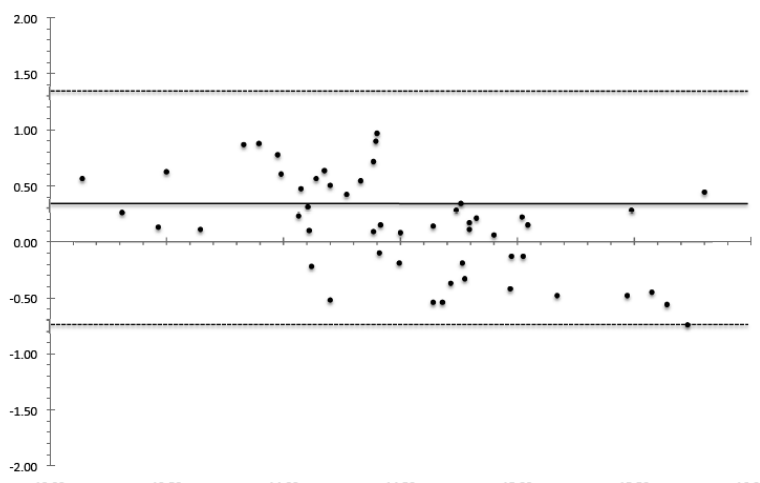


Figure 4. Bland-Altman plot of the age disparity between FELS and TW3 SAs (Y-axis) and mean age based on the two SAs (X-axis). The solid line represents the mean difference and the dashed lines correspond the upper and lower limits of agreement (1.96 standard deviations).

Discussion

Results of the analysis are generally consistent with other studies of youth soccer players using the TW and Fels methods (Malina, 2003). Earlier studies, however, used the TW2 version of the method which differs from the TW3 revision. The distributions of players by maturity status were reasonably consistent with the Fels and TW3 methods, although more players were classified as late and fewer as average or early with the TW3 method; conversely, fewer players were classified as late and more soccer players were classified as on time and early maturers with the FELS method. This observation is consistent with another study of elite Spanish adolescent soccer players 12.5-16.1 years (Malina et al., 2007a).

Differences between SAs obtained by FELS and TW3 methods relates to several factors. The FELS method was developed from a middle class white sample from south-central Ohio in the United States, while TW3 was initially developed on British youth. However, the reference values for the TW3 revision ware derived from samples in four European countries, Argentina, the United States (Texas) and Japan.

The methods also differ in bones of the hand and wrist that are used and in criteria for assessing the level of maturity of each bone. The TW modification provides for radius–ulna–short bone (RUS) and carpal SAs; the 20-bone SA is no longer included. The FELS method utilizes both the long bones of the first, third and fifth digits as well as the carpals in addition to ratios of linear measurements metaphyseal and epiphyseal widths of the long bones. One major difference occurs in the later stage of skeletal maturity which is heavily influenced by the radius. In the TW method, the final stage of the distal radial epiphysis is simply "Fusion of the epiphysis and metaphysis has begun" (Tanner et al. 2001, p. 63). In the Fels method, capping and fusion of the distal radial epiphysis has four grades for the medial and lateral thirds and three grades for the central third. In addition to differences in criteria for the skeletal maturity in specific indicators, the methods also differ in stastistical weights used to derive SAs. Finally, the third edition of the TW method (TW3) reduced the age of attaining skeletal maturity from 18.0 to 16.5 years in boys, whereas skeletal maturity with the Fels method is at 18.0 years.

PREDICTING MATURE HEIGHT WITHOUT SKELETAL AGE IN MALE ADOLESCENT HOCKEY PLAYERS

Percentage of predicted mature height is a potentially useful indicator of maturity status, especially if mature height can be predicted without an estimate of skeletal age. Khamis & Roche (1994) developed equations for the prediction of mature height (height at 18 years) for the sample of the Fels Longitudinal Study based on American children living in south-central Ohio. The protocol has been used successfully as an estimate of maturity status with youth American football players 9-14 years of age (Malina et al., 2005, 2007b). There is a need to compare predicted mature heights with actual mature heights, especially in an independent sample of youth. The present report compared the predicted mature height at an adolescent age with attained mature height.

Methods

The sample included 80 youth roller hockey players 14.8-16.5 years who were studied in 2002. Height and weight were measured using a portable stadiometer (*Harpenden*) and a portable balance (*Seca model* 770) to the nearest 0.1 cm and 0.1 kg, respectively. Mature height was predicted after Khamis & Roche (1994) using age, height and weight of the player and midparent height. Heights of both biological parents were measured. Current height of the player was expressed as a percentage of predicted mature height. Heights of the players were measured again at the same time of the year (September-October) in 2006 providing a measure of attained mature height. Heights of the players at the first observation were then expressed as a percentage of attained mature height.

Results

The difference between predicted and attained mature height was 0.95±1.96 cm (median: 1.20 cm, range -3.7 to +4.0 cm). The difference was, on average, less in 15-year-old (0.30±1.98 cm) than in 16-year-old (1.34±1.85 cm) players. Teenage height was 171.2±6.3 cm [G15 (15 yrs): 168.5±5.9 cm; G16 (16 yrs): 172.8±6.0 cm] compared to attained mature height, 175.6±5.2 cm [G15: 174.4±5.1 cm; G16: 176.4±5.2 cm]. Teenage height represented 98.0±1.6% of predicted mature height [G15: 96.8±1.5%; G16: 98.7±1.2%] and 97.4±1.4% of attained mature height [G15: 96.6±1.5%; G6: 97.9±1.1%]. The correlation between measured and predicted adult height was r=+0.93 [G15: +0.92; G16: +0.94].

Table 6. Means, standard deviations and ranges (minimum-maximum) for chronological age, predicted and attained mature height, and adolescent height as a percentage of predicted mature height in hockey players.

	15 yrs (n=30)	16 yrs (n=50)	Total (n=80)
Chronological age, years	15.2 ± 0.2 (14.8-15.4)	16.2 ± 0.4 (15.5-16.4)	15.8 ± 0.6 (14.8-16.4)
Adolescent Stature, cm	168.5 ± 5.9	172.8 ± 6.0	171.2 ± 6.3
Stature as % predicted mature height	96.8 ± 1.5	98.7 ± 1.2	98.0 ± 1.6
Stature as % measured mature height	96.6 ± 1.5	97.9 ± 1.1	97.4 ± 1.4
Predicted mature height,cm	174.1 ± 4.7	175.1 ± 4.0	174.7 ± 4.9
Measured mature height, cm	174.4 ± 5.1	176.4 ± 5.2	175.6 ± 5.2
Difference	0.3 ± 1.9	1.3 ± 1.9	1.0 ± 1.9

Discussion

The current analysis provides evidence that the method of Khamis & Roche (1994) for predicting mature height without an estimate of skeletal age has reasonable validity in a different population and can be used to derive percentage of mature height as a non-invasive method to assess maturation. Figures 5 and 6 show Bland-Altman plots of the differences between measured and predicted mature heights versus average mature height derived from predicted and measured mature heights in 15 and 16 year old hockey players, respectively. The solid line represents the mean difference and the dashed lines correspond the upper and lower limits of agreement (1.96 standard deviations).

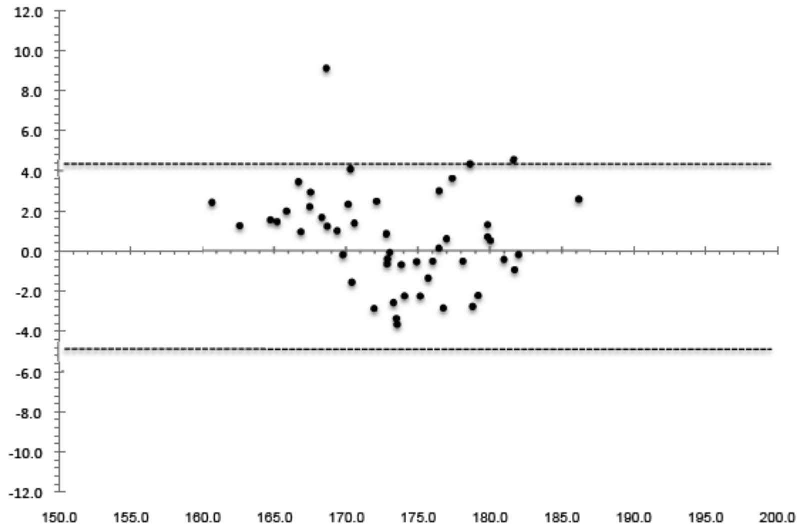


Figure 4. Bland-Altman plot of the differences between predicted and measured mature height relative to the mean based on the two protocols for 15 year old hockey players.

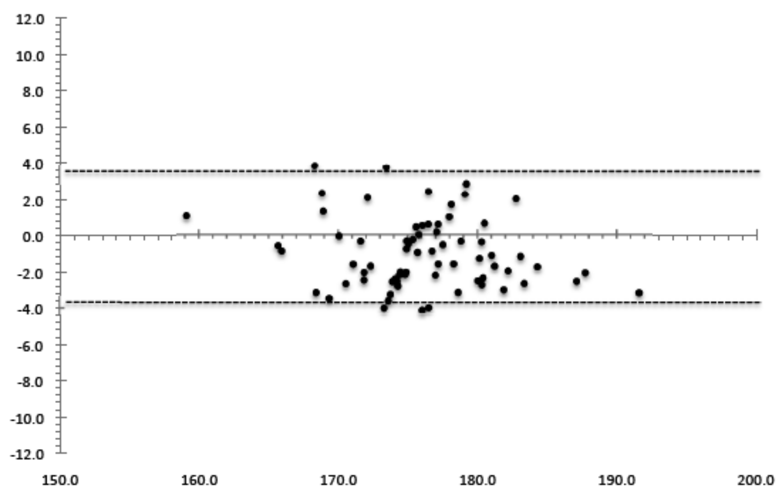


Figure 5. Bland-Altman plot of the differences between predicted and measured mature height relative to the mean based on the two protocols for 16-year-old hockey players.

Given the older adolescent age range of the sample of hockey players, their status study as late, average or early maturing based on percentage of predicted mature height attained at the time of the study was not classified. In a study of youth American football players 9-14 years of age, the concordance between classification as late, average or early maturing on the basis of Fels SAs and percentage of predicted mature height attained at the time of the study was moderate (Malina et al., 2007b). Of interest, players discordant for maturity status by the two methods differed in midparent height and percentage of predicted mature height, but did not differ in predicted mature height.

Beunen et al. (1997) proposed another method to predict adult stature (Beunen-Malina method) using five predictors (chronological age, stature, sitting height, subscapular skinfold and triceps skinfold) in adolescent boys 13-16 years of age. The method does not require midparent stature which may be difficult to obtain. The use of predictor variables take into consideration the differential timing of the adolescent spurt in body segments and changes in subcutaneous fat that occur during adolescence. The Beunen-Malina method for predicting mature stature was recently validated on longitudinal data from the Madeira Growth Study (Beunen et al., 2007). Correlations between measured and predicted mature height for each cohort (13, 14, 15, 16 years) ranged between 0.66 and 0.83. Average measurement of errors varied from -1.0 cm and +2.5 cm, and the residual standard deviation (measurement error) was between 3.5 and 5.0 cm.

Other methods for predicting mature height use SA as one of the predictors. The method complementary to that of Khamis & Roche (1994) for the Fels longitudinal sample is that of Khamis & Guo (1993) which included Fels SA among the predictors of mature height. When both methods, i.e., without and with SA among the predictors, were applied to 87 soccer players 11-12 years, predicted mature height did not differ substantially in the total sample (Coelho e Silva et al., 2005b). When applied to players at the extremes of height, i.e., the 8 shortest and 8 tallest players in the sample, predicted mature heights with and without SA also did not differ. However, when applied to players at the extremes of skeletal maturity, i.e., 8 least and 8 most skeletally mature players in the 11-12 year old sample, predicted mature height without SA in the equation was significantly shorter in the least mature players and taller in the most mature players compared to height predicted with SA in the equation (Figueiredo et al., under review). Hence, across a spectrum of size and maturity status, predicting mature height with or without SA among the predictors gives similar means; however, at the extremes of maturity status, the protocols differ, which may have implications for studies using percentage predicted mature height.

INTEGRATION OF RESULTS OF THE THREE STUDIES

At the beginning of this chapter, the following question was raised: do different methods of assessing biological maturation during childhood and adolescence provide a similar indication of maturity status? The answer, in general, is yes. This was especially apparent in a longitudinal sample of 177 Polish boys followed from late childhood through adolescence. Ages at attaining 18 indicators of maturity status (ages at attaining peak velocity of growth in height, trunk height, leg length and weight; 80%. 90%, 95% and 99% of mature height; stages 2 and 4 of pubic hair and genital development; skeletal maturity (TW2) scores for 11 through 15 years of age; and take off (initiation) of the growth spurt in height were submitted to a principal components analysis. The results indicated two components; the first was a general maturity factor which accounted for 77% of the variance, while the second, which accounted for 12% of the variance, suggested a factor related to skeletal maturation during pre- or early-adolescence (Bielicki et al., 1984).

The ages of the young soccer and roller hockey players in the three studies span early through late adolescence. The first study confirmed a tendency of soccer players 11-14 years of age to overestimate early stages and to underestimate later stages of pubic hair. Although there was some variation between competitive age groups (11-12 and 13-14 years), self-assessment tended to be a valid indicator to evaluate differences in body size among boys of contrasting maturity status. The gradient in body size by stage of pubic hair was PH3>PH2>PH1 and was the same using clinical- or self-assessment.

The second study showed that SAs based on the Fels and TW3 methods were not equivalent in adolescent soccer players. The results reflected in part real inter-individual differences as well as methodological differences. Although variation in skeletal maturity status within a two year competitive age group was considerable, there was reasonable concordance between classifications of players as late, on time and early in maturity status based on the two methods of assessment.

The study of late adolescent hockey players indicated that the Khamis & Roche (1994) protocol for the prediction of mature (adult) height without an estimate of SA had reasonable validity. As such it merits further study as a non-invasive estimate of biological maturity status in adolescent athletes.

REFERENCES

Bayer LM, Bayley N (1959). Growth diagnosis – seleting methods for interpreting and predicting development of one year to maturity. Chicago: University of Chicago Press.

Beunen GP, Malina RM, Lefevre J, Claessens AL, Renson R, and Simons J (1997). Prediction of adult stature and noninvasive assessment of biological maturation. *Medicine and Science in Sports and Exercise, 29:*225-230.

Beunen GP, Rogol AD, Malina RM (2006). Indicators of biological maturation and secular changes in biological maturation. *Food and Nutrition Bulletin,* 27 (supplement):S244-S256.

Beunen GP, Malina RM, Freitas DL, Maia JA, Claessens AL, Almeida SM, Gouveia ER, Thomis MA, Marques AT, Lefevre J (2007). Validation of the Beunen-Malina method for the prediction of adult heoght. *Acta Kinesiologicae Universitatis Tartuensis,*12 (supplement):51-52.

Bielicki T, Koniarek J, Malina RM (1984). Interrelationships among certain measures of growth and maturation rate in boys during adolescence. *Annals of Human Biology* 11:201–210.

Bonat et al., 2002

Coelho e Silva M, Figueiredo A, Morales J, Roxo A, Malina RM (2005a). Validity of pubic hair self-assessment as an indicator of sexual maturation among pubertal athletes. In *Book of Abstracts of the 2005 World Congress of AIESEP - Active Lifestyles: the impact of education and sport*, p. 241.

Coelho e Silva M, Nunes V, Figueiredo A, Malina RM (2005b). Effect of sexual maturity status on current and mature stature estimated with and without skeletal age as a predictor. In N Dikic, S Zivanic, S Ostojic, Z Tornjanski (Eds), *Book of abstracs of the 10th Annual Congress of the European College of Sport Science*, p 59.

Coelho e Silva M, Moreira de Carvalho H, Vaz V, Romeiro J, Figueiredo A, Malina R (2008). Cross-validation of the Khamis-Roche method for the prediction of mature height. In J Cabri, F Alves, D Araújo, J Barreiros, J Diniz, A Veloso (Eds). *Book of abstracts of 13th Annual Congress of the European College of Sport Science*, p. 233 [ISBN 978-972-735-156-5].

Coelho e Silva MJ, Figueiredo AJ, JPena Reyes ME, Malina RM (2009). Skeletal age with FELS and TW3 methods in the assessment of biological maturation among adolescent soccer players. *Medicine and Science in Sports and Exercise*, 41(supplement):S328

Figueiredo AJ, Coelho e Silva MJ, Cumming, SP, Malina RM (under review). Size and maturity mismatches in youth soccer players 11-14 years.

Khamis HJ, Guo S (1993). Improvement in the Roche-Wainer-Thissen stature prediction model: a comparative study. *American Journal of Human*

Biology, 5:669-679

Khamis HJ, Roche AF (1994). Predicting adult stature without using skeletal age: the Khamis-Roche method. *Pediatrics*, 94:504-507; *erratum*, 95:457.

Leone M, Comtois AS (2007). Validity and reliability of self-assessment of sexual maturity in elite adolescent athletes. *Journal of Sports Medicine and Physical Fitness*, 47:361-365.

Malina RM (1994). Physical growth and biological maturation of young athletes. *Exercise and Sports Sciences Reviews,* 22:389-433.

Malina RM, Bouchard C, Bar-Or O (2004). Growth maturation and physical activity, 2nd edition. Champaign, IL : Human Kinetics.

Malina RM, Cumming SP, Morano PJ, Barron M, Miller SJ (2005). Maturity status of youth football players : a noninvasive method. *Medicine and Science in Sports and Exercise*, 37 :1044-1052.

Malina RM, Chamorro M, Serratosa L, Morate F (2007a). TW3 and Fels skeletal ages in elite youth soccer players. *Annals of Human Biology*, 34 :265-272.

Malina RM, Dompier TP, Powell JW, Barron MJ, Moore MT (2007b). Validation of a noninvasive maturity estimate relative to skeletal age in youth football players. *Clinical Journal of Sports Medicine*, 17 :362-368.

Matsudo SM, Matsudo VK (1994). Self-assessment and physician assessment of sexual maturation in Brazilian boys and girls: concordance and reproducibility. *American Journal of Human Biology*, 6:451-455.

Mirwald RL, Baxter-Jones ADG, Bailey DA, Beunen GP (2002). An assessment of maturity from anthropometric measurements. *Medicine and Science in Sports and Exercise*, 34:689-694.

Nicolson AB, Hanley C (1953). Indices of physiological maturity: derivation and interrelationships. *Child Development*, 24:3-38.

Roche AF, Tyleshevski F, Rogers E (1983). Non-invasive measurements of physical maturity in children. *Research Quarterly for Exercise and Sport*, 54:364-371.

Roche A, Chumlea W, Thissen D (1988). Assessing the skeletal maturity of the hand wrist – FELS method. Springfield, IL: CC Thomas.

Sclosserberger NM, Turner RA, Irwin CE Jr (1992). Validity of self-report pubertal maturation in early adolescents. *Journal of Adolescent Health*. 13:109-113

Tanner JM (1962). Growth at adolescence, 2nd edition. Oxford: Blackwell.

Tanner JM, Whitehouse RH, Cameron N, Marshall WA, Healy MJR, Goldstein H (1983). Assessment of skeletal maturity and prediction of adult height, 2nd edition. New York: Academic Press.

Tanner JM, Healy MJR, Goldstein H, Cameron N (2001). *Assessment of skeletal maturity and prediction of adult height (TW3 method)*, 3rd edition. London: Saunders.

Taylor SJC, Whicup PH, Hindmarsh PC, Lampe F, Odoki K, Cook DG (2001). Performance of a new pubertal self-assessment questionnaire - a preliminary study. *Paediatric and Perinatal Epidemiology*, 15: 88-94.

Partially supported by *Fundação para a Ciência e a Tecnologia*

http://dx.doi.org/10.14195/978-989-26-1169-3_3

CHAPTER 3: MATURATION AND STRENGTH OF ADOLESCENT SOCCER PLAYERS

Isabel Fragoso
Filomena Vieira
Luísa Canto e Castro
Astrogildo Oliveira Junior

INTRODUCTION

Sport training during growth depends on the morphological characteristics and stage of maturation. In boys the association between biological maturation and various anthropometric characteristics is most striking up to about 16 years of age. Motor skill and physical fitness tend to be optimized during adolescence, especially strength and power, which depend in part on fat-free mass (FFM). The onset and termination of adolescence, however, vary considerably among boys, and this may confound the relationship between maturity status and motor performance.

Biologically more mature boys often achieve better performance results and are commonly included among young athletes in baseball, football, soccer, swimming, tennis, and ice hockey (Beunen *et al*., 1997). However, performance differences among boys of contrasting maturity status within specific age groups are somewhat reduced. This may be related to three factors: the nature of the biological maturation variables and errors of assessment; the specificity of tests used to evaluate motor performance, which may be related to sport modality and may be influenced by training and learning; and the use of mean comparisons which limits appreciation of variability among individuals.

This study evaluates different methods of maturity assessment in young soccer players in an attempt to identify the best combination of indicators that can differentiate among individuals of contrasting maturity status during adolescence. It also considers the association between morphological and maturational characteristics, and muscular strength to estimate variation associated with maturity status.

METHODS

The sample included 71 boys, 13 to 16 years of age, who attended one of Portuguese top soccer clubs located in the Lisbon metropolitan area. Time spent in sport-specific training was, on average, 8 hours/week, which is less than one-half of the amount of time spent on training in elite sport schools in other countries, about 18-30h/week plus a specific number of days at sport camps (Malina *et al*., 1997).

Anthropometric dimensions were obtained following the protocol in Fragoso and Vieira (2000). The dimensions included measures of overall body size (weight and height, the body mass index [BMI] was calculated), segment lengths (sitting height, arm length, leg length), skeletal breadths (biacromial, biiliocristal, biepicondylar humerus and femur, stylion ulna), skinfolds (biceps, triceps, subscapular, iliac crest, abdominal, thoracic, axillary, thigh, medial calf), and girths (relaxed and tensed [flexed] arm, forearm, thigh, calf). Strength was measured with three tests, the contra movement jump, maximal leg strength and handgrip strength. Handgrip strength was used as the primary strength variable for detailed analysis.

Measures of maturity status included skeletal age and stages of sexual development. Skeletal age of left hand and wrist was assessed by an experienced rater blinded to the chronological age (CA) of the subjects. Thirteen bones were rated with the Tanner-Whitehouse III Method (TW3). The TW is the method of choice in most growth studies (Gilli, 1996). Sexual maturity status was self-evaluated on the basis of five stages of pubic hair [P1-P5] and genital [G1-G5] development) using the criteria of Tanner (1962). Age of voice was obtained prospectively according to the proposed criteria of Cameron (personal communication). Permission from parents and from the boys (self assent) were obtained before data collection.

Descriptive statistics were calculated for the total sample and single year age groups. The data was examined for collinearity and nonparametric correlations between indicators of maturity were done. Principal component analysis of the three indicators of sexual maturity was used to derive a maturation index based on the factor score. The subjects were then divided into three sexual maturity categories (SMC): initial stages (IS), median stages (MS), and last stages (LS) of sexual maturation. IS and LS had factor scores that were, respectively, less or more than 0.5 standard deviations from the mean.

A multiple nonparametric comparison test (Kruskal-Wallis) involving rank orders and an ANOVA and SCHEFFE techniques were used to test differences in handgrip strength among the three maturity groups. A linear model was developed for handgrip strength and maturity category to examine the influence of morphological and maturity variables on strength. The probabilities of F for entrance and removal of the variables were of 0.05 and 0.10 for all variables. The analyses were carried out with SPSS 11.5 software for Windows.

RESULTS

Table 1. Means and standard deviations handgrip strength, chronological age and skeletal age.

	Mean	SD	Max	Min
Handgrip (kg)	43.3	10.5	66.0	24.0
Bone age (yrs)	14.9	1.80	16.5	10.0
Chronological age (yrs)	14.7	1.10	16.9	13.1
Bone age-Chronological age (years)	0.12	1.28	2.87	-3.40

Descriptive statistics for handgrip strength, chronological age (CA) and skeletal age (SA) are summarized in Table 1. Corresponding statistics for CA, SA, strength and anthropometric variables are summarized by single year age categories from 13 to 16 in Table 2. Most of the subjects studied presented a slightly advanced biological age (SA) compared to CA.

The variables presented in Table 2 were used in the regression and were selected after the intercorrelations and dimensionality of anthropometric, SA and sexual maturity were analysed. Mean SA is very similar to CA in 13 and 14 year old boys, and then is in advance of CA among 15 year old boys until 15 years. Among 16 year old boys, SA and CA are about equal as boys approached skeletal maturity or were already skeletally mature. As expected, height increases between age groups from 13 to 15 years, and then is about identical in 15 and 16 year old boys. Upper leg length and stylion-ulnar, biepicondylar femur and maleolar breadths do not differ significantly between 13 and 16 years. The same is true for the thigh, calf and axillary skinfold thicknesses. In general, trunk breadths, especially biacromial breadth, and arm and thigh girth increase with age.

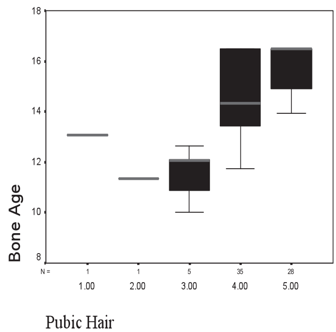
Table 3 summarizes the distribution of stages of sexual maturity in the total sample of boys. There is variation among maturity indicators, but the majority of boys are in stages comprised between 3 and 5. Box plots (Figure 1) show the relationship between bone age and the three indicators of sexual maturity. Almost the entire sample has subjects within level four and five for pubic hair, in level three for voice stage, which means that these subjects have voice alterations for less than two years, and is between level three and four of genital development. At level three of voice and genital stage bone age vary between 10 to 16 years although quite symmetrically on both directions of the mean when speaking about voice stage. The variability of bone age considering the different stages of development of pubic hair is smaller than the one observed for the previous described sexual characteristics.

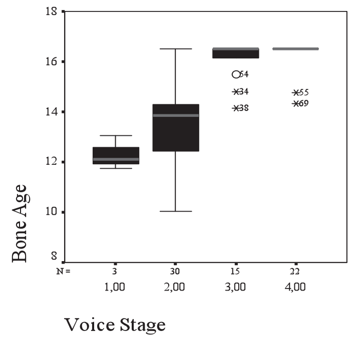
Table 2. Means and standard deviations of all variables by single year age groups.

	13 yrs (n=27)		14 yrs (n=17)		15 yrs (n=13)		16 yrs (n=14)	
Chronological Age	13.6	0.2	14.6	0.2	15.5	0.3	16.5	0.3
Bone Age (years)	13.4	1.5	14.9	1.5	16.2	0.7	16.5	0.0
BA-CA	- 0.23	1.54	0.34	1.47	0.74	0.89	0.01	0.29
Stature (cm)	162.2	8.5	168.6	10.7	175.2	6.1	174.7	5.4
Weight (kg)	53.4	9.7	59.1	10.7	67.3	4.7	72.1	6.0
Sitting height (cm)	84.2	4.7	88.0	6.0	91.3	2.8	92.2	3.1
Body Mass Index (kg/m^2)	20.1	1.9	20.6	1.6	21.9	1.0	23.6	1.7
Upper Arm Length (cm)	33.5	1.9	34.0	2.6	35.7	2.0	39.1	11.4
Upper Leg Length (cm)	41.6	2.3	45.2	12.8	44.3	2.8	44.3	2.6
Thoracic Length (cm)	17.1	1.6	19.2	1.8	20.4	1.6	19.1	1.9
Biepic. Humer. Breadth (cm)	6.4	0.5	6.5	0.5	6.9	0.4	6.9	0.5
Stylion-ulnar Breadth (cm)	5.3	0.6	5.4	0.6	5.5	0.4	5.6	0.2
Biepic. Femur Breadth (cm)	9.3	0.9	9.0	0.5	9.6	0.6	9.3	0.4
Malleolar Breadth (cm)	10.0	14.4	7.4	0.4	8.3	2.7	7.7	0.4
Biacromial Breadth (cm)	34.9	2.5	36.0	2.6	37.8	1.6	39.0	1.6
Torax Transv. Breadth (cm)	24.8	1.9	25.3	1.8	26.1	1.3	28.5	2.2
Torax Sagital Breadth (cm)	16.6	1.7	15.7	2.0	16.7	1.0	19.2	1.6
Biiliocristal Breadth(cm)	23.8	1.8	24.7	2.4	25.4	2.3	26.9	1.6
Tensed Arm Girth (cm)	25.4	2.4	27.2	2.3	29.7	1.7	31.1	1.6
Thigh Girth (cm)	46.5	3.5	47.4	4.0	50.8	2.4	54.4	2.1
Calf Girth (cm)	33.7	3.0	35.8	2.4	37.1	1.3	37.9	1.1
Thoracic Girth (cm)	74.3	5.7	78.3	5.2	82.3	1.4	86.3	3.9
Abdominal Girth (cm)	70.7	4.8	74.5	5.4	78.5	3.0	79.7	5.0
Biceps Skinfold (mm)	4.1	0.9	4.4	1.3	4.5	1.5	5.3	1.2
Triceps Skinfold (mm)	8.1	2.4	8.9	3.3	8.7	2.0	11.0	3.7
Thigh Skinfold (mm)	11.5	3.3	11.8	4.0	10.8	3.0	12.4	2.3
Calf Skinfold (mm)	8.0	2.3	8.8	3.1	7.7	2.5	9.1	3.5
Subscapular Skinfold (mm)	6.5	1.3	7.3	2.0	8.0	1.1	9.6	2.4
Axilar Skinfold (mm)	5.4	1.2	5.3	1.1	5.5	1.0	6.3	2.5
Abdominal Skinfold (mm)	8.4	2.6	9.0	4.1	10.5	3.2	13.0	5.4
Handgrip (kg)	33.9	6.4	45.3	9.1	50.5	5.0	52.6	7.3

Table 3. Total number of boys in each level of genitalia, pubic hair and voice development.

	Stage				
Indicator	1	2	3	4	5
Pubic hair	1	1	5	36	28
Genital	0	20	33	13	5
Voice	0	3	30	16	22





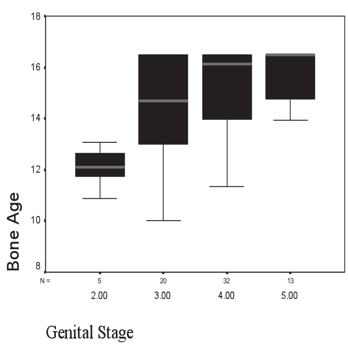


Figure 1. Box-Plots for bone age by stage of by sexual maturity

Stages of sexual maturity are associated with considerable variation in skeletal maturity. This suggests that skeletal and sexual maturation are not necessarily synchronous, although SA and stage of sexual maturity are scored on mathematically different scales and the number of pre- and early-pubertal boys in the sample is quite small. Nonparametric correlations between SA and stage of sexual maturity are significant: voice, r=0.82; pubic hair, r=0.50; and genitalia, r=0.31.

The principal components analysis of the three indicators of sexual maturity yielded one component with an eigen value >1.0. It accounted for

67% of the variance (Table 4). Although results were very similar for the three indicators, pubic hair was most highly related with the first principal component (Table 5). The unstandardized 'sexual maturity index' (SMI) for this sample of 13-16 year old boys was: SMI = 0.405 x VS + 0.561 x PH + 0.480 x GSA.

Table 4. Initial eigenvalues and total variance explained by sexual maturational variables (pubic hair, genitalia development and voice alteration).

Component	Eigen Value	% of Variance	Cumulative %
1	2.00	66.9	66.9
2	0.59	19.6	86.5
3	0.40	13.5	100

Table 5. Correlations with the first component.

	Component 1
Voice Stage (VS)	0.785
Pubic Hair (PH)	0.863
Genital Stage (GS)	0.803

Table 6 shows the correlations between handgrip strength, bone age, each indicator of sexual maturity and the sexual maturity index (SMI). Handgrip strength is related with bone age, voice stage and SMI. As expected, the three indicators of sexual maturity and the SMI are highly intercorrelated

Table 6. Matrix of correlations of different sexual maturation variables.

	HG	BA	VS	PH	GS	SMI
Handgrip	-	0.75	0.73	0.38	0.24	0.53
Bone Age		-	0.83	0.50	0.31	0.66
Voice Stage			-	0.46	0.35	0.73
Pubic Hair				-	0.55	0.84
Genital Stage					-	0.79
SMI						-

All coefficients are significant, $p \leq 0.05$.

To study the association of handgrip and maturity, the sample was divided into three maturity categories as described in the methods (Table 7). More mature subjects are significantly stronger than less mature boys between 13-16 years. Post hoc multiple comparisons indicate that there are significant differences between the IS and LS, and between IS and MS, but no difference between MS and LS (Table 8).

To further evaluate the association of handgrip strength and maturity, several highly correlated variables were considered in an attempt to reduce the dimensionality. The correlation matrix and the corresponding proximity tree showed that bone age in boys is strongly correlated with limb girths. Linear dimensions also had high intercorrelations, so one or two variables were chosen as representative. According to the correlation matrix and dendrogram, almost all girth variables were not included in the statistical treatment. The stepwise method was used to adjust the linear regression model for handgrip strength. The variables chosen for each maturity group were obtained assuming that all the covariates could enter in the full model.

Table 7. Kruskal Wallis test for differences in handgrip strength among sexual maturity groups

HG	Stage	N	Mean Rank
	Initial	15	14.3 kg
	Median	29	38.0 kg
	Last	27	45.9 kg
HG	Chi-Square	Df	p value
	23,087	2	0.000

Table 8. Multiple comparison of handgrip strength among the three sexual maturity groups (nonparametric tests).

Group		Mean Difference	Standard Error	Significance
Initial	Last	-31.57 kg*	5.51	.00
	Median	-23.73 kg*	5.44	.00
Last	Median	7.83 kg	4.57	.24

* p< 0.05 level.

Results of the regressions are summarized in Table 9. Bone age appears in the regression only for the total sample. This suggests a role fo variation in biological maturity in handgrip strength across the age range 13-16 years. Within the specific maturity categories, CA appears a predictor in the MS and LS groups, but not in the IS. This may reflect the limited age range of the sample of boys in the early stage of sexual maturation. It is of interest that skeletal dimensions appear among the significant predictors of strength in the least mature group (IS). Finally the robustness of arm bones also influences the handgrip result.

Table 9. Four adjusted linear regression models for "handgrip strength" for the all sample and for each maturational group level.

	Total Sample	IS	MS	LS
Boys	Coef.	Coef.	Coef.	Coef.
(Constant)	-67.159	-27.040	-50.722	-27.358
Bone Age	2.064			
Chronological Age	4.025		6.370	4.355
Upper Leg Length		-1.405		
Biacromial Breadth		1.042		
Stylion-ulnar Breadth	3.765			
Malleolar Breadth		11.382		1.306
R Square	0.66	0.85	0.44	0.57
Adjusted R Square	0.64	0.81	0.41	0. 53
Standard error	6.31	2.18	8.42	5.01

DISCUSSION

This group of soccer players at 13 years is composed of boys who are only slightly later maturing; their bone ages are slightly lesser than their chronological ages (-0.23). The 15 year old players, on the other hand, are significantly advanced in skeletal maturity; bone age is advanced over CA by along one year (Table 2). These trends suggest that late maturing boys may give-up soccer or may be systematically removed from training programs. On the other hand, the sport of soccer may systematically select for boys advanced in maturity as adolescence progresses. The small difference between 15 and 16 year old boys probably reflects reduced variation as the end of adolescence is approaching.

Biological maturity can be assessed in several ways, and the two more commonly used methods are based on secondary sex characteristics and skeletal age. This study attempted to combine these methods with moderate success. The majority of this sample of soccer players were in stages four and five for pubic hair, which is consistent with observations that boys practicing sport enter each stage of genital and pubic hair development earlier than non-athletes (Malina *et al*., 1997).

Indicators of sexual maturity vary somewhat with overall bone age variability, so that skeletal and sexual maturation do not necessarily proceed synchronously. The nonparametric correlations between stage of each indicator of sexual secondary and bone age were 0.83, 0.50 and 0.31, respectively, for stage of voice, pubic hair and genitalia. The variable results may reflect error associated self-evaluation and bone age assessment, and also the different scales used for sexual maturity (5 stages) and bone age (continuous). There is also the possibility of population variation in indicators of biological maturation (Kemper *et al*., 1997).

Bone age and chronological age were major predictors of handgrip strength in the total sample (Table 9). This may suggest that in similar circumstances of biologic age, chronological age becomes an important factor in variability. This in turn may reflect the advanced experience and longer training history of the older soccer players compared to the younger players. The robustness of wrist bones also appeared as a predictor of handgrip strength in this sample of boys.

Within the three maturity categories, bone age did not appear as a predictor of strength; rather, in the MS and LS categories, chronological age was the major predictor. In contrast, in IS, skeletal breadths were the major predictors of handgrip strength. Once again, the role of chronological age may be reflected in experience and longer training history.

CONCLUSIONS

- High commonality of indicators of sexual maturity suggests that it may be desirable to work with only one indicator. A weighted vector like SMI based on voice, pubic hair and genital development is a potential method including all three criteria.

- Bone age is an most important explanatory variable of handgrip strength.

- The use of a regression model to predict handgrip strength may be especially useful during the initial stages of pubertal maturation.

- It is important that the findings of the present study be replicated in other and larger samples of soccer players and participants in other sports.

REFERENCES

Baxter-Jones AD (1995). Growth and development of young athletes. Should competition levels be age related? *Sports Med, 20* (2), 59-64.

Beunen G. (1993). Biological maturation and physical performance. In W Duquet, JAP Day (Eds). *Kinanthropometry IV*. London; New York: E & F Spon.

Beunen GP, Malina RM, Lefevre J, Claessens AL, Renson R, and Simons J (1997). Prediction of adult stature and noninvasive assessment of biological maturation. *Med Sci Sports Exerc, 29* (2), 225-230.
Bielicki T, Koniarek J, Malina RM (1984). Interrelationships among certain measures of growth and maturation rate in boys during adolescence. *Ann Hum Biol, 1 1*(3), 201-210.
Carter JEL. (1988). Somatotypes of Children in Sports. In RM Malina (Ed.), *Young Athletes. Biological, Physiological and Educational Perspectives* (pp. 153-165). Champaign, IL: Human Kinetics.
Fragoso I, Vieira F (2000). *Morfologia e crescimento. Curso prático*. Cruz Quebrada, Portugal: Faculdade de Motricidade Humana.
Gilli G (1996). The assessment of skeletal maturation. *Horm Res, 45 Suppl 2*, 49-52.
Kemper HC, Post GB, Twisk JW (1997). Rate of maturation during the teenage years: nutrient intake and physical activity between ages 12 and 22. *Int J Sport Nutr, 7* (3), 229-240.
Malina RM (1989). Growth and Maturation: Normal Variation and Effect Training. In CV Gisolfi, DR Lamb (Eds.), *Perspectives in Exercise Science and Sports Medicine*. Vol. 2, pp. 223-265.. Indianapolis, Indiana: Benchmark Press.
Malina RM, Woynarowska, B, Bielicki T, Beunen G, Eweld D, Geithner CA (1997). Prospective and retrospective longitudinal studies of the growth, maturation, and fitness of Polish youth active in sport. *Int J Sports Med, 18 Suppl 3*, S179-185.
Malina RM, Bouchard C (1991). *Growth maturation and physical activity*. Campaign, IL: Human Kinetics.
Mueller WH, Cho SD, Meininger JC, Liehr P, Chan W (2001). Strategies for combining and scaling sexual maturity indicators: the Heartfelt Study. *Ann Hum Biol, 28*(4), 422-430.
Tanner JM (1962). *Growth at Adolescence,* second edition. Oxford: Blackwell Scientific Publications.
Vieira F, Fragoso I, Silva L, Canto e Castro L (2002). Morphology and sports performance in children aged 10-13 years: Identification of different levels of motor skills. In T Reilley, M Marfell-Jones (Eds), *Kinanthropometry VIII*. London: Taylor and Francis.

Ackowledgement: The authors thank Professor Barry Bogin and Dr. Teresa Vargas for their kind help in the revision of this article.

http://dx.doi.org/10.14195/978-989-26-1169-3_4

CHAPTER 4: VARIATION IN SIZE, PHYSIQUE, FUNCTIONAL CAPACITIES AND SOCCER SKILLS IN PLAYERS 11-16 YEARS

Manuel J Coelho e Silva
António Figueiredo
Francisco Sobral
Robert M Malina

INTRODUCTION

Study of the structural and functional characteristics of athletes has a long tradition in physical education and the sport sciences (Malina, 1997). For example, an extensive battery of anthropometric and functional characteristics was routinely collected on Harvard University students during the latter part of the 19th century (Sargent, 1887). These early observations suggested that the development of athletes was governed, in part, by the constitution of the individual, the specific sport, and the time devoted to practice of the sport. Sargent asked many questions that are still relevant today. For example, can outstanding athletic ability be predicted from body structure?, or does the athlete have a physique that is best suited for a specific sport?

It is also increasingly apparent that elite young athletes often show the physical characteristics associated with successful adult athletes in specific sports (Carter and Heath, 1990). Such observations highlight the need to better understand the growth and maturation of young athletes in the context of the training programs to which they are exposed, often beginning at relatively young ages (Malina, 1998; Malina et al., 2004).

A related question when working with young athletes is long term planning. This is a major feature of talent development programs in modern sport. This is especially relevant because some programs have as their objective the identification of youngsters with potential to attain success in sport at national and international levels. It is suggested that a well-organized and intentional program over a long period encourages a more rational use of training methods (Bompa, 1990).

Individual differences in the timing and tempo of the adolescent growth spurt and sexual maturation have a major impact on the body size and performances of boys. In the context of youth sports, early maturing boys who are taller, heavier, and stronger than their average and later maturing age peers, are often given preference given the associated strength and power advantages. Although such contrasts in size and performance are often transient, they may contribute to the exclusion of potentially talented youngsters largely because they are smaller and are deficient in muscle mass and muscular strength and power (Malina *et al*., 2004).

It is important to have a grasp of variation in physical and functional characteristics associated with age and maturity status in young athletes. The body size and maturity characteristics of young athletes in a variety of sports have been summarized (Malina, 1998; Malina *et al*., 2004). Variation in somatotype among youth in many sports has also been summarized (Carter and Heath, 1990). In contrast, variation in functional characteristics, both general and sport specific, of adolescent athletes associated with maturity has received less attention.

The purpose of the present paper is to present the size, physical and functional profile of adolescent football (soccer) players 11-16 years of age. It specifically considers variation by competition age groups, and then examines variation by stage of puberty within these age groups. In addition, a subsample of the players was subsequently examined after an interval of two years, thus providing an opportunity to examine the stabiity of the physical and functional characeristics of the young football players.

MATERIAL AND METHODS

The participants were 95 football (soccer) players 10.9 to 16.6 years of age in central Portugal. The players were grouped into two-year age categories which reflect the competitive structure of youth soccer in Portugal: 11-12, "infantiles" (n=29); 13-14, "initiates" (n=37); and 15-16, "juveniles" (n=29). The players were evaluated in the 2000/2001 season.

Height, weight, biacromial and bicristal breadths, and the dimensions needed to determine somatotype with the Heath-Carter anthropometric protocol (Carter and Heath, 1990) were taken on each athlete. The androgyny index ([3 X biacromial breadth] - bicristal breadth) was also calculated (Tanner, 1951). It provides information about the degree of masculinity in physique. Stage of sexual maturity was assessed at clinical examination using the criteria for pubic hair described by Tanner (1962). The development of pubic hair (PH) is described in five stages from the prepubertal state (PH 1) to the mature state (PH 5). PH 2 represents the initial appearance of pigmented pubic hair, while PH 3 and PH 4 are intermediate stages (Malina *et al*., 2004).

Several dimensions of performance were assessed: (1) cardiovascular endurance - 20-meter shuttle run (PACER: Progressive Aerobic Cardiovascular Endurance Run) and the 12-minute run, (2) running speed - 25 meter dash, (3) agility - 10 x 5 meter shuttle run, (4) explosive power - standing long jump and vertical jump, (5) abdominal muscular strength and endurance - number of sit-ups completed in 60 seconds, (6) static strength - hand grip strength, and (7) lower back/upper thigh flexibility - sit-and-reach.

Two soccer-specific skill tests were administered, passing and dribbling. The tests were adapted from Kirkendall *et al*. (1987):

a) Wall pass

A target area 2.44 m long and 1.22 m high from the floor is drawn on a wall. An area 3.65 m by 4.23 m is marked off on the floor in front of the target area. A restraining line is placed 1.83 m between the baseline and the base of the wall. The ball is set on the restraining line and the subject stands back of the ball ready to kick on the command *go*. The subject continues to kick as many times as possible, with either foot, by immediately kicking the ball or blocking and steadying it, soccer style, before re-kicking. Use of the hands at any time is prohibited, and one point is deducted from the subject's score for each infraction. Three 20-second trials are taken, and the subject's score is the best of the three trial scores. The score is determined by the number of times within 20 seconds that the players successfully propels the ball against the wall. The ball must be directed by the foot, knee or leg. The subject must remain behind the restraining line at all times. If the subject kicks in front of the line, falls forward, or steps over the restraining line during the follow through, the kick does not count.

b) Dribble test

The subject starts to dribble the soccer ball with the feet in and out of markers set at a specific distance from each other. The score is the time elapsed (0.1 second) from the starting signal until the athlete returns to the starting line after dribbling the ball in slalom fashion around the markers. The subjects must complete the test with the ball under control. No practice trials are allowed. Three trials are given. The score of the best trial is retained for analyis.

RESULTS

Descriptive statistics for all variables are summarized in Table 1. As expected, size, functional capacities and soccer skills improve with age group with one exception. There is no change in flexibility. In contrast, somatotype does not change significanty with age group. The adolescent soccer players tend to have, on average, a mesomorphic somatotype, with balanced contributions of endomorphy and mesomorphy.

Table 1. Means and standard deviations for size, physique, function and skill of soccer players by age group. Significance of the differences among age groups is also indicated.

Variable	11-12 yr (n=29)	13-14 yr (n=37)	15-16 yr (n=29)	F	p
Age (years)	12.0±0.5	13.9±0.6	16.1±0.5		
Stature (cm)	145.6±5.3	164.0±9.3	172.5±5.1	110.09	**
Body Weight (kg)	37.8±48	52.5±8.3	63.8±5.8	111.40	**
Androgyny index	75.2±3.6	84.1±5.4	92.9±4.6	102.94	**
Endomorphy	3.09±1.31	3.05±0.96	2.73±0.68	1.13	n.s.
Mesomorhy	4.45±0.93	4.30±0.88	4.46±0.86	0.33	n.s.
Ectomorphy	3.27±0.92	3.59±1.03	3.06±0.70	2.86	n.s.
12-minute run (m)	2451±145	2630±258	2760±252	13.50	**
PACER (#)	66±12	86±12	97±10	52.55	**
25-meter dash (sec.)	4.85±0.26	4.48±0.21	3.97±0.19	115.38	**
Agility: 10x5m (sec.)	20.16±1.53	19.13±1.34	18.93±0.91	7.86	**
Vertical jump (cm)	28.0±5.6	33.8±7.6	43.9±6.4	42.54	**
Standing long jump (cm)	162.0±17.7	185.8±24.6	209.9±18.2	54.87	**
Sit-ups (#)	44±9	47±6	56±7	18.04	**
Hand grip strength (kg)	25.1±3.5	34.7±5.4	42.6±7.3	70.63	**
Sit-and-reach (cm)	15.2±4.9	13.7±6.0	15.5±8.2	0.76	n.s.
Soccer wall pass test (#)	14.1±3.0	16.7±3.5	17.1±2.1	9.55	**
Soccer dribble test (sec.)	11.48±0.96	11.06±0.82	10.68±0.86	9.73	**

n.s. (non-significant), * (p<.05), ** (p<.01).

Table 2. Distribution of stages of pubid hair (PH) in soccer players by single year chronological ages (N=95).

	Stages of Pubic Hair					
Age group	1	2	3	4	5	Total
11.0-11.9	8	6	-	-	-	14
12.0-12.9	1	9	5	-	-	15
13.0-13.0	-	5	8	5	-	18
14.0-14.9	-	-	4	15	-	19
15.0-15.9	-	-	-	6	1	7
16.0-16.9	-	-	-	11	11	22
Total	9	20	17	37	12	95

The distribution of stages of pubic hair within single year age groups is summarized in Table 2. The youngest players (11 years) are prepubertal (PH 1) and early pubertal (PH 2). With one exception, all players 12 years and older are pubertal, and one-half of the 16 year old players are classified as mature. Descriptive statistics for size, physique, functional capacities and soccer skill of soccer players by stage of pubic hair within each age group are summarized in Table 3. Within each age-group players advanced in pubertal status are chronologically older, taller, heavier and more androgynous, although the differences in body weight and the androgyny index are not significant except among 13-14 year old players. In contrasts, somatotypes of players by stage of pubic hair overlap considerably (Figures 1-3). Larger body body size and tend to be more androgynous. Functional capacities and the two soccer skills do not consistently differ among players of contrasting maturity status within each age group, with the exception of cardiovascular endurance (Pacer test), running speed, power (the two jumps) and static strength among 13-14 year old players. Note, however, that sample sizes are rather small, which encourages caution in interpreting the trends.

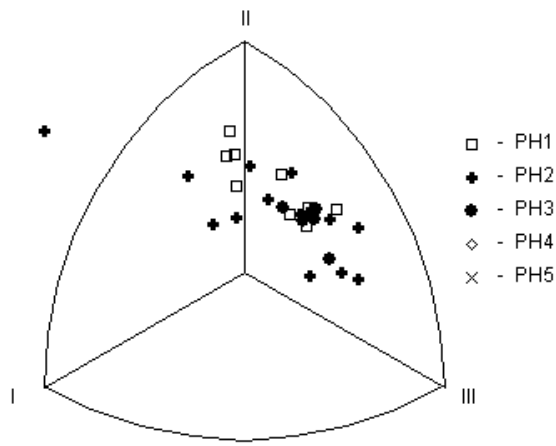


Figure 1. Distributions of somatotypes of soccer players within infantiles (11-12 yr).

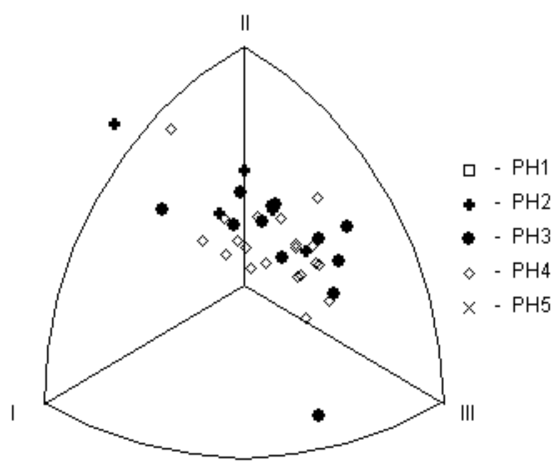


Figure 2. Distributions of somatotypes of soccer players within initiates (13-14 yr).

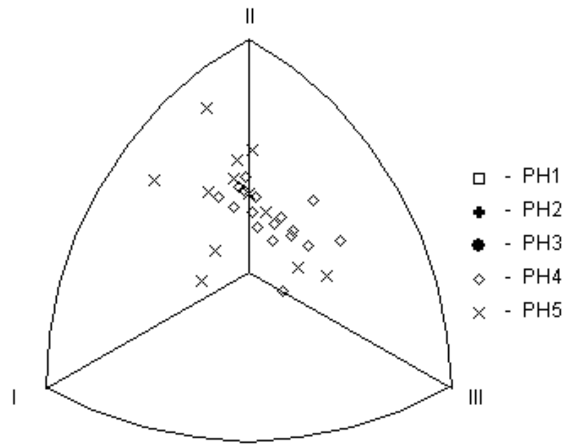


Figure 3. Distributions of somatotypes of soccer players within juveniles (15-16 yr).

Table 3. Means for size, functional capacities and soccer-specific slkills by sexual maturational stages (11-12 yr, n=29).

Variable	PH1 n=9	PH2 n=15	PH3 n=5	F	p
Stature (cm)	142.7	145.2	152.0	7.25	**
Body Weight (kg)	36.6	37.6	40.4	1.01	ns
Androgyny index	74.5	74.9	77.7	0.88	ns
12-minute run (m)	2451	2443	2447	0.09	ns
PACER (#)	61	67	73	1.06	ns
25-meter dash (sec.)	4.89	4.85	4.76	0.37	ns
Agility: 10x5m (sec.)	19.00	17.93	17.55	1.74	ns
Vertical jump (cm)	28.0	28.7	25.8	0.50	ns
Standing long jump (cm)	152.3	166.5	166.0	2.10	ns
Sit-ups (#)	39.9	44.7	48.8	1.78	ns
Hand grip strength (kg)	25.3	24.2	27.4	1.70	ns
Sit-and-reach (cm)	16.8	15.3	12.2	1.60	ns
Soccer wall pass test (#)	14.8	13.9	13.6	0.29	ns
Soccer dribble test (sec.)	11.63	11.41	11.42	0.15	ns

* (p<.05). ** (p<.01).

Table 4. Means for size, functional capacities and soccer-specific slkills by sexual maturational stages (13-14 yr, n=37).

Variable	PH2 n=5	PH3 n=12	PH4 n=20	F	p
Stature (cm)	149.5	161.4	169.3	20.03	**
Body Weight (kg)	43.2	48.7	57.0	11.74	**
Androgyny index	79.3	82.7	86.1	4.71	*
12-minute run (m)	2910	2553	2606	4.20	*
PACER (#)	80	85	88	1.90	ns
25-meter dash (sec.)	4.74	4.55	4.37	12.35	**
Agility: 10x5m (sec.)	17.31	17.09	17.02	0.17	ns
Vertical jump (cm)	26.8	32.0	36.6	4.48	*
Standing long jump (cm)	162.8	176.6	192.5	6.71	**
Sit-ups (#)	44.8	46.1	48.4	1.01	ns
Hand grip strength (kg)	28.1	32.5	37.6	12.63	**
Sit-and-reach (cm)	13.4	12.8	14.4	0.27	ns
Soccer wall pass test (#)	13.8	18.1	16.6	2.91	ns
Soccer dribble test (sec.)	11.73	11.03	10.91	2.19	ns

* (p<.05). ** (p<.01)

Table 5. Means for size, physique, function and skill of soccer players by age group and maturational status (15-16 yr, n=29).

Variable	PH4 (n=17)	PH5 (n=12)	F	p
Stature (cm)	170.8	175.0	5.52	*
Body Weight (kg)	60.7	68.2	19.62	**
Androgyny index	92.0	94.1	1.50	ns
12-minute run (m)	2708	2835	1.85	ns
PACER (#)	94	100	2.95	ns
25-meter dash (sec.)	4.00	3.93	0.91	ns
Agility: 10x5m (sec.)	16.90	16.96	0.03	ns
Vertical jump (cm)	44.9	42.5	1.03	ns
Standing long jump (cm)	207.8	212.8	0.68	ns
Sit-ups (#)	56.3	54.7	0.26	ns
Hand grip strength (kg)	40.9	44.9	2.16	ns
Sit-and-reach (cm)	15.1	16.1	0.09	ns
Soccer wall pass test (#)	17.2	17.0	0.09	ns
Soccer dribble test (sec.)	10.80	10.55	3.11	ns

* (p<.05). ** (p<.01).

IMPLICATIONS AND RECOMMENDATIONS

Results of this descriptive analysis of body size and maturity status are consistent with other observations on adolescent soccer players (Malina, 2003). On average, somatotypes are generally mesomorphic with equal development of endomorphy and mesomorphy, which is consistent with other data for adolescent and adult soccer players (Carter and Heath, 1990). Nevertheless, there is considerable variation in the distribution of somatotypes, especially when pubertal status is considered. The role of selection for physique among young soccer players needs further consideration. Individual factors (self) and coach and/or sport related factors are probably involved in this process.

Distributions of birth dates of soccer players indicate an over-representation of youth born in the first quarter of the selection year. This is labeled as the relative age effect. It has been suggested that the success of adolescent athletes born early in the selection year can be largely explained by physical precocity, especially the body size advantage compared to those born late in the selection year (Helsen *et al*., 2000). Accordingly, players born in the latest quarter of the soccer year (October-December) are smaller and less likely to be noticed by coaches and perhaps not identified as talented. The same has been shown for ice hockey, which has a different calendar year. There is a strong linear relationship between month of birth (January to December) and the proportion of players in the Canadian *National Hockey League* for "Junior A" (Barnsley *et al*., 1985).

Unfortunately, these analyses do not consider individual differences in the timing and tempo of the adolescent spurt and sexual maturation, and their potential role in the selection process for a specific sport. Size in itself is only one factor which is confounded by maturity status in adolescent boys. A player born late in the selection year but who is an early maturer may be as large as a boys born early in the selection year but who is a late maturer. In the present study, maturity-associated variation in size, function and skill was greatest among 13-14 year old players (Table 3). This is the age range when most boys progress through the adolescent growth spurt and sexual maturation and also the age range when performance is quite variable since strength and power have their own growth spurts (Malina *et al*., 2004). Research dealing with the relative age effect needs to extend beyond the distributions of birth dates to other factors that may contribute to successful soccer performance during adolescence (see, for example, Malina et al., 2007).

Research that considers the expectations of coaches for young athletes of contrasting in physical status, maturity and strength is lacking. It also would be of interest to assess the satisfaction or dissatisfaction associated with participationt in sports of young athletes were are early and late in biological maturation.

In summary, the data presented for adolescent soccer players provide a general profile of their growth, maturity, functional and skill characteristics. Coaches need to be aware of such data, especially inter-individual variation. There is a need for studies focused on the perceptions and expectations of coaches on athletes who differ in size, maturity status and skill. Preliminary data suggested considerable variation in playing time associated with functional capacity and skill. The coaches promoted players (more playing time) on the basis of motor fitness and soccer specific skills, whereas somatotype and body size did not seem to be relevant predictors for playing time in this age group of 15-16 year old players (Coelho e Silva *et al*., 2005). Corresponding data are needed for younger age groups when variation in size and maturity is much more apparent. Taking into account the information provided by the present study, the following recommendations should be of interest to coaches and sport authorities:

- *It might be more practical to group athletes into more homogenous age-groups, especially during early phases of sport participation.* During the transition into puberty and during puberty, age groups of one year (12 months) may provide better opportunities for all players.

- *The potential value of matching yound soccer players by maturity status should be systematically evaluated.* Sport authorities already permit the moving up of younger, advanced players into older competitive age-groups. Hence, it may be worthwhile to consider maturity status in this process, especially among players 11-12 and 13-14 years. This may also necessitate less mature older players competing against younger athletes of similar maturity status which may not be viewed as acceptable by adolescent athletes. Though potentially interesting, it is important to examine the implications of such matching for behavior and peer relationships. Asking a 14 year old, slow maturing player to compete with 11-12 year olds may have negative behavioral implications. Similarly, asking a more mature 12 year old to compete with 14 year olds may also have negative behavioral implications (see Malina and Beunen, 1996).

- *The identification of potentially talented individuals should not place too much reliance of size, strength and power advantages associated with early biological maturation in early and mid-adolescent players to the neglect of skill mastery and game sense.* Talent identification is a complicated process (Malina, 1997). Many factors are involved. Selection is the first phase, and all too often initial selections are based on limited data. Coaches need to be aware of changes in size, function and skill associated with adolescence, and their behavioral implications. Size and performance advantages and disadvantages associated with variation in maturity status are often transient. It is important to recognize that adolescent athletes are first adolescents and then athletes.

LITERATURE

Barnsley RH, Thompson AH, Barnsley PE (1985). Hockey success and birthdate: the relative age effect. *Canadian Association for Health, Physical Education and Recreational Journal*. 51: 23-28.

Bompa T (1990). *Theory and Methodology of Training – The Key to Athletic Performance*, (2nd Edition). Kendall/Hunt Publishing Company.

Carter JEL, Heath BH (1990). *Somatotyping: Development and Applications*. Cambridge Cambridge University Press.

Coelho e Silva MJ, Figueiredo A, Relvas H, Malina RM (2005). Correlates of playing time in 15-to 16-year old male soccer players. In T Reilly, J Cabri, D Araujo (Eds), Science and Football V. London: Routledge, pp475-480.

Helsen WF, Hodges NJ, Winckel JV, Starkes JL (2000). The roles of talent, physical precocity and pratice in the development of soccer expertise. *Journal of Sports Sciences*. 18: 727-736.

Kirkendall D, Gruber J, Johnson R (1987). *Measurement and Evaluation for Physical Educators*, 2nd edition. Human Kinetics. Champaign, Illinois.

Malina RM (1997). Talent identification and selection in sport. *Spotlight on Youth Sports.* Vol. 20 (1): 1-3, Michigan State University, East Lansing, MI.

Malina RM (1997). Anthropometry in physical education and the sport sciences. In F Spencer (Ed). *History of Physical Anthropology, An Encyclopedia*. New York, Garland Publishing Co., pp. 90-94.

Malina RM (1998). Growth and maturation of young athletes: Is training for sport a factor. In KM Chang, L Micheli (Eds). Sports and Children. Hong Kong:Williams and Wilkins, pp. 133-161.

Malina RM (2003). Growth and maturity status of young football (soccer) players. In T Reilly, M Williams (eds). *Science and Socer*, 2nd edition. Routledge, Ltd., London, pp 287-306.

Malina RM, Beunen G (1996). Matching opponents in youth spots. In O Bar-Or (Ed). *The Child and Adolescent Athlete*. Oxford, UK: Blackwell Science, pp 202-213.

Malina RM, Bouchard C, Bar-Or O (2004). *Growth, Maturation andPhysical Activity*, 2nd edition. Champaign, Illinois. Human Kinetics.

Malina RM, Ribeiro B, Aroso J, Cumming SP (2007) Characteristics of youth soccer players aged 13-15 years classified by skill level. *British Journal of Sports Medicine* 41:290-295.

Sargent DA (1887). The physical characteristics of the athlete. *Scribners*. 2: 541-561.

Tanner JM (1951). Current advances in the study of physique: Photogrammetric anthropometry and an androgyny scale. *Lancet* 1: 574-579.

Tanner JM (1962). *Growth at adolescence*, 2nd edition. Blackwell Scientific Publications. Oxford.

Partially supported by *Fundação para a Ciência e a Tecnologia*

http://dx.doi.org/10.14195/978-989-26-1169-3_5

CHAPTER 5: GROWTH AND MATURITY PROFILE OF YOUTH SWIMMERS IN MEXICO

Maria E Peña Reyes
Robert M Malina

INTRODUCTION

Sport organization and participation in Mexico has developed considerably since the 1980s. Two factors are have apparently driven this expansion: (1) the assumption that most of the population should have access to sport in any of its different forms (youth sport, popular or recreational sport, and organized sport), and (2) strong interest in improving sport performances at national and international levels, i.e., high performance athletes (CONADE, 1991). In sports such as swimming or diving, opportunities for young participants are often limited due to scarcity of appropriate facilities throughout the country.

Studies of young athletes often focus on the "talented" and in many cases the elite (Malina, 1994, 1998). And, age-group swimmers are well represented among studies of the growth and maturity status of young athletes. Young swimmers are, on average, taller and heavier than reference data for the general population during childhood and adolescence, and in later elite adolescence swimmers tend to especially taller, but not exceptionally heavier. There is, needless to say, variation among studies and geographic regions (Malina, 1994, 1998). The data, however, are primarily available for Europe and the United States. Data for youth swimmers from Latin American countries are limited to reasonably select adolescent samples from Cuba (Alonso, 1986; Pancorbo and Rodriguez, 1986), Brazil (Rocha *et al*., 1977), and Venezuela (Perez, 1977, 1981), and a sample from the Bolivar Games in 1981 (Brief, 1986). More recently, the anthropometry and somatotype of an international sample of young adult swimmers, including those from Latin America, have been described (Carter and Ackland, 1994).

This paper is considers the growth and skeletal maturity status of youth swimmers from two urban centers in Mexico. They are participants in formal swim programs and are not, as a group, select, talented, or elite level swimmers. The data for this sample of Mexican youth swimmers are then compared to data for youth swimmers of approximately the same age from several Latin American countries.

METHODS

The swimmers were part of larger study of the growth and maturity status of youth participants in several sports in different regions of the country in the late 1980s. The cross-sectional sample included 66 males 8.0 to 17.1 years of age and 24 females 8.3 to 14.2 years of age. The swimmers were participants in youth swim programs two urban centers at central and northwestern Mexico. The programs and swimmers are not elite caliber. The children had been training in swimming for periods ranging from six months to two years. Younger children trained twice per week in hourly sessions, while older children trained three times per week in two hour sessions. This study thus provides data on the growth and maturity status of youth enrolled in less formal and less intensive swim programs.

Weight, height, sitting height, and the anthropometric dimensions needed to estimate Heath-Carter somatotype were taken: flexed arm and calf circumferences, bicondylar breadths of the humerus and femur, and the triceps, subscapular, suprailiac and medial calf skinfolds (Carter and Heath, 1990). The body mass index (BMI, kg/m^2) and sitting height/standing height ratio (%) were also calculated.

Hand-wrist radiographs were taken to provide an estimate of skeletal maturity. The Fels method was used to estimate a skeletal age for each child (Roche *et al*., 1988); Fels assessments were not available for four boys and two girls. The radiographs were assessed by a single, experienced individual (MEPR; Peña Reyes, 1992; Peña Reyes and Malina, 2001).

Chronological age (CA) was subtracted from skeletal age (SA) for each child to provide an estimate of the skeletal maturity status of each swimmer as follows:

Late (delayed) = SA behind CA by more than one year;
Average (on time) = SA within plus or minus one year of CA;
Early (advanced) = SA ahead of CA by more than one year; and
Mature = skeletal maturity (an SA is not assigned).

The cut-off points are arbitrary and a broad range of average ("on time") is preferred to allow for error in the assessments (Malina *et al*., 2004).

The swimmers were divided into three chronological age groups for comparison. The age groups approximate, in general, those used in swimming competitions. Three groups were so designated in males: 8-10 years (n=20, 8.0-10.9 years), 11-13 years (n=25, 11.1-13.9 years), and 14-17 years (n=21, 14.1-17.1 years). Two groups were designated in females: 8-10 years (n=14, 8.3-10.9 years), and 11-14 years (n=10, 11.0-14.2 years).

Heights and weights of the swimmers were compared to growth charts for American children (Centers for Disease Control and Prevention, 2000). Satisfactory reference data for Mexican children are not available. The reference values commonly used are based on a mixed-longitudinal sample from a private clinical practice in the Federal District in the 1960s and 1970s (Ramos Galvan, 1975), which may not be representative of the Mexican population. The United States reference values are routinely used in growth and nutritional surveys worldwide.

RESULTS

Male Swimmers. Descriptive statistics for the three age groups of male swimmers are summarized in Table 1. Mean heights approximate the 25th percentile of United States reference data in the two younger age groups, but is between the 10th and 25th percentiles in the oldest age group. Mean weights, on the other hand, are just below the reference median in the 8-10 and 14-17 year age groups, but close to the 25th percentile in the 11-13 year age group. Swimmers in the two older age groups have, on average, proportionally longer legs than those in the youngest age group, which reflects growth in the lower extremities during the early part of adolescence (note, that the sample includes only few boys in late adolescence which is a period characterized by growth in length of the trunk).

Table 1. Means (standard deviations) of male swimmers in three age groups.

	8-10 yrs (n=20)		11-13 yrs (n=25)		14-17 yrs (n=21)	
Age, yrs	9.9	(0.8)	12.3	(0.9)	15.7	(0.9)
Height, cm	134.9	(5.0)	146.9	(9.7)	164.6	(6.2)
Weight, kg	30.3	(5.3)	38.5	(9.1)	58.0	(9.4)
BMI, kg/m^2	16.6	(1.9)	17.7	(2.4)	21.3	(2.3)
Sit Ht/Ht Ratio, %	52.5	(1.1)	51.7	(1.4)	51.7	(1.2)
Endomorphy	2.4	(1.0)	2.4	(1.1)	2.5	(1.0)
Mesomorphy	3.9	(1.1)	3.8	(0.8)	4.0	(0.8)
Ectomorphy	2.8	(1.0)	3.0	(1.1)	2.3	(1.0)

Mean somatotypes of male swimmers show small differences between the two younger age groups, whereas swimmers in the oldest age group slightly more mesomorphic but are especially less ectomorphic (Table 1). Mesomorphy is the dominant characteristic of swimmers in the three age groups.

Skeletal maturity status of the male swimmers is summarized in Table 2. Mean skeletal age is within plus or minus one year of mean chronological age in the three age groups. Allowing for the relatively small sample sizes, the majority of swimmers in each of the three age groups is classified as average or "on time". Among 8-10 year old, late and early maturing swimmers are about equally represented. Among 11-13 year old swimmers, 9 are classified as late and only one as early maturing, whereas among 14-17 year old swimmers, 4 are classified as early and 3 are already skeletally mature, and none is classified as late maturing. There thus appears to be a shift towards boys of average and advanced maturity status in the oldest age group of swimmers.

Table 2. Means (standard deviations) of male swimmers in three age groups in chronological age [CA], Fels skeletal age [SA], and frequencies of skeletal maturity classification.

	CA, yrs		SA, yrs		SA - CA, yrs		Maturity Classification*			
8-10 yrs (n=17)	9.9	(0.9)	10.3	(1.8)	0.4	(1.8)	5	9	3	-
11-13 yrs (n=23)	12.3	(0.9)	11.7	(1.6)	-0.6	(1.1)	9	13	1	-
14-17 yrs (n=21)	15.7	(0.9)	-	-	-	-	-	14	4	3
Not mature (n=18)	15.6	(0.9)	16.1	(1.3)	0.5	(1.1)				

*Maturity Classification: L=late (delayed), A=average ("on time"), E=early (advanced), M=mature, see text for specific criteria.

Characteristics of 11-13 and 14-17 year old swimmers of contrasting maturity status are summarized in Table 3. Late and average maturing 11-13 year old, and average and early (including the skeletally mature) 14-17 year old swimmers are compared. Numbers in the youngest age group are too small for comparison. Within each age group, the more mature swimmers are taller and heavier, and have a larger BMI. The more mature 11-13 year old swimmers also have proportionally longer lower extremities (lower sitting height/standing height ratio), while the proportional difference is less 14-17 year old swimmers. Late and average maturing 11-13 year old swimmers are, on average, similar in somatotype, whereas the more mature 14-17 year old swimmers are more mesomorphic and especially less ectomorphic.

Female Swimmers. Descriptive statistics for the two age groups of female swimmers are summarized in Table 4. Mean heights and weights of 8-10 year old swimmers fall just below the respective reference medians for American children. In contrast, mean height of swimmers 11-14 years approximates the 10th percentile of the reference, while mean weight is at the 25th percentile of the reference. Swimmers in the older age group have proportionally longer legs than those in the younger age group, which is expected since they are likely in adolescence. Mean somatotypes of female swimmers in the two age groups are virtually identical (Table 4). The somatotype is mesomorphic with balanced contributions of endomorphy and mesomorphy

Table 3. Means (standar deviations) of male swimmers 11-13 and 14-17 years grouped by maturity status.

	11-13 Years				14-17 Years			
	Late (n=9)		Average (n=13)		Late (n=14)		Average (n=7)	
CA, yrs	12.0	(0.8)	12.6	(0.9)	15.6	(1.0)	15.8	(0.7)
SA, yrs	10.3	(0.9)	12.6	(1.2)	15.6	(1.1)	-	-
SA - CA, yrs	-1.7	(0.7)	0.0	(0.5)	0.0	(0.5)	-	-
Height, cm	140.6	(4.6)	151.6	(9.7)	163.4	(6.2)	167.1	(5.7)
Weight, kg	33.8	(4.1)	42.0	(9.9)	55.9	(10.3)	62.4	(5.6)
BMI, kg/m2	17.1	(1.5)	18.1	(2.8)	20.8	(2.6)	22.3	(1.3)
Sit Ht/Ht Ratio, %	52.1	(1.4)	51.5	(1.2)	51.8	(1.2)	51.5	(1.2)
Endomorphy	2.4	(1.0)	2.4	(1.1)	2.5	(1.1)	2.3	(0.7)
Mesomorphy	4.0	(0.9)	3.8	(0.9)	3.9	(0.9)	4.3	(0.6)
Ectomorphy	2.9	(0.8)	3.0	(1.2)	2.5	(1.1)	1.9	(0.7)

*This group includes three swimmers who are already skeletally mature. They do not differ in age from the four swimmers who are adanced in skeletal age.

Table 4. Means (standard deviations) of female swimmers in two age groups.

	8-10 yrs (n=14)		11-14 yrs (n=10)	
Age, yrs	9.5	(0.7)	12.8	(1.0)
Height, cm	133.8	(5.0)	147.5	(5.4)
Weight, kg	29.9	(6.0)	39.2	(5.9)
BMI, kg/m^2	16.7	(2.9)	17.9	(1.8)
Sit Ht/Ht Ratio, %	53.0	(0.8)	51.7	(1.1)
Endomorphy	2.7	(1.2)	2.8	(0.7)
Mesomorphy	3.7	(0.8)	3.5	(0.8)
Ectomorphy	2.9	(1.4)	2.9	(0.9)

Table 5. Means (standard deviations) of female swimmers in two age groups in chronological age [CA], Fels skeletal age [SA], and frequencies of skeletal maturity classification

	CA, yrs		SA, yrs		SA - CA, yrs		Maturity Classification*			
							L	A	E	M
8-10 yrs (n=12)	9.5	(0.7)	9.9	(8.8)	0.4	(0.7)	-	11	1	-
11-14 yrs (n=10)	12.8	(1.0)	12.7	(2.0)	-0.1	(1.8)	4	4	2	-

*Maturity Classification: L=late (delayed), A=average ("on time"), E=early (advanced), M=mature, see text for specific criteria.

Skeletal maturity status of the female swimmers is summarized in Table 5. Mean skeletal age is within plus or minus one year of mean chronological age in the two age groups. Allowing for the relatively small sample sizes, 15 of the total sample of 22 swimmers have skeletal ages that are classified as average or "on time". It is perhaps interesting that none of the 8-10 year old female swimmers are classified as late maturing. Among 11-14 year old female swimmers, all three maturity categories are represented. Note, however, that sample sizes are small, and the suggested trends need to be interpreted with care. Given the small numbers, comparison of female swimmers 11-14 years of age of contrasting maturity status is not warranted.

DISCUSSION

In contrast to more elite samples of swimmers from United States and Europe, the present sample of swimmers is, on average, shorter and lighter. However, mean somatotypes are reasonably similar to those of other samples of age-group swimmers (Carter and Heath, 1990). Comparative data for body size and somatotype of youth swimmers of both sexes in several Latin American countries are summarized in Tables 6-7.

Table 6. Mean ages. heights. weights. and somatotypes of samples of Latin American youth male swimmers.

	n	Age (yrs)	Height (cm)	Weight (kg)	Somatotype* Endo	Meso	Ecto
This study	20	9.9	134.9	30.3	2.4	3.9	2.8
This study	25	12.3	146.9	38.5	2.4	3.8	3.0
Cuba (a)	14	12.5	149.1	40.7	2.2	4.0	3.3
Venezuela (b)	22	13.8	158.2	46.5	1.8	4.3	3.7
This study	21	15.7	164.6	58.0	2.4	4.0	2.3
Venezuela(b)	17	17.2	175.6	68.0	2.2	4.9	3.0

*Endo=endomorphy, Meso=mesomorphy, Ecto=ectomorphy; (a) Alonso, 1986; (b) Perez, 1977; (c) Perez, 1981; (d) Pancorbo and Rodriquez, 1986; (e) Brief, 1986

Table 7. Mean ages. heights. weights. and somatotypes of samples of Latin American youth swimmers.

	n	Age (yrs)	Height (cm)	Weight (kg)	Somatotype* Endo	Meso	Ecto
This study	14	9.5	133.8	29.9	2.7	3.7	2.9
Cuba (a)	9	12.5	148.2	42.0	2.8	3.3	2.6
This study	10	12.8	147.5	39.2	2.8	3.5	2.9
Cuba (d)	8	13.2	154.3	47.6	3.0	3.8	2.7
Venezuela (b)	12	13.8	158.2	46.5	2.3	3.8	3.4
Bolivar Games (e)	12	14.5	160.0	54.9	3.4	4.5	2.4
Venezuela (c)	14	14.8	163.7	55.2	3.2	4.1	2.8

*Endo=endomorphy, Meso=mesomorphy, Ecto=ectomorphy; (a) Alonso, 1986; (b) Perez, 1977; (c) Perez, 1981; (d) Pancorbo and Rodriquez, 1986; (e) Brief, 1986

The present samples of male Mexican swimmers 8-10 and 11 -13 years of age are, on average, similar in somatotype. The somatotype of male Mexican swimmers 11-13 years (mean age 12.3 years) is similar to that Cuban swimmers of approximately the same mean age (12.5 years, Alonso, 1986), although the Mexican swimmers are slightly shorter and lighter. The older sample of male Mexican swimmers, 14-17 years (mean age 15.7 years), falls between the two Venezuelan samples of more elite status in body size, but is less mesomorphic and particularly less ectomorphic. The younger sample of Venezuelan swimmers is from a private club (Perez, 1977), while the older sample is nationally representative (Perez, 1981).

Female Mexican swimmers 8-10 and 11-14 years of age are, on average, similar in somatotype. The sample of female Mexican swimmers 11-14 years (mean age 12.8 years) is intermediate in body size and somatotype to two samples of Cuban swimmers of approximately the same ages (Alonso, 1986; Pancorbo and Rodriguez, 1986). The older samples of female Latin American youth swimmers are especially more mesomorphic than the female Mexican swimmers. The sample of swimmers from the Bolivar Games of 1981 is most mesomorphic (Brief, 1986), followed by the nationally representative sample of Venezuelan swimmers (Perez, 1981).

Data for more elite samples of European and Australian male age group swimmers indicate skeletal ages (SA) which are concentrated in the average and advanced categories with relatively few late maturing youngsters in late childhood and early adolescence (Malina, 1994). This trend is also apparent in male swimmers at the XII Central American Swimming Championships in 1981 (Peña Reyes *et al*., 1984). After 14-15 years of age, elite male swimmers from the United States, Belgium, and the Central American Swimming Championships, and a small sample of Olympic swimmers under 18 years of age are advanced in skeletal maturity (Malina, 1994). The data for the present sample of non-elite Mexican males swimmers are generally consistent with these observations on more elite male swimmers, with the exception of the relatively large number of late maturing (n=9) 11-13 year old swimmers.

The skeletal maturity data for the small sample of Mexican female swimmers is generally consistent with available data for more elite samples. In early adolescence, about 10-13 years, samples of elite female swimmers tend to have skeletal ages that are, on average, appropriate for their respective chronological ages, and most swimmers are classified in the average or "on time" category (Malina, 1994). On the other hand, skeletal ages of female participants 9-14 years of age in the XII Central American Swimming Championships in 1981 tended to be in advance of chronological age; at older adolecent ages, the elite swimmers tended toward late skeletal maturity status (Pena Reyes *et al*., 1984).

The trends suggested for the skeletal maturity of youth swimmers need to be interpreted with care. The present study used the Fels method of skeletal maturity assessment (Roche *et al*., 1988). The earlier studies used either the Greulich-Pyle (GP) or Tanner-Whitehouse (TW) methods (Malina, 1994; see also Malina *et al*., 2004). Systematic comparisons of the methods of assessing skeletal maturity in samples of Mexican children are limited. In a sample of Mexican youth soccer players 7-17 years of age, SA-CA differences with the Fels and Tanner-Whitehouse II (TW II) methods were, on average, reasonably similar in players <11, 11-12, and >15 years of age. However, among players 13-14 years of age, the SA-CA difference was, on average, more than twice as great with the TW II method than with the Fels method. Moreover, six boys were assessed as skeletally mature with the TW II method, while only one boy was assessed skeletally mature with the Fels method (Peña Reyes *et al*., 1994). Comparison of the Fels and TW II methods in a sample of marginally nourished children 6-13 years of age from an urban colonia (slum) in Oaxaca, southern Mexico, indicated that Fels skeletal ages lagged consistently behind chronological ages more so than TW II skeletal ages in both sexes. However, the heights of the children were more appropriate for Fels skeletal ages than for TW II skeletal ages (Peña Reyes and Malina, 2001).

Although each method of assessing skeletal maturity yields a skeletal age, the skeletal ages are not directly comparable. The three methods of assessment are similar in principle, but differ in criteria for making assessments and procedures used to construct a scale of skeletal maturity from which skeletal ages are assigned. Detailed comparison of the three methods is beyond the scope of this paper. The reader is referred to a more detailed discussion of the three methods, including the most recent revision of the Tanner-Whitehouse method (TW III), in Malina *et al*. (2004). Nevertheless, systematic comparison of the Fels and Tanner-Whitehouse methods in samples of young athletes in different sports and in different countries is needed.

REFERENCES

Alonso RF (1986) Estudio del somatotipo de los atletas de 12 anos de la EIDE occidentales de Cuba. *Boletin de Trabajos de Anthropologia*, April, pp 3-18.

Brief FK (1986) *Somatotipo y caracteristicas antropometricas de los atletas Bolivarianos. Caracas*: Universidad Central de Venezuela.

Carter JEL, Ackland TR (1994) *Kinanthropometry in Aquatic Sports: A Study of World Class Athletes*. Champaign, IL: Human Kinetics.

Carter JEL, Heath BH (1990) *Somatotyping: Development and Applications*. Cambridge: Cambridge University Press.

Centers for Disease Control and Prevention (2000) National Center for Health Statistics *(http://www.cdc.gov/growthcharts.htm*), CDC growth charts: United States.

CONADE (1991) *Proyecto general de desarrollo de talentos deportivos*. Mexico, D.F.: Comision Nacional del Deporte.
Malina RM (1994) Physical growth and biological maturation of young athletes. *Exercise and Sport Sciences Reviews*, 22, 89-433.
Malina RM (1998) Growth and maturation of young athletes: Is training for sport a factor. In KM Chang, L Micheli (Eds). *Sports and Children*. Hong Kong: Williams and Wilkins, pp 133-161.
Malina RM, Bouchard C, Bar-Or O (2004) *Growth, Maturation, and Physical Activity*, 2nd edition. Champaign, IL: Human Kinetics.
Pancorbo AE, Rodriguez C (1986) Somatotype of high performance junior female swimmers. *Boletin Cientifici-tecnico*, Inder Cuba, 1/2, 30-35.
Peña Reyes ME (1992) *Aplication del metodo Fels para evaluar la maduracion del esqueleto en un grupo de niños de Oaxaca: Estudio comparativo de los métodos Fels y TW2*. Mexico, D.F.: Instituto Nacional de Antropologia e Historia, Serie Antropologia Fisica.
Peña Reyes ME, Cardenas E, del Olmo JL (1984) Crecimiento y maduracion osea en deportistas preadolescentes y adolescentes. In R Ramos Galvan and RM Ramos Rodriguez (Eds). *Estudios de Antropologia Biologica. II Coloquio de Antropologia Fisica Juan Comas,* 1982. Mexico, D.F.: Instituto de Investigaciones Antropologicas, pp 453-466.
Peña Reyes ME, Cardenas-Barahona E, Malina RM (1994) Growth, physique, and skeletal maturation of soccer players 7-17 years of age. *Humanbiologia Budapestinensis,* 25, 453-458.
Peña Reyes ME, Malina RM (2001) Fels and Tanner-Whitehouse skeletal ages of school children 7-13 years in Oaxaca, Mexico. In P Dasgupta, R Hauspie (Eds). *Perspectives in Human Growth, Development and Maturation*. Dordecht, The Netherlands: Kluwer Academic Publishers, pp 55-65.
Perez BM (1977) Somatotypes of male and female Venezuelan swimmers. In O Eiben (Ed). *Growth and Development; Physique*. Budapest: Akademiai Kiado, pp 349-355.
Perez BM (1981) *Los Atletas Venezolanos: Su Tipo Fisico*. Caracas: Universidad Central de Venezuela.
Ramos Galvan R (1975) Somatometria Pediatrica. Estudio semilongitudinal de niños de la Ciudad de México. *Archivos de Investigación Medica* 6, Suppl 1.
Rocha ML, Araujo CGS, de Freitas J, Villasboas LFP (1977) Antropometria dinamica da natacao. *Revista de Educacao Fisica*, Brasil, 102, 46-54.
Roche AF, Chumlea WC, Thissen D (1988) *Assessing Skeletal Maturation of the Hand-Wrist: Fels Method*. Springfield, IL: CC Thomas.

Página deixada propositadamente em branco.

http://dx.doi.org/10.14195/978-989-26-1169-3_6

CHAPTER 6: GYMNAST WRIST: the ulnar variance phenomenon *

Albrecht L Claessens

INTRODUCTION

Nowadays, elite sports for children and youth becomes more and more a public phenomenon. The extreme training demands and controlling young athletes by coaches, often with approval of the parents, together with changes in expectations of performance at top levels, has resulted in public and medical concerns. (Bar-Or, 1996; Ryan, 1995) This is especially true in sports as gymnastics, in which a prepubertal physique is a prerequisite for top level gymnastic achievements. (Claessens, 1999) Further, the demands of artistic gymnastics for females have also changed, eg requirements for more difficult routines, year-round training, enhanced mental stress, and so on (Gould, 2001; Jemni *et al*., 2001; Normile, 1996; Ryan, 1995).

The significant growth and popularity of women's gymnastics became more and more evident after the 1972 and 1976 Olympics, where stars as Olga Korbut and Nadia Comaneci introduced the world, via the media, to this artistic sport (Ryan, 1995). Accompanying this popularity has been the increasingly dominant performance of younger, smaller-sized gymnasts (Caine *et al*., 1996; Claessens, 1999). Average ages, and heights and weights of female gymnasts participating at Olympic and World competitions have declined over the past 20 to 30 years (Claessens, 1999). Over a period of about 25 years, the average chronological age of elite female gymnasts declined by 6 years. Secular declines in mean heights and weights parallel the decrease in chronological age. Over the same period, mean height have declined by 4 to 5 cm. The secular decline in height is accompanied by a dramatic reduction in mean weight of about 8 to 9 kg (Claessens, 1999; Claessens *et al*., 1991). Comparable declines in age, height and weight were also observed in artistic female gymnasts from the United States competing at the 1992 Olympics which were 6% younger, 10% shorter, and 22% lighter compared to their 1976 counterparts (Ryan, 1995). The majority of elite gymnasts also tend to be later-maturing individuals (Claessens, 1999; Malina, 1999, 2001). In general, present-day elite gymnastics has evolved to favor the body of a child in

* Based on a presentation at the Symposium *Science in Artistic Gymnastics*, held in Ghent, Belgium, October 27, 2001. (Claessens, 2001)

contrast to that of a maturing adolescent or young adult (Claessens, 1999). These observations can be in large part be attributed to 'selection' based on the direct biomechanical advantages of a prepubertal physique that include increased strength/weight ratio, greater stability, and decreased moments of inertia. Also, in sports in which performance is subjectively scored, as in gymnastics, physical characteristics in addition to skill, may have added significantly for success (Claessens, 1999; Ryan, 1995).

Not surprisingly, whereas the average age and size of competitive gymnasts have decreased, the difficulty of maneuvres practiced and performed has increased. Frequency, duration, and intensity of training also have increased. Elite-level gymnasts, for example, are reported to train around 40 h/week, 5-6 days/week, the whole year around. On avarage, these gymnasts may exercise 700 to 1300 elements per day, which correspond to 220 000 to 400 000 elements per year (Caine *et al*., 1997). These extremely high training demands and changes in expectations of the sport at elite levels (Normile, 1996) has resulted in both public and medical concerns, especially from an auxological point of view (Claessens, 1999; Malina, 2001). It may be postulated that these very young and immature growing athletes are repeatly subject to numerous microtrauma in general, and more specifically, to chronic, long-term accumulative 'overuse' injuries, caused by strenuous, repetitive loads. Epidemiologic research of injury patterns in male and female gymnasts has been studied extensively by several authors, and reviewed by Caine and co-workers (1996).

Unlike most other sports, gymnastics requires use of the upper extremities as weight-bearing limbs, causing high-impact loads to be distributed through the elbows and wrists (Koh *et al*., 1992; Markolf *et al*., 1990). It is not unexpected that injury occurs in these regions (Caine *et al*., 1996). Among others, wrist pain is often viewed in gymnasts as a result of epiphysial trauma and related changes caused by repetitive gymnastic loading mainly of the distal end of the radius as its interface with the carpals, as claimed by some authors (reviewed by Caine *et al*., 1997). Further on, some authors claim that repetitive injury to the radial epiphysis may inhibit normal growth of the radius resulting in a '*positive ulnar variance*' (Caine *et al*., 1996, 1997).

The aim of this study is to review the available research concerning the ulnar variance phenomenon as it is connected to the female gymnast.

ULNAR-VARIANCE

Ulnar variance refers to the relative positioning of the distal end of the ulna relative to the distal end of the radius. If the distal end of the ulna is more distally located as compared to the distal end of the radius, then the term *positive ulnar variance* (or ulnar overgrowth) is used. When the opposite is seen, i.e. the distal end of the ulna is more proximal located as compared to the distal end of the radius, the phenomenon is called *negative ulnar variance* (Hafner *et al*., 1989). Ulnar variance is mostly determined on postero-anterior radiographs of the hand and wrist, whereby several measuring methods are at hand. Different techniques has to be used for mature and immature wrists (Hafner *et al*., 1989; Kristensen *et al*., 1986; Palmer *et al*., 1982: Steyers and Blair, 1989).

FINDINGS FROM CASE REPORTS AND CROSS-SECTIONAL STUDIES

In general, it has been proposed by several authors that the repetive stress experienced by the skeletally immature wrist during gymnastics training (especially in the young female elite gymnast) may lead to the development of wrist pain, partial arrest of the distal radial growth plate, and the subsequent development of positive ulnar variance. This proposal suggests thus a dose-response relationship, i.e. the closure of the radial growth plate, caused by the gymnastic training load, results in a positive ulnar variance. This line of reasoning is largely based on 'patients' or 'case'-reports, i.e. those individuals who present themselves to a clinic with wrist pain, and on cross-sectional srudies in which a relatively small number of both non-elite and elite gymnasts were studied (Albanese *et al*., 1989; Aldridge, 1987; Carter and Aldridge, 1988; Chang *et al*., 1995; DiFiori *et al*.,1997; Mandelbaum *et al*., 1989). Although, on average, a positive ulnar variance in most studies could be observed, results were contradictory and controversial conclusions were made. Also, because of the small sample sizes and the selective recruitment, the subjects under study were not necessary representative of the elite gymnastic population. To our knowledge, up till now, only one study is carried out in which a representative sample of outstanding female gymnasts was undertaken (Claessens *et al*., 1996; De Smet *et al*., 1994). Ulnar variance was obtained in 201 female gymnasts, all participants at the 24th World Championships Artistic Gymnastics, held at Rotterdam, The Netherlands, October 1987 (Claessens *et al*., 1991). The gymnasts under study came from 27 (from in total 31) countries. Based on the final results for total team scores, the four teams that declined ranked 2nd, 13th, 15th, and 19th. It can thus be said that the gymnasts under study were a representative sample of the elite female gymnastic population as demonstrated by the number of subjects studied (n=201), high level of training (on average 27 hours per week, varying from 13 to 48 hours per week), competition level (world championships), and representativess of nationalities. A negative mean value for ulnar variance (Mean= -1.4 ± 2.6 mm) was obtained, demonstrating thus a negative ulnar variance in this high elite female gymnasts. Further on, it was demonstrated that no relationship between ulnar variance on the one hand, and training and competition level on the other hand could be observed. Based on these results, authors could not support the dose-response relationship. These results were in accordance with the data of DiFiori *et al*. (1997) in non elite female gymnasts.

RESULTS FROM LONGITUDINAL STUDIES

It is demonstrated that results from different studies give controversial conclusions. This is not directly surprising, because the design of these investigations, i.e. cross-sectionnally, does not allow to draw a real cause and effect relationship. Thus, well-controlled longitudinal studies, in which elite gymnasts were followed for several years, were needed, in which the dose-response relationship between gymnastic training and the ulnar variance phenomenon can be studied in a more effective way.

In a longitudinal study, 36 female gymnasts were annually followed for four or five occasions, with a total of 158 observations (Claessens *et al*., 1997). At the first observation, the age of the girls varied between 6 and 14 year. According to their training level (based on the total hours of gymnastic training per week) the total group could be divided in three subgroups: (1) a 'top-level' group (n=13, with 15 hours training / week); (2) a 'subtop' group (n=13, with about 5 to 7 hours training / week), and (3) a 'recreational' group (n=10, with about 1 to 2 hours training / week). Besides stature and weight, ulnar variance was determined according to the method of Hafner *et al*. (1989) for immature wrists. Results for ulnar variance demonstrated that for all age categories a negative value was observed, which means that the distal end of the radius exceeds the distal end of the ulna. With increasing age, this negative ulnar variance became more pronounced, the mean varying from –3.4 mm to –6.5 mm. These results were rather uncommon and this from two viewpoints. Firstly, compared to reference girls (Hafner *et al*., 1989), where a relatively stable negative ulnar variance pattern can be observed throughout the growth period, varying between –2.5 mm at the age of 6 year and –2.8 mm at the age of 15 year; whereas in the gymnasts' sample, an increase in negative ulnar variance could be obeserved throughout the period studied. Secondly, based on the available literature, a rather 'positive ulnar variance' was expected. However, this was not the case in this longitudinal study, indicating that, in the sample studied, gymnastic training seems not to have a negative impact on the ulnar variance phenomenon. This observation was analyzed more in detail in that way, that two extreme groups with different training loads, were also compared. Results from these analyses revealed that no statistical differences in ulnar variance between the 'top-level' and the 'recreational' groups could be observed. Based on the results and within the limitations of their study, Claessens and co-workers (1997) came to the conclusion that the ulnar variance pattern is not directly caused by the gymnastic training load, and could not support the dose-response relationship. It is, however, clear that more longitudinal and intervention studies are needed before more exclusive interpretations can be made.

FACTORS RELATED TO THE ULNAR VARIANCE PHENOMENON

a) Methodological concerns

Different methods are at hand to measure ulnar variance in both mature and immature wrists (Hafner *et al*., 1989; Kristensen *et al*., 1986; Palmer *et al*., 1982). As a result discrepancies between results were obtained using different techniques and data from different studies are not directly comparable (Steyers and Blair, 1989).

In most studies ulnar variance is determined on unilateral radiographs arbitrarily chosen. However, some authors (Claessens *et al*., 1998; DiFiori *et al*., 1997; Freedman *et al*., 1998) have focussed on the problem of right versus left symmetry of ulnar variance. The results of these studies, however, are not unequivocal. DiFiori *et al*. (1997) and Freedman *et al*. (1998) have demonstrated that an individual's ulnar variance is not uniformly symmetrical with the consequence that results who were obtained from different wrists are not directly comparable. In contrast, in a study on 8 – 14 year old female gymnasts, Claessens *et al*. (1998) did not find a significant difference between ulnar variance taken from right and left radiographs. Also, differences in ulnar variance could not be observed between the dominant and non-dominant wrists, as determined by the rotational direction a wheel is turned.

b) Wrist pain and ulnar variance

Several authors claim that wrist pain in gymnasts is associated with a positive ulnar variance (Caine *et al*., 1996). However, based on data gathered on 27 girls and 17 boys, who could be classified as non-elite gymnasts, training on average 11.9 hours per week, DiFiori *et al*. (1997) did not find a significant association between ulnar variance and wrist pain. There was also no significant association between positive radiographic findings and ulnar variance.

c) Maturity status and ulnar variance

It is often argued that the less mature the gymnast, the more negative the impact of gymnastic training on the radial growth plate, and as a consequence, a more positive ulnar variance is observed. However, based on data gathered on 156 world-top immature female gymnasts, no significant relationship was found between skeletal age and ulnar variance, r=+0.16 (Claessens *et al*., 1996). When the data were analysed more in detail, it was clearly demonstrated that ulnar overgrowth was not associated with advanced maturity status of the radius or earlier epiphyseo-diaphyseal fusion; rather, ulnar overgrowth was apparently associated with more advanced maturity status of the ulna (Beunen *et al*., 1999).

d) Gymnastic training load and ulnar variance

In most studies, especially case-reports, a dose-response relationship between training and ulnar variance is suggested. Thus, the higher the gymnasts' training and/or competition level, the more pronounced positive ulnar variance. This cause-effect relationship, however, is not equivocal concluded by all authors and need further consideration. In a study on a representative sample of outstanding (participants world championships) female gymnasts, Claessens *et al*. (1996) did not find any significant correlation between training status and competition scores on the one hand, and ulnar variance on the other hand, correlation values varying from r=-0.11 (r between starting age and ulnar variance) and r=+0.15 (r between competition score uneven bars and ulnar variance). Also, DiFiori *et al*. (1997) did not find a significant association between ulnar variance and training history in 44 non-elite male and female gymnasts, aged 5.8 – 15.8 years. Also, based on data gathered on 36 female gymnasts who were followed longitudinally for four years, Claessens *et al*. (1997) could not demonstrate a significant influence of gymnastics training load and the ulnar variance phenomenon.

e) Body build and ulnar variance

It can be hypothesized that an 'overweight' or 'overfat' body, or a physique not fully suited for gymnastics, will be more at risk for overload or overuse injuries than a physique that is appropriate for the sport. It can thus be argued that the 'heavier' the gymnast, the higher the mechanical load on the gymnasts' wrists, resulting in a more pronounced positive ulnar variance. With the exception of some studies (Claessens *et al*, 1996; Boogaerts, 2002), most of the available studies of ulnar variance in gymnasts has taken the bodily characteristics of the subjects and/or patients into account. It is, however, clearly demonstrated, that female gymnasts competing at the elite level with a body physique characterized as relatively tall and a high lean body mass, not fat, are at greater risk in developing a positive ulnar variance.

f) Basic motor abilities and ulnar variance

To our knowledge, little is known if there is any relationship between the basic motor capacity or physical fitness condition of the gymnast and ulnar variance. However, it can be argued that the relative positioning of the ulna to the radius can be influenced by some motor abilities, in general, or especially at the wrist region (e.g. strength and flexibility characteristics of the wrist, fingers, and so on). Up till now, in none of the published material concerning ulnar variance this relationship was investigated. Very recently, this relationship was studied in a group (n=16) of 16-year old (SD=2.0) sub-top female gymnasts. (Vandenbussche, 2002) Significant correlations between ulnar variance and some motor capacities were found: with hyper extension of the fingers (r=+ 0.65); and with hyper extension of the elbow (r=+0.52). The results of this preliminary study suggest that more flexible gymnasts are at greater risk in developing a positive ulnar variance.

CONCLUSIONS

Based on the available literature of the ulnar variance in female gymnasts it can be concluded that, compared to the reference values, the observed positive ulnar variance in gymnasts is less 'dramatic' than originally stated. We support Rowlands' comment in his 'Editor's Notes' that "The available information is scant, and much more research is needed, but so far most of these seem to be largely false alarms … The psyche of the highly trained athlete, on the other hand, may be more susceptible to injury than the epiphysis" (Rowland, 1993, p. 300). However, the observed data from the literature poses at least the possibility that growth can be affected and the condition must certainty be taken seriously. More research is needed, especially well designed longitudinal studies taking into account a broad spectrum of factors which are connected to the ulnar variance phenomenon. Finally, the importance of optimal training programs, supervised by well-educated coaches, together with the guidance of the young gymnast by a highly qualified medical team, cannot be stressed enough.

REFERENCES

Albanese SA, Palmer AK, Kerr DR, Carpenter CW, Lisi D, Levinsohn EM (1989) Wrist pain and distal growth plate closure of the radius in gymnasts. *Journal of Pediatric Orthopaedics*, 9: 23-28.

Aldridge MJ (1987) Overuse injuries of the distal radial growth epiphysis. In TB Hoshizaki, JH Salmela, B Petiot (Eds). *Diagnostics, treatment and analysis of gymnastic talent.* Montréal: Sport Psyche Editions. Pp 25-30.

Bar-Or O (1996) *The child and adolescent athlete*. Oxford: Blackwell Scientific Publications.

Beunen G, Malina RM, Claessens AL, Lefevre J, Thomis M (1999) Ulnar variance and skeletal maturity of radius and ulna in female gymnasts. *Medicine and Science in Sports and Exercise,* 31: 653 – 657.

Boogaerts I (2002) *Relationship between ulnar variance and morphological characteristics in female gymnasts. A longitudinal study.* (Unpublished master thesis / Prom. Prof. A.L. Claessens) Leuven: Faculty of Physical Education and Physiotherapy, Katholieke Universiteit Leuven.

Caine DJ, Lindner KJ, Mandelbaum BR, Sands WA (1996) Gymnastics. In DJ Caine, CG Caine, KJ Lindner (Eds). *Epidemiology of Sports Injuries*. Champaign, Ill.: Human Kinetics Publishers. Pp 213 – 246.

Caine DJ, Howe W, Ross W, Bergman G (1997) Does repetitive physical loading inhibit radial growth in female gymnasts? *Clinical Journal of Sport Medicine*. 7: 302 – 308.

Carter SR, Aldridge MJ (1988) Stress injury of the distal radial growth plate. *Journal of Bone Joint Surgery (Br.)*, 70-B: 834-836.

Claessens AL (1999) Elite female gymnasts: a kinanthropometric overview. In FE Johnston, B Zemel, PB Eveleth (Eds). *Human growth in context*. London: Smith-Gordon. Pp: 273- 280.

Claessens AL (2001) Ulnar variance in female gymnasts: an overview. In M Lenoir, R Philippaerts (Eds). *Science in Artistic Gymnastics.* Gent (Belgium): Publicatiefonds voor Lichamelijke Opvoeding. Pp: 61-73.

Claessens AL, Veer FM, Stijnen V, Lefevre J, Maes H, Steens G, Beunen G (1991) Anthropometric characteristics of outstanding male and female gymnasts. *Journal of Sports Sciences*. 9: 53 - 74.

Claessens AL, Lefevre J, Beunen G, De Smet L, Veer AM (1996) Physique as a risk factor for ulnar variance in elite female gymnasts. *Medicine and Science in Sports and Exercise.* 28: 560 – 569.

Claessens AL, Lefevre J, Philippaerts R, Thomis M, Beunen G (1997) The ulnar variance phenomenon: a study in young female gymnasts. In N Armstrong, B Kirby, J Welsman (Eds) *Children and Exercise XIX. Promoting Health and Well-Being.* London: E & FN Spon, pp 537 – 541.

Claessens AL, Moreau M, Hochstenbach L (1998) Rotational direction and the ulnar variance phenomenon in young female gymnasts. *Journal of Sports Sciences*, 16: 431 – 432.

Chang C-Y, Shih C, Penn I-W, Tiu C-M, Chang T, Wu J-J (1995) Wrist injuries in adolescent gymnasts of a Chinese Opera School: radiographic survey. *Radiology,* 195: 861-864.

De Smet L, Claessens A, Lefevre J, Beunen G (1994) Gymnast wrist: an epidemiologic survey of ulnar variance and stress changes of the radial physis in elite female gymnasts. *The American Journal of Sports Medicine,* 22: 846 – 850.

DiFiori JP, Puffer JC, Mandelbaum BR, Dorey F (1997) Distal radial growth plate injury and positive ulnar variance in nonelite gymnasts. *The American Journal of Sports Medicine,* 25: 763- 768.

Freedman DM, Edwards GS, Willems MJ, Meals RA (1998) Right versus left symmetry of ulnar variance. *Clinical Orthopaedics and Related Research*, 354: 153 – 158.

Gould D (2001) The psychology of performance excellence: the case of elite gymnastics. In M Lenoir, R Philippaerts (eds.) *Science in Artistic Gymnastics.* Gent (Belgium): Publicatiefonds voor Lichamelijke Opvoeding, pp 39-60.

Hafner R, Poznanski AK, Donovan JM (1989) Ulnar variance in children: standard measurements for evaluation of ulnar shortening in juvenile rheumatoid arthritis, hereditary multiple exostosis and other bone or joint disorders in childhood. *Skeletal Radiology,* 18: 513 – 516.

Jemni M, Friemel F, Sands W, Mikesky A (2001) Evolution du profil physiologique des gymnastes durant les 40 dernieres annees. *Canadian Journal of Applied Physiology*, 26: 442-456.

Koh TJ, Grabiner MD, Weiker GG (1992) Technique and ground reaction forces in the back handspring. *The American Journal of Sports Medicine,* 20: 61-66.

Kristensen SS, Thomassen E, Christensen F (1986) Ulnar variance determination. *Journal of Hand Surgery (Br.),* 11: 255 – 257.

Malina RM (1999) Growth and maturation of elite female gymnasts: is training a factor? In FE Johnston, B Zemel, PB Eveleth (Eds). *Human growth in context*. London: Smith-Gordon, pp 291- 301.

Malina RM (2001) Growth and maturity of young artistic gymnasts: status, progress, and issues. In M Lenoir, R Philippaerts (Eds). *Science in Artistic Gymnastics.* Gent (Belgium): Publicatiefonds voor Lichamelijke Opvoeding, pp 21-38.

Mandelbaum BR, Bartolozzi AR, Davis CA, Teurlings L, Bragonier B (1989) Wrist pain syndrome in the gymnast: pathogenetic, diagnostic, and therapeutic considerations. *American Journal of Sports Medicine,* 17: 305 – 317.

Markolf KL, Shapiro MS, Mandelbaum BR, Teurlings L (1990) Wrist loading patterns during pommel horse exercises. *Journal of Biomechanics,* 23: 1001-1011.

Normile D (1996) Where is women's gymnastics going? *International Gymnast,* 38: 46 – 47.

Palmer AK, Glisson RR, Werner FW (1982) Ulnar variance determination. *Journal of Hand Surgery,* 7: 376 – 379.

Rowland TW (1993) Risks of sports participation in children: the Pretoria experience. *Pediatric Exercise Science,* 5: 299 – 300.

Ryan J (1995) *Little girls in pretty boxes: the making and breaking of elite gymnasts and figure skaters.* New York: Doubleday.

Steyers CM, Blair WF (1989) Measuring ulnar variance: a comparison of techniques. *The Journal of Hand Surgery*, 14A: 607-612.

Vandenbussche S (2002) *Ulnar variance as related to basic motor abilities in female gymnasts: a longitudinal study.* (Unpublished master thesis – in Dutch) / Prom. Prof. A.L. Claessens) Leuven: Faculty of Physical Education and Physiotherapy, Katholieke Universiteit Leuven.

Página deixada propositadamente em branco.

Part 2:

TALENT

Página deixada propositadamente em branco.

http://dx.doi.org/10.14195/978-989-26-1169-3_7

CHAPTER 7: PHYSICAL DEVELOPMENT OF YOUNG TALENTED TENNIS PLAYERS

Tamara Kramer
Barbara Huijgen
Marije T Elferink-Gemser
Jim Lyons
Chris Visscher

INTRODUCTION

"Talent" can be defined as ability above the normative average. Talented athletes perform better than peers during training and competition and have the potential to reach elite level (e.g., Elferink-Gemser, Visscher, Lemmink & Mulder, 2004; Helsen, Hodges, Van Winckel & Starkes, 2000; Howe, Davidson & Sloboda, 1998). Talent selection and identification, therefore, become important determinants of success in sport. They have been defined as the prediction of future performance of for example young tennis players or the identification of young players that will achieve success at national or international levels (MacCurdy, 2006). In tennis, there are many aspects that must be well developed to become a professional player. These components are physiological, physical, psychological, technical, and tactical (MacCurdy, 2006). According to MacCurdy (2006), physiological components are considered to be defined by height, weight as well as other anthropometric elements with physical aspects (e.g., running, jumping, agility, and power).

Psychological components are defined by levels of self-confidence, self-esteem, personality and motivation. Technical and tactical skills, however, are probably the most important aspects. Technique is important for being able to execute the correct moves with a minimum of error, whereas tactics refer to the ability to make rapid and correct decisions as play unfolds (MacCurdy, 2006). As might be expected, all of these aspects are better developed in talented as opposed to average tennis players although they must be further developed during youth and adolescence in order for talented players to advance to level of professional. While recognizing the relative importance of the psychological, technical, and tactical components of the skill, this review will concentrate on the physical attributes of a tennis player.

Tennis is an intermittent anaerobic sport, involving quick stops and starts, with an aerobic recovery phase (Fernandez, Mendez-Villanueva & Pluim, 2006). Research with regard to the physical development of young talented tennis players is not extensive. However, it is of relevance to know which aspects are important to become an elite senior player and how these aspects develop through the years from junior to senior elite player. Kovacs (2007), however, proposes that three general physical skills (anaerobic, aerobic and auxillary), and their constituent subcomponents, are important for tennis performance (figure 1). The anaerobic components include speed, agility, strength, power and muscular endurance. Speed refers to the running speed on court and off court and tennis specific speed (Kovacs, 2006). For a tennis player it is important to reach high velocity during the first meters of the sprint to the ball. Agility is the way of moving on the tennis court, for example, sprinting with changes of direction. In tennis you need to be able to change direction quickly to get to the ball (Kovacs, 2006). Thus, speed and agility are the ability to move around the court quickly and smoothly to position for a shot (Roetert, Piorkowski, Woods & Brown, 1995). Strength of the body parts and the power of the body are also anaerobic components and therefore also part of this review. Strength is the amount of weight you can lift or handle at any one time (Roetert et al., 1995). Strength is important for hitting the ball hard, however, also necessary for preventing injuries (Kovacs, 2006). Power is the amount of work one can perform in a given period (Roetert et al., 1995). Power is necessary for al the explosive movements that a player makes on the court (Kovacs, 2006). Muscular endurance is the number of times a muscle can lift a weight or how long muscles can hold an amount of weight (Roetert et al., 1995). Strokes in tennis could be very long, thus requiring good muscular endurance for hitting the ball hard constantly.

The aspects of the aerobic component are muscular and aerobic endurance. Muscular endurance, as mentioned earlier, is the number of times a muscle can lift a weight or how long muscles can hold an amount of weight (Roetert et al., 1995). In a tennis context, this is important for prolonged rallies later in the match. Aerobic endurance, on the other hand, refers to the ability to take in, transport and use oxygen (Roetert et al., 1995). In a study by Banzer, Thiel, Rosenhagen & Vogt (2008) it was found that VO_2max is a good indicator for the performance of a tennis player. VO_2max is the highest rate at which a player can consume oxygen during exercise, which reflects the aerobic fitness of a player. The higher the VO_2max of the player was the higher the rank of the player on the world ranking list was (Armstrong, Welsman & Winsley, 1996). Thus for aerobic capacity, the VO_2max is one of the outcome variables.

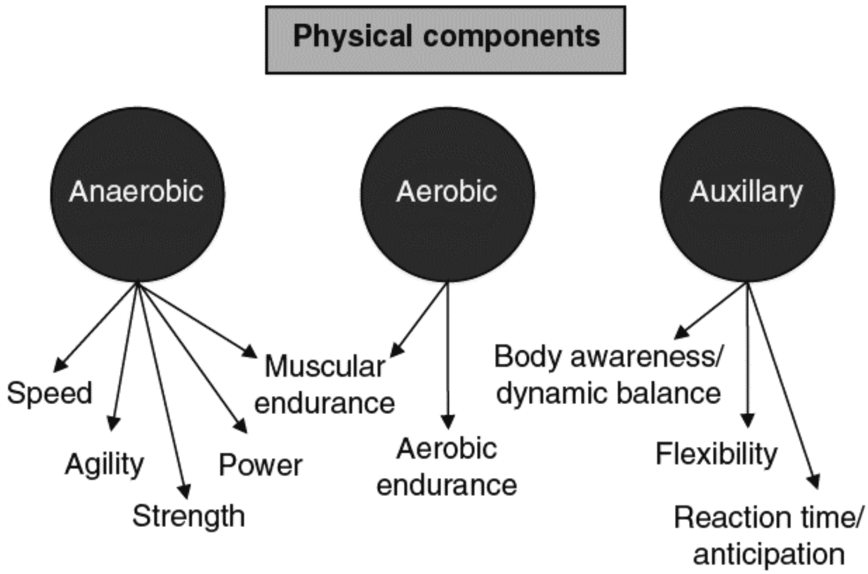


Figure 1. The physical skills and components relevant to tennis performance. Adjusted from Kovacs (2007).

The third physical component is termed auxillary. This component includes body awareness, dynamic balance, flexibility, reaction time and anticipation. The ability to recognize different parts of one's own body, and their relative positions is called body awareness. It is essential for performing smooth, coordinated movements, and must be well-developed in tennis Dynamic balance is necessary for tennis players, because they have to sprint, followed by quickly standing still to play a ball and they have to be in balance all the time. Flexibility is the motion that is available at a joint (Roetert et al., 1995). Flexibility is important for protecting against injuries (Chandler, Kibler, Stracener, Ziegler & Pace, 1992). Reaction time is needed for being able to react quickly on fast services or fast returns or strokes. Because of the interaction between the players on both sides of the net, anticipation of what the other players is going to do is an important aspect to develop.

Another study was found that tried to identify the normative scores for tennis talents (Roetert et al., 1995). In the study of Roetert, Garret & Brown (1992) it was found that physical performances are strongly related to ranking. The better the physical performance, the higher the ranking was. The aim of this review is to give an inside in the state of the art about development of physical performances in young talented tennis players.

Secondary aims of this review are to investigate if differences exist between the development of boys and girls in this area and if differences exist between elite and sub-elite tennis players.

METHODS

The limiting terms of the study were that the age of the population that has been studied in the articles were between 6-30 years. Articles with players in the age 6-18 years were preferred, although, articles with players aged between 18 and 30 years old were also allowed. The elite tennis players in this review are players that compete at an international or national level and the sub-elite tennis players are players that compete at a regional level. The non-elite players are players that are not better than the average tennis player. Only English written articles were included and all research designs were included. The searches were conducted using three common academic search engines: PubMed, LiveTrix and Google Scholar. There were no restrictions on publication dates of the articles. Search terms were based on the components for performance detailed by Kovacs (2007) as well as terms commonly associated with the game of tennis and with tennis players. Thus, the search terms used were tennis, racquet sport, talents, elite, adolescence, youth, performance, development, anaerobic, aerobic, physiological, physical, endurance, agility, speed, power, strength, muscular, flexibility, dynamic balance, body awareness, reaction time, anticipation, field test and on-court. Combinations of these search terms were also used. The reference sections of the articles identified via the search terms were also used to identify potentially relevant sources that may have been omitted in the initial search. The selection criteria for the articles used in this review were based upon the article title and the abstract of the article.

RESULTS

The search terms returned a total of 60 articles of which 17 were used for the components anaerobic, aerobic and auxillary. Of the 60 articles, 43 were excluded because these studies did not measure physical components that are in line with the interest of this review. Several articles included more than one component, and therefore all are included in the current review. For the anaerobic components, seven articles were found. The search for aerobic component produced 13 articles and for the auxillary component six articles were found. In the article of Kovacs, Pritchett, Wickwire, Green & Bishop (2007) age of the tested tennis players is not given, however since the players are college males, the assumption is that these males are between 18 and 22 years old.

Anaerobic component

<u>*a) Speed*</u>

For the sub-component speed, three articles were found. Speed in earlier tennis research was measured with over 5 metres, 10 metres and over 20 metres (Berg, Coetzee & Pienaar, 2006; Kovacs et al., 2007; Kraemer et al., 2003). These tests were simple sprints. Table 1 shows the results (see appendix). In the study of Berg et al. (2006), they compared early, middle and late maturation girls with each other. The late maturation group were the fastest on the 5 meter and 10 meter sprint. The second best were the early maturation group and than the middle maturation group. The studies of Kovacs (2007) and Kraemer et al. (2003) did not compare different groups of age. Furthermore, these studies could not be compared with each other because one study measured males and the other measured females. Males were faster than females on the speed tests.

<u>*b) Agility*</u>

A total of five articles were found that measured the agility sub-component however the tests that were used differed from each other. Berg et al. (2006) used the AIS test for agility (the AIS test was not explained in the article). Kovacs et al. (2007) used the spider test to measure the agility. With the spider test, a player picks up five tennis balls and places them in a rectangle behind the center of the baseline. The balls are located on the crossing of the single sideline with baseline, on the crossing of the service line and single sideline cross, and on the split of the service line with the middle service line. The total distance is not known from the article.

Kraemer et al. (2003) used a lateral agility test using regulation-sized tennis racquets modified from the USTA agility test protocol (United States Tennis Association, 1998). In this test, a tennis player has to move form the middle of the field 4.12 m to the forehand side, move back to the middle and then move to her backhand side.. The time it takes to execute this twice is the score. For further explanation of the test see Kraemer et al. (2003).

Roetert et al. (1992) also used the spider test (see above) and the hexagon test. The hexagon test is a test on the tennis court at which a hexagon is drawn with angles of 120 degrees and 24 inches (0.61 metre) per side. The player stands in the middle and jumps over a side of the hexagon and jumps back into it in a clockwise manner. The time this takes would be the score. Roetert et al. (1995) used the spider test, hexagon test and the lateral agility test to measure the agility The results of the articles are shown in table 1 (see appendix).

The AIS test could not be compared with other research, because no other articles using this test were revealed by the search. For the spider test, it was found that players got faster with increasing age. Only elite players were measured and males are faster than females across all age categories (12, 14 and 16 years). For the lateral agility test, at the age of 12 there are no differences in speed between the females and males. Looking at the age of 14 and 16, it was found that the males are faster. Again only elite players were measured. The hexagon test showed that males are faster at the age of 12 and 14, however, females are faster at the age of 16 years. Also with this test there only elite were players measured.

c) Strength

For the sub-component strength, eight articles were found in which strength is measured in different ways (Bencke et al., 2002; Berg et al., 2006; Bloomfield, Blanksby, Beard, Ackland & Elliot, 1984; Kovacs et al., 2007; Kraemer et al., 2003; Perry, Wang, Feldman, Ruth & Signotile, 2004; Roetert et al., 1992; Roetert et al., 1995). Grip strength, arm flexion, arm extension, thigh flexion and leg extension were the measurements. Grip strength was measured with a hand grip dynamometer (Berg et al., 2006; Bloomfield et al., 1984; Kovacs et al., 2007; Kraemer et al., 2003; Perry et al., 2004; Roetert et al., 1992; Roetert et al., 1995). Arm flexion was measured isometric with a dynamometer and sitting on a chair (Bencke et al., 2002; Bloomfield et al., 1984). Thigh flexion and leg extension were both measured by following the procedure developed by Clarke (1976). The results of these measurements are shown in table 2 (see appendix). It was found that that grip strength increased as function of age and males scored higher on grip strength than females across all ages. Elite players scored higher than the sub-elite players on grip strength and arm flexion strength. For thigh flexion and leg extension strength, it was found that strength increases with age.

d) Power

The search for articles that measured power revealed seven articles. The power measurements used in earlier research are vertical counter movement jump, squat jump and the Wingate test (Bencke et al., 2002; Berg et al., 2006; Bloomfield et al., 1984; Kovacs et al., 2007; Kraemer et al., 2003; Roetert et al., 1992; Roetert et al., 1995). Vertical counter movement jump is a jump in which the feet of the player are standing shoulder width apart and the player can only use his/her arms to jump as high as possible. The jump height in centimetres is the score (Bencke et al., 2002; Berg et al., 2006; Bloomfield et al., 1984; Kraemer et al., 2003; Roetert et al., 1992; Roetert et al., 1995).. With the squat jump, the player is already standing in squat position and than jumps as high as possible (Bencke et al., 2002). The Wingate test is performed on a cycle ergometer (Bencke et al., 2002; Kovacs et al., 2007; Kraemer et al., 2003). The players have to pedal as fast as possible for 30 seconds while the corresponding power is calculated. The power of a players, is the number of watts per kilogram body weight that a person can pedal for 30 seconds.

The results of these articles are shown in table 3 (see appendix). The articles showed that, for the jump data, elite scored better than non-elite and that power increased with age. The males had higher power scores than the females. For the Wingate data, it was shown that the elite females scored lower than the non-elite females. For the males the elite males scored higher than the non-elite males.

d) Anaerobic muscular endurance

No articles were found about the development of anaerobic muscular endurance in young tennis players.

Aerobic component

a) Aerobic muscular endurance

No articles were found about the development of aerobic muscular endurance in young tennis players.

b) Aerobic endurance

A total of 13 articles were found for aerobic endurance. Results show that the aerobic endurance development of young tennis players are mostly measured by VO_2max, heart rate during testing, as well with a 1 ½ mile run (Armstrong et al., 1996; Baxter-Jones, Goldstein & Helms, 1993; Bergeron et al., 1991; Cooke & Davey, 2008; Faff, Ladyga & Starczewska-Czapowska, 2000; Girard, Chevelier, Levegue, Micallef & Millet, 2006; Kovacs et al., 2007; Kraemer et al., 2003; Leone, Lariviere & Comtois, 2002; Perry et al., 2004, Roetert et al., 1992; Roetert et al., 1995). The VO_2max (explained in the introduction) is measured on a treadmill (Armstrong et al., 1996; Baxter-Jones et al., 1993; Bergeron et al., 1991; Cooke et al., 2008; Faff et al., 2000; Girard et al., 2006; Kovacs et al., 2007; Kraemer et al., 2003; Leone et al., 2002; Perry et al., 2004). During the 1 ½ mile run, the purpose is to run as fast as possible and the time it takes to complete this is the score (Roetert et al., 1992; Roetert et al., 1995). Only Berg et al. (2006) measured aerobic endurance with a shuttle run test. The shuttle run test is taken following the protocol given by the Australian coaching council (1998).

In table 4 (see appendix) the results of these articles are shown. Males have a higher VO_2max than females in all studies. The studies also showed that the VO_2max of males increases until they are 18 years old. The VO_2max of females increased during young adolescence (age 10 until 16), although, slightly decreased if the females are approximately 16 years old. Middle maturation females scored the best on the shuttle run test, the second best were the late maturation females and then the early maturation females. The time for the 1 ½ mile run is faster for males than for females. And when players get older they get faster on the 1 ½ mile run. Overall, the elite players scored higher on all aerobic tests than the sub-elite players.

Auxillary component

a) Body awareness/dynamic balance

No articles were found regarding the development of body awareness or dynamic balance in young tennis players.

b) Flexibility

A total of six articles were found that measured flexibility. The measurements included internal and external shoulder rotation, hamstring flexibility, arm flexion, gastrocnemicus, quadriceps, thigh rotation, ankle flexion and hip flexibility (Berg et al., 2006; Bloomfield et al., 1984; Chandler et al., 1990; Kibler & Chandler, 2003; Kovacs et al., 2007; Leone et al., 2002; Perry et al., 2004). In the article of Roetert & Ellenbecker (1998), a description of the shoulder internal and external flexibility test, and the hamstring flexibility test that Berg et al. (2006) used can be found. The method of measurement that were used in the article of Bloomfield et al. (1984), can be found in the book of Clarke (1976). All these flexibility measurements were done in degrees.

Chandler et al. (1990) measured shoulder flexibility with the athlete supine, the scapula stabilized, the shoulder abducted to 90 degrees, and the glenohumeral joint rotated into maximum internal and external rotation. Hamstring flexibility was measured with one leg of the athlete on the table, and the opposite leg actively raised and flexing the hip while keeping the knee fully extended. The quadriceps flexibility was measured with one leg of the athlete flexed at the hip and the knee held with the band close to the chest. The measured leg hung off the side of the table and the knee was flexed actively, and then taken the point of tension for the measurement to be taken. Gastrocnemicus flexibility was measured with the knee of the athlete in complete extension and the foot maximally dorsiflexed.

Kibler et al. (2003) measured shoulder rotation, hamstring flexibility, gastrocnemicus flexibility and quadriceps flexibility. The shoulder rotation was measured with supine with 90 degrees humeral adduction and than rotated internally or externally. Hamstring flexibility was measured supine and flexion of the hip measured while the leg is extended. Gastrocnemius was measured supine with straight leg and then making a dorsiflex movement in the ankle. The quadriceps flexibility was measured while the subject lying on a table with the leg of the side and then flexing the knee.

Kovacs et al. (2007) measured the internal and external shoulder range of motion (ROM). The players were tested in a supine position with 90 degrees of glenohumeral joint abduction. The universal goniometer axis was aligned with the long axis of the humerus, with the distal most tip of the olecranon being the superficial landmark for alignment. The stationary arm of the goniometer was placed in a vertical position with the moving arm aligned with the lateral aspect of the ulna. Starting at the anatomical zero rotation position in 90 degrees of abduction, the players were asked to maximally externally rotate their shoulder. Hamstring flexibility was measured similarly in Chandler et al. (1990). Hip flexibility was measured as described in Ross, Nordeen & Barido (2003). Quadriceps flexibility was measured so that the participants lay prone on a table and the goniometer was set so that the stationary arm was aligned with the greater trochanter; the moving arm was aligned with the fibular head and lateral malleolus. The axis was placed over the lateral femoral epicondyle. Passive ROM in the sagittal plane was then assessed with the involved knee beginning at 90 degrees from the table (horizontal) and then the participant was instructed to flex the knee while maintaining a neutral spine.

In the article by Perry et al. (2004), shoulder rotation was measured while the subject was lying on a hard and flat surface with the shoulder of the dominant side stabilized and arm abducted to 90 degrees. The players were asked to rotate their glenohumeral joint to pain-free range of motion first internally and second externally.

The results are shown in table 5 (see appendix). They show that flexibility decreases with age however there are no differences between elite and sub-elite tennis players. It should be noted here that not all the measurements were done in both groups. The females are more flexible in general than males.

c) Reaction time/ anticipation

No useful articles were found about development of reaction time or anticipation.

DISCUSSION

The aim of this review was to gain insight into the physical factors underlying the development of young talented tennis players. Secondary aims of this review were to investigate if differences exist between the development of males and females in this area and if differences exist between elite and sub-elite tennis players. In summary, the results suggest that for all three physical components identified by Kovacs (2007), anaerobic, aerobic and auxillary, the elite players scored higher than the sub-elite or the non-elite and males scored higher than females in general. For the anaerobic component aspect of speed, it was found that elite players scored higher than sub-elite players and that males scored higher than females. In terms of agility, it was found that males are faster than females in general, and for speed it was found that speed increased by an increase of age. During late adolescence, higher scores on strength were found during the early youth, and males scored higher than females. The elite tennis players scored higher than the sub-elite players. Power increases with age and males have greater power than females. Elite female players scored lower on the Wingate test than sub-elite female players although elite male players scored higher on the Wingate test than sub-elite males. With respect to the aerobic endurance aspect, it was found that males improve to a greater degree with age than do females. VO_2max in females peaking at age 16. In general, males scored higher than females on all the aerobic endurance tests and the same is the case for elite players compared with sub-elite players. Earlier studies regarding the auxillary sub-component only considered flexibility with this characteristic. Flexibility decreasing with age for both genders but with females were more flexible than males overall.

There were no consistent differences in flexibility between elite and sub-elite tennis players.

The aspect speed was measured with tests over short distances (5, 10 and 20 m). The three different articles that measured speed used the same tests. However, these researchers only measured one group of elite tennis players who were 18-22 years old. The rest of the players were sub-elite players thus comparisons of these groups with each other is difficult. The elite group was faster than the sub-elite, however the elite players were older and males were compared with younger sub-elite females (Berg et al., 2006; Kovacs et al., 2007; Kraemer et al., 2003). More information regarding the speed of talented tennis players would be necessary for comparing elite groups of different ages and to determine appropriate reference values. It is interesting that there is so little information regarding speed in the tennis physiology literature. This is particularly true given that it is such an important aspect of the game. Simply put, the faster a tennis player can get to the ball the more time a he/she has to prepare for a shot (Roetert et al., 1995). In earlier cross-sectional research, it was found that talented youth soccer players show improvement on sprinting tests with increasing age (Rosch et al., 2000; Vanderford, Meyers, Skelly, Stewart & Hamilton, 2004). It can be hypothesized that these results might also be found in a group of tennis players with different ages, however, further research is needed to test this hypothesis.

The anaerobic component agility allows for a player to be in the correct position and provides a solid platform from which to hit the ball (Roetert et al., 1995). Agility is crucial to good court movement (Salonikidis & Zafeiridis, 2008). Agility tests were seen as the most important predictor for ranking the junior tennis players (Kovacs, 2006). Only one study however (Roetert et al., 1995), compared different age groups across this dimension. This study showed that males and females showed increased agility at increasing ages. A reason for this might be the natural processes of growth and maturation (Nedeljkovic, Mirkov, Kukolj, Ugarkovic & Jaric, 2007). For example, longer legs could help to be faster. Roetert et al. (1995) also showed that males have better agility than females. This could be explained by the assumption that females have higher fat percentage than males and this could explain why the males are faster (Praagh & Dore, 2002), beacause higher fat percentage leads to less muscles and thus lower agility. The current review showed that sub-elite players are less fast on the agility tests than elite tennis players. This could show that agility is an important factor and maybe a differentiated factor for being elite or a sub-elite player.

On reason that strength is important in tennis is for reducing injuries (Roetert et al., 1995). The results presented in the reviewed literature suggest that elite tennis players are stronger than sub-elite or non-elite tennis players.

In general, elite players train more often than sub-elite or non-elite tennis players. For elite players, strength is perhaps even more important because of preventing overuse injuries. Differences were also found between age groups with older players, older players shown to be stronger than the younger players. In the article by Naughton, Farpour-Lambert, Carlson, Bradney & Praagh (2000), it was found that strength can be developed through training it is also a natural part of growth and maturation. The gender differences that are visible in general life, such as males being stronger than females, are also found in the current review with respect to tennis players. Not only strength is important for tennis, explosive movements for which power is needed are required as well. Greater power allows a tennis player to respond more quickly and to produce forceful movements with less effort. Players with greater power get into position quickly and can make effective shots (Roetert et al., 1995). Earlier research showed that power increases until 14 years of age and after this age a plateau would be reached (Malina, Bouchard & Bar-Or, 2004; Wilmore & Costill, 1999). This idea is not found in the current review where it was found that power increases in talented tennis players at least until the age of 16. The males in the current review scored higher on all tests than did females, perhaps due to gender specific differences in body compositions and hormones (Praagh et al., 2002; Naughton et al., 2000). As well, elite players scored higher than the sub-elite or non-elite players explained perhaps by greater levels of training (Elferink-Gemser, Visscher, Duijn & Lemmink, 2006; Praagh et al., 2002) No article was found that looked at the training hours of elite tennis players and sub-elite tennis players, further research is necessary to look at the differences in training hours between elite and sub-elite tennis players.

No articles were found concerning anaerobic and aerobic muscular endurance development in talented tennis players. One reason might be that coaches are not as interested in muscular endurance as in the physical aspects such as speed, agility, power, strength and aerobic endurance. It was found that aerobic endurance increases with age (Baxter-Jones et al., 1993). In the study by Baxter-Jones et al. (1993) that followed 453 young athletes drawn from soccer, swimming, gymnastics, and tennis for three years. With 8, 10, 12, 14 and 16 years of age it was found that the VO_2max of males increased significantly with increasing ages where as females showed a similar pattern. However, the significant increase in VO_2max found in males in the latter stages of puberty was not shown in females. This is also found in the current review, however, with females' aerobic performance slightly decreased after the age of 16. An explanation for this would be that VO_2max increases with body weight and females that are 16 years old do not increase their body weight much anymore (Baxter-Jones et al., 1993). In the study by Naughton et al. (2000), it was found that females develop VO_2max less well than do males.

Elferink-Gemser et al. (2006) showed as well that females develop their VO_2max until the age of 16 and after that age a plateau is reached.

With respect to the auxillary component, external shoulder rotation increases with age as part of flexibility. The increases in shoulder external rotation in tennis players is also a likely adaptation to the tennis serve (Chandler et al., 1990). Furthermore, the internal shoulder rotation decreases with age with tennis players especially on the dominant side (Berg et al., 2006; Chandler et al., 1990). The decrease in shoulder internal rotation, particularly on the dominant side, can be explained as an adaptation of the posterior shoulder musculature to the tennis stroke (Chandler et al., 1992). Tennis athletes showed a greater internal shoulder rotation in their dominant arm than other athletes, however, they also have a smaller range of external rotation (Kovacs, 2006). Tightness in internal rotation in tennis players can be a source of potential injury and decreased performances (Chandler et al., 1990). With respect to the hamstring flexibility, it was found that this is reasonably stable during the ages of 5 to 11 years, after which it increases up until the age of 15 (Berg et al., 2006). Early maturation girls showed more flexibility than the middle and late maturation girls. Young elite tennis players have better flexibility than young sub-elite tennis players. This could be a result of elite players knowing the importance of good hamstring flexibility and perhaps thereby training more on flexibility than do sub-elite players. Hamstring flexibility is important for stopping, starting, running, and jumping on the tennis court (Roetert et al., 1995). Hip flexibility is lower in elite than non-elite players (Bloomfield et al., 1984). In this review, hip flexibility is measured only at male elite tennis players and could not be compared with another group of players. The overall finding for flexibility is that flexibility decreases with age. Perhaps the idea that a baby is very flexible and if a child does not train his or her flexibility it decreases could explain why flexibility decreases with age. This also seems the case with tennis players, but further research is necessary to explain why flexibility decreases with age. Perhaps tennis players should pay more attention to their flexibility and the importance of flexibility in reducing injuries.

In general, the groups of players tested on physical skills were rather small. Only the study by Roetert et al. (1995) used large groups of players. However, the population of talented tennis players is not very large in general. As well, the countries of the studies differ. Most studies were conducted in the USA although there are also studies conducted in Denmark and South Africa. Most of the studies are also cross-sectional in nature while longitudinal studies would be preferred for following the observation of development of talented tennis players. A recommendation for further research would thus be to do a longitudinal study. The current review suggests that many differences between countries and studies exist in the way development in young talented tennis players is measured. A worldwide protocol in which the test procedure of development of tennis players would be described is recommended. The results of this current review suggest that it is important to develop all three physical components, anaerobic, aerobic and auxillary, to become a professional tennis player. Differences exist between the development of males and females as well as between elite and sub-elite tennis players. A worldwide protocol which describes the way in which physical development in young talented tennis players should be measured ideally, is also needed. This could be done by means of a standardized protocol for different levels and age groups, so that these groups can be compared with each other. Therefore it is necessary to conclude what qualities are required during youth to ultimately reach the top in tennis.

REFERENCES

Armstrong N, Welsman J, & Winsley R (1996). Is peak VO2 a maximal index of children's aerobic fitness? *International Journal of Sports Medicine.*, *17*, 356-359.

Australian Coaching Council (1998). *20m shuttle run test.* Australian sport commission: Belconnen, ACT.

Banzer W, Thiel C, Rosenhagen A, & Vogt L (2008). Tennis ranking related to exercise capacity. *British Journal of Sports Medicine, 42*, 152-154.

Baxter-Jones A, Goldstein H, & Helms P (1993). The development of aerobic power in young athletes. *Journal of Applied Physiology, 75*, 1160-1167.

Bencke J, Damsgaard R, Saekmose A, Jorgensen P, Jorgensen K, & Klausen K (2002). Anaerobic power and muscle strength characteristics of 11 years old elite and non-elite boys and girls from gymnastics, team handball, tennis and swimming. *Scandinavian Journal of Medicine & Science in Sports, 12*, 171-178.

Berg Lvd, Coetzee B, & Pienaar AE (2006). The influence of maturation on physical and motor performance talent identification determinants of U-14 provincial girl tennis players. *Journal of Human Movement Studies, 50*, 273-290.

Bergeron MF, Maresh CM, Kraemer WJ, Abraham A, Conroy B, & Gabaree C (1991). Tennis: a physiological profile during match play. *International Journal of Sports Medicine, 12*, 474-479.

Bloomfield J, Blanksby BA, Beard DF, Ackland TR, & Elliott BC (1984). Biological characteristics of young swimmers, tennis players and non-competitors. *British Journal of Sports Medicine, 18,* 97-103.

Chandler TJ, Kibler WB, Stracener EC, Ziegler AK, & Pace B (1992). Shoulder strength, power, and endurance in college tennis players. *The American Journal of Sports Medicine, 20*, 455-458.

Chandler TJ, Kibler WB, Uhl TL, Wooten B, Kiser A, & Stone E (1990). Flexibility comparisons of junior elite tennis players to other athletes. *The American Journal of Sports Medicine, 18*, 134-136.

Clarke HH (1976). *Application of measurement to health and physical education.* New Jersey: Prentice-Hall.

Cooke K, & Davey P (2008). Predictors of oxygen uptake and performance during tennis. *International Journal of Sports Medicine, 29*, 34-39.

Elferink-Gemser MT, Visscher C, Lemmink KAPM, Mulder Th (2004). Relation between multidimensional performance characteristics and level of performance in talented youth field hockey players. *Journal of Sports Sciences, 22*, 1053-1063.
Elferink-Gemser MT, Visscher C, van Duijn MA, & Lemmink KAPM (2006). Development of the interval endurance capacity in elite and sub-elite youth field hockey players. *British Journal of Sports Medicine, 40*, 340-345.
Faff J, Ladyga M, & Starczewska-Czapowska J (2000). Physical fitness of the top Polish male and female tennis players aged from twelve years to senior category. *Biology of Sport, 17*, 179-192.
Fernandez J, Mendez-Villanueva A, & Pluim BM (2006). Intensity of tennis match play. *British Journal of Sports Medicine, 40*, 387-391.
Girard O, Chevalier R, Leveque F, Micallef JP, & Millet GP (2006). Specific incremental field test for aerobic fitness in tennis. *British Journal of Sports Medicine,. 40*, 791-796.
Helsen WF, Hodges NJ, Van Winckel J and Starkes JL (2000). The roles of talent, physical precocity and practice in the development of soccer expertise*. Journal of Sports Sciences*, *18,* 727-736.
Howe MJA, Davidson JW and Sloboda JA (1998). Innate talents: Reality or myth. *Behavioral and Brain Sciences*, *21*, 399-442.
Kibler WB, & Chandler TJ (2003). Range of motion in junior tennis players participating in an injury risk modification program. *Journal of Sports Science and Medicine, 6*, 51-62.
Kovacs MS (2006). Applied physiology of tennis performance. *British Journal of Sports Medicine, 40*, 381-385.
Kovacs MS (2007). Tennis physiology: training the competitive athlete. *Sports Medicine, 37*, 189-198.
Kovacs MS, Pritchett R, Wickwire PJ, Green JM, & Bishop P (2007). Physical performance changes after unsupervised training during the autumn/spring semester break in competitive tennis players. *British Journal of Sports Medicine, 41*, 705-710.
Kraemer WJ, Hakkinen K, Triplett-Mcbride NT, Fry AC, Koziris, LP, Ratamess NA, Bauer JE, Volek JS, McConnell T, Newton RU, Gordon SE, Cummings D, Hauth J, Pullo F, Lynch JM, Fleck SJ, Mazzetti SA, & Knuttgen HG (2003). Physiological changes with periodized resistance training in women tennis players. *Medicine & Science in Sports & Exercise, 35*, 157-168.
Leone M, Lariviere G, & Comtois AS (2002). Discriminant analysis of anthropometric and biomotor variables among elite adolescent female athletes in four sports. *Journal of Sports Sciences, 20*, 443-449.
MacCurdy D (2006). Talent identification around the world and recommendations for the chinese tennis association. *ITF Coaching*, 1-10.
Malina RM, Bouchard C, & Bar-Or O (2004). *Growth, maturation and physical activity.* Champaign, IL: Human Kinetics Publishers.
Naughton G, Farpour-Lambert NJ, Carlson J, Bradney M, & van Praagh PE (2000). Physiological issues surrounding the performance of adolescent athletes. *Sports Medicine, 30*, 309-325.
Nedeljkovic A, Mirkov DM, Kukolj M, Ugarkovic D, & Jaric S (2007). Effect of maturation on the relationship between physical performance and body size. *The Journal of Strength & Conditioning Research,. 21*, 245-250.

Perry AC, Wang X, Feldman BB, Ruth T, & Signorile J (2004). Can laboratory-based tennis profiles predict field tests of tennis performance? *The Journal of Strength & Conditioning Research, 18*, 136-143.

Praagh Ev, & Dore E (2002). Short-term muscle power during growth and maturation. *Sports Medicine, 32*, 701-728.

Roetert EP, Garrett GE, & Brown SW (1992). Performance profiles of nationally ranked junior tennis players. *Journal of Applied Sport Science Research, 6,* 225-231.

Roetert EP, Piorkowski PA, Woods RB, & Brown SW (1995). Establishing percentiles for junior tennis players based on physical fitness testing results. *Clinics in Sports Medicine , 14*, 1-21.

Roetert P, & Ellenbecker TS (1998). *Complete conditioning for tennis.* Champaign: Human Kinetics Publisher.

Rosch D, Hodgson R, Peterson TL, Graf-Baumann T, Junge A, Chomiak J, & Dvorak J (2000). Assessment and evaluation of football performance. *The American Journal of Sports Medicine, 28*, S29-S39.

Ross MD, Nordeen MH, & Barido M (2003). Test-retest reliability of Patrick's hip range of motion test in healthy college-aged men. *The Journal of Strength & Conditioning Research, 17*, 156-161.

Salonikidis K, & Zafeiridis A (2008). The effects of plyometric, tennis-drills, and combined training on reaction, lateral and linear speed, power, and strength in novice tennis players. *The Journal of Strength & Conditioning Research, 22*, 182-191.

United States Tennis Association (1998). *Complete Conditioning for Tennis.* Champaign, IL: Human Kinetics.

Vanderford ML, Meyers MC, Skelly WA, Stewart CC, & Hamilton KL (2004). Physiological and sport-specific skill response of olympic youth soccer athletes. *The Journal of Strength & Conditioning Research, 18*, 334-342.

Wilmore JH, & Costill DL (1999). *Physiology of sport and exercise.* Champaign, IL: Human Kinetics Publishers.

APPENDIX

Table 1. Results of the anaerobic development of young tennis players regarding the aspects speed and agility.

Characteristics					
Author	N	Age (years)	Gender	Country/level	Level
Berg et al. (2006)	4	13.00±1.27	F	South Africa/talents (Early maturation)	SE
	11	12.96±0.53	F	South Africa/talents (Middle maturation)	SE
	10	13.59±0.68	F	South Africa/talents (Late maturation)	SE
Kovacs et al. (2007)	8	18-22	M	USA/NCAA Division I	E
Kraemer et al. (2003)	30	19.3±1.6	F	USA/ USTA ranking	SE
Roetert et al. (1992)	83	8-12	M	USA/USTA ranking	E
Roetert et al. (1995)	148	12	F	USA/USTA ranking	E
	219	14	F	USA/USTA ranking	E
	61	16	F	USA/USTA ranking	E
	158	12	M	USA/USTA ranking	E
	241	14	M	USA/USTA ranking	E
	66	16	M	USA/USTA ranking	E

Speed			
Author	Speed 5 meter (s)	Speed 10 meter (s)	Speed 20 meter (s)
Berg et al. (2006)	1.34±0.16	2.25±0.24	
	1.41±0.14	2.32±0.18	
	1.31±0.10	2.21±0.12	
Kovacs et al. (2007)	1.07±0.03	1.79±0.03	3.07±0.05
Kraemer et al. (2003)		2.22±0.10	3.83±0.27
Roetert et al. (1992)			

Agility				
Author	AIS (s)	Spider test (s)	Lateral agility test (s)	Hexagon test (s)
Berg et al. (2006)	9.46±0.77			
	9.57±0.61			
	9.39±0.75			
Kovacs et al. (2007)		16.50±0.17		
Kraemer et al. (2003)			7.07±0.95	
Roetert et al. (1992)		18.85±1.26		15.93±2.66
Roetert et al. (1995)		<17.2	<6.4	<10.4
		<16.7	<6.2	<10.0
		<16.6	<6.0	<9.9
		<17.0	<6.4	<10.6
		<15.8	<6.0	<10.3
		<15.0	<5.7	<10.0

Table 2. Results of the anaerobic development of young tennis players regarding the aspect strength.

Author	N	Age (years)	Gender	Country/level	Level
Bencke et al. (2002)	6	11.9 (10.0-12.2)	F	Denmark/Elite	E
	7	11.7 (9.4-12.7)	F	Denmark/NonElite	NE
	12	11.9 (10.5-12.7)	M	Denmark/Elite	E
	12	11.1 (10.0-12.7)	M	Denmark/NonElite	NE
Berg et al. (2006)	4	13.00±1.27	F	South Africa/talents (Early maturation)	SE
	11	12.96±0.53	F	South Africa/talents (Middle maturation)	SE
	10	13.59±0.68	F	South Africa/talents (Late maturation)	SE
Bloomfield et al. (1984)	10	7-8	F/M	Australia/Elite	E
	32	9-10	F/M	Australia/Elite	E
	23	11-12	F/M	Australia/Elite	E
Kovacs et al. (2007)	8	18-22	M	USA/NCAA Division I	E
Kraemer et al. (2003)	30	19.3±1.6	F	USA/ USTA ranking	SE
Roetert et al. (1992)	83	8-12	M	USA/USTA ranking	E

Author	Grip strength Dominant hand (kg)	Grip strength non dominant hand (kg)	Dominant arm Flexion Isometric (kg)	Dominant arm extension isomotric (kg)
Bencke et al. (2002)			25.3 (21.2-45.7)	27.5 (21.8-47.2)
			20.1 (11.4-39.1)	28.8 (11.6-37.7)
			30.0 (16.7-48.0)	30.7 (16.2-55.0)
			25.6 (20.6-37.5)	28.4 (24.9-38.3)
Berg et al. (2006)	33.37±6.60	27.00±6.00		
	29.63±4.64	25.77±4.62		
	29.00±6.05	24.05±4.75		
Bloomfield et al. (1984)	7.4±2.9			15.8±3.2
	11.0±2.5			18.8±3.7
	15.0±3.4			20.4±4.8
Kovacs et al. (2007)	53.13±1.79	46.00±2.28		
Kraemer et al. (2003)	330.6±40.3 (newton)	261.9±20.6 (newton)		
Roetert et al. (1992)	21.95±5.77	18.55±5.08		

Author	Non Dominant arm flexion isometric (kg)	Non Dominant arm extension Isometric (kg)	Thigh flexion strength (kg)	Leg extension strength (kg)
Bencke et al. (2002)	23.7 (17.3-40.2)	26.1 (18.8-34.6)		
	25.3 (9.6-41.9)	27.2 (12.6-31.1)		
	21.7 (13.3-43.1)	28.8 (14.1-52.1)		
	24.9 (16.2 32.6)	28.5 (21.5-34.6)		
Bloomfield et al. (1984)			22.4±2.9	26.9±5.3
			28.8±4.6	32.1±5.9
			33.5±9.0	36.4±8.2

Table 3. Results of the anaerobic development of young tennis players regarding the aspect power

Author	N	Age (years)	Gender	Country	Level
Bencke et al. (2002)	6	11.9 (10.0-12.2)	F	Denmark/Elite	E
	7	11.7 (9.4-12.7)	F	Denmark/NonElite	NE
	12	11.9 (10.5-12.7)	M	Denmark/Elite	E
	12	11.1 (10.0-12.7)	M	Denmark/NonElite	NE
Berg et al. (2006)	4	13.00±1.27	F	South Africa/talents (Early maturation)	SE
	11	12.96±0.53	F	South Africa/talents (Middle maturation)	SE
	10	13.59±0.68	F	South Africa/talents (Late maturation)	SE
Bloomfield et al. (1984)	10	7-8	F/M	Australia/Elite	E
	32	9-10	F/M	Australia/Elite	E
	23	11-12	F/M	Australia/Elite	E
Kovacs et al. (2007)	8	18-22	M	USA/NCAA Division I	E
Kraemer et al. (2003)	30	19.3±1.6	F	USA/ USTA ranking	SE
Roetert et al. (1992)	83	8-12	M	USA/USTA ranking	E
Roetert et al. (1995)	148	12	F	USA/USTA ranking	E
	219	14	F	USA/USTA ranking	E
	61	16	F	USA/USTA ranking	E
	158	12	M	USA/USTA ranking	E
	241	14	M	USA/USTA ranking	E
	66	16	M	USA/USTA ranking	E

Author	Vertical counter movement Jump (cm)	Squat jump (cm)	Wingate test (Watt)	WIngate test (watts/kg)
Bencke et al. (2002)	24.5 (22-27)	23.0 (22-26)	279 (233-433)	7.2 (6.4-7.7)
	24.0 (20-33)	23.0 (20-30)	317 (186-418)	7.5 (5.9-8.8)
	26.0 (21-36)	25.5 (19-29)	314 (205-529)	7.4 (6.7-9.1)
	26.5 (21-34)	24.5 (19-28)	272 (232-430)	7.3 (6.7-8.3)
Berg et al. (2006)	26.75±4.71			
	27.86±4.68			
	23.25±7.64			
Bloomfield et al. (1984)	20±4			
	25±5			
	28±6			
Kovacs et al. (2007)				8.53±0.19
Kraemer et al. (2003)	40±8		570±78	
Roetert et al. (1992)	36.88±6.05			
Roetert et al. (1995)	>39.62			
	>47.24			
	>48.26			
	>43.94			
	>52.58			
	>63.75			

Table 4. Results of the aerobic development of young tennis players regarding the aspect aerobic endurance

Author	N	Age (years)	Gender	Country/level	Level
Armstrong et al. (1996)	18	9.9±0.4	F	UK/--	--
	17	9.9±0.4	M	UK/--	--
Baxter-Jones et al. (1993)	160	10.7±0.8	F	UK/young athletes	E
		12.0±1.0	F	UK/young athletes	E
		15.5±1.9	F	UK/young athletes	E
	149	11.6±1.3	M	UK/young athletes	E
		13.0±1.2	M	UK/young athletes	E
		16.2±1.7	M	UK/young athletes	E
Berg et al. (2006)	4	13.00 ±1.27	F	South Africa/talents (Early maturation)	SE
	11	12.96± 0.53	F	South Africa/talents (Middle maturation)	SE
	10	13.59 ±0.68	F	South Africa/talents (Late maturation)	SE
Bergeron et al. (1991)	10	20.3 ±2.5	M	USA/Division I	SE
Cooke et al. (2008)	8	23±8	F	Republic of Singapore/ rating 3.1 or lower	SE
	8	20±6	M	Republic of Singapore/ rating 3.1 or lower	SE
Faff et al. (2000)	7	12.0-13.0	M	Poland/ top tennis players	E
	10	13.1-14.0	M	Poland/ top tennis players	E
	15	14.1-15.0	M	Poland/ top tennis players	E
	17	15.1-16.0	M	Poland/ top tennis players	E
	14	16.1-18.0	M	Poland/ top tennis players	E
	9	> 18.0	M	Poland/ top tennis players	E
	6	12.0-13.0	F	Poland/ top tennis players	E
	17	13.1-14.0	F	Poland/ top tennis players	E
	12	14.1-15.0	F	Poland/ top tennis players	E
	16	15.1-16.0	F	Poland/ top tennis players	E
	4	16.1-18.0	F	Poland/ top tennis players	E
	6	> 18.0	F	Poland/ top tennis players	E
Girard et al. (2006)	9	16.0±1.6	M	France/junior competitive	E/NE
Kovacs et al. (2007)	8	18-22	M	USA/NCAA Division I	E
Kraemer et al. (2003)	30	19.3±1.6	F	USA/ USTA ranking	SE
Leone et al. (2002)	15	13.9±1.3	F	Canada/elite	E
Perry et al. (2004)	10	14.70±1.49	F	USA/USTA ranking	E
	23	15.09±1.31	M	USA/USTA ranking	E
Roetert et al. (1992)	83	8-12	M	USA/USTA ranking	E
Roetert et al. (1995)	148	12	F	USA/USTA ranking	E
	219	14	F	USA/USTA ranking	E
	61	16	F	USA/USTA ranking	E
	158	12	M	USA/USTA ranking	E
	241	14	M	USA/USTA ranking	E

Author	VO_2max (ml/kg/min) (treadmill)	Heart rate (beats/min) during treadmill	Heart rate during match play (beats/min)	Shuttle run test (Level)	1 ½ mile run (min:sec)
Armstrong et al. (1993)	51±6 62±6	211±9 203±3			
Baxter-Jones et al. (1993)	47.4±5.8 48.6±5.3 47.1±5.3 54.1±5.2 57.6±5.6 59.5±6.1				
Berg et al. (2006)				6.80 ±1.08 7.35 ±1.59 7.15 ±0.74	
Bergeron et al. (1991)	58.5±9.4	195.6± 6.3	144.6±13.2		
Cooke et al. (2008)	52.8±6.8 64.8±6.8				
Faff et al. (2000)	55.8±4.4 60.1±2.4 61.0±3.6 60.6±3.6 59.7±4.6 62.3±4.8 54.7±5.2 56.2±5.1 53.5±4.4 52.5±3.2 56.6±3.2 55.8±3.3	198±6 202±9 201±4 197±8 196±7 197±9 205±11 204±7 204±8 201±7 201±5 190±11			
Girard et al. (2006)	57.4±6.4	194.3±6.7			
Kovacs et al. (2007)	53.9±1.11				
Kraemer et al. (2003)	45.7±2.2				
Leobe et al. (2002)	49.5±4.4				
Perry et al. (2004)	45.62±4.72 56.01±5.66				
Roetert et al. (1992)					755.17±111.48
Roetert et al. (1995)					<640 <630 <615 <600 <565

Table 5. Results of the auxillary development of young tennis players regarding the aspect flexibility

Author	N	Age (years)	Gender	Country	Level
Berg et al. (2006)	4	13.00±1.27	F	South Africa/talents (Early maturation)	SE
	11	12.96±0.53	F	South Africa/talents (Middle maturation)	SE
	10	13.59±0.68	F	South Africa/talents (Late maturation)	SE
Bloomfield et al. (1984)	10	7-8	F/M	Australia/Elite	E
	32	9-10	F/M	Australia/Elite	E
	23	11-12	F/M	Australia/Elite	E
Chandler et al. (1990)	86	15.4 (13-22)	F/M	USA/Elite	E
Kibler et al. (2003)	29	13.6	M	USA/National ranking	SE
	22	13.2	F	USA/National ranking	SE
Kovacs et al. (2007)	8	18-22	M	USA/NCAA Division I	E
Perry et al. (2004)	10	14.70±1.49	F	USA/USTA ranking	E
	23	15.09±1.31	M	USA/USTA ranking	E

	Upper body flexibility				
Author	Arm flexion-extension (deg)	Internal shoulder rotation (deg) Non Dominant	Internal shoulder rotation (deg) Dominant	External shoulder rotation (deg) Non Domimant	External shoulder rotation (deg) Dominant
Berg et al. (2006)		92.00±17.37	88.25±12.99	100.75±13.07	108.25±16.00
		102.00±19.29	99.36±21.22	106.27±10.36	114.09±10.22
		100±13.9	92.7±10.85	104.8±9.75	107.2±10.19
Bloomfield et al. (1984)	238.0±9.0				
	240.0±14.0				
	231.0±14.0				
Chandler et al. (1990)		76±12	65±19	103±11	110±11
Kibler et al. (2003)			49.4		106.9
			52.9		112.3
Kovacs et al. (2007)		46.50±5.85	35.88±6.17	87.00±6.15	90.88±6.69
Perry et al. (2004)			99.67±9.96		107.50±13.28
			92.29±17.64		107.38±8.36

	Lower body flexibility					
Author	Hamstring flexibility (deg) Left non dominant	Hamstring flexibility (deg) Right dominant	Gastrocnemicus (deg) left	Gastronecmicus (deg) right	Quadriceps (deg) left	Quadriceps (deg) right
Berg et al. (2006)	85.50±18.23	92.00±17.00				
	94.00±9.66	100.36±10.41				
	90.3±12.55	99.7±14.98				
Chandler et al. (1990)	79±16	76±15	11±11	9.5±12	124±20	122±24
Kibler et al. (2003)	65.9	65.9	5.9	5.9	123.1	123.1
	77.1	77.1	6.4	6.4	127.6	127.6
Kovacs et al. (2007)	63.13±3.43	61.13±4.86			35.25	36.63

	Lower body flexibility			
Author	Thigh latero-medial rotation (deg)	Ankle dorsi-plantar flexion (deg)	Hip dominant (deg)	Hip non dominant (deg)
Bloomfield et al. (1984)	139.0±41.0	77.0±10.0		
	120.0±21.0	79.0±9.0		
	117.0±22.0	73.0±10.0		
Kovacs et al. (2007)			23.25±1.42	21.38±2.00

http://dx.doi.org/10.14195/978-989-26-1169-3_8

CHAPTER 8: PHYSIOLOGICAL AND FUNCTIONAL CHARACTERISTICS OF ADOLESCENT ATHLETES IN SEVERAL SPORTS: impications for talent identification

Vaclav Bunc

INTRODUCTION

The body size and composition of adolescent athletes receive considerable attention in discussions of adolescent athletes in a variety of sports. Of equal and perhaps more importance are functional and physiological characteristics associated with, on one hand, muscular strength, power and endurance, and on the other hand, aerobic and anaerobic capacities. These characteristics are often included in inventories aimed at identifying potentially talented young athletes in many sports. The identification process is influenced, of course, by the course of normal growth and maturation which are highly individual processes. As a result, there is considerably inter-individual variation, especially during the adolescent growth spurt. Likewise, there is considerable variation in the responsiveness to training, i.e., trainability, during adolescence. In later adolescence, adult size is almost attained, whereas functional variables continue to develop. Hence, it is appropriate to consider the physiological characteristics of late adolescent athletes. This paper thus presents a profile of the body size, composition and physiological characteristics of elite late adolescent athletes in a variety of sports.

METHODS

The subjects were top Czech athletes of both sexes, 249 males and 146 females, in nine sports: triathlon, long and middle distance running, cross-country skiing, cycling, soccer, basketball, canoeing, swimming. All subjects trained at least 6 days a week and had been engaged in high-intensity training for at least 5 years. The mean time spent in intensive training was about two hours per session. The best of the athletes competed regularly at international events and were successful in European and/or World junior Championships. As a group, the sample can be labelled as including the best, young Czech athletes.

Height and weight were measured. Body composition was estimated with whole-body impedance using a commercially available bio-impedance system (BIA 2000-M). A tetrapolar electrode configuration with the subject in a supine position on the right hand and foot in positions which are recommended by producer. Prior to positioning the electrodes, each site was prepared by swabbing with alcohol and then allowed to dry. A current of 400 μA at frequencies 1, 5, 50, and 100 kHz was introduced to the subject. Capacitance and resistance (angle between these variables) from whole impedance were used to derive estimates of extra-cellular mass (ECM) and body cell mass (BCM). The ratio of ECM to BCM was used as an estimate of muscle mass.

An incremental exercise test to subjective exhaustion on a treadmill at 5% inclination was used to estimate oxygen uptake and VO_2max. The initial speed of running ranged from 9 $km.h^{-1}$ to 13 $km.h^{-1}$ depending on the speed predisposition of the subjects. The running speed was increased each minute by 1 $km.h^{-1}$ until subjective exhaustion. Heart rate was monitored by means of short-range radio telemetry (Sporttester, Polar). The computer printed out these values every 30 s. The maximal value was defined as the mean of the two highest consecutive values.

Respiratory variables and gas exchange were measured using an open system. The athletes breathed through a two-way valve with a small dead space (Jaeger or TEEM 100). Pulmonary ventilation was measured using a pneumotachograph (Jaeger or TEMM 100) calibrated before and after each test by a mechanical pump. The oxygen concentration was measured using a paramagnetic analyser and the CO_2 concentration using an infrared analyser (both Jaeger). Both analysers were calibrated throughout the physiological range of measurement using gases of known concentration. Both instruments were compared and the differences between the data determined by both were less than 1.5%.

The coefficients of energy cost of running were calculated from the maximal intensity of exercise where a reliable relationship between the intensity of exercise and the energy expenditure was still observed. This corresponds to the anaerobic threshold, in the present study the ventilatory threshold (VT). Although many non-invasive methods may be used, a non-linear increase in pulmonary ventilation with respect of VO_2 or VCO_2 is at present the simplest, and probably the most accurate method for determining the VT. The criterion for VT determination was a non-linear increase in pulmonary ventilation versus VO_2 or VCO_2 (Bunc *et al.*, 1987). The ventilatory threshold was assessed by means of a two-compartment linear model using these relationships. This was done with a computer algorithm to establish a two-line regression intersection point .

Blood lactate concentration was measured in the third minute after finishing the exercise from samples of arterialized blood collected from the finger tip. The enzymatic method (Boehringer kits) was used to analyse the blood sample.

RESULTS

Descriptive statistics for age, height, weight and estimated body composition are summarized by sport for male and females athletess, respectively, in Tables 1 and 2. With the exception of basketball players (196.1 cm) followed by swimmers (182.3 cm), mean heights of male athletes in the other sports vary within a relatively narrow range, 176.8 cm to 180.6 cm. Mean weights of male athletes are more variable, ranging from 63.09 kg for long distance runners to 85.4 kg for basketball players. In contrast to body weight, estimated relative fatness and the ratio of ECM/BCM, on average, fluctuate within a relatively narrow range.

Table 1. Means and standard deviations for age and physical characteristics of late adolescent male athletes.

Sport	n	age (years)		mass (kg)		height (cm)		%fat		ECM/BCM	
Triathlon	58	17.3	1.8	69.5	6.9	179.6	4.1	10.4	2.2	0.72	0.06
L.D. running	29	17.0	0.8	63.9	4.9	178.1	4.5	8.0	1.9	0.71	0.07
M.D. running	35	17.4	1.1	66.2	4.1	179.5	4.0	9.0	2.0	0.70	0.09
C.C. skiing	28	17.3	0.8	67.5	4.1	176.8	3.4	8.1	3.0	0.71	0.08
Biathloni	56	17.4	0.7	68.2	3.8	179.3	3.2	9.4	2.7	0.72	0.07
Cycling	15	17.5	0.6	65.9	3.1	177.0	3.0	8.6	1.4	0.72	0.08
Soccer	32	16.9	1.2	70.9	3.0	180.6	2.1	9.6	1.2	0.74	0.07
Basketball	17	17.4	0.9	85.4	2.9	196.1	4.2	11.9	1.6	0.78	0.10
Squash	16	16.8	1.8	66.5	3.0	178.5	.5	9.7	2.1	0.76	0.08
Tennis	12	16.9	1.5	68.5	2.7	179.1	3.7	10.2	2.2	0.77	0.09
Canoeing	21	17.4	0.8	74.5	5.1	179.5	4.6	11.4	1.9	0.70	0.06
Swimming	14	17.3	0.9	73.6	3.5	182.3	3.2	12.0	2.4	0.73	0.11

Table 2. Means and standard deviations for age and physical characteristics of late adolescent female athletes.

Sport	n	age (years)		mass (kg)		height (cm)		%fat		ECM/BCM	
Triathlon	39	17.1	1.1	61.3	3.6	169.3	2.0	12.5	1.9	0.74	0.08
L.D. running	12	17.1	0.9	56.8	1.9	167.3	2.1	9.4	1.3	0.73	0.10
M.D. running	18	17.2	1.0	57.3	2.2	169.5	2.4	10.3	2.0	0.72	0.09
C.C. skiing	16	17.4	1.1	59.2	1.9	171.2	2.1	9.5	1.4	0.72	0.08
Biathlon	41	17.2	0.8	61.3	1.7	171.8	1.8	10.6	1.5	0.73	0.09
Cycling	11	17.1	0.8	57.4	2.4	168.3	1.9	11.1	1.7	0.74	0.09
Soccer	10	16.9	0.7	56.3	2.1	165.3	1.7	13.0	1.9	0.80	0.08
Basketball	12	17.0	0.8	72.3	2.6	183.1	1.9	14.2	2.1	0.83	0.07
Squash	14	16.3	0.8	57.4	5.0	167.2	4.0	14.5	2.0	0.86	0.10
Tennis	11	16.5	0.9	58.5	4.0	168.1	3.6	14.7	2.2	0.87	0.08
Canoeing	15	16.5	0.8	65.7	5.2	172.3	4.1	12.8	1.6	0.76	0.08
Swimming	13	17.2	1.1	64.8	2.5	172.6	2.0	13.9	1.9	0.75	0.10

The distribution of mean heights of female athletes is similar to that of male athletes. Basketball players are, on average, tallest (183.1 cm), whereas the heights of athletes in other sports vary within a relatively narrow range, 167.3 cm for long distance runners to 172.6 cm for swimmers. The mean height of the small sample of female soccer players, 165.3 cm, appears to be an exception. Mean weights of female athletes are a bit more variable, 56.3 kg in soccer players to 65.7 kg in canoeists. The range of estimated relative fatness and ECM/BCM in female athletes is greater than the corresponding range in males. The estimated fatness of female athletes was greater than in male athletes in the same sport.

Table 3. Means and standards deviation of selected maximal functional variables based on treadmill ergometry (%5 slope) in late adolescent male athletes.

Sport	n	$VO_{2max}.kg^{-1}$ (ml)		V_{max} ($l.min^{-1}$)		v_{max} ($km.h^{-1}$)		LA_{max} ($mmol.l^{-1}$)	
Triathlon	58	71.9	5.9	137.6	15.7	18.8	1.3	12.8	2.1
L.D. running	29	74.8	3.6	121.6	12.4	19.0	0.8	12.6	1.8
M.D. running	35	69.7	4.5	138.7	16.7	19.1	0.9	13.4	2.0
C.C. skiing	28	76.9	2.3	147.1	8.9	19.6	0.5	13.6	1.4
Biathlon	56	75.3	2.7	145.5	9.1	18.8	0.6	13.5	1.6
Cycling	15	68.4	5.2	132.3	19.6	18.1	0.7	13.3	1.7
Soccer	32	60.9	2.9	127.5	9.6	17.6	0.7	12.6	1.9
Basketball	17	56.2	1.9	142.5	10.4	16.8	0.9	12.4	1.6
Squash	16	58.9	8.5	106.2	12.8	17.0	0.9	13.4	0.8
Tennis	12	57.5	5.2	109.5	9.6	16.5	0.8	13.1	1.2
Canoeing	21	62.2	3.0	137.4	18.1	17.8	0.8	12.9	1.2
Swimming	14	63.5	3.1	148.6	18.7	17.5	0.8	11.8	2.4

Table 4. Means and standard deviations of selected maximal functional variables based on treadmill ergometry (%5 slope) in late adolescent female athletes.

Sport	n	VO2max.kg-1 (ml)		Vmax (l.min-1)		vmax ($km.h^{-1}$)		LA_{max} ($mmol.l^{-1}$)	
Triathlon	39	61.9	2.4	126.6	13.0	15.7	0.6	12.7	1.2
L.D. running	12	65.7	2.6	119.3	12.4	16.4	0.6	12.5	1.6
M.D. running	18	62.3	2.1	118.6	12.7	16.4	0.8	13.7	2.4
C.C. skiing	16	66.5	2.3	119.1	8.6	16.3	0.9	13.3	2.0
Biathlon	41	64.7	2.0	117.5	9.1	16.0	0.9	13.0	1.8
Cycling	11	59.8	2.0	116.2	12.9	15.4	0.8	12.9	1.8
Soccer	10	50.6	1.6	94.1	7.8	14.7	0.6	12.1	1.2
Basketball	12	48.9	1.8	109.5	6.4	14.3	0.7	12.0	1.8
Squash	14	53.4	5.7	86.8	6.0	14.5	0.9	13.0	0.7
Tennis	11	52.9	3.2	90.8	8.4	14.3	0.8	13.1	1.0
Canoeing	15	51.8	2.3	120.3	11.8	15.6	0.9	13.0	1.6
Swimming	13	57.9	2.2	133.4	14.8	15.2	0.5	11.7	2.4

The profiles of maximal functional variables for male and female athletes are summarized in Tables 3 and 4, respectively, both groups of young athletes. There are small and non-significant differences in maximal oxygen uptake among endurance athletes of both sexes (triathlon, cross country skiing, long and middle distance runners, cyclists), whereas maximal oxygen uptake of endurance athletes is, on average, greater than in swimmers and team sport athletes.

Table 5. Means and standard deviations for selected functional variables at VT and the coefficient of energy cost of running (C. with treadmill with slope of 5%) in late adolescent male athletes.

Sport	n	VO2.kg-1 (ml)		%VO2max.kg-1		V (km.h-1)		%vmax		C (J.kg-1.m-1)	
Triathlon	58	59.5	4.9	82.7	2.1	15.4	1.5	81.9	2.6	3.74	0.13
L.D. running	29	62.8	4.5	83.9	2.9	16.1	1.8	84.7	2.3	3.70	0.11
M.D. running	35	57.8	4.2	82.9	2.7	16.2	2.0	84.9	2.0	3.69	0.10
C.C. skiing	28	64.4	2.8	83.7	1.9	15.8	0.7	80.6	1.1	3.74	0.09
Biathlon	56	62.4	2.1	82.8	1.6	15.1	0.6	80.3	1.0	3.75	0.09
Cycling	15	57.0	5.1	83.3	2.3	14.9	1.2	82.5	2.9	3.80	0.12
Soccer	32	48.6	3.1	79.8	2.6	13.8	0.9	80.4	1.6	3.76	0.10
Basketball	17	44.2	1.0	78.6	2.0	12.8	0.8	76.3	2.0	3.90	0.11
Squash	16	46.6	1.9	79.2	1.6	13.4	0.5	78.8	2.3	3.84	0.12
Tennis	12	45.2	2.1	78.6	2.4	13.2	0.6	80.0	2.1	3.87	0.10
Canoeing	21	49.4	3.1	78.9	2.0	14.1	0.5	79.3	2.4	3.86	0.14
Swimming	14	50.4	3.7	80.3	2.2	14.2	1.8	81.1	1.9	3.84	0.09

Descriptive statistics for selected functional variables at the ventilatory threshold are given in Tables 5 and 6 for male and female athletes, respectively. The coefficient of energy cost of running (C) is also included in the tables. The functional variables at VT are practically identical among endurance oriented athletes of both sexes.

Table 6. Means and standard deviations for selected functional variables at VT and the coefficient of energy cost of running (C. with treadmill with slope of 5%) in late adolescent female athletes.

Sport	n	VO2.kg-1 (ml)		%VO2max.kg-1		v (km.h-1)		%vmax		C ($J.kg^{-1}.m^{-1}$)	
Triathlon	39	51.4	2.9	83.1	1.9	13.2	0.8	84.0	1.9	3.71	0.13
L.D. running	12	54.3	3.4	83.7	2.0	13.8	1.0	84.3	2.1	3.71	0.09
M.D. running	18	51.6	2.7	82.9	2.3	13.7	1.2	83.7	2.2	3.70	0.10
C.C. skiing	16	55.2	2.8	83.0	2.0	13.6	1.3	84.0	2.1	3.74	0.09
Biathlon	41	53.1	2.2	82.1	1.7	12.8	1.2	80.0	1.8	3.76	0.08
Cycling	11	49.7	2.9	83.1	2.4	12.6	0.9	82.0	2.5	3.82	0.08
Soccer	10	39.6	1.8	78.1	1.6	11.7	0.6	79.8	2.0	3.84	0.07
Basketball	12	38.0	1.7	77.6	1.8	11.3	0.7	79.2	1.8	3.86	0.08
Squash	14	42.6	1.6	79.7	1.6	11.9	0.9	82.1	1.9	3.82	1.00
Tennis	11	41.8	2.0	79.0	1.9	11.7	0.8	81.8	2.2	3.85	0.09
Canoeing	15	41.0	2.4	79.1	1.8	12.4	1.1	79.8	2.0	3.84	0.09
Swimming	13	46.8	3.0	80.9	1.7	12.4	1.1	81.5	2.0	3.86	0.10

Correlations between laboratory variables and performance (race times) variables were calculated for the sample of endurance athletes. The performance times were obtained three after the laboratory tests in the athletes. Performance time was not related to pulmonary ventilation and blood lactate in a combined sample of male and female athletes. In contrast, the relationship between competition performance and several other functional variables were moderate to high: maximal oxygen uptake in ml.kg-1.min-1 (males, -0.63 to –0.81; females, -0.71 to –0.88), maximal speed of treadmill running (males, -0.60 to –0.81; females, -0.66 to –0.87), speed of running at the anaerobic threshold level (males, -0.56 to – 0.82; females, –0.71 to -0.78).

DISCUSSION

Nowadays is currently running the debate about the basic physiological nature of majority modern sports events, particularly about the relative importance of the aerobic and anaerobic energy systems and about the degree of involvement of the lactic acid system.

The significance of the aerobic energy system may be clarified by considering the values for maximal oxygen uptakes of soccer players obtained in numerous studies over the years.

The young trained athletes typically manifest maximal oxygen values of 60-65 ml.kg-1.min-1 approximately 20-30% higher than the values of VO2max expected from general population (Astrand and Rodahl, 1986, Bunc, 1989). There are no significant differences in the maximal oxygen uptake between systematically trained children whose training is oriented toward running (fitness orientation) or playing (skill development orientation). This observation is valid even if the children train three times per week, 70 minutes per practice.

In young subjects, the combined aerobic plasticity, represented by the change in oxygen uptake in the values measured at the complete bed rest to the values measured during endurance training appears to be about 20-25% lower than oxygen uptake during endurance training (Astrand and Rodahl 1986).

In adults, the maximal oxygen uptake of 60 ml.kg-1.min-1 seems to be sufficient even at high performance levels of majority players, although there are studies, which suggests that 65 ml.kg-1.min-1 is necessary for top level adult competition (Tumilty, 1993; Reilly et al., 1990). Values of oxygen uptake around 60 ml.kg-1.min-1 are about 10 ml.kg-1.min-1 above the average for the general population of the same age, but are at least 15 ml.kg-1.min-1 below the oxygen uptake of long distance runners and cross-country skiers (Astrand and Rodahl, 1986; Bunc and Heller, 1989). Soccer players, therefore, seem to have good but not exceptional aerobic capacity.

High values of maximal oxygen uptake per unit body mass are typical for athletes with high endurance abilities (Astrand and Rodahl, 1986; Maud and Foster, 1995; Rowland, 1996). Both specific muscle mass and oxidative capacity of working muscles may be increased by specific training and thus the VO2max.kg-1 may reflect a specific predisposition for endurance exercise. Maximal oxygen uptake in trained athletes is generally higher in work situations that allow optimal use of specifically trained muscle fibres VO2max.kg-1 (Wilmore and Costill, 1994). This may underlie some of the differences in "running" VO2max.kg-1 when results of specialists in middle-distance running, cycling and swimming are compared.

The values of maximal functional variables (largely maximal oxygen uptake) are similar to those of top young Czech middle-distance runners and/or cyclists and slightly higher than elite top swimmers of the same age, which were evaluated by the same protocol. These values are lower than those found in Czech top long-distance runners of the same age. The majority of the young athletes started regular sports training in cycling and/or running. In contrast the majority of adult athletes are according to their basic single-sport orientation swimmers.

Maximal oxygen uptake has routinely been used to assess endurance running performance. In fact, successful performance in competitive distance running has been primarily attributed to $VO_{2max}.kg^{-1}$. A number of investigators have reported significant correlations between maximal oxygen uptake per unit body mass and success in distance running (Astrand and Rodahl, 1986; Dengel, 1989; O´Toole and Douglas, 1995).

The range of $VO_{2max}.kg^{-1}$ was relatively large in all groups of endurance oriented athletes, and these values are slightly lower than values in top adult athletes of the same sports event. The higher values in maximal oxygen uptake in subjects with higher performance levels suggest that a high maximal oxygen uptake is necessary to become a world-class athlete. Thus, there may only be limited possibilities to compensate for a low $VO_{2max}.kg^{-1}$. A high level of maximal oxygen uptake per se does not guarantee good performance, since technique and psychological factors may exert either positive or negative influences. In practice, this implies that both laboratory and performance must be considered simultaneously.

The literature regarding the physiological characteristics of elite young endurance athletes shows that nearly all male competitors have $VO_{2max}.kg^{-1}$ values higher than 73 and females higher than 65 $ml.kg^{-1}.min^{-1}$ (Astrand and Rodahl, 1986; Wilmore and Costill, 1994). Thus, a high maximal oxygen uptake unit body mass is often considered a prerequisite for success in endurance sports. The importance of the run segment to overall triathlon performance was recently made evident by a study which noted it to be the best predictor of overall time in a triathlon (O´Toole and Douglas, 1995).

The higher values of maximal oxygen uptake in adults than in the young athletes can be explained by the higher training state of adults, i.e. a higher degree of adaptation to exercise. The higher energy cost of running - lower running economy in young soccer players confirms this conclusion.

The other two potential factors, which could explain physiological difference between very young and adult athletes are:

- A small difference in relative VO_{2max} $.kg^{-1}$ between young and adult players (compared to a larger difference in the absolute values of oxygen uptake in young and adult trained players) may be related, in part, to a greater variation in body composition in younger subjects. As stated by Cureton *et al*. (1978), the increased body fat lowers the maximal oxygen uptake (expressed relative to body mass), because it increases body mass without contributing to oxygen use.

- The nature of training stimulus influences the capacity for improvement of maximal oxygen uptake.

The significantly lower values of LA_{max} and confirm the lower anaerobic capacity of young athletess comparing to adults. This situation is well documented in literature (e.g. Astrand and Rodahl, 1986).

Metabolic adaptation, which can be indirectly characterized as the ability to utilize effective the functional capacity of the organism during a prolonged period, can be estimated as the percentage of maximal functional variables (mainly maximal oxygen uptake) at VT (Bunc *et al*., 1987). In untrained subjects, % $VO_{2max}.kg^{-1}$ is in the range of 50%-70% of maximal oxygen uptake; in trained subjects, values are in the range of 80%-90% of VO2max (Bunc *et al*., 1987; Wilmore and Costill, 1994)

The higher the level of adaptation to physical activity, the higher the values of $\%VO_{2max}$ at the VT level. The untrained children of the same age as our young players, which were evaluated in our laboratory by the same protocol had values of $\%VO_{2max}$ in the range of 60-70%. The young long distance runners had the same values ranging from 80% to 86%.

Balsom (1988) found no significant correlation between performance decrement and anaerobic threshold expressed as percentage of maximal oxygen uptake. His moderately trained college players had a threshold value of 70.5% of maximal oxygen uptake, which is somewhat lower than the values reported by several other investigators. The adult players in our older study (Bunc *et al.*, 1987) had a % VO_{2max} value of 80.5%. Rhodes *et al.* (1986) found the same value of $\%VO_{2max}$ in the Canadian Olympic Team and considered it to be „remarkably high for anaerobically trained athletes".

The dilemma for the coach and player is to determine how to improve fitness through an organized fitness programme without sacrificing player's game performance and without neglecting skill development, which gave game its unique character. This is a special concern for very young players, who must firstly try to improve their basic motor abilities. It is likely that an increase in fitness level will be more useful if there is an improvement in the player's skill and the game sense.

As in other sports, where skills play an important role, the functional data are not the sole predictor of game success, but they play a decisive role in the selection of young players for competitive soccer teams and for a long term training process.

The total energy cost of training loads imposed on the group of young athletes during the year was more or less independent of the quantitative and qualitative structure of training. Almost constant energy demands of the training programme resulted in practically constant values of maximal functional variables associated with maximal oxygen uptake per kg body mass during one year of training. Any change in the functional variables can only result from the basic alterations in the quality and, in particular, the quantity of training programs for top level soccer players. These changes are most unlikely to occur during a single year. This suggests that the maximal oxygen uptake related to kg body mass can be changed in trained athletes only with a great difficulty, consequently it has a little practical use for evaluating the effect of the training stimulus on the course of adaptation to this level of exercise (Brooks, 1985; Bunc *et al.*, 1987; Costill, 1976).

The changes in absolute values of maximal oxygen uptake in children are mainly connected with changes in the body mass (Astrand and Rodahl, 1986). On the other hand, the changes in energy cost of moving, generally in adaptation to exercise, are significantly influenced by the duration of training.

The coefficient C can be used for the evaluation of the adaptation to the specific movements of a sport (Bunc and Heller, 1989). The higher the level of adaptation to a given type of exercise, the lower the amount of energy necessary to transfer 1 kg of body mass along a distance 1 m. If it is assumed that adaptation to running is highest in runners, then this is reflected in the lowest values of C in runners of both sexes against to values in players or non-runners (Bunc and Heller, 1989). The lowest values of C are perhaps the result of running training because these athletes were forced to exercise at very high speed, specifically middle distance runners of both sexes.

The data and results from other groups of endurance oriented athletes suggest that there may be some critical level of maximal functional variables (mainly maximal oxygen uptake) below which an athlete will not be successful. However, above this theoretical critical level, other factors play a more important role in performance.

It should be cautioned that physiological capacities are not the sole predictors of racing success. Nevertheless, they provide significant insights into the basis of endurance performance.

REFERENCES

Astrand PO, Rodahl K (1986). *Textbook of work physiology*, 3rd ed. New York: McGraw Hill Book Co.

Balsom PD (1988). The relationship between aerobic capacity, anaerobic power, anaerobic capacity, anaerobic threshold, and performance decrementation in male collegiate soccer players. *MSc thesis*, Faculty of Springfield College.

Brooks GA (1985). Anaerobic threshold: review of the concept and direction for future research. *Med Sci Sports Exerc.* 17 (1): 22-31.

Bunc V, Heller J (1989). Energy cost of running in similarly trained men and women. *Eur J Appl Physiol*; 59:178-83.

Bunc V, Heller J, Leso J, Sprynarova S, Zdanowicz R (1987). Ventilatory threshold in various groups of highly trained athletes. *Int J Sports Med*; 8: 275-80.

Costill DL (1979). *A scientific approach to distance running.* Los Altos: Track and Field; 14:12-40.

Cureton KJ, Sparling PB and Evans C. *et al*. (1978) Effect of experimental alterations in excess weight on aerobic capacity and distance running performance. *Med Sci Sports Exerc*. 10: 194-9.

Dengel DR, Flynn MG, Costill DL, Kirwan JP (1989). Determinants of succes during triathlon competition. *Res Quart Exerc Sport*; 60: 234-8.

Maud PJ, Foster C (1995). *Physiological assessment of human fitness*. Champaign: Human Kinetics.

O´Toole ML, Douglas PS (1995). Applied physiology of triathlon. *Sports Med*. 19(4):251-67.

Reilly T, Secher N, Snell P, Williams C (1990). *Physiology of sports*. E and FN Spon, Champman and Hall: London.

Rhodes EC, Mosher RE, McKenzie DC, Franks IM, Potts JE (1986). Physiological profile of the Canadian Olympic soccer team. *Can J Appl Sport Sci.* 11 (1): 31-36.

Tumilty D. (1993). Physiological characteristics of elite soccer players. *Sports Med* 1993, 16 (2): 80-96.

Wilmore JH, Costill DL (1994). *Physiology of sport and exercise*. Champaign: Human Kinetics.

The study was supported by grant from the Czech Ministry of Education No. MSM 115100001.

Página deixada propositadamente em branco.

http://dx.doi.org/10.14195/978-989-26-1169-3_9

CHAPTER 9: EFFECTS OF MATURATION ON POTENTIAL PREDICTORS OF TALENT IN SOCCER

Casper Jorna
Marije T Elferink-Gemser
Chris Visscher

INTRODUCTION

The basic definition of talent identification lies within the recognition of a natural gift or ability of a superior quality that is at least partially innate and affected by numerous environmental conditions (Williams et al, 2000b; Pearson et al., 2006;). Another aspect of talent is performing better than the rest in a certain domain. Furthermore, talent is considered to be domain specific. Williams et al. (2000b) suggested that talent may not be evident at an early age but there will be some indicators that enable trained individuals to identify its presence. Sport science is making an increasing effort in discovering the important predictors and characteristics of talent in soccer (Williams et al., 2000a). Young potentially talented soccer players arrive at the soccer academy as early as age 6 or 7.

In elite soccer there was found to be an over representation of players born in the first quarter of the selection year (Helsen et al., 2005; Vaeyens et al., 2005). This bias towards an overrepresentation is referred to as the RAE [Relative Age Effect]. The explanation often focuses on the advantage of size. Those born early in a particular year, or in other words those who are older at the selection date within the same age category, are, on average: taller, heavier, stronger and more developed than those born later in that year. In most sports, as in soccer, size may be a significant factor in it self. Especially when strength, power and speed are important for different aspects of the game (Helsen et al., 2005; Vaeyens et al., 2005). Thus, when young players tend to be biologically mature coaches and trainers are biased to selecting them. As a result, maturation might also have an effect on the selection and prediction of talent.

When considering the large and ever increasing amount of research done in the soccer domain it is surprising that the effects of maturation on potential predictors of talent has had so little attention thus far. The first publications of maturational effects on talent characteristics started to appear around 1990 but most research is done in the last 10 years (Table 1). This literature-based review assesses different studies done on biological maturation in soccer within the context of potential predictors of talent. The aim of this review is to assess the effects of maturation on potential predictors of talent in the soccer population within a multi-disciplinary approach. In the discussed research there is great diversity of methods used to establish biological maturation. After an introduction in the important predictors of talent, and maturation assessment methods, the available literature was examined.

METHODOLOGY

In the search for relevant articles the following databases have been consulted PubMed, Web of Science and Google Beta. The keywords (physical, biological or sexual) "maturation", "growth", "puberty", "adolescents", "youth" or "development" were used alone or in combination with the words "soccer", "football" or "talent (identification)", "elite" and/or "high potential". The articles were refined with terms closely associated with physical-, physiological- and/or psychological characteristics. Because of the scarcity of studies on maturation there was no date constraint on the found literature. Since most studies are of the last decade, more focus will be on this period.

Selected articles were reviewed on the following criteria; Type of study (cross-sectional or longitudinal), number of a participants (only males will be discussed), origin of subjects, age range, competition level of the participants (elite, sub-elite, non-elite, or recreational), appearance or absence of control group, aspects concerning player position on the field, maturation assessment method, onset of maturation (early, on-time or late), and maturational effects on potential predictors of talent in soccer.

RESULTS

Talent predictors in soccer

Because of the broad demands of a soccer game, a multidisciplinary approach is essential in the research and development of talent (Pearson et al., 2006; Vaeyens et al., 2006; Williams et al, 2000b). It is suggested that the potential prediction of talent lies in the physical, physiological, psychological and sociological aspects of soccer (Pearson et al., 2006; Vaeyens et al., 2006; Williams et al, 2000b).

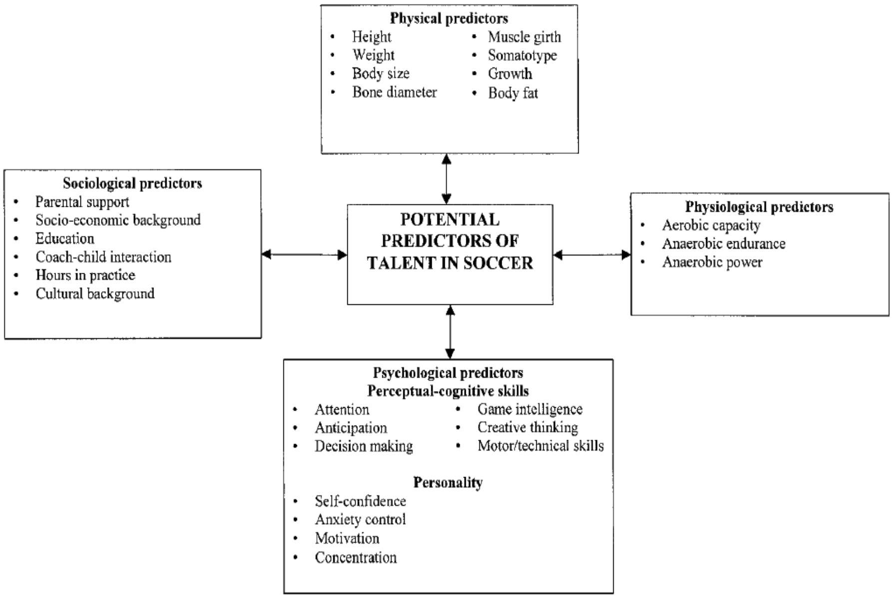


Figure 1. Potential predictors of talent in soccer (Williams et al, 2000b).

a) Physical predictors

Elite adolescent players tend to be taller and heavier than their peers. This difference declines when adulthood is reached (Beunen et al., 1997; Cacciari et al., 1990; Hansen et al., 1999a). Williams and Reilly (2000b) suggested that the physical characteristics of players are related to performance. The somatotype, mostly mesomorph, and physique of elite adolescent players is comparable to that of elite adult players (Williams et al, 2000b; Reilly et al., 2000a). The adult stature is strongly influenced by genetics whereas other physical predictors, for instance muscle mass and percentage adipose tissue are more influenced by training and dietary. The under-16 team fat percentages are reported to be comparable to elite adult players, which is about 11% of adipose tissue (Reilly et al., 2000a). When it comes to height Reilly et al. (2000a) reported several studies where certain playing positions have a tendency for taller and heavier players (e.g., defenders and goalkeepers) even though tall forwards and midfielders have also been reported. The variability might influence the tactical role allocated to the individual player within the team.

b) Physiological predictors

The activity pattern during a match, of non-elite adolescent players shows many differences when compared to elite adult players. However the activity pattern of elite adolescent players does not differ much from the activity pattern seen in elite adult players (Strøyer et al., 2004). Bangsbo et al. (1994) reported that the average energy demand of a soccer match is around 5700 Kj for a 75 kg adult man with a VO_2-max of 60 ml/kg/min. The average maximal oxygen intake for elite adult players is reported to be in the range of 55 to 69 ml/kg/min with higher average values for better teams. The variation in oxygen uptake is partly due to different playing positions (Strøyer et al., 2004). During a match the relative load approximates 70-80% of the VO_2-max for elite adult and elite adolescent players. Elite adult players have an average Heart Rate (HR) of about 160-165 beats per minute (bpm) depending on the match intensity (Bangsbo et al., 1994; Reilly et al., 2000a). The HR of an elite 12 year old is higher, 198-202 bpm (Armstrong et al, 1997; Strøyer et al., 2004). During a match high intensity sprints alternate with low intensity walking and jogging. The critical phases of play, for instance winning possession of the ball or scoring opportunities are mostly anaerobic while the predominant metabolic (energy demands) pathways are aerobic. As such, soccer is classified as a high intensity intermitted sport (Lemmink et al., 2004).

In the adolescent period (13-16 years), the VO_2-max is in the range of 55 increasing to 69 ml/kg/min for elite players and in the range of 56 declining to 52 ml/kg/min for the non-elite players (Baxter-Jones et al., 1993; Hansen et al., 2002). Considering the wide range of VO_2-max values reported to be acceptable at highest levels, VO_2-max appears not to be a suitably sensitive measure on its own of performance capability. Rather there seems to be a minimum requirement of 60 ml/kg/min in modern-day elite adult soccer (Reilly et al., 2000a). VO_2-max for elite adolescent players from age 12 and up, must be higher than 58 ml/kg/min (Hansen et al., 2002).

On average an adult match calls for an all out sprint every 90s and high intensity effort every 30s. In elite adolescent soccer about 7.9% to 9% of the time is spend as high intensity running (Strøyer et al., 2004). Muscle strength is suggested to be relevant for kicking the ball, tackling, and tolerating physical contact. The inter-limb coordination, and balance between flexors and extensors are important for injury prevention (Reilly et al., 2000a). Because of the delayed development in anaerobic energy pathways in adolescence, the relative contribution to the total energy demand is less. For instance, in a maximal effort of less then 60 seconds children derive 60% of the total energy demand from anaerobic sources while this is 80% in adult athletes. It is hypothesised that adolescents are less able than adults to affect ATP rephosphorylation through glycolysis during high intensity exercise (Van Praagh et al., 2002). However, children have a lower lactate production and recover faster after intense maximal exercise bouts. Anaerobic power and capacity are measured with several different methods. The amount of energy obtained by anaerobic processes cannot yet be measured directly (Armstrong et al., 2001b). Several studies reported lower anaerobic power for soccer players compared to sprinters and middle distance runners but 10% - 20% more anaerobic power when compared to age matched control groups (Reilly et al., 2000a). The anaerobic capacity increases with maturation until that of adults is reached after the teenage years (Reilly et al., 2000a). High anaerobic power and capacity are necessary for top class performance in soccer.

c) Psychological predictors.

In soccer there are obvious physical and physiological demands like VO_2-max and sprinting ability. Nevertheless, it is well recognized that the psychological aspects often distinguish between elite and non-elite peers (Morris et al., 2000). Psychological predictors can be subdivided in perceptual-cognitive skills and personality (figure 1).

One of the promising approaches to talent development is the measurement of perceptual-cognitive skills such as anticipation and decision-making (Williams, 2000; Williams et al, 2000b). Elite adolescent players show consistent differences when compared to their non-elite peers (Reilly et al., 2000b; Williams, 2000). When tested they are: "faster and more accurate in recognizing patterns of play; better at anticipating the actions of their opponents based on contextual information; characterized by more effective and appropriate visual search behaviour; more accurate in their expectations of what is likely to happen given a certain set of circumstances" (Williams and Reilly, 2000b, Page 661). In addition, they score higher on technical skill tests (Malina et al., 2005; Malina et al., 2007b). Furthermore, cognitive aspects like higher school grades and greater creativity are associated with elite adolescent players (Williams, 2000).

Morris (2000) mentioned several important personality traits that are associated with soccer such as "Emotionally stable, tough and realistic, conventional, and cold and aloof" (Morris (2000), page 718). A frequently heard term when it comes to personality traits is motivation (Morris et al., 2000). In research by Reilly et al. (2000b), motivational orientation is found to be an important discriminating factor in differentiating between elite and non-elite players. Elite adolescent players seem to adopt a more task orientated instead of ego orientated approach as well as being more self-confident than their non-elite peers (Reilly et al., 2000b). Task orientation and success have been correlated with endorsement of effort and persistence (Van-Yperen et al., 1999). Elite adolescent players are also less likely to experience somatic anxiety than their less successful peers and tend to perceive cognitive and somatic anxiety as facilitative to performance (Reilly et al., 2000b).

d) Sociological predictors

Williams and Reilly (2000b) argued that an important determinant for success is socialisation into the particular culture. Parents are typically the ones introducing a child in the world of organized soccer. Parental support and a positive attitude towards the involvement in soccer are very important. However, friends and coaches are the ones who have an extremely important role in stimulating the child in further involvement. Furthermore, social class has a significant effect upon participation. Even though soccer is originally thought of as a sport for the working classes, it becomes ever more clear that children from middle class and up have an advantage because of financial support, greater flexibility, and more mobility and support in transport (Williams et al, 2000b).

Also, the role of the coaches and their involvement is important in the development of the child. Elite players have great respect towards their coach. A good coach knows when to push players and when to reduce or intensify the training, expectations and support. Furthermore, it is suggested that ten years of extensive practice are needed to achieve expertise (Williams et al, 2000b).

Maturation

The terms growth and maturation are often used interchangeably when describing the physical and biological development of children and adolescents. Nevertheless the terms refer to a different process. Beunen et al (2004) and Malina et al. (2004a) described growth as an increase in the size of the body as a whole or the size attained by specific parts of the body, while maturation refers to the tempo and timing of progress towards the mature biological state. The variation in the progress over time implies variation in the rate of change. In this review maturation refers to the biological process unless mentioned otherwise.

Within the growth and maturation research several methods have been used to establish the biological maturation. By establishing the maturity status and the onset of maturation, an estimate can be made of a player being early, on-time, or delayed in maturation. The maturation in childhood and adolescence is usually viewed in the context of three types of indicators: Skeletal, Sexual or Somatic (Malina et al., 2004a). Of these three types only skeletal age can be used in both childhood and adolescence. However, it is probably the most costly and time consuming method (Malina et al., 2007a).

The estimation of skeletal age involves the matching of bone x-rays with a reference sample and provides valid and reliable indication of the status of the maturation process (Malina et al., 2004a; Malina et al., 2007a). In most cases a hand-wrist radiograph is matched to a set of criteria. As can be seen in table 1, the Tanner-Whitehouse and the Fels method are most frequently used in soccer research. When Skeletal Age (SA) is estimated it can be compared to the Chronological Age (CA) to establish if an adolescent is early, on-time, or delayed in his/her skeletal maturity (Malina et al., 2004a; Malina et al., 2007a).

During adolescence the assessment of sexual maturity is a useful indicator of maturation. For boys these include the development of pubic hair, genitals and to a lesser extent hormone levels. Pubic hair and genital development are rated relative to the criteria set by Tanner in 1962. The stages of Pubic Hair (PH) and Genital (G) development range from 1 (pre-pubertal) to 5 (post-pubertal) in which the 2nd stage represents the first overt manifestation of characteristics. Although the stages for pubic hair and genital development are equivalent they should not be combined for an overall score. Rather, they are an indication of advancement in maturation (Malina et al., 2004a).

Somatic maturity refers to the timing of maximum growth during adolescence. The maximal gain in height, or grow spurt, is referred to as the Peak Height Velocity (PHV). Any study has to last at least 5 years after which the PHV can be mathematically derived (Philippaerts et al., 2006). Percentage of attained adult stature is another somatic indication of maturation. The adolescents who are closer to their (predicted) adult stature in the same age group are more advanced in maturation (Malina et al., 2004a).

Table 1. Overview of reviewed maturation studies in soccer payers

Type of predictors in the study		N*	Maturation assessment method	Maturity status	Aspects of Predictors **
Physical	Malina 2000	Portugal, elite, n=135, 10.7-16.5 yr	SA: Fels method	38,5% vs. 11,85% [2]	A
	Hansen 1999a	Copenhagen area, elite x local, n=98, 10.5-13.0 yr	Testicular Volume and Testosterone		A

(continues)

(continuation of Table 1)

Physiological	Baxter-Jones et al. 1993	London, intensively trained***, n=65, 12-16	Self Assessed Tanner & Testicular Volume	Early mature	A, B
	Baxter-Jones et al. 1995	London, intensively trained***, n=65, 12-16 r	Self Assessed Tanner & Testicular Volume	Early mature	A, B
	Sproviero et al. 2002	Italy, elite, n=14, 12,3 ± 0,5 - 17,1 ± 0,8 yr	PH Stage: Tanner		A, B, C
	Philippaerts et al. 2006	Ghent, Belgium, elite x sub-elite x local, n=33, 10-16 yr	Peak Height Velocity	>36% Early mature	A, B, C
	Segers et al. 2008	Ghent, Belgium, elite, n=13, 13-15 yr	SA: Tanner-Whitehouse method	46% vs. 54% [1]	A, B, I
	Malina et al. 2004b	Porto area, Portugal , elite, n=69, 13.2-15.1 yr	Pubic Hair Stage Tanner	Early mature	A, B, C, H
	Strøyer et al. 2004	Copenhagen area, elite x local, n=26, 12,2 ± 0,7 - 14,0 ± 0,2 yr	Testicular Volume		A, B, C, G
	Hansen et al. 2002	Copenhagen area, elite x local, n=49, 11,7 ± 0,8 - 15,8 ± 0,6yr	Testicular Volume		A, B, D
	Cacciari et al. 1990	Bologna, Italy, soccer x non-soccer, n=399, pre-pubertal-16	SA: Tanner-Whitehouse, PH Stage: Tanner, Testicular Volume		A, D
	Hansen et al. 1999b	Copenhagen area, elite x local, n=98, 11,9 ± 0,5 - 13,8 ± 0,4	Testicular Volume		A, B, C, D
Psychological & sociological	Cumming et al. 2006	USA, Recreational, n=33, 9,0 - 14,8 yr	Expected adult stature	Advanced in Maturation	F
Multidisciplinary approach	Vaeyens et al. 2006	Ghent, Belgium, elite x sub-elite x local, n=232, 12-16 yr	SA: Tanner-Whitehouse method		A, B, C, E

Notes: [*] Male players only. [**] Aspects of potential predictors: *(A)* Physical; *(B)* Aerobe; *(C)* Anaerobe/strength; *(D)* Hormonal; *(E)* Skill; *(F)* Psycho-social; *(G)* time-motion; *(H)* position; *(I)* Biomechanics. [***] Comparison between different sports. *(1):* Controlled percentage early vs. late maturing players. *(2)*: Early vs. Late maturing players. [SA] Skeletal Age, [PH] Pubic Hair, [GYSP] Ghent Youth Soccer Project

Reviewed studies

a) Studies on physical predictors

Malina et al. (2000) assessed the anthropometrical characteristics and maturity status in a cross-sectional study of elite Portuguese adolescent players. A total of 135 players were tested who all played at the highest level in the Portuguese league in their age group. Of the 135 players 19 also played for the national team. The age ranged from 10,7 to 16,5 years (yr). Maturity status was estimated by means of skeletal maturity using the Fels method. No control group was included. Of the 135 players 38,5% was considered early mature or mature within their age group compared to chronological age. In contrast only 11,85% was considered late mature. When it comes to playing position of national team members, forwards were the most ahead of chronological age (1,2 ±0,4 yr) followed by defenders (1,0±0,4 yr) and midfielders (0,5 ±0,5 yr). The data suggested that, with age and presumably experience, boys advanced in skeletal maturation dominate soccer.

In a short longitudinal study by Hansen et al. (1999a) the relationship of maturation with the differences in anthropometrical characteristics were evaluated. All 98 elite and non-elite adolescent players (age: 10,5 - 13 yr) participated at the highest level in their age group in the Copenhagen area. The first ranked teams in the competition were classified as elite and the lowest ranked teams as non-elite. No control group was included and no aspects concerning the players' position were mentioned. Maturation was estimated with testicular volume. Elite teams were significantly older than non-elite teams. Elite teams were also found to be significantly more mature even when adjusted for age. Elite teams were heavier, taller and had lower fat percentages. Values for serum testosterone and insulin-like-growth factor were higher for elite compared to non-elite players.

b) Studies on physiological predictors

Two of the evaluated papers made a comparison between soccer, swimming, tennis, and gymnastics in a mixed-longitudinal study on the development of physiological characteristics. Both papers were written by Baxter-Jones et al. (1993 and 1995) and consisted of the same 453 participants from the London area, both male and female. For the soccer population only males were included and no control group was used. The age of the 65 soccer participants was 12 to 16 years. The soccer population was reported to be intensively trained with about 13 training hours per week. However, no distinction was made in a player's position. Maturation was estimated with testicular volume and self assessed sexual maturity in Tanner stages. Soccer players reported to be less mature than swimmers and tennis players and more mature than gymnasts. Twenty-seven of the sixty-five soccer players were on average 13,7±0,9 years in Tanner stage 2 to 3. The average VO_2-max was 55,7±3,7 ml/min/kg at stage 1 (age 13,1±0,7 yr) and 61,5 ± 4,9 at stage 5 (age 15,9±1,4 yr) (Baxter-Jones et al., 1993). Aerobic power was found to be significantly related to pubertal development. The athletes in sports in which large physiques were necessary for performance (e.g., swimming, soccer and tennis) tended to be advanced in sexual maturation (Baxter-Jones et al., 1995).

Sproviero et al. (2002) studied the longitudinal effects of maturation on the physiology of 14 well trained adolescent soccer players. They were classified as elite and played at a professional Italian soccer club. The age at the first test was between 12,3±0,5 and 15,1±0,8 years, and at second test players were between 14,3±0,3 and 17,1±0,8 years. No control group was included. Besides the exclusion of goalkeepers no differences in playing position were mentioned. Sexual maturation was assessed using Tanner pubic hair stages. No comparison was made when it comes to the onset of maturation. The anthropometrical growth corresponded to the change in the level of maturation. Furthermore, the aerobic capacity in ml/kg/min showed a significant increase corresponding to the transition period from Tanner stage 2 to 3-4, e.g., 60,01±5,1 ml/kg/min and 67,3 ± 4,6 ml/kg/min respectively. The same relation was found for anaerobe muscle power. In the later Tanner stages (4 and 5) the increase was still significant for anaerobe muscle power but not for aerobe capacity.

The grow spurt is a well known phenomenon in adolescence. Philippaerts et al. (2006) investigated the relationship between peak height velocity and physical performance in a mixed-longitudinal study for 33 adolescent soccer players (13-16 yr). In addition to the included 33 players, 25 players were excluded because of reaching PHV before the beginning of the study suggesting early maturation. They had a chronological age of 12,12,6±0,5 years and a skeletal age of 13,5±1,2 years. The study included elite(6 training hours per week), sub-elite (4 training hours per week) and non-elite (3 training hours per week) without making reference of player positions or using a control group. Maturity was assessed with skeletal age (Tanner-Whitehouse) and PHV. The 33 players were selected from the Ghent Youth Soccer Project, Belgium, and had a mean age at PHV of 13,8±0,8 years. Age at Peak weight velocity was the same. Running speed attained maximal growth just before PHV, and maximal aerobic power reached maximal growth coinciding with PHV. During PHV the greatest gain was found in muscular strength, balance, speed of limb movement, trunk strength, upper-body muscular endurance, explosive strength and power. Trends of gain in muscular strength and power remain after peak height velocity.

Segers et al. (2008) did a systematic research on running economy. They matched 6 early (CA: 14,3±0,6 yr) and 7 late maturing (CA: 14,4±0,5 yr) adolescent soccer players. The subjects were all participant in the previous mentioned mixed-longitudinal study: Ghent Youth Soccer Project. They practised at least 4,5 hours/week. There was no comparison with a control group or mentioning of player position differences. The skeletal age of the 13 participants was assessed using the Tanner-Whitehouse system. Early and late matures did not significantly differ in age but early maturing players were significantly taller, heaver, stronger and had a higher absolute VO_2-max (3,84 ± 0,5 vs. 2,57 ± 0,4 l/min). However when compensated for body weight the difference in VO_2-max is not significant (57,19 ±3,58 vs. 57,63 ± 5,58 ml/leanbodymass^{1,058}/min). The study found no difference in running economy between early and late matures.

The objective of a cross-sectional study by Malina et al. (2004b) was to estimate the contribution of experience, body size and maturity status to variation in the functional capacity of 69 soccer players between 13,2 and 15,1 years. No control group was used to compare the soccer population to the non-soccer population. The elite players competed at the highest level in their age group in the Portuguese first division. Sexual maturation was attained using the PH stage method. Of these 69 players, 19 players were biological mature (PH stage 5) and 21 players were almost mature (PH stage 4). Furthermore, 45% of players 13,2 to 13,9 years of age and 64% 14,0 to 15,1 years of age were in PH stages 4 and 5. The distribution of stages of pubic hair suggested that they were advanced in maturation. When it comes to the position of the player, on average, midfielders scored highest on aerobic capacity but lowest in speed and power whereas forwards and defenders were quite similar in speed and power. While forwards were significantly older, 70% of the forwards and defenders was in pubic hair stage 4 or 5 which suggested that as a group they were in advance of midfielders in maturity status. When controlled for age, height and weight advanced maturation was associated with better aerobe resistance and anaerobe capacity and power. Stage of maturity and years of training in soccer accounted for 21% of the variance in aerobic capacity while weight and stage of maturity accounted for 50% of the variance in anaerobic sprinting capacity. The stage of maturity, together with height accounted for 41% of the variance in anaerobic power.

The physiological demands and activity pattern of a match have been mapped for different maturational stages by Strøyer et al. (2004). Twenty-six adolescent players from the three most successful clubs in the Copenhagen area, Denmark, were recruited. Age, maturation, and the ranking of their team in the competition divided the participants in three groups, ten non-elite (12,2±0,7 yr) and nine elite players (12,6±0,6 yr) at the beginning of adolescence, and seven elite players (14,0±0,2) at the end of adolescence. No control group was used and no distinction was made in player positions. Maturation was estimated by measurement of testicular volume. No mentioning was made about timing of the onset of maturation in the groups, although reaching the end of maturational development at age 14 was considered early mature (Malina et al., 2004a). The absolute VO_2-max was not significantly different at the beginning of adolescence for the elite and non-elite. However VO_2-max did increase with maturation for the elite towards the end of adolescence (2,47±2,8 vs. 3,59±4,4 l/min). When adjusted for body weight the difference was not significant (58,6±5,0 vs. 63,7±8,5 ml/kg/min). For elite players the maximum heart rate did not significantly change during adolescence but the rest heart rate was significantly lower for the older group (66,5±5,1 bpm vs. 57,1±3,7 bpm). The exercise level during match play and VO_2-max tended to be higher for the midfielders/attackers compared to the defenders, with differences increasing with age. Maturation was found to have no significant effect on relative aerobic load and relative HR for elite players.

The aim of a longitudinal study by Hansen and Klausen (2002) was to evaluate the development in aerobic power in elite as well as non-elite Danish adolescent soccer players, and to relate it to maturation, haemoglobin and hematocrit levels. No control group was used or distinction in playing positions. The maturation of all forty-nine subjects (10 -16 yr) was assessed using the testosterone levels and testicular volume. The status of elite (21) and non-elite (28) were based on the ranking of their team in the highest level of competition. The elite players were significantly older and more mature. The advanced maturity is consistent when elite and non-elite were matched by chronological age suggesting earlier maturation in the elite group. Moreover, elite players had steeper increase in VO_2-max and higher VO_2-max values throughout the adolescent period, both absolute and when adjusted for weight. Furthermore, a relationship was found between maturation, haemoglobin concentrations as well as with the development of aerobic power.

Cacciari et al. (1990) investigated the effects of soccer on anthropometrical and hormonal aspects of growth. The 399 Italian boys who participated in this cross-sectional study consisted of two groups. 175 Participants played competitive soccer (4-14 hours/week) and the control group of 224 participants had never performed regular sporting activities. No mentioning was made of players' position. The participants were classified as pre-pubertal (testicular volume lower than 2,5 ml) or pubertal (age 10-16). For estimating maturation skeletal age, PH and testicular volume were used. The football players were significantly more mature then the controls in all three methods(SA (yr): 12,57±1,41 vs. 13,21±1,97; PH stage: 2,39±1,17 vs.

2,97±1,50; Testicular volume (ml): 8,19±5,42 vs. 11,23±6,87). Hormonal levels (Cortisol, testosterone and DHEA-S) were significantly higher in football players compared to controls and correlated positive with all somatic growth indicators (e.g., weight and height).

To examine the development of muscle strength in relation to training and testosterone in adolescence, Hansen et al. (1999b) did a longitudinal study on 98 Danish adolescent soccer players (11-14 yr) of which 48 were elite. Elite and non-elite was classified in the same way as the studies by Hansen et al. (1999a), Hansen and Klausen (2002) and Strøyer et al. (2004). No control group was used nor were playing positions included. Once again, elite players were older, taller, stronger and more mature compared to non-elite players; even when adjusted for chronological age. No regard was given to the onset of maturation. Elite and non-elite players had a similar increase in testosterone levels across adolescence with elite players scoring consistently higher on aerobe capacity. Furthermore, testosterone had a positive relationship with strength development.

c) Studies on psychological predictors

The cross-sectional studies by Malina et al. (2005) and Malina et al. (2007), were both on sport specific skill characteristics in adolescent soccer players aged 13,2-15,1 years. Both studies, together with the study by Malina et al. (2004b), used the same sample of 69 adolescent soccer players. The subjects were elite and played at the highest level in the Portuguese division. No control group was included in the studies. Stage of pubic hair was used to asses the maturity status. The onset of maturation was reported earlier in this review in the study by Malina et al. (2004b).

The aim of the study done by Malina et al. (2005) was to estimate the contribution of experience, body size and maturity status to the variation in sport specific skills. There was considerable variation in the scores of the skill tests, but none of the scores grouped by player positions were significant. Although there was a trend of better scores on the skill test for increasing maturity status, it was only significant for the dribbling speed test. This significant result persisted when age, height and body mass were used as covariates. The stage of maturity and years of training accounted for 13 % of the variance in the ball control test with the body. Maturity, height, and height*body mass interaction accounted for 14 % of the variance in ball control test with the head. Age and maturity stage accounted for 21 % of the variance in the test requiring dribbling speed. Even though the contributions were small, the results suggested that advanced biological maturity status was associated with better performance on four skill tests.

The second study, done by Malina et al. (2007) described the characteristics of adolescent soccer players grouped by skill level. A total of 12 of 14 players in the highest skill quintile and 11 of the 14 players in the high skill quintile were in PH stages 4 or 5. Although the highest quintile was on average half a year older then the lowest the trend suggested that advanced maturity status was coherent with high skill scores. All skill quintile were equally represented in defenders and midfielders. The forwards were centred around the middle three quintiles. Furthermore, maturity (positive) and height (negative) together accounted for 21 % of the variance in the combined skill score.

d) Studies on sociological predictors

Cumming et al. (2006) examined, cross-sectional, the relationship between maturity status, Body Mass Index, age and perception of autonomy support in 70 north-American participants of which 43 were male (9,0 – 14,8 yr). No distinction was made in position on the field nor was a control group included. The mean number of years participants competed in recreational soccer was 5,1 ± 1,9 yr. Maturity status was assessed by a participants' predicted adult stature. The players were classified as advanced in maturity status. Maturity status significantly predicted 18% of the variance in the autonomy support from the coach. All other variables were found not to be significant.

e) Studies with a multidisciplinary approach

Talent research in soccer should take on a multidisciplinary approach as discussed earlier in the results. A study by Vaeyens et al. (2006) assessed anthropometry, functional capacity, and sport specific skills as well as maturity status of elite, sub-elite and non-elite players. Participants were grouped according to playing level: Elite (first or second division); sub-elite (third or fourth division), and non-elite (regional division). No control group was included. A mixed-longitudinal sample of 232 Belgium players was tested annually over 5 consecutive years. Participants (12-16 yr) were enrolled in the earlier mentioned Ghent Youth Soccer Project and were grouped in one year chronological age categories. Furthermore, goalkeepers were excluded, limiting the analyses to defenders, midfielders and forwards. Skeletal age was assessed with the Tanner-Whitehouse method. Although there was no mentioning of the onset of maturation the results showed that maturity affected anthropometry in all age groups. Maturation also significantly affected strength, power and flexibility in de under 14 and under 15 players. Additionally, maturation affected sprint speed and cardio respiratory endurance in the under 15 and 16 age group. Sport specific skill was only significantly affected in the under 14 group.

DISCUSSION

The aim of this literature based review was to asses the effects of maturation on potential predictors of talent in the soccer population within a multi-disciplinary approach. In total 16 studies met the criteria and have been reviewed. Two studies were specifically designed to measure the effects of maturation on physical predictors, nevertheless physical aspects and maturation were also discussed in other studies. Ten of the sixteen reviewed studies were on the effects of maturation on physiological predictors, two concerned the maturational effects on psychological and cognitive skills and only one the effect on sociological predictors. However, there is an overlap in the last three mentioned studies. Finally, one study was discussed with regard to a multidisciplinary approach and maturation effects in soccer. As can be seen in table 1, some of the studies used either the same participants or are a selection of the larger coordinated study. Accordingly, some caution is needed with the interpretation of the results.

Although research suggests that the physical characteristics of young players are related to performance, many of the physical qualities that distinct elite from sub-elite may not be noticeable until full adulthood is reached (Williams et al, 2000b). Research by Cacciare et al. (1990) suggests that soccer does not have a significant influence on an individual's definitive physical development, established genetically. Young athletes, as soccer players, grow in a similar manner as non-athletes and much of the variation in body size is associated with the variation in the rate of maturation (Malina et al., 2004a). However, soccer might affect the onset of adolescence (Cacciari et al., 1990). Philippaerts et al. (2006) reported a main gain in height, or grow spurt, or Peak Height Velocity (PHV) in the elite soccer population at age 13,8 ± 0,8 Years. The age of Peak Weight Velocity (PWV) was found to be identical. However, twenty-five participants were not included in this research because they had already reached PHV and had a SA more than one year ahead of CA, suggesting early maturation. Research in the general population reported PHV to occur at age 14.1 ± 0.9 years (Beunen et al., 2000). Although the age at which PHV is reached in soccer is not far from that of the normal population, the trend is towards early maturation in soccer. Running speed attains maximal growth just before PHV, and maximal aerobic power reaches maximal growth coinciding with PHV. During PHV the greatest gain was found in muscular strength, balance, speed of limb movement, trunk strength, upper-body muscular endurance, explosive strength, and power (Naughton et al., 2000; Philippaerts et al., 2006). This is most probably related to the spurt in muscle mass during adolescence that occurs shortly after PHV. Trends of gain in muscular strength and power remain after PHV and might also reflect an influence of the training effect (Naughton et al., 2000; Philippaerts et al., 2006;

Yague et al., 1998). The maximum gain in power in the adolescent elite soccer population lies at PHV whereas in the general adolescent population the maximum gain in power is closer to PWV. The small differences might lie in the overlapping of PHV and PWV in elite adolescent soccer players rather than PWV following PHV as is the case in non-athletes (Geithner et al., 2004; Malina et al., 2004a).

Regarding the positions of the players on the field, forwards and defenders tend to be more advanced in sexual maturation than midfielders. In the ages 14 through 16, Malina (2004) found an over representation of the later adolescent stages PH 4 and PH 5 in forwards and defenders. This is in contrast to midfielders in which all five stages were equally represented. Forwards and defenders are reported to be advanced in skeletal age compared to chronological age by 1,2±0,4 years and 1,0±0,4 years respectively. Midfielders were, on average, advanced in skeletal age by 0,5±0,5 years (Malina et al., 2004b; Malina et al., 2000). Malina et al. (2004b) reported that midfielders score highest on aerobic resistance but lowest in speed and power. Forwards scored slightly higher in speed and power compared to defenders, but scored lowest on aerobic resistance. When aerobic capacity, speed and power are viewed by pubic hair stages they increased with maturation. The trends were most noticeable in aerobic capacity and speed and to a lesser extent in power. Furthermore, it is suggested that this age and maturity associated variation might reflect the specific size demands of different playing positions (Malina et al., 2000; Malina et al., 2004b).

As with the normal population, the physiological capacity in the elite adolescent soccer population increases with biological and chronological age (Hansen et al., 2002; Malina et al., 2007b; Strøyer et al., 2004). A progressive increase in absolute aerobic power through the pre- mid- and late adolescent years is confirmed by several studies (Naughton et al., 2000; 1025; Malina et al., 2007b; Malina et al., 2004b; Mota et al., 2002). When considering the known difference in aerobic capacity between the trained and the untrained population, young elite soccer players show higher absolute aerobic capacity values compared to the normal population on the later maturational stages (Baxter-Jones et al., 1993). There seems to be almost no difference in VO_2-max between the non-elite and the elite players in the beginning of adolescence (Hansen et al., 2002; Strøyer et al., 2004). However when comparing elite and non-elite adolescent soccer players, elite players seem to have higher and steeper increase in VO_2-max values compared to non-elite players (Hansen et al., 2002). Furthermore, it has been suggested that the degree of maturation influences VO_2-max through its close association with weight, muscle mass and haemoglobin concentrations together with an increasing influence of the training effect (Armstrong et al., 2001a; Hansen et al., 2002). In general, growth in aerobic power was found significantly related to physical growth (age, height, and weight) and to pubertal development (Baxter-Jones et al., 1993; Mota et al., 2002; Naughton et al., 2000).

Although many studies have come to the conclusion that the VO_2 consumption and thus aerobe capacity was affected by the increase in body weight during maturation, there is no agreement to what extent absolute VO_2-max consumption should be corrected for body weight during maturation. Italian research found that VO_2-max increases with biological maturation after compensating for body mass (Sproviero et al., 2002). Soccer players at age 12,3±0,5 in Tanner stages 1&2 increased significantly in VO_2-max when reaching age 14,3±0,3 in Tanner stages 3&4 (60,01±5,1 vs. 67,3±4,6 ml/kg/min). This is confirmed by results in Denmark. Elite adolescent players did increase significantly in absolute VO_2-max within the same age range as in the Italian study (2,47±2,8 vs. 3,59±4,4 l/min) but although a trend can be seen in the increase in VO_2-max when compensated for body weight, it was not significant (58,6±5,0 vs. 63,7±8,5 ml/kg/min) (Strøyer et al., 2004). When comparing early and late matures within one age group Armstrong et al. (1999) and Segers et al. (2008) found that the difference in the VO_2 consumption is not dependent on maturation when it is compensated for body weight. This is in accordance with research done in the Ghent Youth Soccer Project. The differences in absolute VO_2 at age 14 is significant between early and late matures (3,84 ± 0,5 vs. 2,57 ± 0,4 l/min) but not when compensated for body weight (57,19 ±3,58 vs. 57,63 ± 5,58 ml/leanbodymass^{1,058}/min). These inconsistencies might be the result of the way of scaling VO_2-max and body weight. This is either done by calculating VO_2 consumption per kg body weight or by using an allometric approach by calculating VO_2 per kg body weight multiplied by a scaling factor (Armstrong et al., 1999; Segers et al., 2008). Moreover, not all studies use the same calculations, for example body weight in lean body mass or in total body weight. Maturation alters the effects of body size and this should be taken into account when interpreting the results of physical performance tests (Armstrong et al., 1999; Nedeljkovic et al., 2007).

A matter closely associated with aerobic capacity, and therefore also important in soccer, is running technique. Although it is suggested that running economy is influenced by maturation, research shows otherwise. A study among Belgian boys shows that maturation seems to have no effect on running economy in elite adolescent soccer players (Segers et al., 2008). When early and late matures were compared, the cardiovascular capacity was relatively the same when adjusted for lean body mass and cannot be the cause for lack of difference in running economy (Philippaerts et al., 2006; Segers et al., 2008). It is suggested that while absolute stride length between early and late matures was the same and late matures have shorter legs, a relatively larger stride length enables less mature players to run with the same running economy (Segers et al., 2008). There seem to be no significant differences within an elite soccer population but their might be a difference between elite and non-elite adolescent players. Although Danish pre-pubertal and pubertal elite players of age 12 showed relatively better values when it comes to running economy and VO_2-max compared to their non-elite peers the differences were not statistically significant (Strøyer et al., 2004). In general it can be concluded that maturation facilitates an increase in absolute aerobe capacity, to what extent this increase is necessary, or caused by a larger physique remains a matter of discussion. Fact is that it enables a player to perform at a higher level (Armstrong et al., 1999; Naughton et al., 2000).

An average child has about 30% of the anaerobic power of a 20-year adult (Van Praagh et al., 2002). However elite adolescent soccer players exhibit higher peak anaerobic power outputs during all adolescent stages than their sedentary peers, in particular in the stages 3 to 5 (Vaeyens et al., 2006). This difference is most likely caused by the training effect. The maximal muscle power is related to cross-section of the muscles involved in the exercise (Van Praagh et al., 2002). But even when scanned for body dimensions like relative strength and maximal oxygen uptake, early matures seem to have an advantage over late matures (Segers et al., 2008). When anaerobic power is expressed relative to body weight it becomes apparent that it increases most in the 2nd, 3rd and 4th pubic stage (Sproviero et al., 2002). This is in agreement with research among adolescent soccer players 13-15 years of age. Sexual maturation significantly contributed to the explained variance on anaerobic capacity (e.g. sprint and vertical jump ability) (Malina et al., 2004b). In research by Hansen (1999b) the development of isometric strength and performance in broad jump was related body size but also to changes in serum testosterone concentrations, indicating that testosterone is important for development of strength in young boys. However, elite players were stronger than non-elite players independent of testosterone concentration, also with correction for body size, indicating that other factors associated with being elite also effect the development of strength. Values of testosterone levels are higher for pubertal and lower for pre-pubertal soccer players than the general population. Research concluded that testosterone was important in strength development for boys (Hansen et al., 1999b). It is assumed that the higher values in adolescent subjects were justified by them being more sexually developed than the controls, while in pre-pubertal subjects the effects of the intensity of training prevailed, causing a decrease in plasma testosterone, as in adult athletes (Cacciari et al., 1990). Thus it seems like the difference in power is mostly caused by the training effect but maturation plays a fundamental role in the onset of development and trainability of anaerobic power and capacity (Armstrong et al., 2001b; Hansen et al., 1999b; Naughton et al., 2000).

The impact of biological growth and maturation on psychological and social development of young athletes has received relatively little attention (Cumming et al., 2006). The lacking of research on the effects of maturation on personality, in the adolescent soccer population, provides an indication that this has received even less attention. The physical changes associated with growth and maturation and the changes and growth of the brain may have a profound impact upon the technical skills, self-perception, motives, beliefs, and ultimately, behaviour of young athletes (Cumming et al., 2006; Malina et al., 2005; Van-Yperen et al., 1999).

Although there is no consent about how much the maturation contributes to the development of technical skills, it is associated with better technical performance on several skill tasks like dribbling, ball control and shooting (Malina et al., 2005; Malina et al., 2007b). Malina et al. (2005) found a general trend in better performance on skill tests continuing into sexual maturation. However, this was only significant for a dribbling test with pass. In their analyses maturity explained between 10 and 20 % of the variance on different technical performance tasks. Malina et al. (2007) also found that aerobic resistance and maturity status together explained a significant amount of the variance in the skill score of 14 year old elite soccer players. This was confirmed in other age groups by research from Vaeyens et al. (2006). They showed that difference in maturity status influenced technical skills in elite adolescent players and it was most apparent at the age of 14. As such, advanced maturity status is associated with better skills. This might also reflect the positive influence of maturation on earlier mentioned components in adolescent boys (e.g., strength, speed and power) which are closely related with technical skills. The effect of maturation on technical skills is also influenced by the maturational changes in the central nervous system. This affects the neural control and perceptual-cognitive skills such as anticipation and visual search strategies (Williams, 2000, Williams et al, 2000b, Malina et al., 2005).

Cumming et al. (2006) suggest that the ‘mediated effects model of adaptation’ provides an appropriate theoretical framework from which to examine the psychological and social significance of maturation in adolescent soccer. How an individual adjusts socially and psychologically to changes associated with maturation and growth depends on his or her ideation about his or her biological changes and the subjective meaning or affective significance attributed to them. Psychological and behavioural effects are mediated by internalized psychological factors like body image, self-esteem, self-perception and evaluation, beliefs, and mind-sets on body development. The effects are presumably moderated by exogenous or contextual factors as socio-cultural contexts, ideals, practice, and expectations by coaches or parents. Significant others (coaches and parents) tend to evaluate biologically early mature males as socially better adjusted, having a better physiques, and better physiological abilities compared to their later maturing peers (Cumming et al., 2006).

In general it is assumed that progression in maturation coincides with more autonomy support because physically better suited players (early matures) have greater potential for success and require less supervision. But contrary to this expectation Cumming et al. (2006) found that advanced maturity status was associated with lower perception of autonomy support from coaches. So instead of experiencing less autonomy as controlling and reducing intrinsic motivation, elite soccer players might perceive less autonomy as more informational and thus prosper.

There is a substantial lack of research when it comes to the development of psychological characteristics in the context of sexual/biological maturation and (elite) soccer. Furthermore, identified psychological characteristics that are important in elite adult soccer are sometimes assumed to be present in some form in the elite adolescent player. Those who posses and retain these characteristics may have a higher chance of developing into an elite professional players (Morris et al., 2000). But there is no hard evidence that the variables which are important for success in adolescence are the same as in adulthood. In addition, there is hardly any evidence that important psychological traits remain stable in the transition from adolescence into adulthood (Morris et al., 2000; Patton et al., 2007). So once again one should be cautious with interpreting these results. Relatively little is still known about the effects of maturation on psychological aspects of adolescent soccer players.

In the introduction the Relative Age Effect was mentioned. This overrepresentation of players born in the first quarter of the selection year was based on the physiological advantages of the more biologically mature players. In the discussed research in this review, this phenomenon is confirmed (Baxter-Jones et al., 1993; Baxter-Jones et al., 1995; Cumming et al., 2006; Malina et al., 2000; Malina et al., 2004b; Malina et al., 2005; Malina et al., 2007; Philippaerts et al., 2006; Segers et al., 2008). The selection bias present in the relative age effect can also be witnessed in the effects of maturation, a so called "Relative Maturation Effect". Therefore, it is of importance for the selection process to take maturation into account. Potential talent may perhaps be overlooked because of inferior physiological performance as a consequence of being late in the maturing process. On the other hand, this might raise an ethical question. Should coaches keep the early mature and physiological strong player, who is considered to be of inferior potential and not elite worthy, to be kept in the academy to raise the performance level and facilitate the development of the late maturing talented player?

In summary, elite adolescent soccer player develop in a similar way as the normal population. Maturation seems to have no effect on the definitive stature established genetically but it does have a significant effect on the development of physical predictors of elite adolescent soccer players towards an elite adult physique. Physiological predictors are affected as well. Maturation facilitates an increase in absolute aerobe power and capacity and plays a fundamental role in the onset of development and trainability of anaerobic power and capacity. With regard to the psychological predictors, not much is known about the effects of maturation on the perceptual-cognitive skills in soccer. However, maturation seems to have a positive effect on the development of technical skills. The research on sociological predictors within the soccer population is rather scarce. When taking the high potential discriminative power of psychological and sociological predictors into consideration, this will need to receive significantly more attention in further research. Furthermore, maturation has to be taken into account when scouting and evaluating talent in soccer.

REFERENCES

Armstrong N, Welsman JR (2001a). Peak oxygen uptake in relation to Growth and maturation in 11-17 yr old humans. *European Journal of Applied Physiology*, 85: 546-551

Armstrong N, Welsman JR, Chia MYH (2001b). Short term power output in relation to growth and maturation. *British Journal of Sports Medicine*, 35: 118-124

Armstrong N, Welsman JR, Kirby BJ (1997). Sub-maximal Exercise and maturation in 12-year-olds. Journal of Sports Sciences, 17: 107-114

Armstrong N, Welsman JR, Nevill AM, Kirby BJ (1999). Modelling growth and maturation changes in peak oxygen uptake in 11-13 yr olds. *Journal of Applied Physiology*, 87: 2230-2236

Bangsbo J (1994). Energy demands in competitive soccer. *Journal of Sports Sciences,* 12: s5-s12

Baxter-Jones A, Goldstein H, Helms P (1993). The development of aerobic power in young athletes. *Journal of Applied Physiology*, 75(3): 1160-1167

Baxter-Jones ADG, Helms P, Mafulli N, Baines-Preese JC, Preece M (1995). Growth and development of male gymnasts, swimmers, soccer and tennis players: a longitudinal study. *Annals of Human Biology*, 22(5): 381-394

Beunen G, Malina RM (2004). Growth and Biologic Maturation: Relevance to Athletic Performance. In: "*Growth, Maturation, and Physical Activity, 2nd edition*". Human Kinetics, USA.

Beunen ,G., Ostyn M, Simons J, Renson R, Claessens AI, vanden Eynde B, Lefevre J,Vanreusel B, Malina RM, van't Hof MA (1997). Development and tracking in fitness components: Leuven longitudinal study on lifestyle, fitness and health. *International Journal of sports Medicine*, 18: s171-178

Beunen G, Thomis M, Aes HH, Loos R, Malina RM, Claessens AL, Vlietinck R (2000). Genetic variance of adolescent growth in stature. *Annals of Human Biology*, 27(2): 173- 186

Cacciari E, Mazzanti L, Tassinari D, Bergamasehi R, Magnani C, Zappulla F, Nanni G, Cobianchi C, Ghini T, Pini R, Tani G (1990). Effects of sport (football) on growth: axiological, anthropometric and hormonal aspects. *European Journal of Applied Physiology*, 61: 149-158

Cumming SP, Battista RA, Standage M, Ewing ME, Malina RM (2006). Estimated maturity status and perceptions of adult autonomy support in youth soccer players. *Journal of Sports Sciences*, 24(10): 1039-1046

Geithner CA, Thomis MA, Eynde BV, Maes HHM, Loos RJF, Peeters M, Claessens ALM, Vlietninck R, Malina RM, Beunen GP (2004). Growth in peak aerobic power during adolescence. *Medicine and Science in Sport and Exercise*, 36(9): 1616-1624

Hansen L, Klausen K (2002). Development of aerobic power in pubescent male soccer players related to hematocrit, haemoglobin and maturation. *Journal of Sports Medicine and Physical Fitness*, 44: 219-223

Hansen L, Klausen K, Bangsbo J, Muller J (1999a). Short longitudinal study of boys playing soccer, Parental Height, Birth Weight and length, anthropometry, and pubertal maturation in elite and non-elite Players. *Paediatric Exercise Science*, 11: 199-207

Hansen L, Bangsbo J, Twisk J, Klausen K (1999b). Development of muscle strength in relation to training level and testosterone in young male soccer players. *Journal of Sports Medicine and Physical Fitness*, 87: 1141-1147

Helsen WF, Winckel J, Williams AM (2005). The relative age effect in youth soccer across Europe. *Journal of Sports Sciences*, 23(6): 629-636

Lemmink KAPM, Visscher C, Lambert MI, Lamberts RP (2004). The interval shuttle run test for intermittent sport players: evaluation of reliability. *Journal of Strength and Conditioning Research*, 18: 67-73

Malina RM, Bouchard C Bar-Or O (2004a). *Growth, Maturation, and Physical activity*. Second edition. Human kinetics, USA.

Malina RM, Chamorro M, Serratosa L, Morate F (2007a). TW3 and Fels skeletal ages in elite youth soccer players. *Annals of Human Biology*, 34(2): 265-272

Malina RM, Cumming SP, Kontos AP, Eisenmann JC, Ribeiro B, Aroso J (2005). Maturity-associated variation in sport-specific skills of youth soccer players aged 13-15 years. *Journal of Sports Science*, 23 (5): 515-522

Malina RM, Eisenmann JC, Cumming SP, Ribeiro B, Aroso J (2004b). Maturity-associated variation in the growth and functional capacities of youth football (soccer) players 13-15 years. *European journal of Applied Physiology*, 91: 555-562

Malina RM, Peña Reyes ME, Eisenmann JC, Horta L, Rodrigues J, Miller R (2000). Height, mass and skeletal maturity of elite Portuguese soccer players aged 11-16 years. *Journal of Sports Sciences*, 18: 685 - 693

Malina RM, Ribeiro B, Aroso J, Cumming JC (2007b). Characteristics of youth soccer players aged 13-15 years classified by skill level. *British Journal of Sports Medicine*, 41: 290-295

Morris T (2000). Psychological characteristics and talent identification in soccer. *Journal of Sports Sciences*, 18: 715-726

Mota J, Guerra S, Leandro C, Pinto A, Ribeiro JC, Duarte JA (2002). Association of maturation, sex, and body fat in cardio respiratory fitness. *American Journal of Human Biology*, 14: 707-712

Naughton G, Farpour-Lambert NJ, Carlson J, Bradney M, Van Praagh E (2000). Physiological issues surrounding the performance of adolescent athletes. *Sports Medicine*, 30(5): 309-325

Nedeljkovic A, Mirkov DM, Kukolj M, Ugarkovic D, Jaric S (2007). Effect of maturation on the relationship between physical performance and body size.. *Journal of Strength and Conditioning Research*, 21(1): 245 -250

Patton GC, Viner R (2007). Pubertal transitions in health. *The Lancet*, 369: 1130–39

Pearson DT, Naughton GA, Torode M (2006). Predictability of physiological testing and the role of maturation in talent Identification for adolescent team sports. *Journal of Medicine and Science in Sport*, 9: 277-287

Philippaerts RM, Vaeyens R, Janssens M, Van Renterghem B, Matthys D, Craen R, Bourgois J, Vrijens J, Beunen G, Malina RM (2006). The relationship between peak height velocity and physical performance in youth soccer players. *Journal of Sports Sciences*, 24(3): 221-230

Reilly T, Bangsbo J, Franks A (2000a). Anthropometric and physiological predispositions for elite soccer. *Journal of Sports Sciences*, 18: 669-683

Reilly T, Williams AM, Neville A, Franks A (2000b). A multidisciplinary approach to talent identification in soccer. *Journal of Sports Sciences*, 18: 695-702

Segers V, De Clercq D, Janssens M, Bourgois J, Philippaerts R (2008). Running economy in early and late maturing youth soccer players does not differ. *British Journal of Sports Medicine*, 42: 289-294

Sproviero E, de Vito G, Felci U, Macaluso A, Marchettoni P (2002). Physiological Evaluation of elite young soccer players. *Medicino dello Sport*, 55:181-187

Strøyer J, Hansen L, Klausen K (2004). Physiological profile and activity pattern of young soccer players during match play. *Medicine and Science in Sport and Exercise*, 36(1): 168-174

Vaeyens R, Philippaerts RM, Malina RM (2005). The relative age effect in soccer: A match-related perspective. *Journal of Sports Sciences*, 23(7): 747-756

Vaeyens R, Malina RM, Janssens M, Van Renterghem B, Bourgois J, Vrijens J, Philippaerts RM (2006). A multidisciplinary selection model for youth soccer: the Ghent Youth Soccer Project. *British Journal of Sports Medicine*, 40: 928-934

Van Praagh E, Doré E (2002). Short-Term Muscle Power During Growth and Maturation. *Sports Medicine*, 32(11): 701-728

Van-Yperen NW, Duda JL (1999). Goal orientations, beliefs about success, and performance improvement among young elite Dutch soccer players. *Scandinavian Journal of Medicine & Science in Sports*, 9: 358-364

Williams AM (2000). Perceptual skil in soccer: implications for talent identification and development. *Journal of Sports Sciences*, 18: 737-750

Williams AM, Reilly T (2000a). Searching for the stars. *Journal of Sport Sciences*, 18, 655-656

Williams AM, Reilly T (2000b). Talent identification and development in soccer. *Journal of Sports Sciences*, 18: 657-667

Yague PH, De la Fuente JM (1998). Changes in height and motor performance relative to peak height velocity: A mixed-longitudinal study of Spanish boys and girls. *American Journal of Human Biology*, 10(5): 647-660

Página deixada propositadamente em branco.

Part 3:

TRAINING

Página deixada propositadamente em branco.

http://dx.doi.org/10.14195/978-989-26-1169-3_10

CHAPTER 10: PROMOTING QUALITY IN YOUTH SPORTS

António Marques
José Oliveira

INTRODUCTION

In the last few years, debate among experts and coaches has focused on the quality of youth sport programs. Underlying motivations are the special training needs of children and youth, and the continuous search for better results in sport.

There is no quality in youth sport programs without well-prepared, qualified coaches. The preparation of coaches requires an appropriate theoretical framework based upon knowledge produced by scientific and empirical research. However, much of the research dealing with the practices of coaches has not always been satisfactory and errors have been made based on research.

Several key aspects of the debate on quality in youth sport programs are subsequently considered. In youth sport, quality demands that coaches are prepared to think and understand sport far beyond the immediate results of competition. A coach's commitment to youth sport should be understood within the framework of pedagogical and moral (ethical) responsibility preparing youth for the future.

Parents, communities and society at large expect coaches to be competent and responsible in offering opportunities for youth to practice sport and to develop abilities and qualities under safe conditions within a sound social environment regarding moral and ethical principles. On the other hand, it is not acceptable for coaches, parents and/or staff to use youth activities as an instrument to achieve their own expectations, interests and objectives to the detriment of the developmental needs of youth.

Coaches should be required to improve their practices in the leadership of youth sport programs. They should not only be expected to accomplish specific sport tasks, but should be expected to be responsible and competent to prepare youth for future life. This requires that coaches are familiar with the biological, psychological and social characteristics of growth and development during childhood and adolescence, and can integrate this knowledge into their practice. Coaches should also be prepared to organise sport activities under appropriate pedagogical principles and ethical values. In this way, coaches can prepare young athletes not only for the demands of future top level sport but also for life in general. These tasks are highly demanding from the technical and physical points of view, and also require a strong moral foundation to face the demands of professional sport.

What is a competent coach? Is he/she the one who achieves the best competition results with young athletes? As already noted, results are not the most effective criterion to evaluate the competence or quality of a coach. Other criteria are required.

Meinberg (1991) proposed the following perspective. The competent coach in youth sport programs is not the one who achieves immediate results in competition throughout an early intensive specialisation, but the one who succeeds in bringing to the higher stages of top level sport the great number of young athletes. In competitive sport, results obtained in early stages of youth preparation have no social relevance if they limit the possibilities for advancement through the stages of a sport career. Winning is important for children and adolescents, but it can not be so important for coaches.

If we want to assess coach competence, several questions should be asked. Among the young athletes coached, how many have succeeded, some years later, in reaching the higher stages of top level sport? How many of a coach's young athletes are still involved in top level training?

It was suggested for a long time that simply increasing the number of hours and years of training would, as a consequence, result in better performance in high levels. A direct relationship between training volume and performance quality in advanced stages of a sport career was assumed (Bremer, 1986). The error in this assumption is now being gradually understood. Training strategies based strictly on increasing load volume, with no emphasis on the load quality, led to poor results in advanced stages and perhaps contributed to increasing rates of drop out.

High performance at the top level depends mostly on what was done in the initial stages and not so much on the number of years of training. Top-level results are apparently influenced by the quality of the loads rather than by the number of hours in training. However, further evidence is needed to confirm this assertion. Nevertheless, even if it could not be confirmed, it is necessary for coaches of youth to change this approach.

The daily life of children and adolescents is filled with a variety of activities in education, sport, music, dance, foreign language acquisition, computer training, and so on, in addition to normal social demands of peers and family. These needs are important to youth development and limit the time available for sport training. Coaches should not encourage youth to sacrifice these activities in order to concentrate on sport.

The interests of young people are becoming more and more diverse. Moreover, parents are aware that their child's chance for a successful career in sport depends on the opportunities provided in the first years of formation, but that opportunities for such careers are extremely few.

Hence, the promotion of the interest and enjoyment in sport activities should constitute a priority for coaches (Rahn, 1993). This implies that coaches carefully choose training methods and content.

What motivates a 10 year old child to swim non-stop 2 hours a day, 7 days a week? Is such a monotonous training program necessary for success in swimming? Can the great number of dropouts from such programs be avoided?

Methods based on games are viewed by some pedagogues (Kurz, 1988; Marques, 1995; Rost, 1995) as a very important strategy to promote an athlete development in the early stages of preparation. Marques *et al*. (2000), for example, analysed 981 training units of Portuguese young athletes, 10-15 years, in several team sports - basketball, soccer, team handball and volleyball. In the age group 10-12 years, coaches used most of the time (55%) in training methods not based on the game approach.

Promotion of quality demands the choice of more interesting activities which may bring even more young people into sport practice. It also assumes that coaches will be able to do their best using more effective methods in the particular sport activity to provide better work and to achieve more effective results.

The aim of this paper is to address recent theoretical developments which may help coaches promote quality in youth sport programs. Quality is a word that is part of daily vocabulary, but has different meanings among individuals and contexts. The term quality is in many ways an elusive and abstract concept (Carman, 1990). For the present discussion, the promotion of quality refers to the improvement of the effectiveness of training as suggested by Martin (1991): "for the same work, more effectiveness in the results." The subsequent discussion considers improvement in the quality of training in the context of the following variables: sport technique, decision making processes in sport activity, speed training, training load, and sport competition.

PATHS TO QUALITY IN YOUTH SPORT PRACTICES

Both the individual and sport performance are complex realities. Athletic performance depends on bio-psycho-social determinants. The interactions of bio-energetic and informational processes, which are influenced by cognition, will and emotion, are central. However, in most cases, neither the practices of coaches nor the models that underlie the methods are committed to this view. Both theory and practice of sport training focus largely on the "principle of load-adaptation of the bio-energetic systems" (Bauersfeld, 1991). Even if information processes are perceived as an important factor for the practice of a sport, they are often not considered, which is erroneous. This is especially important for children who are learning a sport. These ages are a sensitive period for motor learning in general and for the acquisition of sport fundamentals in particular. Sensorimotor and cognitive aspects need to be emphasised in sport practice during childhood.

As a general principle, training priorities before puberty should be oriented to the informational dimension – decision and co-ordination mechanisms – of the sport activity. After puberty priorities should focus on the metabolic and muscular dimensions (Martin, 1991; Martin *et al*., 1993; Rost, 1995; Marques, 2000). Accordingly, several aspects of improved quality in the training of children and adolescents are subsequently considered:

- Improvement of sport technique
- Choice of adequate decisions during sport activities
- Improvement of speed training
- Choice of appropriate loads
- Development of the competitive system.

IMPROVING SPORT TECHNIQUE

The process of improvement of sport technique was always considered a major issue in youth training and because of this was regarded in most sport disciplines as a key factor of the activity programs. In general, specific technique models were developed for youth training starting based on the demands of top level sport; technique training became a more and more autonomous training complex in youth sport programs; technique training was being supported by theoretical assertions; and youth competition often integrated complexes of different techniques (Bauersfeld, 1991).

Further aspects of technique training need consideration. First, a major role should be played by movement regulation and control. The demands related to sport technique research and knowledge development, particularly movement representation and perception, should be emphasized. Second, technique training and motor learning should not be viewed from a narrow perspective. On the contrary, they should be organized in an integrative relationship with other motor, decisional and energetic demands of the specific sport activity. However, interactions between the latter and technique training are seldom considered in an adequate manner. Experts and researchers need to more carefully consider these issues, focusing attention on the demands of the coordination and learning processes. Improving quality in the future should be based on defining new training orientations and principles that focus on a continuous increase of the degree of difficulty of the coordination and motor learning demands (Martin, 1991).

EMPHASING THE ROLE OF THE DECISIONAL PROCESSES DURING SPORT ACTIVITIES

In youth programs and particularly tactic/strategy sports, decision making in sport actions should be a major objective. It is very important that in all stages of the process of sport preparation, young athletes can play an active and conscious role in the learning and training. This implies that coaches focus more on situations that can be stimulating for learning and that can help youth to choose adequate options during sport activities. It also implies that coaches do not always provide youth the answers needed to resolve the problems they face in sport activities. Coaches must be able to objectively define what they want youth to learn in each stage of the training process and to help youth to make the right decisions by formulating the principles and orientations that guide decision-making. This will promote a more effective learning/decision making process.

A great variety of the activities offered to youth in training and competition are not the most adequate and do not properly stimulate the sport learning process. They are often too complex for youth who are not yet either able or prepared to respond to these demands. Team sports, for instance, require attention, anticipation, decisions and quick responses, which are cognitive competencies that are not completely developed in children under 10 years of age (SMPC, 2000).

Good learning processes are those that stress active and conscious participation by setting problems and providing youth with opportunities to experience a diversity of situations, e.g., rejecting some options and choosing others among the possible solutions, and not those that are strictly dependent on feedback from coaches, as happens very often. Using the example of team sports, if a coach wants athletes in top level stages to respond quickly and correctly to game demands, he/she needs to prepare them appropriately since the early stages of the learning/training process. The athletes should be prepared to respond with short reaction times and in reduced game areas because time and space for play are not readily provided by opponents.

INCREASING MOVEMENT'S SPEED DURING SPORT ACTIONS

Speed training is a priority in many youth sport programs (Bauersfeld, 1991; Martin, 1991; Rost 1995; Marques and Oliveira, 2001). However, some coaches do not focus on speed abilities.

An analysis on the structure of training sessions of young Portuguese athletes 10-12 years in several team sports indicated that speed abilities play a minor role – only 5% of training's total time, 2.5% to reaction speed, 0.7% to movement speed and 2.3% to maximal speed (Marques *et al*., 2000). Because speed abilities are important to the formation of young athletes (Bauersfeld, 1991; Martin *et al*, 1993; Martin, 1999), they should be prioritized in close relation to technique and tactic/strategy formation. However, this happens neither on a regular basis nor in the proper manner. Most of the time, emphasis is oriented to the muscular and metabolic components of speed and less to the aspects that depend on control and regulatory mechanisms of the nervous system. The latter emphasis is more adequate for children because at this stage are in a sensitive period for the development of coordination processes.

Maturation of the nervous system takes place earlier than the maturation of the metabolic and muscular systems, which are generally ready to support intensive loads after puberty. The development of the functional mechanisms of neuromuscular and nervous systems which control fast movements do not occur in a natural manner, i.e., as a maturation process (Rost, 1995). On the contrary, they occur in close relation to the activities that children experience during this period of development. Thus, if a coach wants to stimulate these mechanisms, appropriate situations should be selected. This can be done, for example, by adopting competitive models that reduce the game area (small games) or by reducing the distances.

In Germany, young long distance swimmers compete often over short distances such as 25 or 50 meters no matter the stroke. In the United States, young swimmers do not ordinarily participate in long distance competitions (Rost, 1995).

The improvement of speed training methods should be understood as a major priority in youth sport because this ability is a determinant of top level performance in most sport disciplines. But before puberty, training methods should stress the information systems in relation to the sensitive period of coordination and sport technique.

The development of a superior organisation of the nervous system and the stimulation of neuromuscular regulation and control mechanisms through fast and intensive sport movements should be done during maximal load exercises and movements under time pressure, as happens during competitive situations. However, these kinds of situations also increase the number of coordination errors. As a consequence, coaches need first to assure correct execution of motor skills and sport techniques. The degree of complexity of many competitive actions and exercises, and the low level of development of the energetic and muscular systems do not always allow specific speed training based on competitive exercises. Taking this into account, the strength demands of speed exercises can be reduced and exercises that allow higher movement speed can be emphasized so that youth can easily and quickly identify and respond to game demands (Bauersfeld, 1991). The importance of a systematic improvement of intra- and inter-muscular coordination throughout fast muscle contractions during situations of reduced resistive training should be emphasized (Martin, 1991).

In such situations, motor transfer to specific sport practices is not negatively influenced if the training exercises are similar to the competitive activities. This is why loads under time pressure should be used on a regular basis in youth sport programs in all training situations and not only during speed training.

CHOOSING THE MORE APPROPRIATE LOADS

Results in high level stages do not depend on the continuous increase of load volumes in youth programs. There is a need to better identify appropriate loads for youth training. This requires more careful choice of both load and content of training (Martin, 1991). In an attempt to build of a new model for training loads in youth sport programs, four main orientations are suggested:

(i) Preparing young athletes to support high loads in top-level stages

Good results in top level sport should not be expected without very intensive loads. Young athletes need to be prepared to support such loads when they reach advanced stages. By using multilateral loads in youth sport programs, coaches can enhance and strengthen the basis that allows, some years later, the application of very intensive loads. This will presumably improve results and reduce impacts of such loads on the body.

(ii) Stressing a specific multilateral load

Some formulations of training theory suggest that the adaptive potential of the organism is limited to so-called "adaptation reserves" (Martin, 1991). For this reason, the spectrum of factors to be trained must be limited to the relevant demands of a competition in the specific sport. General training should thus aim at the specific demands of each sport (Bauersfeld, 1991; Rahn, 1993; Marques, 1999; Marques *et al*., 2000).

Accordingly, coaches need to use multilateral loads by increasing the capacity levels of specific performances through the choice of appropriate exercises. Such a program promotes both the objectives of general training and transfer effects from general to specific exercise.

(iii) Focusing on quality of training loads

Improving the quality of training loads requires concentration on those components of the performance which are essential for top level sport in each discipline. These components are understood as pre-requisites for the opening of new reserves of sport performances which are not properly stimulated during the formation stages.

If these components have such an essential role, they need to be defined for each sport discipline and the periods (times) when they can be properly stimulated during the long term process of athlete development need to be identified. If specific training does not take place during these particularly sensitive periods, it will be likely very difficult to do so later.

(iv) Individualisation

Finally, the focus on quality also requires the establishment of conditions that allow a stronger individualisation of the coaching process (Martin *et al*., 1993). Such individualisation is one of the major possibilities for promoting quality.

THE DEVELOPMENT OF THE COMPETITION SYSTEM

The increasing social relevance of youth sport over the last four decades or so and the search for better solutions to the process of sport specialisation has resulted in the development of a youth competition at the regional, national and international levels. Although youth training systems have improved, the same cannot be stated about the system of competitions. There is a lack of theory dealing with youth competitions. In most cases, competition models are very traditional and conservative. They are quite similar in organisational form and content to competitions in top level sport. This is unfortunate because the demands of these competitions are very high and the possibilities for child and adolescent athletes are not the same as for adult athletes.

More precise formulations of a competition theory for youth are needed. These may include, among others, the following:

- Function and objectives of youth sport competitions
- Types of competitions for different stages of development and preparation
- Number and frequency of competitions during each phase of sport formation
- Organisation, regulation and content of competitions at different stages of sport preparation
- Relationships between training and competition at different stages of sport preparation.

There is much work to be done to improve the quality of youth sport competitons. This will require the contributions and efforts of researchers from all disciplines of the sport sciences and experts in youth sport in building of a sound competition theory.

Training and competition are the two main subsystems of sport, and by definition they are related. Theories and models of training and of competition for children and adolescents need to be developed jointly.

Continued application of the specialized competition models of adult and top level sport to youth will undoubtedly result in premature specialization of children and adolescents. The specialised demands of competition with emphasis on results necessarily requires specialisation of the training process, which has as a consequence premature increase of load volumes and intensities to levels that are not appropriate for children and adolescents and for the objectives of youth sport formation. Overuse injuries and other negative implications for development and health are often outcomes of such efforts.

As a result, several European researchers and pedagogues have focused on the contents of competitive activities during early stages of development in an attempt to formulate a more adequate and harmonious relationship between the contents of training programs and the contents of competitive activities (Thieß, 1991, 1995; Rost, 1995; Tschiene, 1995, Marques, 1997; Lima, 2000; Marques and Oliveira, 2002). If both training and competition in youth sport programs are to be understood primarily as a means for formation, the practice of training and competitive exercises needs to be brought into the same framework.

Pedagogical guidelines for the early phases are oriented to the idea of diversity in activities and are aimed at promoting multilateral development. The same should occur in competitive sport activities. They should be considered as a training means, constituting a highly motivating stimulus to children and offering them the chance to participate in a variety of competitive activities, either formal or informal, highly structured or unstructured, in accordance to the objectives of sport formation during the early stages.

In summary, in each phase of the long term process of sport preparation, there should be a balanced, coherent relationship between the content of the activities in training and in competition according to the following orientation:

- Stages of multilateral training - multilateral competitions,
- Stages of adapted specialised training - adapted specialised competitions,
- Stages of highly specialised training - highly specialised competitions.

OVERVIEW AND IMPLICATIONS FOR TEACHING AND COACHING

The debate on the quality in youth sport programs will continue. Many other topics contribute to make this debate more significant. It is important to be aware that children and adolescents in sport are the subjects and not only the objects of intervention by coaches. Implications for teaching and coaching include the following, among others:

- Continued improvement of teaching and learning methods of sport techniques focusing on movement regulation and control processes and emphasising the role of movement representation and perception. On the other hand, technique training should be planned in an integrative manner with other demands of sport activity.

- Emphasis on the role of decisional processes during sport activities by setting appropriate problems and providing opportunities that offer children and adolescents possibilities to choose the best solutions during each situation.

- Give speed training high priority in youth sport programs by focusing on control and regulation mechanisms of this ability during childhood rather than on the metabolic and muscular mechanisms, which should be emphasised after puberty.

- Choose more appropriate training loads in youth sport programs by planning load dynamics according to three main principles: (a) children and adolescents should be prepared to support very intensive loads in top level stages; (b) multilateral loads specifically oriented to the specialised demands of a chosen sport should be used; and (c) focus should be on the quality of training loads by identifying those components of top level performance which are essential to top performance and work on them during the right periods of the long term process of sport formation.

- Finally, emphasize the fact that adult competitions are much too demanding for children and adolescents, and that competitive activities in youth sport programs should be organised according both to formation objectives and the needs of the young athletes.

LITERATURE

Bauersfeld K-H (1991). Tendenzen der Weiterentwicklung des Kinder- und Jugendtrainings. In H. Kirchgässner (Hrsg.) *40 Jahre Deutsche Hochschule für Körperkultur Leipzig*. Sankt Augustin, Academia. Alemanha, pp. 82-92.

Bremer D (1986). Wettkampfsport im Grundschulalter. *Leistungssport* 2: 5-10. Münster: Deutscher Sportbund, Philippka-Sportverlag.

Carman, J. M. (1990). Consumer perceptions of service quality: an assessement of SERVQUAL dimensions. *Journal of Retailing*, 66:33-55.

Kurz D (1988). *Pädagogische Grundlagen des Trainings*. Studienbrief 4 der Trainerakademie Köln, Schorndorf: Hofmann-Verlag.

Lima T (2000). Competições para jovens. In CEFD (Ed) *O melhor da revista Treino Desportivo*. Lisboa: CEFD, pp. 235-248.

Marques A (1995) O desenvolvimento das capacidades motoras na escola. Os métodos de treino e a teoria das fases sensíveis em questão. *Horizonte* 66:212-216.

Marques A (1997). A preparação desportiva de crianças e jovens. O sistema de competições. In Guedes O (Org.) *Atividade Física: uma abordagem multidimensional*. João Pessoa: Ideia, pp. 157-169.

Marques A (1999) Crianças e adolescentes atletas: entre a escola e os centros de treino... entre os centros de treino e a escola. In Adelino J, Vieira J, Coelho O (eds) *Treino de Jovens*. Lisboa: CEFD. Secretaria de Estado do Desporto, pp. 17-30.

Marques A (2000) Sobre as questões da qualidade no treino dos mais jovens. In FM Silva (Org.) *Produção do Conhecimento no Treinamento Desportivo: Pluralidade e Diversidade*. João Pessoa: UFPB, Editora Universitária, pp. 51-59.

Marques A, Maia J, Oliveira J, Prista A (2000). Training Structure of Portuguese Young Athletes. In A Prista, A Marques, J Maia (Org.) *10 Anos de Actividade Científica. Faculdade de Ciências de Educação Física e Desporto*, Lisboa: Ministério da Juventude e Desporto, Colecção Estudos, pp. 270-279.

Marques A, Oliveira J (2001). O treino dos jovens desportistas. Actualização de alguns temas que fazem a agenda do debate sobre a preparação dos mais jovens. *Revista Portuguesa de Ciências do Desporto*, 1(I):130-137. Porto: FCDEF-UP.

Marques A, Oliveira J (2002). O treino e a competição dos mais jovens: rendimento *versus* saúde. In V Barbanti, AC Amadio, J Bento, A Marques (Eds) *Esporte e Atividade Física: Interação entre rendimento e saúde*. São Paulo: Manole, pp. 51-78.

Martin D (1991). Zum Belastungsproblem im Kinder- und Jugendtraining unter besonderen Berücksichtung von Vielseitigkeit oder Frühspezialisierung. In H Kirchgässner (Hrsg) *40 Jahre Deutsche Hochschule für Körperkultur Leipzig*. Academia Verlag Sankt Augustin, pp. 115-123.

Martin D (1999). Capacidade de performance e desenvolvimento no desporto de jovens. In Adelino J, Vieira J, Coelho O (Eds) *Treino de Jovens*. Lisboa: CEFD, Secretaria de Estado do Desporto, pp. 37-59.

Martin D, Carl K, Lehnertz K (1993). *Manuale di Teoria dell'Allenamento*. Roma: Società. Stampa Sportiva.

Meinberg E (1991) *Die Moral im Sport. Bausteine einer neuen Sportethik*. Aachen: Meyer & Meyer Verlag.

Rahn S (1993) Zu einigen Problemen des allgemeinen Trainings bei der Entwicklung von Leistungsvoraussetzungen im Nawuchsleitungssport. In: J Lenz, K Nitzsche, H Polster (Dir.) *Leistungsvoraussetzungen im Nawuchstraining*. Sankt Augustin, Academia, pp. 16-25.

Rost K (1995). Le gare nello Sport Giovanile. *SdS/Rivista di Cultura Sportiva* 32(XIV):69-73. Roma: CONI.

Sports Medicine and Performance Commission (2000). Sports Medicine and Performance Commission Position Statement Addressing 10-and-under National Championship. *http:// www.avca.org/sportsmed/smpcArticles/10andunderposition.html.*

Thieß G (1991). Das Nawuchstraining im Spiegel von 20 Jahren "Leistungssport". Fortschritte und Defizite. *Leistungssport* 6(21):12-14. Münster: Deutscher Sportbund, Philippka-Sportverlag.

Thieß G (1995). Die Ausarbeitung einer Wettkampflehre hat begonnen. *Leistungssport* 1(25):5. Münster: Deutscher Sportbund, Philippka-Sportverlag.

Tschiene P (1995). Adaptive Aspekte des Wettkampfs. *Leistungssport* 1(25):16-19. Münster: Deutscher Sportbund, Philippka-Sportverlag.

http://dx.doi.org/10.14195/978-989-26-1169-3_11

CHAPTER 11: READING AND WRITING THE GAME: TACTICAL SKILLS IN TEAM SPORTS

Marije T Elferink-Gemser
Rianne Kannekens
Barbara Huijgen
Yvonne Tromp
Laura Jonker
Tynke Toering
Chris Visscher

INTRODUCTION

Several team sports can be categorized as invasion sports, in which players compete at the same field of action as their opponents. The sports are time dependent and can be sub-categorized into goal-throwing (e.g., basketball), try scoring (e.g., rugby), and goal-striking games (e.g., soccer, field hockey). They are characterized by the need for players to constantly adapt to opposition by rapid adaptation to changing play configurations and to the movement of the ball. In such games, players have to deal with a complex and rapidly changing environment while invading the opposing team's area of the field in order to score (Almond, 1986; Hughes and Bartlett, 2002; Williams, 2000). Success requires that players of all ages have well-developed physiological and technical characteristics in addition to cognitive skills as well (French and Thomas, 1987; Helsen and Starkes, 1999; Nougier and Rossi, 1999; Starkes, 1987; Williams et al.,1993). The integration of physical, technical and cognitive skills is generally apparent in studies showing that many talented athletes not only perform well in sports but also in school settings (Jonker et al., 2009).

Playing at a high level of performance in invasion sports means choosing the right action at the right moment and performing that course of action efficiently and consistently throughout the match (Baker et al., 2003a; Gréhaigne et al., 2001). To perform the right action at the right moment, with a successful performance or outcome, proper understanding of the game is necessary. Reading the game and reacting in parallel can therefore be viewed as a key characteristic for high level of performance. However, what is the meaning of reading the game properly and reacting at the same time with the appropriate action? A number of terms have been used to describe successful performance, for example, *game intelligence*, *implicit knowledge*, *tricks of the trade*, *practical intelligence*, *tactics*, *tactical knowledge* and *tactical skills* (Bjurwill, 1993; Gréhaigne and Godbout, 1995; Gréhaigne et al., 1999; McPherson, 1994). The term *tactical skills* is the presently utilized label (McPherson and Kernodle, 2003). *Tactical skills* are cognitive skills and are different from, but tightly coupled to *strategy*. Both, *tactical* skills and *strategy* are needed to read the game and execute the right action at the right moment. *Tactical skills* refer more to 'the decision-making activity during the game and to the knowledge about adaptations in action' in contrast to s*trategy* which refers to 'knowledge about programming' or 'planning' (Bjurwill, 1993; Mouchet, 2005). In other words, *tactical skills* relate to the quality of an individual player to perform the right action at the right moment and should therefore be distinguished from *strategy*, which relates to choices discussed in advance with the trainer in order for the team to organize itself (Gréhaigne and Godbout, 1995).

McPherson and Thomas (1989) predicted that the type of cognitive processes of athletes during competition could be linked to their knowledge base of the task. *Knowledge structure of sports* can be defined as 'knowledge of the game's goal structure combined with knowledge of related game events in terms of the game's goal structure'. This means that sport knowledge may not only refer to the decisions concerning the appropriate action in the context of the game situation ("if-then"), but also to the ability to execute the complex sport skill ("do") (McPherson and Thomas, 1989). These two important sources of knowledge are also defined as *declarative* ("knowing what to do") and *procedural* ("really doing it") knowledge and are the basis of tactical skills.

Distinguishing between on-the-ball and off-the-ball situations is one way to categorize elements of tactical skills related to the nature of match play in invasion games (Oslin et al., 1998). On-the-ball actions refer to attacking, situations where the team is in possession of the ball and tries to score. Off-the-ball actions refer to defense, preventing the opposing team from scoring. Tactical skills related to attack can thus be distinguished from those related to defense (Bjurwill, 1993). Tactical skills are similar across invasion games, such as maintaining possession of the ball, attacking the goal, and creating space in the attack, as are defending space or defending against an attack (Mitchell, 1996).

TACTICAL SKILLS AND TECHNIQUE

There is a difference between response selection and response execution in sports compared to response selection and execution in other domains (e.g., chess, computer language). In sports, tactical skills not only involve the ability to determine which decision is most appropriate in a given situation, but also involve decisions whether the decision can be successfully executed within the constraints of the required movement. In invasion sports, these constraints are largely physiological and technical, and limit the tactical options available to the athlete (Janelle and Hillman, 2003). Although athletes are free to circulate between plan (strategy) and tactical adaptation, this freedom is influenced by personal characteristics and the game circumstances (Mouchet, 2005).

Physiological and technical skills improve during adolescence (Elferink-Gemser et al., 2006; Huijgen et al., 2009; Visscher et al., 2006). Speed, power and other functional capacities improve (Baxter-Jones et al., 1993; Hansen et al., 1999) and together with the development of intellectual and motor skills lead to improved technical abilities (Gil et al., 2007). Invasion sports require a combination of physiological, technical, psychological and tactical skills for good performance (Elferink-Gemser et al., 2004; 2007). Evidence indicate increased sprinting performance and technical proficiency in dribbling performance in talented youth soccer players during adolescence (Huijgen et al., 2009; Kukolj et al., 2003; Gil et al., 2007; Vaeyens et al., 2006). These improved abilities permit additional tactical options for players (Visscher et al., 2005). Therefore, good physiological and technical skills provide more choices available for players and the ability to execute the actions more quickly and proficiently. To be an outstanding player, correct technique needs to be selected and performed as determined by the demands of the situation (Ali et al., 2007).

TACTICAL SKILLS AND LEVEL OF PERFORMANCE

The relation between tactical skills and performance has been examined by many researchers. Due to more highly developed tactical skills, expert athletes are better able to select the appropriate response for a situation within the context of the game's goal structure, based on less information, and can do so more quickly than novice athletes (Thomas et al., 1986; Williams et al., 1993). It is suggested that the difference between experts and novices is that experts can '*read the game*' quicker and more accurately than novices (Baker et al., 2003b). Tactical skills are thus an important attribute of expertise. It is also suggested that the level of knowledge structure of a sport situation and an individuals' knowledge of 'what to do' affects the quality of decision(s) made in the context of a game situation, and the quality of decisions made within the context of the game are the best discriminators between expert and novice children regardless of age (French and Thomas, 1987).

The contribution of basketball knowledge (declarative) and specific basketball skills (procedural) to the development of skilled decision-making and overall basketball performance was studied in groups of high- and low-skilled youth 8-10 and 11-12 years of age (French and Thomas, 1987). Highly skilled basketball players possessed more basketball knowledge and scored higher on specific basketball skills. To clarify the content and structure of knowledge used in tactical skills, knowledge structures of male youth tennis players 10-11 and 12-13 years was examined using a verbal report instrument

(McPherson and Thomas, 1989). Results suggested that the content of an experts' knowledge compared to players of a lower level consisted of concepts that were more complex.

To date, research into the relationship between tactical skills and performance or competitive levels has been restricted largely to identifying expert-novice differences. The studies all show that expert athletes outscore novice athletes on many aspects of tactical skills. Experts have an extensive and rich domain-specific knowledge structure due to the development of an enhanced declarative knowledge base and a well-developed procedural knowledge base. The knowledge structures of experts consist of representations in which the concepts are more varied, complex and interrelated. Furthermore, experts have highly evolved problem representations that contain well-developed action plans and current event profiles. In contrast, the novice performers have a limited amount of domain-specific knowledge, generate more single concepts which are less interrelated, and use rudimentary goals or at best have access to rudimentary action plan profiles (French et al., 1996; Starkes, 1987; Williams and Davids 1995) .

Although valuable, the studies indicate relatively little on how the best can be distinguished from good players, which is a prerequisite in the field of talent development. In a recent study on tactical skills of world-class youth soccer teams, differences in highly experienced players were not as apparent as differences between experts and novices, although within an elite team the best players had different performance profiles than the 'lesser' players on their team (Kannekens et al., 2009). It was concluded that tactical skills were fundamental to high-level soccer performance. Talented youth players also outscored regional youth players on both declarative and procedural tactical skills (Visscher et al., 2005). Talented players knew better what to do during games and also better performed the proper action at the right moment. With increasing levels of performance, i.e., within a group of talented players, elite youth players outscored sub-elite youth players on procedural knowledge, but not on declarative knowledge. In other words, sub-elite youth players know what to do equally as well as elite youth players. However, when it comes to performing the right action at the right moment with opponents limiting space and time available, the elite players outscore their sub-elite counterparts.

MEASURING TACTICAL SKILLS

To measure the interaction between declarative and procedural knowledge within the sports domain, it is very important to have an instrument that can differentiate players' response selection and execution during actual competition. One of the developed instruments to examine the representation of conceptional knowledge (e.g., declarative and procedural knowledge) and to examine how this knowledge guides the solution process during problem solving or task performance, is a verbal report instrument (McPherson, 1994; McPherson and Thomas, 1989). Using verbal report procedures, athletes must verbalize the area of the display, which they consider particularly informative. Data can be collected either concurrently, during or retrospectively following completion of the performance. Consequently, a more direct measure of attentional allocation and information extraction is provided, leading to more insight in which information the athletes attend to and how they use it (Ericsson and Simon, 1980; Williams et al., 1999).

To clarify issues regarding sport-specific knowledge bases, a coding system makes it possible to code responses in the verbal reports into concepts. A *concept* was defined as 'a unit of information about response selection in the context of a game situation' (McPherson and Thomas, 1989). Three different concepts are used to examine the knowledge bases: condition, action or goal concepts. *Condition concepts* are 'abstract concepts specifying when and under which conditions to apply the action or patterns of action to achieve the goal'. *Action concepts* refer to 'the action selected or patterns of action selected which produces goal related changes in the context of a game situation'. *Goal concepts* are 'the game's goal structure usually hierarchically organized'. By coding these concepts, the content and structure of knowledge in tactical skills can be determined. The content of knowledge can be assessed by the information stored, which in turn can be measured by the total number of concepts, total number of different concepts, and quality of each concept. The goal, action and condition concepts interact and the structure of knowledge can be measured by the frequency of connections between concepts and the units (linkage) of concepts (McPherson and Thomas, 1989).

In addition to the coding system, a memory model was introduced (French and McPherson, 1999). The model suggests that the knowledge base for sports includes declarative and procedural knowledge (for both response selection and execution) and also other sport-specific memory adaptations and structures. The model depicts two specialized memory adaptations in long-term memory, termed *action plan profiles* and *current event profiles*. The former are 'rule-governed prototypes stored in long-term memory used to match certain current conditions with appropriate visual and/or motor actions'. These conditions are typically explicit environmental cues (i.e., player location) or general game strategies (i.e., tennis player being taught to rush to the net on a short shot). *Current event profiles* are 'tactical scripts that guide constant building and modifying of pertinent concepts (past, current, and/or future) to monitor during the competitive event' (French and McPherson, 1999). The current event profile is built upon past competitions and from specialized monitoring, encoding, and retrieval processes that are used to collect information throughout the current competition. To form a complete current representation of the game, both profiles are needed. The action plan and current event profiles were introduced to illustrate differences in levels of processing during sport competition.

Although there are several ways to assess tactical skills, there is to date no standard measure. Cognitive psychologists have used propositional-type analyses of subjects' think-aloud protocols whereas others measured tactical skills with picture or film slides of game situations (Allard and Burnett, 1985; Allard et al., 1993; Chamberlain and Coelho, 1993), by using the opinion of expert coaches, or through self-assessment (Elferink-Gemser et al., 2004). Most studies assessing tactical skills in experimental test situations in a laboratory setting had subjects view action sequences on a video projection screen (Bard et al., 1994; Helsen and Starkes, 1999; McMorris and Graydon, 1997; Williams et al., 1993). This design, however, does not account for the fact that response execution affects response selection since the athletes were only required to state which decision they thought was correct (response selection); they were not required to execute it (response execution).

Even though these settings are useful for fundamental research, they are less suitable for applied purposes. For example, laboratory studies are different from the real-world settings in which a player has to deal with the pressure of opponents, time constraints, and stress (McPherson and Kernodle, 2003). In the field, there is a clear need for information about the tactical skills of individual players, for instance, to help trainers guide youth players toward a higher performance level. Information on tactical skills could also prove to be very valuable in leading talented players to the top or in evaluating training effects. A measurement that is specifically designed for application in sports practice and that takes real-world settings into account is the Tactical Skills Inventory for Sports (TACSIS, Elferink-Gemser et al., 2004). Whether the inventory is capable of measuring the whole concept of tactical skills cannot completely be ascertained without an accepted reference instrument. Yet, this instrument was constructed with the help of expert trainers and was embedded in theory. This method of gathering items can be considered logical validity, also referred to as face validity, and supports the notion that the TACSIS is really measuring tactical skills (Thomas and Nelson, 1996).

THE TACSIS

The Tactical Skills Inventory for Sports (TACSIS) includes four subscales: *knowing about ball actions*, *knowing about others*, *positioning and deciding*, and *acting in changing situations*. To construct the self-reporting inventory, the theoretical elements on tactical skills according to the framework created by

McPherson (1994) were discussed with nineteen highly qualified trainers of youth national and district selection invasion sports teams in the Netherlands (soccer and field hockey). The framework consists of continuums that move from response selection to response execution and from knowledge (knowing what to do) to action (doing it) in addition to the distinction between attacking versus defensive situations. The trainers were asked to put forward those elements they considered most important for high performance (Elferink-Gemser et al., 2004). Questions were formulated and reformulated until consensus was reached within the team of experts on the content of the inventory. Thirty-four items regarding sports performance were put in questionnaire form using a 6-point Likert scale, ranging from 'very poor' to 'excellent' or from 'almost never' to 'always'. To provide players with an external reference the players are required to compare themselves with the top in their age category. As a consequence, all players are provided with a reference point relating to their age category.

To examine the structure of relations among items in the original sample for the purpose of bringing them together into a smaller set of variables or constructs (Nunnally and Bernstein, 1994), a factor analysis was conducted using a sample of 209 youth players (15.8±1.6 years, range 12.6-18.9 years), all participants in competitive field hockey (n=123) or soccer (n=86). Principal component analysis with the four factors fixed followed by varimax rotation yielded a structure which accounted for 50% of the response variance. Twenty-two items met the criterion of having a factor loading greater than or equal to 0.55 (Elferink-Gemser et al., 2004). Items of the TACSIS are presented in Table I.

The scale for *knowing about ball actions* contains four items related to declarative knowledge of attacking situations, an example of which reads: 'I know exactly when to pass the ball to a teammate or when not to'. The five items of the scale for *knowing about others* address declarative knowledge of defensive situations (e.g., 'I know quickly how the opponent is playing'). *Positioning and deciding* has nine items on procedural knowledge of attacking situations (e.g., 'my getting open and choosing positions is'). The four items of scale for *acting in changing* situations gauge procedural knowledge of defensive situations (e.g., 'my interception of the opponent's ball is'). By testing the four key elements of tactical skills, i.e., declarative versus procedural and attacking versus defensive situations, the TACSIS captures all four aspects of tactical skills.

The TACSIS has been shown to have good psychometric characteristics with internal consistency coefficients (Cronbach's alphas) of all four subscales ranging from 0.72 to 0.89 (Elferink-Gemser et al., 2004). The intraclass correlation coefficients for repeated measures were as follows: 0.76

for *knowing about others*, 0.88 for *positioning and deciding*, 0.82 for *acting in changing situations*, and 0.60 for *knowing about ball actions*. To validate the players' scores on the TACSIS, regular trainers for three of the national youth soccer teams were asked to rate the tactical skills of each of 18 Dutch players on a 6-point Likert scale, ranging from 'Very poor' to 'Excellent'. The Spearman's correlation between the trainers' ratings and the players' TACSIS sum score was 0.79, underlining the validity of the measure (Kannekens et al., 2009).

Table 1. Items of the Tactical Skills Inventory for Sports (TACSIS; Elferink-Gemser et al., 2004).

Knowing about ball actions		Declarative knowledge	Attack
1	I know exactly when to pass the ball to a teammate or when not to		
2	If we receive the ball (getting ball possession), I know exactly what to do		
3	While executing an action in a match, I know exactly what to do subsequently		
4	If I possess the ball, I know exactly whom I have to pass to		
Knowing about others		Declarative knowledge	Defense
1	My judgment of the opponent's play is		
2	I know quickly how the opponent is playing		
3	Although I do not see my opponents, I know where they are going		
4	Without seeing my teammates, I know where they are going		
5	If an opponent receives the ball, I know exactly what he is going to do		
Positioning and deciding		Procedural knowledge	Attack
1	Decisions I make during matches about proceeding actions are generally		
2	I know how to get open during a match		
3	My positioning during a match is generally		
4	My overview (in ball possession or in team's ball possession) is		
5	My anticipation (thinking about proceeding actions) is		
6	I am good at taking the right decisions at the right moments		
7	In the opinion of my trainer, my understanding of the game is		
8	My getting open and choosing position is		
9	In the opinion of my trainer, my positioning is		
Acting in changing situations		Procedural knowledgde	Defense
1	My interception of the opponent's ball is		
2	My interception of the ball is		
3	If our team loses the ball during a match, I quickly switch to my task as defender		
4	I quickly react to changes, as from not possessing the ball to ball possession		

Note: items had to be answered on a 6-point scale, ranging from 1 = very poor to 6 = excellent or from 1 = almost never to 6 = always, while comparing oneself with top players in the same age category.

Being a self-report instrument, measures are susceptible to the individual's self-confidence. Since confidence is associated with elite performance in various sports, this might affect the results obtained with such a measurement (Mahoney et al., 1987; Woodman and Hardy, 2003). Therefore, in terms of the validity of the TACSIS, it is important that players are at least 14 years of age or have experience of at least five years in invasion sports. In case the TACSIS is used with youth players, it is recommended that they play at a high level of performance. The TACSIS can be applied in youth players provided that the players have been confronted frequently with all aspects of their performance on the field. For example, in talented players, trainers, coaches, peers and parents give feedback on how fast they are, how well they dribble the ball and also whether or not they perform the right action at the right moment. When players are confronted by (significant) others about their tactical skills for many years, they ultimately develop knowledge of how good (or bad) they really are. In other words, regardless of their enhanced confidence, elite players are thought to have a realistic perspective of their tactical skills. The TACSIS is thus suitable for gathering data on tactical skills of experienced youth athletes in invasion sports. With the TACSIS, information can be gathered on 'knowing what to do' and 'doing it' in attacking as well as in defensive situations.

CONCLUSION

The knowlegde base on physical, physiological and technical components of performance in a variety of team sports is relatively rich. The influence of psychological skills on successful performance is also increasingly recognized. In contrast, tactical skills have been less studied even though these skills have are closely related to successful performance, especially in invasion sports. Although there are several ways to assess tactical skills, to date there is no standard measure. A measurement that is specifically designed for application in sports practice and that takes real-world settings into account is the Tactical Skills Inventory for Sports (TACSIS). The instrument is suitable for gathering data on tactical skills of experienced youth athletes participating in invasion sports. The TACSIS provides information on 'knowing what to do' and 'doing it' in attacking defensive situations. The tactical skills are related to *positioning and deciding*, *knowing about ball actions*, *knowing about others* and *acting in changing situations*.

REFERENCES

Ali A, Williams C, Hulse M, Strudwick A, Reddin J, Howarth L et al. (2007) Reliability and validity of two tests of soccer skill. *Journal of Sports Sciences, 25 (13),* 1461-1470.

Allard F, Burnett N (1985) Skill in Sport. *Canadian Journal of Psychology-Revue Canadienne de Psychologie, 39,* 294-312.

Allard F, Deakin J, Parker S, Rodgers W (1993). Declarative knowledge in skilled motor performance: Byproduct or constituent? In JL Starkes, F Allard (Eds), *Cognitive issues in motor expertise*. Amsterdam: Elsevier Science Publishers BV, pp 95-107.

Almond L (1986) Reflecting on theses: a games classification. In R Thorpe, D Bunker, L Almond (Eds), *Rethinking games teaching.* Loughborough, England: Loughborough University of Technology, pp 71-72.

Baker J, Cote J, Abernethy B (2003a) Learning from the experts: practice activities of expert decision makers in sport. *Research Quarterly for Exercise and Sport, 74,* 342-347.

Baker J, Cote J, Abernethy B (2003b) Sport-specific practice and the development of expert decision-making in team ball sports. *Journal of Applied Sport Psychology, 15,* 12-25.

Bard C, Fleury M, Goulet C (1994) Relationship between perceptual strategies and response adequacy in sport situations. *International Journal of Sport Psychology, 25,* 266-281.

Baxter-Jones A, Goldstein H, Helms P (1993) The development of aerobic power in young athletes. *Journal of Applied Physiology, 75,* 1160-1167.

Bjurwill C (1993) Read and react - The football formula. *Perceptual and Motor Skills, 76,* 1383-1386.

Chamberlain CJ, Coelho AJ (1993) The Perceptual side of action: Decision-making in sport. In JL Starkes, F Allard (Eds), *Cognitive Issues in Motor Expertise*. Amsterdam: Elsevier Science Publishers BV, pp 135-157.

Elferink-Gemser MT, Visscher C, Lemmink KAPM, Mulder Th (2004) Relation between multidimensional performance characteristics and level of performance in talented youth field hockey players. *Journal of Sports Sciences, 22*, 1053-1063.

Elferink-Gemser MT, Visscher C, Lemmink KAPM, & Mulder Th (2007) Multidimensional performance characteristics and performance level in talented youth field hockey players: A longitudinal study. *Journal of Sports Sciences*, *25*, 481-489.

Elferink-Gemser MT, Visscher C, Van Duijn MAJ, Lemmink KAPM (2006) Development of the interval endurance capacity in elite and sub-elite youth field hockey players. *British Journal of Sports Medicine, 40*, 340-345.

Elferink-Gemser MT, Visscher C, Richart H, Lemmink KAPM (2004) Development of the tactical skills inventory for sports. *Perceptual and Motor Skills, 99,* 883-895.

Ericsson KA, Kintsch W (1995) Long-term working-memory. *Psychological Review, 102,* 211-245.

Ericsson KA, Simon HA (1980) Verbal reports as data. *Psychological Review*, 87, 215-251.

French KE. McPherson SL (1999) Adaptations in response selection processes used during sport competition with increasing age and expertise. *International Journal of Sport Psychology, 30,* 173-193.
French KE, Nevett ME, Spurgeon JH, Graham KC, Rink JE, McPherson SL (1996) Knowledge representation and problem solution in expert and novice youth baseball players. *Research Quarterly for Exercise and Sport, 67,* 386-395.
French KE, Thomas JR (1987) The relation of knowledge development to children's basketball performance. *Journal of Sport Psychology, 9,* 15-32.
Gil S, Ruiz F, Irazusta A, Gil J, Irazusta J (2007) Selection of young soccer players in terms of anthropometric and physiological factors. *Journal of Sports Medicine and Physical Fitness, 47,* 25-32.
Grehaigne JF, Godbout P (1995) Tactical knowledge in team sports from a constructivist and cognitive perspective. *Quest, 47,* 490-505.
Grehaigne JF, Godbout P, Bouthier D (1999) The foundations of tactics and strategy in team sports. *Journal of Teaching in Physical Education, 18,* 159-174.
Grehaigne JF, Godbout P, Bouthier D (2001) The teaching and learning of decision making in team sports. *Quest, 53,* 59-76.
Hansen L, Bangsbo J, Twisk J, Klausen K (1999). Development of muscle strength in relation to training level and testosterone in young male soccer players. *Journal of Applied Physiology, 87,* 1141-1147.
Helsen WF, Starkes JL (1999) A multidimensional approach to skilled perception and performance in sport. *Applied Cognitive Psychology, 13,* 1-27.
Hughes MD, Bartlett RM (2002) The use of performance indicators in performance analysis. *Journal of Sports Sciences, 20,* 739-754.
Huijgen BC, Elferink-Gemser MT, Post WJ, Visscher C (2009) Soccer skill development in professionals. *International Journal of Sports Medicine*.
Janelle CM, Hillman CH (2003) Expert performance in sport: Current perspectives and critical issues. In JL Starkes, KA Ericsson (Eds), *Expert performance in sports: Advances in research on sport expertise*. Champaign, IL: Human Kinetics, pp 49-83.
Jonker L, Elferink-Gemser MT, Visscher C (2009) Talented athletes and academic achievements: a comparison over 14 years. *High Ability Studies*, *20*, 55-64.
Kannekens R, Elferink-Gemser MT, Visscher C (2009) Tactical skills of world-class youth soccer teams. *Journal of Sports Sciences, 27,* 807-812.
Kukolj M, Ugarkovic D, Jaric S (2003) Profiling anthropometric characteristics and functional performance of 12 to 18-year-old elite junior soccer players. *Journal of Human Movement Studies, 45,* 403-418.
Mahoney MJ, Gabriel TJ, Perkins TS (1987) Psychological skills and exceptional athletic performance. *The Sport Psychologist, 1,* 181-199.
McMorris T, Graydon J (1997) The effect of exercise on cognitive performance in soccer-specific tests. *Journal of Sports Sciences, 15,* 459-468.

McPherson SL (1994) The development of sport expertise - Mapping the tactical domain. *Quest, 46,* 223-240.
McPherson SL (1999) Expert-novice differences in performance skills and problem representations of youth and adults during tennis competition. *Research Quarterly for Exercise and Sport, 70,* 233-251.
McPherson SL, Kernodle MW (2003) Tactics, the neglected attribute of expertise. Problem representations and performance skills in tennis. In JL Starkes, KA Ericsson (Eds), *Expert Performance in Sports. Advances in Research on Sport Expertise*. Champaign, IL: Human Kinetics, pp 137-167.
McPherson SL, Thomas JR (1989) Relation of knowledge and performance in boys' tennis - Age and expertise. *Journal of Experimental Child Psychology, 48,* 190-211.
Mitchell SA (1996) Tactical approaches to teaching games: improving invasion game performance. *Journal of Physical Education, Recreation and Dance,* 67(2), 30-33.
Mouchet A (2005) Subjectivity in the articulation between strategy and tactics in team sports: an example in rugby. *Italian Journal of Sport Sciences,* 12, 24-33.
Nougier V, Rossi B (1999) The development of expertise in the orienting of attention. *International Journal of Sport Psychology, 30,* 246-260.
Nunnally JC, Bernstein IH (1994) *Psychometric theory*. New York: McGraw-Hill.
Oslin JL, Mitchell SA, Griffin LL (1998) The game performance assessment instrument (GPAI): Development and preliminary validation. *Journal of Teaching in Physical Education, 17,* 231-243.
Starkes JL (1987) Skill in field hockey - The nature of the cognitive advantage. *Journal of Sport Psychology, 9,* 146-160.
Thomas JR, French KE, Humphries CA (1986) Knowledge development and sport skill performance - Directions for motor behavior research. *Journal of Sport Psychology, 8,* 259-272.
Thomas JR, Nelson JK (1996) *Research methods in physical activity*. Champaign, IL Human Kinetics.
Vaeyens R, Malina RM, Janssens M, Van Renterghem B, Bourgois J, Vrijens J et al. (2006) A multidisciplinary selection model for youth soccer: the Ghent Youth Soccer Project. *British Journal of Sports Medicine, 40,* 928-934.
Visscher C, Elferink-Gemser MT, Lemmink KAPM (2006). Interval endurance capacity of talented youth soccer players. *Perceptual and Motor Skills, 102*, 81-86.
Visscher C, Elferink-Gemser MT, Richart H, Lemmink, KAPM (2005) Necessity of including tactical skills measurement in a field hockey talent development program. *10th Annual Congress of the European College of Sport Sciences (ECSS)*, Belgrade, Serbia, 187-188.
Williams AM (2000) Perceptual skill in soccer: Implications for talent identification and development. *Journal of Sports Sciences, 18,* 737-750.

Williams M, Davids K (1995) Declarative knowledge in sport - A by-product of experience or a characteristic of expertise. *Journal of Sport & Exercise Psychology, 17,* 259-275.
Williams M, Davids K, Burwitz L, Williams J (1993) Cognitive knowledge and soccer performance. *Perceptual and Motor Skills, 76,* 579-593.
Williams AM, Davids K, Williams JG (1999) Visual perception and action in sport. London and New York: Taylor and Francis.
Woodman T, Hardy L (2003) The relative impact of cognitive anxiety and self-confidence upon sport performance: a meta-analysis. *Journal of Sports Sciences, 21,* 443-457.

Página deixada propositadamente em branco.

http://dx.doi.org/10.14195/978-989-26-1169-3_12

CHAPTER 12: IMPORTANT FEATURES OF TALENT COACHES FOR TALENT DEVELOPMENT IN SPORTS

Mathijs van Ark
Marije T Elferink-Gemser
Ad Roskam
Chris Visscher

INTRODUCTION

Elite sports have a vast importance in society, have much attention in the media, and a lot of money is involved. As a consequence, the development of talented athletes in sports is becoming a big issue nowadays. A talented athlete can be defined as an athlete who performs better than his or her peers during training and competition, and who has the potential to reach elite level (Howe *et al*., 1998; Helsen *et al*., 2000, Elferink-Gemser *et al*., 2004). More and more it is realized that talent development plays an important role in reaching elite level in sports and excelling at this level (Singer and Janelle, 1999, Williams and Reilly, 2000, Ericcson, 2003). Talent development is influenced by multiple factors; a successful interaction of biological, psychological, and sociological factors is needed for the development of expertise in sport (Baker *et al*., 2003). One of the important factors for talent development is the coach of a talented athlete (talent coach) (Singer and Janelle, 1999, Baker *et al*., 2003, Gould *et al*., 2002). A coach's degree of knowledge and skills in many areas affect the performance of an athlete (Abraham *et al*., 2006). Six features with which a talent coach can contribute to the development of a talented athlete are outlined below.

The first features which are important for a talent coach are his experience and education. One of the important ways to learn the profession of coaching is by experience. Previous experiences as a player, assistant coach, or an instructor provide a coach with (sport-specific) knowledge about the sport in which the coach is functioning (Lemyre *et al*., 2007). The level of education of a coach seems to be an important characteristic as well. Several studies have demonstrated that elite coaches are more likely to have a higher level of education (Lyle, 2002). For example, Gould *et al.* (1990) found that a large percentage of elite U.S. national team, Pan American, and Olympic coaches have a high education (78% has a Bachelor degree or higher).

The synchronization of the role of the coach with developmental stages of an athlete is a second feature with which a talent coach can contribute to the development of a talented athlete. Talent is a dynamic concept and factors which form a talent do not only interact, but also change over time (Abbott *et al.*, 2005). Several authors have phrased stages through which talented athletes progress over time (Bloom 1985, Côté 1999, Balyi *et al., not dated*). The cognitive, physical, and emotional needs of children change at the various stages of their sport participation. Due to these changes it is important that the role of coaches change accordingly (Côté *et al.*, 2003). Martindale *et al.* (2007) also confirm the importance of emphasis on appropriate and ongoing development (not on early success).

A third important way in coaching talented athletes is goal setting. Despite some contradiction in the literature, the current opinion about goal setting is that it is beneficial in the sports domain (Kyllo and Landers, 1995, Mooney and Mutrie, 2000, Weinberg *et al.*, 2001, Martindale *et al.,* 2007). Skills are better acquired and maintained when goals are set than when performers are instructed to only do their best in sports participation (Boyce, 1992). Martindale *et al.* (2007) also stresses goal setting as one of the important generic characteristics of effective talent development environments (in direct process of coaching).

A fourth feature is the motivational climate implicated by a talent coach. Abbott and Collins (2004) conclude in their review that it is not the performance at a young age of a talented athlete that is a good indicator of eventual attainment in a sport. In contrast, motivation and appropriate learning strategies appear to be more important in order to fully develop one's potentials. Motivation of an athlete is associated with the motivational climate (Ntoumanis and Biddle, 1999). The coach of an athlete was found to have an important role in constructing the motivational climate (Pensgaard and Roberts, 2002). An often used distinction in motivational climates is the distinction between mastery climate and performance climate (Dweck, 1999). In a performance climate the athlete's perceived success and competence is based on performance compared to others (win/lose). A performance climate is created when the coach promotes intra-team rivalries, favours the most talented players, and punishes players for making mistakes. In contrast, athletes with a mastery based motivation feel successful on a self-referenced basis. A mastery climate is created by a coach when athletes are encouraged to focus on their own personal development (Cumming *et al.,* 2007).

The degree of autonomy supportive behaviour exhibited by the talent coach is a fifth feature. Autonomy supportive behaviour can be defined as 'a coach who takes the athlete's perspective, acknowledges the athlete's feelings and provides him with pertinent information and opportunities for choice, while minimizing the use of pressures and demands' (Black and Deci, 2000, p. 742). Conversely, a coach can also exhibit controlling behaviours, which are defined as 'pressures to think, feel or behave in specified ways, thereby ignoring an athlete's needs and feelings' (Mageau and Vallerand, 2003, p. 886). By exhibiting autonomy-supportive behaviours coaches can influence important aspects for a talented athlete to reach elite level (Mageau and Vallerand, 2003).

Finally, a talent coach also has to take into account external influences, since the athlete's relationships with significant others are important to their successes (Morgan and Giacobbi, 2006). The family and especially the parents play an important role in the development of a talented athlete (Côté, 1999). Most parents positively influence the development of their child, a number of parents also exist who unknowingly interfere with their child's development (Gould *et al.*, 2006).

The studies mentioned above investigated important features for talent coaches. However, these studies focused only on one aspect with which a talent coach can contribute to the development of talented athletes. In contrast, this research strives to give a more complete overview on all features mentioned of talent coaches with which they can contribute to the development of a talented athlete. To our knowledge, no such research is conducted before, with exception of a study by Martindale *et al*. (2007). They investigated talent development environments from the elite youth coach perspective and phrased five main generic characteristics for effective talent development environments: 1) long-term aims and methods; 2) wide-ranging coherent messages and support; 3) emphasis on appropriate development, not early success; 4) individualized and ongoing development; and 5) integrated, holistic and systematic development. To extend upon Martindale *et al*.'s research, the current research focuses on more specific features of talent coaches. These specific features may help in the selection and/or training of talent coaches.

The first part of this research consists of interviews with top level Dutch talent coaches to reveal which features are important for talent coaches in the development of talented athletes. It is assumed that these coaches possess and exhibit the right features for the development of talented athletes. In the second part of this study, it is investigated if these apparent features can be linked to degree of successfulness of a talent coach. To our knowledge features of talent coaches have never been linked directly to a degree of successfulness before. To establish successfulness, the eventual level (at senior age) of talented athletes coached by talent coaches is used.

Consequently, the purpose of the first part of this research is to find out which specific features top level talent coaches possess. The purpose of the second part of this research is to find out which of these features are linked to the degree of successfulness of a talent coach.

PART 1

Methods

The sample consisted of nine top level Dutch talent coaches (8 male and 1 female) from different sports: 5 individual and 4 team sports. Sports included are sports in which Dutch athletes compete with the best countries in the world: swimming, speed-skating, athletics, tennis, judo, soccer, volleyball, handball and field hockey. The top level talent coaches were selected by the national sport association in cooperation with the Dutch Olympic committee (NOC*NSF). The top level talent coaches were selected on the following criteria: 1) coaching highest level youth (aged 15-20 years), 2) coached multiple talents who reached elite level in the past, 3) at least 5 years of experience as a talent coach, and 4) head coach of athlete(s) (not only a coordinating role). All talent coaches coach at least one Dutch national team in the age category of 16 to around 20 years at the moment. Coaching is their main occupation for at least 3 years. Seven talent coaches coach and/or train a group of talented athletes almost daily, 2 talent coaches coach their group of talented athletes less frequently, because their athletes train and play games at their clubs.

The participants were contacted by telephone and after a short clarification of the study, they were asked to cooperate with an interview concerning coaching of talented athletes. All participants agreed to participate. A convenient time was scheduled for the interview at a location requested by the talent coaches. In most cases this was the working place or a canteen near the training venue of the participant. The procedures were in accordance with the medical ethical standards of the University of Groningen.

First, the interviewer shortly explained the purpose of the study and then asked permission to audiotape the interview. Subsequently, the participants were told the processing of the interview would occur anonymously. A semi-structured interview guide was constructed in line with a deductively constructed set of features with which a talent coach can contribute to the development of a talented athlete. Therefore, the interview guide comprised six main sections (education & experience, synchronization with developmental stages, goal setting, implementation motivational climate, autonomy supportive behaviour, and considering significant others). On every feature a set of questions was constructed in order to reveal the way in which the participants coached in this area. The first question on every theme was a general question concerning the theme. Follow up questions were asked on specific parts of the features. In the end, the participants were asked which characteristics of a good talent coach were important in their opinion. Finally, the participants were asked to distribute 100% over the six features from the set of important features of talent coaches, attributing higher percentages to more important features. Questions on every theme were carefully constructed based on literature and effort was made to gain honest open-ended responses (Foddy, 1993). A pilot interview was accomplished in order to examine the interview guide. Furthermore critical appraisal of experts with domain related knowledge was used to evaluate and refine the interview questions.

The audio recordings of the interviews were transcribed completely. Both deductive and inductive approaches were used to analyse the data. First an initial set of features was constructed deductively. Subsequently, inductive analysis of the interviews lead to a revision of the initial set of features (insertion and/or deletion of features). This method of analyzing data is based on a form of concept driven coding: template analysis (King, 1998).

Results

Table 1 shows the initial set of features and sub features with which a talent coach can contribute to the development of a talented athlete derived deductively.

Table 1. Initial set of features with which a talent coach can contribute to the development of a talented athlete

Education and experience	
	- Education
	- Experience as athlete
	- Experience as coach
Synchronization with developmental stages	
	- Development from guidance and support of coach in early years to responsibility shift from coach to individual in later years.
Goal setting	
	- Short & long term
	- Explicit
	- Athletes involved

(continues)

(continuation)

Motivational climate	
	- Focusing on development athlete not outcome games
	- No intra-team rivalries
	- Not punishing athletes for making mistakes
	- Not favouring most talented athletes
Autonomy supportive behaviour	
	- Involving athlete in training and development
	- Acknowledging an athlete's feelings and perspectives
	- Providing pertinent information and opportunities for choice
	- Independence athlete
	- Minimizing use pressures and demands
Considering significant others	
	- Involving & informing parents
	- Role model

a) Education and experience

Six talent coaches have a Bachelor degree or higher. Five talent coaches have accomplished a college education that is related to sport. All talent coaches accomplished the highest sport specific coach education in their sport. Six of them also possess, are attending, or are planning to attend the highest coach education of the Dutch Olympic Committee (NOC*NSF). All talent coaches participated in their sport as well, seven talent coaches performed at national level in their sport and two performed at an international level. The mean years of coaching experience by the talent coaches is 19,7 years (SD = 7,6). Seven talent coaches coached every age group. The two others did not coach respectively athletes younger than 14 and 16 years old. All but one of the participants said they did participate in activities to acquire extra knowledge. One talent coach did not participate in extra courses due to lack of time. Activities to acquire more knowledge in which the talent coaches participated were: giving lectures/courses themselves (*n*=6), attending sport alliance organised extra courses (*n*=5), attending courses organised by NOC*NSF (*n*=5), visiting conferences (*n*=2), and extra education in management (*n*=1).

b) Synchronization with developmental stages

All but one of the talent coaches indicated a scale from a more leading style of coaching in younger years of athletes to more independent athletes and only guiding them when they grow older. One talent coach for example stated that he asks a lot of discipline from younger athletes as an investment for later years, because then it is easier for them to take care of themselves when they grow older. A quote of a talent coach with another example in which this is indicated is presented below.

"As the talented athlete grows older, my style of coaching changes from leading through guiding between certain boundaries to supervision. The pace of this development (from leading to supervision) varies from one talented athlete to another."

Eight talent coaches stated that besides current performance, they take into consideration the potential development in selecting athletes. For example, talent coaches take the development of anthropometric characteristics, amount of training accomplished by an athlete in the past and anthropometric characteristics of parents into consideration when selecting talented athletes. The following quote provides an example that underlines the importance of taking into consideration potential development when selecting talented athletes.

"Of course you consider time (at for example 100 meters) when selecting talented athletes. Time is a tangible fact. But then you also consider how the time is realized."

All but one of the talent coaches coached athletes of the same age differently because of different characters of the athletes. A talent coach for example stated that every child is different, therefore he coaches every talented athlete in a different way. Three talent coaches stated that they take into consideration the physical load possible in a developmental stage of an athlete. For example, a talent coach stated that he decreased the amount of training a lot because of the possible load for the knee-joint in the growth spurt of a particular athlete. A quote of a top level talent coach which supports the different approach of different athletes is shown below.

"Each talented athlete is unique and needs his own approach."

c) Goal setting

In both team sports as well as individual sports, talent coaches reported that group goals are formulated. All talent coaches also indicated that individual goals per athlete are set. An example of a quote of a talent coach which indicates this is presented below.

"The goal of the Dutch National youth selection is to reach the World Championships. From this overall goal I detract the individual goals."

All talent coaches reported that long as well as short term goals are set. Main goals are formulated for a long term; these goals have sub-goals which are further elaborated in execution goals. One talent coach for example stated that rough goals are formulated for a number of years, concrete goals for one year and the goals are elaborated per month. A quote of a talent coach which provides another example of how goals for different terms are set is shown below.

> *"The personal development plan (PDP) states the individual goals for the period of one year together with some intermediate goals. Team-goals are being formulated for half of a season and the goals for each match on a weekly basis. Furthermore, every Monday I outline the goals for that week and at the beginning of every training I tell them the goals for that specific day."*

Eight talent coaches record the goals. One talent coach only explicitly stated the goals, but would have recorded goals in case he coached a team with which he would work on a daily basis. Three talent coaches for example record goals per athlete in a document called Personal Development Plan. All talent coaches reported that goals are formulated in consultation with coach and athlete. Seven explicitly stated that goals are initially formulated by their athletes. A quote of a talent coach with which this is indicated is presented below.

> *"We make a Personal Development Plan (PDP) for each player. In this plan the player formulates his own goals first and then we add the goals which we have for this specific player . We review the PDP every three months along with the player."*

The talent coaches indicated that goals were set on several areas. The following areas in which goals are set were listed the most: physical (*n*=6), technical (*n*=5), cautious with performance (*n*=3), performance (*n*=3), organization of daily activities (*n*=3) and mental (*n*=3) goals.

d) Motivational climate

Eight talent coaches stated that development of a talented athlete to elite national team level is most important. A talent coach for example stated that the ultimate goal of a coach of a national youth team is not winning the Youth European or World Championships, but the ultimate goal is to prepare as much athletes as possible for the elite national team. Five talent coaches indicated that they focus more on the process (things to do well in a contest) than the outcome of a contest. A quote with which a talent coach indicated the importance of development of talented athletes is presented below.

"We always coach toward performance and never toward results. My players are being trained to want to play well instead of wanting to win. We use the verb ´to win´ very little."

Although the outcome of contests is less important, three talent coaches explicitly stated that contests are definitely important for the development of a talented athlete. One talent coach for example compared the relationship between winning contests and development to the question: which came first, the chicken or the egg? A quote from which it appeared that contests are important as well is shown below.

"In the end, you train youthful athletes for long term performance. In fact, I consider developing athletes as providing them with a good education to the maximum of their potential but, of course, when you participate in an European Youth Championship, you very much live in that moment, that is when you need to perform. You work toward that goal, but experiencing it is a part of the learning process as well. In that respect these issues are two separate ones."

The importance of cooperation within a group of talented athletes is stated to be important by seven talent coaches. Some contradiction exists between the talent coaches in the application of intra-team rivalries. Some talent coaches (n=3) indicated that they apply intra-team rivalries, while others (n=2) indicated that they do not. Four talent coaches stated that they apply intra-team rivalries now and then, but intra-team rivalries have to be applied with care. One talent coach for example stated that rivalry between two athletes must lead to an improvement of both athletes. A quote which indicated that intra-team rivalries are applied with care is presented below.

"In the end you have to get the best players within the National Team. Rivalry is always an issue within the National Team and I consider it positive because it improves players. But you have to be careful that it (rivalry) doesn´t become too dominant, that is when the coach has to interfere. Though, I believe that some rivalry is part of top sports."

The talent coaches use punishments and rewards differently. Most talent coaches (n=5) face athletes with their mistakes, four talent coaches indicated that they explain athletes why they did something right or wrong. Two talent coaches stated that they punish athletes by letting them do something non favourable, for example putting away the equipment, when they loose in a training. In contrast, four talent coaches indicated that they incidentally use punishment when athletes make mistakes.

Seven talent coaches indicated that they try to give athletes an equal amount of attention. Three talent coaches indicated that athletes get less attention when they do not put in effort themselves. The next quote is an example of a talent coach who indicated this.

> *"I pay an equal amount of attention to everyone, however, they have to deserve it by living as a professional. If anyone shows less effort, he also gets less attention."*

e) *Autonomy supportive behaviour*

All talent coaches involve athletes in their development, for example by letting them formulate their own goals or constructing a personal development plan per athlete. Seven talent coaches explicitly stated that goals are initially formulated by the talented athletes themselves. One talent coach tried to increase the consciousness of his talented athletes as well by letting them fill in a self evaluation form. Eight talent coaches provide a talented athlete with opportunities for choice. A talent coach for example outlined the consequences of moving closer to or further away from a training venue to a talented athlete. A quote by which a talent coach indicated that he provides athletes with consequences of choices is outlined below.

> *"You talk about the future with the athlete. At this moment, for example, we talk about next year. Then I ask the athlete what he wants and I present him the consequences and we discuss these together."*

All talent coaches indicated that they try to increase the independence of their athletes in one way or the other. Three talent coaches explicitly stated that they give responsibilities to the talented athletes. One talent coach for example stated that enhancing independence is a high priority because athletes must be able to make their own decisions when they become adults. A quote in which this is stated is shown below.

> *"Independence starts with little things, for example that you make them responsible for bringing the equipment with them or being on time somewhere."*

The feelings of talented athletes are taken into consideration by all talent coaches. It is implicitly stated by the talent coaches that they take an athlete's perspective. One talent coach for example, stated that he sometimes feels like a coach, father, mother, brother, and trainer of an athlete at the same time. Another talent coach stated that when an athlete does not feel happy, an athlete can not achieve an optimal performance. A coach therefore needs to adjust to the feelings of an athlete. An example of a quote in which it is stated that feelings of talented athletes have to be considered is presented below.

> *"You can attain very much if you are able to connect with people in the right way in order to direct them. It is important to deal with the emotions of the athletes to accomplish this."*

No relevant statements were found in the data on the sub feature 'minimizing use of pressures and demands'.

f) Considering significant others

Most talent coaches (*n*=6) explicitly stated that they inform parents of talented athletes, but they do not want parents to interfere and wish that parents distance themselves more from their child. One talent coach for example stated that he realized that parents are a huge sponsor in the youth of an athlete, therefore he explains for example the training schedule to them. Another talent coach stated that he involves parents in practical things but does not involve them in the content of a training for example. The following quote of a talent coach indicated a way of involving parents of talented athletes.

> *"With the Dutch National Youth Selection we always organize special days for parents prior to the season and before big tournaments in order to inform them about what it takes to become a top level athlete… I try to involve parents a lot, but I also try to teach them to let their children go."*

Furthermore the talent coaches (*n*=3) indicated that parents can always come to them when they have a question. All talent coaches take into consideration the importance of education for the talented athletes. Two talent coaches for example stated that athletes need to realize that only a very small number of athletes earn such an amount of money during their elite sport career that they do not have to work anymore, therefore education is essential. Another example is the following quote of a talent coach.

> *"It is only possible to complete a programme as a top level athlete if one combines it with education. Education prepares you for the rest of your life where sport does not."*

Three talent coaches reported that a social life is important as well, it is indicated that a balance between sport and social life is needed. An example of a quote with which this is indicated by a talent coach is shown below.

> *"You don't have a social life? No? Then we have to arrange one, a year without a social life is impossible, let's arrange that you can party those two weekends after the game… and relax"*

All talent coaches use role models of athletes in one way or the other to motivate talented athletes. A talent coach for example showed videos of elite level games and explained why they performed at that level. Another example of a quote of a talent coach in which the use of role models is indicated is presented below.

> *"It is very easy to compare yourself to those who perform less but then I tell them to look at top-class athletes and they come to very different conclusions."*

The largest part of the initial set of features with which a talent coach can contribute to the development of a talented athlete is in agreement with statements of the talent coaches. All main features remained intact and the largest part of the sub features did not change either (see table 2).

Only one new feature was indicated by more than two talent coaches (n=3) in their answers to the question 'what do you think are important features for a good talentoach?'. This was, 'knowing which qualities a talented athlete has'. It was also stated by the talent coaches that they take into consideration characters of athletes, this bears some resemblance with knowing which qualities an athlete has, therefore these issues were added to the set of features together in the new sub feature 'know and take into consideration qualities and characters of different athletes' as part of the feature 'synchronization with developmental stages'. Another sub feature added to the feature synchronization with developmental stages was 'take into consideration physical load possible', because top level talent coaches also stated that they take into consideration the changing physical load possible in various developmental stages. Two sub features were deleted from the feature 'motivational climate': 'no intra-team rivalries' and 'not punishing athletes for making mistakes'. These sub features were deleted because of contradictory statements by the talent coaches on these subjects. The sub feature 'minimizing use of pressures and demands' was deleted from the feature 'autonomy supportive behaviour', because no relevant statements on this sub feature were found in the data. The sub feature 'involving and informing parents' from the feature 'considering significant others' was adapted to 'informing parents' because talent coaches stated that they did inform parents but did not want them to become to much involved. Furthermore, top level talent coaches stated that they took into consideration school and social life of a talented athlete, therefore 'take into consideration school and social life' was added as a sub feature.

Table 2. Final set of features with which a talent coach can contribute to the development of a talented athlete

Education and experience	
	- Education
	- Experience as athlete
	- Experience as coach
Synchronization with developmental stages	
	- Development from guidance and support of coach in early years to responsibility shift from coach to individual in later years.
	- Know and take into consideration qualities and characters of different athletes
	- Take into consideration physical load possible
Goal setting	
	- Short & long term
	- Explicit
	- Athletes involved
Motivational climate	
	- Focusing on development player not outcome games
	- Not favouring most talented athletes
Autonomy supportive behaviour	
	- Involving athlete in training and development
	- Acknowledging an athlete's feelings and perspectives
	- Providing pertinent information and opportunities for choice
	- Independence athlete
Considering significant others	
	- Informing parents
	- Taking into consideration school and social life
	- Role model

The talent coaches stated that it was difficult for them to answer the final question 'distribute 100% over the six features important for talent coaches, attributing higher percentages to more important features'. Although they stated it was difficult, they indicated that 'synchronization with developmental stages' was the most important feature and 'considering significant others' was stated to be the least important one.

PART 2

Method

The sample consisted of talent coaches (*n*=14; 13 males and 1 female) who coached highest level youth club teams (14-20 years old) of two soccer clubs and two field hockey clubs of the highest national competition level for at least 2 seasons in the period 2000-2005.

After a short clarification of the study, the participants were asked to cooperate with an interview with regard to coaching of talented athletes in their teams of the concerning clubs during the period 2000-2005. The procedures were in accordance with the medical ethical standards of the University of Groningen.

First, it was determined which athletes (14-19 years old) the talent coaches coached during the period 2000-2005 from the two field hockey clubs and the two soccer clubs. Lists of these athletes were displayed to the talent coaches before the interview started.

Subsequently, it was determined which of the talented athletes born in 1988 (currently 19 years or older) reached national top level in their sport at present. National top level is defined as premier league in field hockey and premier league or first division in soccer. This data was used to calculate a degree of successfulness of a talent coach. As a measure for degree of successfulness a percentage is computed. The formula presented below computes a coach's percentage of coached talented athletes reaching top level in their sport.

$$\text{Successfulness} = \frac{\sum \text{years coach of a talented athlete who reached top level}}{\sum \text{years coach of all talented athletes}} \times 100\%$$

Figure 1. Formula for calculating a coach's percentage of talented athletes coached who reached top level

First, the interviewer shortly explained the purpose of the study; subsequently the participants were told the processing of the interview would occur anonymously. A structured quantitative interview guide was constructed in line with available literature and part 1 of this research. This interview provided scores on the several apparent important features of a talent coach with which he contributed to the development of a talented athlete. The scores were based on several questions concerning a specific feature.

A score on the feature 'education and experience' was obtained by calculating a mean score on five items. Rank scores from 1-10 were established on every item, a score of 1 represented the lowest level of education or experience and a score of 10 represented the highest level of education or experience. The five items were: level of education, level of education in coaching, years of coaching, number of age categories coached, and highest level participated in as an athlete.

A score on the feature 'considering developmental stages' was obtained by calculating the mean score on 6 items. Talent coaches had to provide a score from 1-10 on every item. A score of 1 represented not at all considering developmental stages and a score of 10 represented totally considering developmental stages. The items were: 1) to what extent did you coach more on encouraging autonomy when athletes grow older, 2) to what extent did you coach more on encouraging responsibility when athletes grow older, 3) to what extent did you coach more on encouraging consciousness when athletes grow older, 4) to what extent did you coach more on encouraging involvement in an athlete's own development when athletes grow older 5) to what extent did you consider physical development between athletes, and 6) indicate on a scale from regarding current level (1) to potential development (10) which factor was more important in selecting talented athletes.

A score on the feature 'goal setting' was obtained by calculating the mean score on 3 items. The 3 items were: 1) indicate (1-10) how often talent coaches set short and long term goals (1 = never, 10 = always), 2) which percentage of the goals were written down (score is the percentage divided by 10, 10% or lower represented a score of 1), and 3) which percentage of the goals were initially formulated by athletes (score is the percentage divided by 10, 10% or lower represented a score of (1).

A score on the feature 'motivational climate' was obtained by calculating the mean score on 3 items. Talent coaches were asked to provide an indication on a 10-point scale. A score of 1 represented an indication of a performance climate and a score of 10 represented an indication of mastery climate. 1) Indicate on a scale from importance of outcome contests (1) to importance of playing well (10) on which aspect you focused before and during games, 2) Indicate on a scale from importance of winning (1) to importance of learning new things (10) on which aspect you focused more during a season, and 3) indicate on a scale from favouring more talented athletes (1) to favouring every athlete for an equal amount (10) what you do more.

A score on the feature 'autonomy supportive behaviour' was obtained by calculating the mean score of 7 items. Talent coaches had to provide a score from 1-10 on every item, a score of 1 represented not at all exhibiting the autonomy supportive behaviour and a score of 10 represented totally exhibiting the autonomy supportive behaviour. The items were: 1) to what extent do you try to enhance a talented athlete's autonomy, 2) to what extent do you try to enhance a talented athlete's responsibility, 3) to what extent do you involve a talented athlete in his development, 4) to what extent do you try to enhance a talented athlete's consciousness of one's own development, 5) to what extent do you take into account feelings of an athlete by altering the training schedule, 6) to what extent do you take into account feelings of an athlete by altering the way of approaching athletes, and 7) to what extent do you provide consequences of choices for the careers of athletes.

A score on the feature 'considering significant others' was obtained by calculating the mean score on 3 items. Talent coaches had to provide a score from 1-10 on every item. A score of 1 represented not at all considering significant others and a score of 10 represented totally considering significant others. The items were: 1) to what extent do you inform parents about their role, 2) to what extent are you informed of and do you take into consideration the school/study of an athlete, and 3) to what extent are you informed of and do you take into consideration the social life of an athlete.

Degree of successfulness and the scores on every feature were computed for every talent coach. Subsequently, Spearman correlation coefficient (rho) was computed between degree of successfulness and the separate features of a talent coach with which he can contribute to the development of a talented athlete. An alpha value of 0,05 (1-tailed) was used to indicate significance. A poor correlation coefficient was defined as rho $<$ 0,3, a moderate correlation was defined as 0,3 $<$ rho $<$ 0,6, a good correlation coefficient was defined as 0,6 $<$ rho $<$ 0,8, and an excellent correlation coefficient was defined as rho $>$ 0,8 (Söderman and Malchau, 2001).

RESULTS

Table 3 shows the degree of successfulness and scores on the features with which a talent coach can contribute to the development of talented athletes of all talent coaches.

Table 3. Degree of successfulness and scores (1-10) on the six features with which a talent coach can contribute to the development of a talented athlete of the talent coaches. Legend: [DS] degree of successfulness; [EE] education and experience; [SDS] synchronization with developmental stages; [GS] goal setting; [IMC] implementation of motivational climate; [ASB] autonomy supportive behaviour; [CSO] considering significant others

Talent coach	DS (%)	EE	SDS	GS	IMC	ASB	CSO
1	21	7.75	7.17	3.40	9.33	7.14	7.33
2	41	5.05	7.79	6.00	5.92	9.43	5.67
3	56	5.05	9.17	2.53	5.00	8.71	5.67
4	32	5.50	7.28	5.00	6.60	6.76	6.33
5	43	6.40	7.33	5.45	4.67	7.71	4.67
6	30	6.85	7.33	3.00	5.67	7.29	6.00
7	22	7.75	7.50	3.05	6.22	7.43	3.00
8	24	4.60	6.83	5.40	6.33	5.86	4.67
9	25	7.75	6.67	3.80	8.67	8.71	8.00
10	33	5.95	8.17	5.75	6.00	8.14	7.67
11	58	6.85	10.00	7.93	6.33	8.71	6.67
12	24	5.50	9.42	[a]	5.75	7.64	7.67
13	42	5.50	8.17	4.80	9.33	8.14	7.00
14	38	6.85	7.17	4.03	5.73	8.29	8.33

Note: [a] A score from this talent coach could not be obtained on this feature. Spearman correlation coefficients (rho) between degree of successfulness and the six features of talent coaches with which they can contribute to the development of talented athletes are presented in table 4. Significant correlations exist between degree of successfulness and synchronization with developmental stages, and between degree of successfulness and autonomy supportive behaviour.

Table 4. Spearman correlation coefficients (rho) and p-values (1-tailed significance) between the six features of talent coaches with which they can contribute to the development of talented athletes and degree of successfulness (n=14)

	Degree of successfulness
Education and experience	-0.33 (0.13)
Synchronization with developmental stages	0.51* (0.03)
Goal setting	0.40 (0.09)
Implementation motivational climate	-0.33 (0.12)
Autonomy supportive behaviour	0.65* (0.01)
Considering significant others	-0.06 (0.42)

* significant correlation with an alpha of 0,05

DISCUSSION

Top level talent coaches were highly educated and had much experience as a coach as well as an athlete. The results of the second part showed a moderate negative correlation of -0,326 (p = 0,128) between the score on education and experience and degree of successfulness. This finding is remarkable because it is contradictory to findings from the first part. Literature supports the results of the first part; several studies have demonstrated that elite coaches are more likely to have a higher level of education (Lyle, 2002). For example, 78% of elite U.S. national team, Pan American and Olympic coaches have a Bachelor degree or higher (Gould *et al*., 1990). The importance of experience is supported in the literature as well, one of the ways with which youth sport coaches learn to coach are previous experiences as a player, assistant coach or an instructor (Lemyre *et al*., 2007).

A possible explanation for the results of part 2 is that scores on education and experience are combined. Therefore a closer look is taken at the several items which comprise the score of education and experience. The score on the item 'highest level participated in as an athlete' stands out (rho = 0,332). It is considerably higher than the score on 'level of education in coaching' (rho = 0,010) and in the opposite direction compared to 'level of education' (rho = -0,506), 'years of coaching' (rho = -0,239), and 'number of age categories coached' (rho = -0,214). From these correlations it appears that the highest level participated in as an athlete provides the strongest association with degree of successfulness. The correlations of the other items are hard to explain considering the results of part 1 and available literature.

Interviews with top level talent coaches revealed that they synchronized their coaching role with developmental stages of a talented athlete. Furthermore, top level talent coaches also indicated that synchronization with developmental stages was the most important feature of a talent coach with which he can contribute to the development of talented athletes. The results of the second part of this study are in consistence with this, a moderate correlation (rho = 0,506) which was significant (p = 0,033) was found between degree of successfulness and synchronization with developmental stages.

Top level talent coaches changed their role as a coach from more leading to only guiding athletes (more independent athletes) when athletes grow older. This is for example supported by Bloom (1985) who named three stages: The early years, middle years and later years. In the early years children are involved in fun and playful activities and they rely heavily on the guidance and support of their coach or teacher. The middle years are characterized by children who become more involved in a particular activity and it becomes more serious. Coaches are more technically skilled than at the previous level. During the later years performers become experts in their chosen activity and this activity dominates their lives. According to Bloom, responsibility for training and competition shifts from coaches to the individual in this phase. Approximately similar stages are phrased by Côté (1999), the stages of Côté (1999) are more sensitive to the sport domain and identified by an age range. The corresponding stages with Bloom's stages are respectively: the sampling years (ages 6-12), specializing years (13-15) and investment years (age 16+). In a model of talent development, constructed by Abbott and Collins (2004), the task of a coach differs per development stage. The task of a coach in the sampling, specializing and investment years is respectively caring coach orientation, technical coaching and collaborative coach/athlete decision-making.

Top level talent coaches also took into consideration potential development when selecting talented athletes. This parallels with previous research illustrating that emphasis in talent identification should lay on potential development of talented athletes and not on current measures of performance (Abbott *et al*., 2005).

Furthermore, top level talent coaches took into consideration the character of talented athletes when coaching them. This is consistent with a finding of Gould *et al*. (2002). They found that the same coaching strategies were not appropriate for each athlete, different athletes required different things from their coaches at different points in their careers.

Another aspect that was synchronized by the talent coaches was the possible load of talented athletes. This parallels previous research illustrating that the content and amount of training have to be adjusted per developmental stage (Naughton *et al*., 2000, Wilmore *et al*., 2008, Balyi *et al*., *not dated*). For example, the optimal window of trainability for aerobic capacity occurs at the onset of Peak Height Velocity and the optimal window of trainability for strength is for girls immediately after Peak Height Velocity or at the onset of the menarche, while for boys it is 12 to 18 months after Peak Height Velocity (Balyi *et al., not dated)*. However, also possible physical overload has to be taken into account, because adolescent athletes who experience rapid growth as well as large increases in training volumes may be vulnerable to overuse injuries (Naugthon *et al*., 2000).

Interviews with top level talent coaches furthermore revealed that top level talent coaches set explicit goals on short- as well as long term with athletes involved in the goal setting process. These results are consistent with results from the second part, a moderate correlation (rho = 0,396; p = 0,090) was found between degree of successfulness and goal setting.

Top level talent coaches took care that long as well as short term goals were set. This is supported by Kyllo and Landers (1995), they concluded in their review concerning goal setting in sport and exercise that besides absolute and moderate goals, also combined short- and long-term goals were associated with the greatest effect. To set both short- and long-term goals, was also found to be important by Weinberg *et al*. (2001).

Furthermore, top level talent coaches reported the goals. Findings of Weinberg (1994) confirm that goals should be written down.

It was also indicated by top level talent coaches that goals were first formulated by the athletes and finally formulated in consultation between coach and athlete, furthermore individual as well as team-goals were formulated. Literature supports that athletes should be involved in goal setting, it is for example found that goal setting can be improved as a result of involving athletes in goal setting by allowing individuals to participate in goal setting (Kyllo and Landers, 1995). Widmeyer and Ducharme (1997) also found that having input on goals is beneficial for the performance of an athlete.

The interviews with top level talent coaches revealed that a mastery climate tended to be more favourable than a performance climate, although some actions with which one climate is created above the other show contradictory results. Results of the second part are contradictory to this, a negative moderate correlation (rho = -0,334; p = 0,122) was found. These equivocal results are hard to explain. Literature suggests that a mastery climate is beneficial. Young athletes who were coached by coaches who promoted a mastery-involving motivational climate had less anxiety than athletes who were coached by coaches who did not promote a mastery climate (Smith *et al.*, 2007). Additionally, sport enjoyment and positively rating the coach were predicted by a mastery climate in youth sport, while winning percentage is approximately the same in comparison with a performance climate (Cumming *et al.*, 2007). Another piece of support for a mastery climate arises from a physical educating setting, a mastery climate implemented by the teacher positively influences intrinsic motivation and negatively influences amotivation in physical education pupils (Ommundsen, 2007).

A possible explanation of the different results between part 1 and 2 might be the difference in level of talented athletes coached. Talent coaches from the second part of this study might for example have to favour higher talented athletes because not every athlete is as highly talented as the talented athletes in part 1. The mentioned literature does not provide information on this aspect, because the participants were mainly recreational.

Interviews with top level talent coaches revealed that they exhibit many autonomy supportive behaviours. Findings of the second part of this study are consistent with this, degree of successfulness is correlated with autonomy supportive behaviour, a good correlation (rho = 0,653) which was significant (p = 0,006) was found between degree of successfulness and autonomy supportive behaviour. Literature supports these findings, the research reviewed in Mageau and Vallerand (2003) shows that autonomy-supportive behaviours of a coach have a beneficial impact on athlete's intrinsic and self-determined extrinsic motivation, which are important determinants of performance and persistence. Mageau and Vallerand (2003) mention several studies which provide evidence for the autonomy supportive behaviours mentioned in the sub features. Involving an athlete in training and development is for example supported by Boggiano (1998), acknowledging an athletes feelings and perspectives is for example supported by Koestner *et al*. (1984) and Deci *et al*. (1994), providing pertinent information and opportunities for choice is for example supported by Cordova and Lepper (1996), and the independence of an athlete is supported by Boggiano *et al*. (1993).

Another piece of support for autonomy supportive behaviours of coaches in a sport setting is provided by Pelletier *et al*. (2001). They showed that perceived autonomy supportive behaviours of coaches were related to types of self-regulation, individuals who exhibit these types of self-regulation show more persistence than ones who do not. The importance of self-regulation is also supported by Abbott and Collins (2004). They found that self-regulated learning strategies can have a key role in positively facilitating the interaction of an athlete with his environment and enabling an athlete to fulfil his potential. Supplementary support for self-regulation is found in the academic domain, self-regulated learning is found to be a successful way to achieve good performance (Pintrich and De Groot, 1990, Boekaerts, 1999). Furthermore, high achievers use self-regulatory learning more often and more effectively than low achievers Zha (1993).

Finally, interviews with top level talent coaches revealed that they consider significant others. A poor negative correlation (rho = -0,062; p = 0,417) was found between degree of successfulness and considering significant others in the second part of this research. This contrast is not very striking, because top level talent coaches also stated that considering significant others was the least important feature with which talent coaches can contribute to the development of a talented athlete.

Top level talent coaches inform parents of talented athletes. Literature also suggests that talent coaches should educate parents of talented athletes about the role parents have (Gould *et al*., 2006). Top level talent coaches also take into consideration school and social life of talented athletes. To our knowledge no research is conducted on the importance of taking into consideration education and social life of a talented athlete by a talent coach. Top level talent coaches also used role models. Literature supports this, the utilization of role models is found to be important for talent development by Martindale *et al*. (2005). Although considering significant others seems to be an important feature with which a talent coach can contribute to the development of talented athletes, it seems to be the least important one and It does not seem to predict degree of successfulness of a talent coach.

STRENGTH & LIMITATIONS

Several limitations exist in the method of approach. Although attempts were made to obtain honest responses from the talent coaches, it was possible for talent coaches to provide desirable answers. The data collected in the second part was collected in a retrospective fashion, results can therefore be subject to attribution effects and memory bias. This must be considered in interpreting the findings. Furthermore, It has to be taken into consideration that other people (athlete, parents etcetera) who play an important role in the functioning of a talent coach, have not been included in the first part of this study. Therefore, to obtain an even better picture, future research should incorporate the way in which talent coaches implement their coaching in practice. Athletes, parents and possible other significant people a talent coach works with should be included in further research as well. To obtain a current picture of features with which a talent coach can contribute to the development of talented athletes, the participants operated in different sports. As a result of this, not all talent coaches employed features in exactly the same way. Future research should detect a possible difference between various sports. A difference of features employed by top level talent coaches can also be expected from the kind of data used.

A limitation of the second part of this research was the interview guide, reliability and validity of the questions have never been investigated. Therefore, the reliability and validity of the interview guide needs to be investigated in further research. Furthermore, the way in which the degree of successfulness was operationalized is arbitrary. It depends for a large part on characteristics of the talented athletes. However, in our opinion no better measurable way of degree of successfulness exists, since a talent coach will always be dependent on the potential of his athletes.

This investigation had a number of strengths. First, the level of the studied talent coaches was very high. This results in a accurate picture of important features with which a talent coach can contribute to the development of a talented athlete. To make sure the participants were indeed top level talent coaches, the selection criteria were strict. A minor disadvantage of these strict criteria was the resulting small sample size.

Another strength of this research was the method of approach. This paper presents an innovative way of investigating important features with which a talent coach can contribute to the development of talented athletes by linking features of a talent coach with their degree of successfulness. With this new way of investigating talent coaches, it becomes possible to obtain a better understanding of important features of a talent coach for talent development.

Another strength of this research is the combination of qualitative as well as quantitative data. Outcomes from the qualitative data from the first part are examined by the quantitative data from the second part. This increases the importance which can be attached to the findings of this research (Foss and Ellefsen, 2002)

Consequently, top level talent coaches possess all features corresponding with available literature (education and experience, synchronization with developmental stages, goal setting, implementation motivational climate, autonomy supportive behaviour, and considering significant others) with which they can contribute to the development of talented athletes. Autonomy supportive behaviour and synchronization with developmental stages have the highest association with degree of successfulness and seem to be the most important features with which a talent coach can contribute to the development of talented athletes. Goal setting is associated with degree of successfulness to a lesser extent, although goal setting seems to be an important feature in the contribution to the development of talented athletes as well. Education and experience and motivational climate yet show more contradictory results, although it appears from the first part of this study and available literature that a talent coach can also contribute to the development of talented athletes with these features. Considering significant others seems to be the least important feature with which a talent coach can contribute to the development of talented athletes.

The outcomes of this research may optimize talent development by improving the knowledge of one of the important factors for talent development (talent coach). With this knowledge, the chance for talented athletes to reach elite level can be increased, by for example focusing on the important features with which a talent coach can contribute to the development of talented athletes in the training and selection of talent coaches.

ACKNOWLEDGMENTS

This study is conducted with cooperation of the *Dutch Olympic Committee* (NOC*NSF). We are grateful to all participants who cooperated with this study.

REFERENCES

Abbott A & Collins D (2004). Eliminating the dichotomy between theory and practice in talent identification and development: considering the role of psychology. *Journal of Sports Sciences, 22,* 395-408.

Abbott A, Button C, Pepping GJ & Collins D (2005). Unnatural selection: talent identification and development in sport. *Nonlinear Dynamics, Psychology & Life Sciences, 9,* 61-88.

Abraham A, Collins D & Martindale R (2006). The coaching schematic : Validation through expert coach consensus. *Journal of Sports Sciences, 24,* 549-564.

Balyi I, Cardinal Ch, Higgs C, Norris S & Way R (not dated). Canadian sport for life: Long-term Athlete Development (Resource paper V2) Vancouver: Canadian Sport Centres, URL: http://www.sport.nl/content/pdf/207220/LTAD_E NG_66p_June5.pdf

Baker J, Horton S, Robertson-Wilson J & Wall M (2003). Nurturing sport expertise: Factors influencing the development of elite athlete. *Journal of Sports Science and Medicine, 2,* 1-9.

Black AE & Deci EL (2000). The effects of instructors' autonomy support and students' autonomous motivation on learning organic chemistry: A self-determination theory perspective. *Science Education, 84,* 740-756.
Bloom BS (1985). *Developing Talent in Young People*. New York: Ballantine.
Boekaerts M (1999) Self-regulated learning: where we are today. *International journal of educational research, 31,* 445-457.
Boggiano AK (1998). Maladaptive achievement patterns: a test of a diathesis-stress analysis and helplessness. *Journal of Personality and Social Psychology, 74,* 1681-1695.
Boggiano AK, Flink C, Shields A, Seelbach A & Barrett M (1993). Use of techniques promoting students' self-determination: effects on students' analytic problemsolving skills. *Motivation and Emotion, 17,* 319-336.
Boyce BA (1992). The Effects of Goal Proximity on Skill Acquisition and Retention of A Shooting Task in A Field-Based Setting. *Journal of Sport & Exercise Psychology, 14,* 298-308.
Cordova DI & Lepper MR (1996). Intrinsic motivation and the process of learning: beneficial effects of contextualization, personalization, and choice. *Journal of Educational Psychology, 88, 715-730*.
Cote J (1999). The influence of the family in the development of talent in sport. *Sport Psychologist, 13,* 395-417.
Cote J, Baker J & Abernethy B (2003). From play to practice. In *Expert Performance in Sports: Advances in Research on Sport Expertise* (Edited by Starkes, J.A. & Ericsson, K.A.). Champaign, IL: Human Kinetics, pp 89-114.
Cumming SP, Smoll FL, Smith RE & Grossbard JR (2007). Is winning everything? The relative contributions of motivational climate and won-lost percentage in youth sports. *Journal of Applied Sport Psychology, 19,* 322-336.
Deci EL, Eghari H, Patrick BC & Leon DR (1994). Facilitating internalization: the self-determination theory perspective. *Journal of Personality, 62,* 119-142.
Dweck CS (1999). Self theories and goals: their role in motivation, personality, and development. Philidelphia: Taylor & Francis.
Elferink-Gemser MT, Visscher C, Lemmink KAPM & Mulder Th (2004). Relation between multidemensional performance characteristics and level of performance in talented youth field hockey players. *Journal of Sports Sciences, 22,*1053-1063
Ericsson KA (2003). Development of elite performance and deliberate practice. In *Expert Performance in Sports: Advances in Research on Sport Expertise* (Edited by Starkes, J.A. & Ericsson, K.A.). Champaign, IL: Human Kinetics, pp 49-84.
Foddy WH (1993) *Constructing questions for interviews and questionnaires: theory and practice in social research*. Cambridge: Cambridge University Press.

Foss B & Ellefsen B (2002). The value of combining qualitative and quantitative approaches in nursing research by means of method triangulation. *Journal of Advanced Nursing, 40,* 242-248.
Gould D, Gianni J, Krane V & Hodge K (1990). Educational needs of elite U.S. National Team, Pan American, and Olympic coaches *Journal of Teaching in Physical Education, 9,* 332-344.
Gould D, Dieffenbach K & Moffett A (2002). Psychological characteristics and their development in Olympic champions. *Journal of Applied Sport Psychology, 14,* 172-204.
Gould D, Lauer L, Rolo C, Jannes C & Pennisi N (2006). Understanding the role parents play in tennis success: a national survey of junior tennis coaches. *British Journal of Sports Medicine, 40,* 632-636.
Helsen WF, Hodges NJ, Van Winckel J & Starkes JL (2000) The roles of talent, physical precocity and practice in the development of soccer expertise. *Journal of Sports Sciences, 18,* 727-736.
Howe MJA, Davidson JW & Sloboda JA (1998). Innate talents: Reality or myth. *Behavioral and Brain Sciences, 21*, 399-442.
Koestner R, Ryan RM, Bernieri F & Holt K (1984). Setting limits on children's behaviour: the differential effects of controlling versus informational styles on intrinsic motivation and creativity *Journal of Personality, 52,* 233-248.
King N (1998) Template analysis. In *Qualitative Methods and Analysis in Organizational Research.* (Edited by G. Symon and C. Cassell) London: Sage, pp 118-134.
Kyllo LB & Landers DM (1995). Coal Setting in Sport and Exercise - A Research Synthesis to Resolve the Controversy. *Journal of Sport & Exercise Psychology, 17,* 117-137.
Lemyre F, Trudel P & Durand-Bush, N (2007). How youth-sport coaches learn to coach. *Sport Psychologist, 21,* 191-209.
Lyle J (2002) *Sports coaching concepts : a framework for coaches' behaviour*. London [etc.]: Routledge.
Mageau GA & Vallerand RJ (2003). The coach-athlete relationship: a motivational model. *Journal of Sports Sciences, 21*, 883-904.
Martindale RJJ, Collins D & Abraham A (2007). Effective talent development: The elite coach perspective in UK sport. *Journal of Applied Sport Psychology, 19,* 187-206.
Martindale RJJ, Collins D & Daubney J (2005). Talent development: A guide for practice and research within sport. *Quest, 57,* 353-375.
Mooney RP & Mutrie N (2000). The effects of goal specificity and goal difficulty on the performance of badminton skills in children. *Pediatric Exercise Science, 12,* 270-283.
Morgan TK & Giacobbi PR (2006). Toward two grounded theories of the talent development and social support process of highly successful collegiate athletes. *Sport Psychologist, 20,* 295-313.

Naughton G, Farpour-Lambert NJ, Carlson J, Bradney M & Van Praagh E (2000). Physiological Issues Surrounding the Performance of Adolescent Athletes. *Sports Medicine, 30,* 309-325.

Ntoumanis, N & Biddle, S.J.H. (1999). A review of motivational climate in physical activity*Journal of Sports Sciences, 17,* 643-665.

Ommundsen Y & Kvalø SE (2007). Autonomy-Mastery, Supportive or Performance Focused? Different teacher behaviours and pupils' outcomes in physical education. *Scandinavian Journal of Educational Research, .51,* 385-414.

Pelletier LG, Fortier MS, Vallerand RJ & Briere NM (2001). Associations Among Perceived Autonomy Support, Forms of Self-Regulation, and Persistence:A Prospective Study. *Motivation and Emotion, 25,* 279-306.

Pensgaard AM, & Roberts GC (2002). Elite athletes' experiences of the motivational climate: The coach matters. *Scandinavian Journal of Medicine & Science in Sports, 12,* 54-59.

Pintrich PR & De groot EV (1990). Motivational and Self-Regulated Learning Components of Classroom Academic-Performance. *Journal of Educational Psychology, 82,* 33-40.

Singer RN & Janelle CM (1999). Determining sport expertise: From genes to supremes. *International Journal of Sport Psychology, 30,* 117-150.

Smith RE, Smoll FL & Cumming SP (2007). Effects of a motivational climate intervention for coaches on young athletes' sport performance anxiety. *Journal of Sport & Exercise Psychology, 29,* 39-59.

Söderman P & Malchau H (2001) Is the Harris hip score system useful to study the outcome of total hip replacement. *Clinical Orthopaedics and related Research, 384,* 189-197.

Weinberg RS (1994). Goal-Setting and Performance in Sport and Exercise Settings - A Synthesis and Critique. *Medicine and Science in Sports and Exercise, 26,* 469-477.

Weinberg R, Butt J & Knight B (2001). High school coaches' perceptions of the process of goal setting. *Sport Psychologist, 15,* 20-47.

Widmeyer WN & Ducharme K (1997). Team building through team goal setting. *Journal of Applied Sport Psychology, 9,* 97-113.

Williams AM & Reilly T (2000). Talent identification and development in soccer. *Journal of Sports Sciences, 18,* 657-667.

Wilmore JH, Costill DL & Kenny WL (2008). *Physiology of sport and exercise*. Champaign, IL: Human Kinetics.

Zha Z (1993). Programs and practices for identifying and nurturing giftedness and talent in People's Republic of China. In *Internatioal handbook of research and development of Giftedness and Talent (*Edited by K. Heller, F.J. Monks and A. H. Passow). Oxford: Pergamon Press, pp 809-814.

Página deixada propositadamente em branco.

http://dx.doi.org/10.14195/978-989-26-1169-3_13

CHAPTER 13: YOUTH SOCCER

Sean P Cumming
Martyn Standage
Robert M Malina

QUESTIONS TO CONSIDER?

- What are the growth and maturity characteristics of young soccer players?

- How does growth and maturation impact upon the socialization process in youth soccer?

- Does maturity status act as an exclusionary factor in elitist youth soccer programs?

- How does maturity status influence the nature and quality of young soccer players' interactions with adults?

> "It's a game of athleticism, a game of power and competition and strength. Anybody who thinks football is just a game of deftness of touch without those other things wouldn't win".
>
> Sir Bobby Robson,
> professional soccer manager.

If one is to understand participation behavior and performance in youth soccer, it is important to recognize the contribution and interaction of various biological, psychological and cultural factors. Sport may be a social phenomenon, but the biological organism performs within a particular cultural context (Malina, 2002). Researchers studying the socialization process in youth soccer would do well to adopt a biocultural perspective. To date, however, few psychologists or sociologists have examined the contribution of biological or maturational factors upon the socialization process in youth sport (Weiss and Glenn, 1992). With this in mind, the purpose of this chapter is to review the extant literature and discuss theoretical and research issues as they relate to the biological maturity status of young soccer players and how it may impact upon the socialization process in the sport.

THE MEDIATED EFFECTS MODEL OF PSYCHOLOGICAL AND BEHAVIORAL ADAPTATION TO PUBERTY

The mediated effects model of adaptation to puberty assumes that the psychological and behavioral effects of puberty are mediated by the individual's "…ideation about his or her biological changes and the subjective meaning or affective significance attributed to them" (Peterson and Taylor, 1980, p. 137). In short, the effects of pubertal changes are mediated by intervening variables or moderated by exogenous or contextual factors. Young athletes' subjective evaluations of their maturational development may be partially derived from cues in their immediate social environments (e.g., parents, peers, coaches, administrators). Research examining the psychological and behavioral consequences of early and late maturation has shown that the peer and parental environments are especially instrumental in determining adolescent satisfaction with bodily changes change (Blyth *et al.,* 1985; Faust, 1983; Peterson and Taylor, 1980).

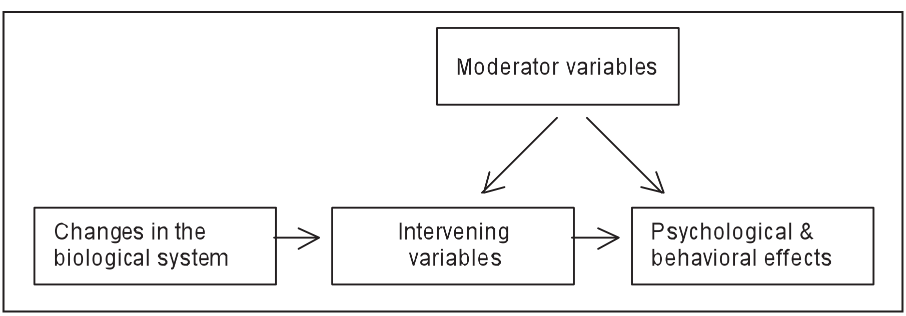


Figure 1. Mediated Effects Model of Psychological and Behavioral Adaptation to Puberty (Adapted from Peterson and Taylor, 1980)

Maturity associated changes in height, weight, body composition, and physical aptitude may have significant social stimulus value for male and female athletes. The evaluations, reactions, and impressions conveyed by parents, peers, coaches, and/or administrators may directly or indirectly communicate positive or negative information regarding physical appearance, competence or autonomy. Adults rate early maturing males as having superior physiques and physical abilities (Jones and Bayley, 1950). This tendency is most evident beyond the age of 14 years. Little information is available on how adults rate the physical characteristics or aptitude of early and late maturing females. Research does, however, suggest that the family environment is influential in helping females adjust psychologically and behaviorally to the physical changes associated with maturation (Brooks-Gunn and Ruble, 1983). Similarly, the reactions of significant others, i.e., peers, educators, family, and so on, are instrumental in determining the perception of adolescent females own physical attractiveness (Schonfeld, 1964).

GROWTH AND MATURITY CHARACTERISTICS OF YOUNG SOCCER PLAYERS

The size, physique, and functional characteristics of young athletes typically reflect the demands of specific sports. To this end, soccer is a sport that requires a high degree of both skill and athleticism. The height, mass and biological maturity status of male youth soccer players has been documented in a number of European, Latin American and North American countries (Malina, 2003). The average heights and weights of samples of male youth soccer players, most of which could be classified as elite, fluctuate about the reference medians for the general population from childhood through mid-adolescence. In later adolescence, however, average heights of male soccer players typically fall at or below the reference medians, while mean weights continue to fall above the reference medians. The greater weight-for-height of soccer players most likely reflects an increase in the proportion of fat-free mass (i.e., muscle mass) and a dominantly mesomorphic physique (Malina, 2003; Carter and Heath, 1990).

Male youth soccer players are, on average, typically advanced in biological maturity status, particularly after the age of 13 years (Malina *et al*., 2000; Malina, 2003). This is not surprising; advanced maturity in males is associated, on average, with larger stature, body mass and fat-free mass, and greater physical competence as reflected in standardize performance tasks of speed, strength, power, and so on. Italian youth soccer players, when compared with control samples, were more advanced in biological maturity status (skeletal and genital), particularly after 12-13 years of age (Mazanti *et al*., 1989). Mexican (Peña-Reyes *et al.,* 1994), Portuguese (Malina *et al*., 2000) and Spanish (Malina et al., 2007) male soccer players were advanced in skeletal maturity after 13-14 years of age. The advanced maturity status of young soccer players was especially apparent during mid-adolescence (13-15 years), which is the interval of the adolescent growth spurt in the majority of boys. In later adolescence, there is catch-up of later maturing boys so that maturity-associated variation in size and performance is reduced.

Despite the growing popularity of women's soccer, little information exists on the growth and maturation of female youth soccer players. The few studies that have been conducted with female soccer players indicate that from late childhood to early adulthood the heights of female soccer players are, on average, marginally above the median reference values for their age (Cumming, 2002; Siegel, 1995). Across all ages, the female soccer players also tend to have longer legs than the general population (Siegel, 1995). The weights of female soccer players typically fall at or above median reference values, except in later adolescence and early adulthood when the weight of the players is consistently above the reference median (Cumming 2002; Siegel, 1996). In late childhood and early adolescence the weight-for-height of female soccer players, as expressed by the body mass index (BMI, kg/m^2), varies above and below the median reference values for the general population. Between the period of late adolescence and early adulthood, however, the BMI of female soccer players is typically above reference medians (Cumming, 2002; Siegel, 1996), indicating as in male soccer players proportionally more weight-for-height. The somatotypes of female soccer players are reasonably well-balanced in late childhood and adolescence between. In early adulthood, however, players tend to be, on average, mesomorphic endomorphs (Siegel *et al*., 1996).

Although data are limited, female soccer players, like female athletes in many team sports, tend to approximate the average, i.e., are "on time," in biological maturity status (Malina, 1983, 2002). The data for female players are based on the age at menarche, which is a late event in the adolescent sequence of pubertal events. Menarche occurs, on average, about one year after peak height velocity (Malina *et al*., 2004). As noted earlier and in contrast to female soccer players, male soccer players tend to be advanced in biological maturity (skeletal age and sexual maturation).

THE IMPACT OF BIOLOGICAL MATURITY STATUS UPON THE SOCIALIZATION PROCESS IN YOUTH SOCCER

The physical and functional characteristics associated with maturity status may have significant social stimulus for coaches, administrators, and/or parents. Early maturing males and average-to-late maturing females have, on average, physiques and functional characteristics that are more suitable for success in soccer. Soccer is a sport that requires aerobic and muscular endurance, speed, power and agility, and characteristics associated with late maturation in boys and early maturation in girls are associated, on average, with poorer levels of physical performance in these functional requirements of soccer. This does not mean that all late maturing boys and early maturing girls are excluded from the sport because of their maturity status. Rather, they are simply less likely to be represented in the sport at more successful or elite levels during adolescence. Indeed, the challenge for adults who train and develop youth soccer players is to provide opportunities for the skilled late maturing boy and skilled early maturing girl to experience success in the sport so that their motivation will be maintained and they will persist in the sport.

Players who are more successful or who have greater physical potential for success in a sport, specifically soccer, may receive greater encouragement from adults to play, more positive feedback, and more opportunities to further develop their skills (i.e., access to better coaches, invitations to play for elite level programs or attend elite player development camps). Indeed, perceptions of positive coaching behavior were positively correlated with soccer self-esteem in a sample of Norwegian male youth soccer players (Ommundsen and Vaglum, 1991a).

Greater physical potential for success in soccer, however, does not always result in more favorable reactions from adults. High expectations for success may lead adults to exert a greater degree of pressure or control over youth who are physically more gifted for playing soccer. Male soccer players who were older and more advanced in maturity status were more likely to perceive their coaches as controlling as opposed to being supportive of autonomy. In contrast to the observations for males, estimated maturity status of female soccer players was unrelated to perceptions of autonomy support from coaches or parents (Cumming, 2002). Previous sport-based research has also shown that coach-created situations perceived by athletes as controlling (i.e., being told what to do and how to do it) undermine the intrinsic motivation, creativity, and self-expression of athletes (Vallerand, 2001).

Biological maturity may also act as an exclusionary factor in youth soccer, particularly males. Elite youth soccer programs may systematically exclude male players on the basis of maturity status (Malina, 2002). A study of males playing for several elite male youth soccer teams in Portugal indicated an equal proportion of early and late maturing players prior to 13 years of age (Malina *et al*., 2000). The proportion of early maturing males, however, increased significantly in the older adolescent age groups (i.e., 13-16 years). Similarly, in a study comparing the estimated maturity status of male youth soccer players competing in travel and recreational soccer programs in Mid-Michigan (U.S.), males playing travel soccer were more advanced in maturity status (Cumming, 2002).

Corresponding data for females are very limited, and comparisons of elite and non-elite female soccer players are lacking. Some data limited to estimated maturity status based on predicted adult height suggest no differences in the maturity status of females in recreational and more competitive travel programs (Cumming, 2002). More research is warranted to ascertain the potential exclusionary impact of variation in biological maturity status in female youth soccer programs. Although maturity status may not act as an exclusionary factor in more elite level programs for females, it may act to exclude females from general participation in soccer which may have implications for patterns of habitual physical activity.

Maturity-associated variation in size, muscularity and physical competence is most evident between the ages of 11 and 13 years in females and 13 and 15 years in males. However, such variation begins to manifest itself in the years immediately preceding, the initiation of the transition into adolescence for most girls and boys, about 9-10 and 11-12 years, respectively (Malina *et al*., 2004). Issues related to the potential impact of maturity status per se and associated changes in size, body composition and performance upon motivated behavior and treatment of talented young athletes need more systematic attention in the sport psychology research community.

The chronological age of a child and the range of the age group for competition may accentuate the impact of variation in biological maturity status on the processes of inclusion and exclusion in soccer and other sports. This is related to when a youngster is born within the selection or competitive year. At present in soccer, January 1 marks the beginning of the selection or competitive year (it is August 1 for Little League Baseball). Male youth soccer players who are born in early in the selection year are thus the oldest children in an age group and are more likely to be identified as talented, to be exposed to higher levels of coaching, and to be represented more often at the professional and national levels. Players who are born in the later quarter of the selection year tend to drop out of soccer, either voluntarily or perhaps systematically, around the age of 12 years (Helsen *et al.,* 1998). This phenomenon is referred to as the 'season-of-birth bias' (Simmons and Paull, 2001). It has been observed in elite youth and professional adult soccer players in the Netherlands, England, Belgium, Sweden, Germany, Brazil, Japan, and Australia (Brewer *et al.,* 1995; Helsen *et al*., 1998; Musch and Hay, 1999; Simmons and Paull, 2001). The season-of-birth bias also shifts with start date of the competitive year. In England, the selection year starts in September. The majority (58.7–71.8 %) of players selected for the English Football Associations centers of excellence were born between September and December (Brewer *et al*., 1995). In Sweden, where the selection year starts in January, the majority of male soccer players (62.2–62.7%) were born between January and April. In a sport such as soccer, where greater physical size and functional capacity are generally desirable, players born early in the competitive year have a distinct advantage.

The manner in which players are grouped may also accentuate the impact of age and biological maturity status upon the processes of inclusion and exclusion. The majority of youth soccer programs in the United States group competitors by chronological age, typically using two-year age brackets (e.g., 11-12 [11.0-12.9] years, or 13-14 [13.0-14.9] years). In addition to a relatively broad range of variation in chronological age within the age group, players vary considerably in biological maturity status. Indeed, an 11 year old boy who is late in maturity and a 12 year old boy who is advanced in maturity may vary by as much as 4 or 5 years in biological age (Malina *et al*., 2004). Many soccer programs in Europe, particularly those in communities where there are a limited number of children, group players relative to an upper age limit (e.g., under 16 years, under 17 years). This allows for more players within a broader age range. However, the broader the age range, the greater the potential impact of chronological age per se (which often translates into experience in the sport) and biological maturity status on the processes of inclusion and exclusion in the sport.

Players who are younger and/or later in biological maturation may struggle to compete against youth who are older and/or more advanced in maturity. These players may become discouraged and drop out of the sport, or they may be systematically excluded by the sport. Note, however, that in later adolescence (17-18 years of age), the differences in size and performance among boys of contrasting maturity status are reduced considerably. Indeed, it is often the later maturing boy who attains a greater height in young adulthood (Malina *et al*., 2004). A question of interest is the following: Are talented later maturing boys excluded from the sport due in part to the size, strength and power disadvantage associated with their maturity status early in adolescence, and in part to the preferences of coaches for larger, more powerful boys who tend to be advanced in biological maturity? A related question that needs attention is the following: How can the sport retain or protect skilled smaller, later maturing boys as they progress through adolescence?

Corresponding questions regarding the socialization and/or selection of girls for soccer have not yet surfaced. Nevertheless, the potential impact of issues raised in the context of boys' programs needs consideration in programs for girls.

The physical characteristics of young soccer players may also influence the amount of playing time and coach attention. Later maturing males and earlier maturing females may spend a significant amount of time on the bench (i.e., not playing), particularly if the coach places a high priority on winning and/or the league/program has no policies regarding equal playing time. Youth who are not selected to play for more elite soccer programs, or do not receive equal playing time, may begin to doubt their competence as soccer players and as a result may believe that they do not the competence to be successful in soccer. Low perceptions of competence, in turn, can have profound psychological and behavioral ramifications during adolescence. Youth who doubt their ability to perform or learn in an achievement arena typically report reduced enjoyment and greater anxiety, and are more likely to drop out of that activity (Weiss and Chaumeton, 1992). Among Norwegian male soccer players 12 to 16 years of age, low perceptions of soccer competence and peer popularity negatively influence persistence in the sport. The relationship was mediated in part by changes in the enjoyment of soccer. Perceptions of competence were most predictive of enjoyment and continued participation among males 14 to 16 years of age (Ommundsen and Vaglum, 1991b).

The implications of the growth and maturity characteristics of young soccer players extend beyond the processes of inclusion and exclusion. It has been alleged that youth soccer coaches affiliated with professional soccer clubs have recruited physicians to help accelerate the growth and maturity of talented yet physically smaller players. Burns (1996), for example, reported that Diego Maradona, the former captain of the Argentinean national soccer team, had undergone treatment to accelerate his growth and maturity while playing for Cebollitas, a youth team affiliated with Argentinos Juniors. It is unclear, however, what exactly the treatment involved. In an interview with Burns (1996), Francisco Cornejo, the head trainer at Cebollitas discussed how Maradona was given a series of vitamins and injections:

> *"Diego was so small when I took him on that he didn't seem to be strong enough. I wanted Paladino (the physician) to round him off, get him fatter and bigger. So I asked the doctor to give him vitamins and other things to help him develop. Cacho (Palidino) I said to him, you fix him. This boy is going to grow up to be a star" (Burns, 1996, p. 19-20).*

On meeting Maradona, Paladino believed that "the boy looked thin – not necessarily underdeveloped for his age, but lacking sufficient weight to be a successful sportsman" (Burns, 1996, p. 20). Paladino later declared the treatment a success stating that "When I finished with him (Maradona) he was like a racing colt" (Burns, 1996, p.20).

Chemical substances such as synthetic growth hormone and anabolic steroids have been allegedly used to improve the physical status of young athletes. This approach, however, compromises the physical and psychological health of the child. The administration of anabolic steroids during childhood and adolescence may accelerate sexual and skeletal maturation, and in turn reduce final stature (Johnson and Van de Loo, 2002). Synthetic growth hormone, when administered to short children with growth hormone deficiency, results in small gains in stature. However, the health risks and benefits of giving synthetic growth hormone for short children with normal levels of naturally produced growth hormone are unclear. More importantly, the effects of synthetic hormone on the normal growth hormone production are not known.

While chemical substances have been utilized to accelerate the growth and maturation of young athletes, other more basic methods of manipulation, perhaps, corruption have been used in youth soccer for males. One method used by team managers is the fielding of over-age players to gain an unfair advantage. For example, in the 2001 under-16 Asian youth soccer championship, it was alleged that sixteen of the under 16 players were at least 19 or 20 years old. Hand-wrist radiographs were used to estimate the "ages" of the boys (Sports Illustrated, 2001). The use of hand-wrist radiographs to estimate chronological age in this context has limitations. Boys attain skeletal maturity, on average, by about 18.0 years of age, depending on the method of assessment used (Malina *et al*., 2004). However, one of 10 Mexican youth soccer players (Peña Reyes *et al*., 1994) and 7 of 43 Portuguese elite youth soccer players (Malina *et al*., 2000) 15-16 years of age were already skeletally mature, i.e., their estimated ages based on hand-wrist radiographs were 18.0 years. Two methods of assessing skeletal maturation were used among elite Spanish soccer players; 2 of 14 players >15.0 years were skeletally mature with the Fels method while 11 of 14 were skeletally mature with the Tanner-Whitehouse 3 method of assessment (Malina et al., 2007). These players would have been eliminated from the competition if their skeletal ages were used, even though their chronological ages based on birth dates were in fact 15 and 16 years! The same trend is also apparent in adolescent ice hockey players (Malina, 1998). This illustrates a major limitation of using radiographs to assess ages of adolescent athletes, and emphasizes the need for accurate birth certificates. The latter, of course, is a problem in areas of the world where birth dates are not systematically recorded. On the other hand, there is also the possibility of team managers, and possibly parents, falsifying birth dates, which has been reported in some youth sport competitions.

A 'win at all costs' approach adopted by some team managers and administrators may carry-over into coaching sessions and create what psychologists have labeled an "ego-involving" or "performance-oriented" climate (Ames, 1992). When an athlete perceives an environment as highly ego-involving, their perception of competence is placed "on the line" each time he/she engages in the activity (i.e., soccer). Accordingly, in such environments continual success is necessary for sustained motivation. Moreover, in order to maintain one's relative standing in competitive settings, individuals may show a lack of concern for justice, fairness, and the welfare of others when ego-involved (Nicholls, 1989). Research conducted with United States Olympic Development youth soccer players suggests that situations perceived as ego-involving are associated with less adaptive types of motivation (Treasure *et al.,* 1999) and lower levels of sportspersonship manifest in a lack of respect for rules, officials, and social conventions (Treasure *et al.,* 1998).

PRACTICAL SOLUTIONS

Those involved in the administration of youth soccer programs and talent development often have relatively little or limited understanding of the processes of growth and maturation, their relationships to athletic performance, and their impact on behavior. Coaches and administrators of youth soccer programs need to be aware of the impact of growth and maturation on the physical and psychological development of young athletes. As noted earlier, youth who are extremely early or late in the timing of adolescence need to be reassured that they are normal, i.e., not different from their peers, and that the maturity-related differences in size and athleticism will eventually be reduced and/or eliminated over time. Adolescents are particularly sensitive to the many changes associated with puberty and must learn to deal with them. The coach is in a privileged role of counselor and confidant, and should provide the support and understanding necessary for youth to adjust to the many changes associated with puberty.

Coaches should be aware of the transient nature of the size and performance advantages associated with variation in maturity status during adolescence so that these characteristics should not be as primary factors for selecting players. These strategies typically favor early over late maturing athletes, and may reduce the likelihood that the players with the most potential for success at the highest level of competition will be still be playing soccer or be available for selection in their late adolescent or early adult years (Malina, 2001). Late maturing players need to be given equal opportunity to develop their skills and continue to participate in soccer. More importantly, the long term development of the young athlete should be emphasized rather than the immediate gratification of the coach or parents that is often associated with winning at age group competitions.

The preceding also applies to female soccer players, with perhaps more concern for the skilled early maturing athlete. Changes in physique and body composition during the growth spurt and sexual maturation may influence athletic performance and perceptions of the self. Adolescent girls, particularly those involved in athletics, are very sensitive to changes in body weight and composition. Coaches need to avoid making comments with regards to body weight, especially in cultures or sports where ‘thinness’ is perceived as being more desirable. Instead, coaches should focus on issues such as health, nutrition, and fitness. Athletes need to be nurtured through these changes in manner that is positive and supportive.

Many soccer programs in the United States have established policies regarding the inclusion and exclusion of young athletes, and equal playing time. Most recreationally-based soccer programs in the United States employ a policy of participation for all. Any child wishing to play soccer is allocated to a team, regardless of their competence. The American Youth Soccer Organization (AYSO) have instituted an "Everyone Plays" rule, requiring each player on a team to play at least one-half of every game. This rule applies to all AYSO teams, (whether regular season teams or teams specially constituted for such event) participating in non-AYSO tournaments or games within or without the U.S.A., regardless of whether the other team, the referee or the sponsors of the tournament or game apply or follow such a rule.

The English Football Association recently implemented changes in the way that young players are grouped for the purpose of talent identification (Simmons and Paull, 2001). A review of the selection criteria for junior squads revealed that many individuals, identified at young ages as having the potential to play at the professional and international, did not make the expected progress. The new strategy for identifying the players with the most potential involved the physical matching of players within selection trials (i.e., players are matched against players of a similar size or physique). Selection was then based upon criteria such as technical skills and tactical awareness. This strategy "…was designed to allow players of more varied physiques to emerge…" on the basis of their skill and tactics (Simmons and Paull, 2001, p. 677), and to provide equal opportunity for players of all shapes and sizes.

To overcome the impact of individual differences in growth and maturation upon the process of inclusion and exclusion in youth soccer, Brewer *et al.* (1995) suggests that soccer associations should establish 'current' and 'potential' squads. Current squads should include the best players, both physically and technically, at the time of the selection trials. Potential squads, in comparison, should contain players that are technically gifted yet lacking in physical development. Such a method would help minimize the impact of age and maturity status upon the process of inclusion of exclusion in youth soccer and would increase the likelihood that talented yet physically less gifted players would remain in the system.

REFERENCES

Ames C (1992). Achievement goals, motivational climate, and motivational processes. In GC Roberts (Ed). *Motivation in Sport and Exercise*. Champaign, IL: Human Kinetics, pp 161-176.

Blyth DA, Simmons RG, Zakin DF (1985). Satisfaction with body image for early adolescent females: The impact of pubertal timing with different school environments. *Journal of Youth and Adolescence*, 14, 207-225.

Brewer J, Balsom P, Davis J (1995). Seasonal birth distribution amongst European soccer players. *Sport, Exercise and Injury*, 1, 154-157.

Brooks-Gunn J, Ruble DN (1983). The experience of menarche from a developmental perspective. In J Brooks-Gunn and AC Peterson (Eds). *Girls at Puberty: Biological and Psychosocial Perspectives*. New York: Plenum, pp 155-178.

Burns J (1996). *Hand of God: Life of Maradona, Soccer's fallen star*. Guilford, CT: The Lyons Press.

Carter JE, Heath BH (1990). *Somatotyping – Development and Applications*. Cambridge: Cambridge University Press.

Cumming SP (2002). A bio-psychosocial investigation of self-determined motivation in recreational and travel youth soccer programs. *Unpublished doctoral dissertation*, Michigan State University, East Lansing.

Faust MS (1983). Alternative constructions of adolescent growth. In J Brooks-Gunn and AC Peterson (Eds.), Girls *at puberty: Biological and Psychosocial Perspectives*. New York: Plenum, pp 105-125.

Helsen WF, Starkes JL, Winckel JV (1998). The influence of relative age on success and dropout in male soccer players. *American Journal of Human Biology*, 10, 791-798.

Johnson MD, Van de Loo DA (2002). Anabolic steroid use in adolescent athletes. In F Smoll, R Magill, F Ash (Eds). *Children in Sport*, 3rd edition. Dubuque, IO: Kendall/Hunt Publishing Company, pp 83-101.

Jones MC, Bayley N (1950). Physical maturing among boys as related to behavior. *Journal of Educational Psychology*, 41, 129-148.

Malina RM (1983). Menarche in athletes: A synthesis and hypothesis. *Annals of Human Biology* 10, 1-24.

Malina RM (1998). Growth and maturation of young athletes - Is training for sport a factor? In K-M Chan and LJ Micheli (Eds). *Sports and Children*. Hong Kong: Williams and Wilkins Asia-Pacific, pp 133-161.

Malina RM (2001). Youth football players: Perspectives from growth and maturation. Insight – *The F.A. Coaches Association Journal*, 1 (5), 27-31.

Malina RM (2002). The young athlete: Biological growth and maturation in a biocultural context. In F Smoll, R Magill, F Ash (Eds). *Children and Youth in Sport*, 3rd edition. Dubuque, IO: Kendall/Hunt Publishing Company, pp 261-292.

Malina RM (2003). Growth and maturity status of young soccer (football) players. In T Reilly and M Williams (Eds). *Science and Soccer*, 2nd edition. London: Routledge, pp 287-306.

Malina RM, Bouchard C, Bar-Or O (2004). *Growth, Maturation and Physical Activity*, 2nd edition. Champaign, IL: Human Kinetics.

Malina RM, Chamorro M, Serratosa L, Morate F (2007). TW3 and Fels skeletal ages in elite Routh soccer players. *Annals of Human Biology*, 34, 265-272.

Malina RM, Peña Reyes ME, Eisenmann JC, Horta L, Rodrigues J, Miller R (2000). Height, mass, and skeletal maturity of elite Portuguese soccer players 11-16 years of age. *Journal of Sport Sciences*, 18, 685-693.

Mazanti L, Tassanari D, Bergamaschi R, Nanni G, Magnani C, Ghini T, Pini R, Amendola C, Drago E, Cacciari E (1989). Hormonal, auxological, and anthropometric aspects in young football players. In JR Bierich, E Cacciari, S Raiti (Eds). *Growth Abnormalities*. New York: Raven Press, pp 363-369.

Musch J, Hay R (1999). The relative age effect in soccer: Cross-cultural evidence for a systematic discrimination against children born late in the competition year. *Sociology of Sport Journal*, 16, 54-64.

Nicholls JG (1989). *The competitive ethos and democratic education*. Cambridge, MA: Harvard University Press.

Ommundsen Y, Vaglum P (1991a). Soccer competition anxiety and enjoyment in young boy players: The influence of perceived competence and significant others' emotional involvement. *International Journal of Sport Psychology*, 22, 35-49.

Ommundsen Y, Vaglum P (1991b). The influence of low perceived soccer and social competence on later dropout from soccer: a prospective study of young boys. *Scandinavian Journal of Medicine and Science in Sports*, 1, 180-188.

Peña-Reyes ME, Cardenas-Barahona E, Malina RM (1994). Growth, physique, and skeletal maturation of soccer players 7-17 years of age. *Humanbiologica Budapestinesis*, 25, 453-458.

Peterson AC, Taylor B (1980). The biological approach to adolescence: Biological change and psychological adaptation. In J Adelson (Eds). *Handbook of Adolescent Psychology.* New York: Wiley, pp 117-155.

Schonfeld W (1964). Body image disturbances in adolescents with inappropriate sexual development. *American Journal of Orthopsychiatry*, 34, 493-503.

Siegel SR (1995). Growth and maturity status of female soccer players from late childhood through early adulthood. *Unpublished master's thesis*, University of Texas, Austin.

Siegel SR, Katzmaryzk PT, Malina RM (1996). Somatotypes of female soccer players 10-24 years of age. In E Bodzsar, C Susanne (Eds). *Studies in Human Biology*. Budapest: Eotvos University Press, pp 277-285.

Simmons C, Paull GC (2001). Season of birth bias in association football. *Journal of Sport Sciences*, 19, 677-686.

Sports Illustrated (2001). *Cheating does not pay*: Asia bans teams, players for over-age infractions (May 10).

http://sportsillustrated.cnn.com/soccer/news/2001/05/10/asia_rdp/index.html.

Treasure DC, Roberts GC, Standage M (1998). Predicting sportspersonship: Interaction of achievement goal orientations and perceptions of the motivational climate. *Journal of Sport and Exercise Psychology*, 20, S12.

Treasure DC, Standage M, Lochbaum M (1999). Perceptions of the motivational climate and situational motivation in elite youth sport. *Paper presented at the annual meetings of the Association for the Advancement of Applied Sport Psychology.* Bannf, Alberta, Canada (September).

Weiss MR, Chaumeton N (1992). Motivational orientations in sport. In TS Horn (Ed), *Advances in Sport Psychology*. Champaign, IL: Human Kinetics, pp 61-99.

Weiss MR, Glenn SD (1992). Psychological development and females' sport participation: An interactional perspective. *Quest*, 44, 138-57.

Página deixada propositadamente em branco.

http://dx.doi.org/10.14195/978-989-26-1169-3_14

CHAPTER 14: THE CHALLENGES FOR YOUTH COACHES IN YOUTH SPORTS

Carlos Eduardo Gonçalves
António Figueiredo
Manuel Coelho e Silva

The importance of the coach in all aspects of sport practice has been unanimously highlighted and his activity frequently studied in the last few decades. Updates and adjustments to the theoretical approaches used are, however, a testimony to the conceptual and methodological difficulties raised at the academic level and the persisting uncertainties about the scope, content personal and professional qualities, learning pathways and professional status still associated with the practice of coaching.

Historically, in its pedagogical aspect, the study of human intervention in the context of interaction with other human beings has never been peaceful. The search for objectivity and rationality, necessary condition and fundament for a detachment that would allow a technological framework for the transmission of knowledge, was and still is a main concern of investigation. The progressive autonomy attained by disciplines comprised in sport science (biology, psychology, sociology, biomechanics) only stressed the issue furthermore, on account of bringing along into the sport system consolidated methods from their subjects of origin. The epistemological storm of the last decades left its marks on pedagogy and the "war of sciences" (Santos, 2005) keeps alight on a field that, only in appearance, shows up as secondary.

Here the concern with the public well-being is the guiding principle: the investigation is born from the desire for an objective usefulness (Tillion, 2009). In order to be able to discourse on the subject of the human sciences, erudition is, by itself, not enough, and the experience lived is the basic substrate on which the knowledge relative to our species is grounded: the events lived are key to the ones observed. With the so called exact sciences, when a researcher observes a phenomenon, it is possible to make the distinction between the observer, the instrument and the object. With the human sciences, observer, instrument and object are separated by vague boundaries and the experiments are customarily biased. There is a fundamental empathy between the observer and the observed, companion of the slow pace at which the knowledge is assimilated. A significative scientific efficiency can only be born from a rigourous alternation between action and research. More than the publishing of scientific articles, it is more important to perfect actions, sometimes minor, that lend themselves better to influence active communities.

Upon accepting that coaching children and youths is an act of education and that sport contributes to the development of the autonomous individual character, the study of the coach as a pedagogical agent is reinstated with interest, assuming the affirmative perspective of the search for a usefulness of the scientific knowledge (Schmidt-Millard, 2003). Whilst in high performance sport the specialization and focus on results and the existence of multi-disciplinary technical teams allow the coach to concentrate in the questions that favour performance, in the context of children and youth sport being a coach is beyond the mere organization and management of training sessions and competition supervision. Bronfenbrenner's (1999) bio-ecological model of development points out that the quality of interactions between the participants and the coach (among other subjects) is determinant for the success of the sportive experience conveying to the coach multiple and complex responsibilities.

Recent research in the topic has been focusing around three main areas: a) the contents of the coach's knowledge; b) the instruction and education of the coach; c) intervention upon the coach's practices.

Only recently has the theoretical and practical wealthiness of the accumulated research in the areas mentioned been recognised as "useful scientific knowledge", assuming a multi- and inter-disciplinary character and overflowing from the psychological and sociological research unto the pedagogical field where the development of children and youth coaching has always taken place. Despite the weight of practical results that truthfully influence the coaching practice, we support Harwood's (2008) statement that future research on the topic should be accompanied by the pursuit of a greater objectivity on the instruments measuring the behaviour of the coach.

The development of the coach cannot be seen as the mere accumulation of knowledge or empirical experience but rather, as a process of conceptual, cognitive and affective changes. The coach's route from noviciate to seniority is seldom continuous. Indeed, while analysing the way in which the best youth coaches face their role, Gilbert and Trudel (2004), point out the fact that many of them associate the content of their intervention with the competitive level attained, emphasizing the issues related to specific preparation according to the increase of their athletes specialization.

In face of the current knowledge imprecision and debility of the theoretical framework some authors (Jones, 2006; Mclaren, 2007), in pursuit of a post-structuralist re-conceptualisation and of modern critical thought, point out in recent literature the frailties of the coach's activity, when taken as a professional occupation, and clearly place it in the field of pedagogy demanding it to be theoretically located and analysed in that context. Although departing from a different point, Araújo (2009) argues that many intervention programs in sport pedagogy are based on "no theoretical framework" with consequences to the analysis and interpretation of the data. Furthermore, the same author blames the lack of correspondence between theory and practice.

The epistemological hazards when approaching the theme are important. First, due to the irreducibility of the individualism of the coach's activity, influenced by a sportive and living biography (Feltz, Hepler, Roman, & Paiement, 2009; Ramos, Nascimento, & Graça, 2009). Second, due to the wide ecological variability in which coaches, athletes, families and sport agents interact in different social, economical, geographical and organizational contexts. Third, due to the complexity of the tasks, never repetitive, because resulting from human relationships.

Against this background, any epistemological and theoretical approach anchored in the positivist paradigm wishing to quantify and generalize the research, lack a solid foundation. Although refusing the narrow and mystifying classification of post-modern, the challenge posed to positivism assumes the complexity of social life and the ever changing role of the several subjects in interaction, along with all their intentions, beliefs and hesitations. It is not a question of proving our theories and models exact, but instead a search to interpret reality, taking the circumstances, existing structures and the power of the human agency (Toulmin, 2003) into account. The scientific knowledge resulting from this human agency cannot be reduced to a value-free cognitive dimension, being as it is historically and ecologically immersed. Because these epistemological and ethical choices are the ones determining the research design and the methodological choices that legitimate the knowledge about the reality.

There seems to be a consensus among coaches in that they value more their own daily experiences as a source of learning than organized curricular instruction. Seemingly there is no reliable evidence on the effect of training programs on their behaviour and the responsibility of the competent teaching institutions ends with the issue of a certification. More than putting together a plan of formal education/training, the interactions between learners/athletes and professors/coaches, designated by Wikeley and Bullock (2006), are the more capable ones, the ones that make up the basis of the learning relationship and the ones that posses the potential to transform the involvement of children and youths in sport into positive experiences with lifelong impact.

However, edification through practice has for the coach the cost of always being individual and predominantly solitary. For the young coach this process can be a source of doubt, tension or even frustration. Because even if the several available coaching training curricula, from public or private responsibility, brought an effective dissemination of the scientific knowledge of training, notoriously raising the level of specific preparation of the coaches, these still perceive the daily practice as the best route to attain proficiency in pedagogy and communication, cornerstones of the quality of the relationship with the athletes (Harwood, 2008; Cassidy, Potrac & McKenzie, 2006). In face of this problem, the potential contained in the concept of Coaches' Community of Practice seems to offer a good perspective of development (Culver & Trudel, 2006).

The fact that many coaches seem to prefer to share experiences and knowledge with coaches outside their clubs or leagues is a severe limitation for cooperative work. However, recent interventional studies (Harwood , 2008; Culver & Trudel, 2006) proved that the situation can be reversed if the coaches believe in the relevance of the benefits, participate in the decision process, and time is available to assess the changes in behavior. These studies also showed that the will to cooperate and to share their weaknesses in front of colleagues must come from inside the organization and rarely works with the help of outside specialists. The role of the head coach as a "more capable one " among equals is crucial in bringing together the other members of the coaching staff.

Thus, this initiation of the coach in the tradition and culture of his community can be fostered by a process of mentoring, led by a coach with a higher level of experience and expertise. Many coaches recognize that during their career they have gone through an informal but important process of mentoring. The problem is that this vital personal interaction results most of the time from hazardous circumstances. The inclusion of deliberate mentoring in a self-regulated Community of Practice should be able to provide the quality and stability required by the personal and professional growth of a young coach.

Because the really meaning of professional expertise cannot be reduced to a succession of years on the job. Coaching expertise is a construction of knowledge built through specific and social practice and learned through formal and informal sources (Gilbert & Trudel 2004). Therefore, it seems that much of the young coach's new or restructured knowledge emerges from the context of practice where he/she interacts with athletes, families, other coaches, and the traditions and culture of the organization (Ramos, Nascimento & Graça, 2009). It means that road to coaches' expertise is strongly contextualized and one the key factors for the success of this personal and social experience is given by the community of practice and the quality of the mentor(s).

The blend of formal coach education with the participation in a community of practice provides the young coach with important theoretical and practical tools to deal with the challenges of youth sport. However, the heavy influence of context demands a deep capacity of reflection about the conditions of daily practice and ecological environment. Only the reflective thinking allows the coach to transfer his/her experience to similar situations. Having in mind the conflict experienced by youth coaches between the search for victories and the well being of participants, only a reflective attitude about practice within a caring community of coaches enables the novice to transform subjective experience in the objective reality of practice (Žižek, 2008).

The study of the effects of the ecology of practice on coaches' learning and insertion in the sport culture at various levels is a promising field of research. The theoretical frameworks described by Araújo and Davis (2009) or Krebs (2009) provide interesting possibilities to understand how different organizations and different cultures are more favourable or detrimental to the personal or professional growth of young coaches.

The truth is that coaches exist and develop themselves in function of sport results. What is the meaning of those results is a major question that can be a factor of tension and conflict for youth coaches. The current shift in the social perspective on sport, in favour of an instrumental understanding of participation, viewed as a way to a more active and healthy lifestyle, is an additional pressure on the coaches. The contradiction between sport specific results, consequence of the normal sport activity, based on a typical training ethic, and the expectations of the youngsters and their families, leads to frustration, the coaches blaming the lack of enthusiasm and compromise of the new generations. The cooperative reflection within a positive community of coaches associated to expert mentoring, would certainly help the novices to act in a non-routine, changing environment.

This important problematic issue leads us again to the beginning of this chapter. Being a (youth) coach means to be a pedagogical agent in a very specific context. Coaches'education is a field of study where very little has been done to improve the quality of training and its assessment. If we agree that youth coaches education programs must include the integration in communities of practice with positive environments and that expert mentors play important roles in the professional growth of the novices, than sport organizations must deal with the topic in a serious manner. Until now, intervention studies, sometimes with excellent results, have been carried in episodic way. Longitudinal designs are needed to assess the effects of organized interventions, mentoring programs, and coaches' satisfaction and dropout. If coaches' quality is vital for youth sport, than efforts are needed to help young youth coaches to become experts to help young athletes to experience sport as a part of their personal development.

REFERENCES

Araújo D, & Davids K (2009). Ecological approaches to cognition and action in sport and exercise: ask not only what you do, but where you do it. *International Journal of Sport Psychology*, 40, 1, 38-49.

Benjamin W (2004). Imagens de pensamento. Lisboa, Assírio & Alvim.

Bronfenbrenner U (1999). Environments in developmental perspective: theoretical and operational models. In SL Friedman & TD Wachs (Eds.), *Measuring environment across the life span: Emerging methods and concepts* (pp. 3-28). Washington, DC, American Psychological Association.

Cassidy T, Potrac P, & McKenzie A (2006). Evaluating and reflecting upon a coach education initiative: The CoDe of Rugby. *The Sport Psychologist*, 20, 146-161.

Culver D, & Trudel P (2006). Cultivating coaches' communities of practice. In R Jones (Ed.), *The Sports Coach as Educator* (pp. 97-112). London, Routledge.

Feltz D, Hepler T, Roman N, & Paiement C (2009). Coach efficacy and volunteer youth sport coaches. *The Sport Psychologist*, 23, 1, 24-41.

Fraser-Thomas J & Côté J (2009). Understanding adolescents positive and negative developmental experiences in sport. *The Sport Psychologist*, 23, 1, 3-23.

Gilbert W, & Trudel P (2004). Role of the coach: how model youth team sport coaches frame their roles. *The Sport Psychologist*, 18, 21-43.

Harwood C (2008). Developmental consulting in a professional football academy: the 5Cs Coaching Efficacy Program. *The Sport Psychologist*, 22, 109-133.

Krebs R (2009). Bronfenbrenner's bioecological theory of human development and the process of development of sports talent. *International Journal of Sport Psychology*, 40, 108-135.

McLaren P (2007). Pedagogia crítica. Mangualde, PT, Edições Pedago.

Ramos V, Nascimento JV, & Graça A (2009). Análise do processo de instrução no treino de jovens: um estudo de caso no basquetebol. *Revista Portuguesa de Ciências do Desporto*, 9, 1, 52-63.

Schmidt-Millard T (2003). Perspectives of modern sports pedagogy. *European Journal of Sport Science*, 3, 3, 1-7.

Tillion G (2009). Fragments de vie. Paris, Le Seuil.

Toulmin S (2003). Como a razão perdeu o seu equilíbrio. In BS Santos (Ed.), *Conhecimento prudente para uma vida decente* (pp. 253-272). Porto, Afrontamento.
Werthner P, & Trudel P (2006). A new theoretical perspective for understanding how coaches learn to coach. *The Sport Psychologist*, 20, 198-212.
Wikeley F, & Bullock K (2006). Coaching as an educational relationship. In R Jones (Ed.), *The Sports Coach as Educator* (pp. 14-24). London, Routledge.
Žižek S (2008). Violence – Six sideways reflections. New York, Picador.

EDITORS

Manuel J. Coelho e Silva
Born in 1968, June 25 [Coimbra]. 1991, BS Physical Education and Sport [Technical University of Lisbon]. 1996, MS Pediatric Sport Science [University of Porto]. 1999-2000, visiting student [Michigan State University]. 2002, PhD Physical Education and Sport Science [University of Coimbra]. 2013, Chair European Pediatric Work Physiology Meeting.

António J. Figueiredo
Born in 1970, June 14 [Coimbra]. 1998, BS Physical Education and Sports Sciences [University of Coimbra]. 2000, visiting student [University of Northern Iowa]. 2002, MS Developmental Biokinetics [University of Coimbra]. 2008, PhD Physical Education and Sport Science [University of Coimbra].

Marije T Elferink-Gemser
Born in 1973, August 7 [Sneek, The Netherlands]. 1996, Ms Sports Research [University of Groningen]. 1997, Teacher's degree for Higher Medical Education [University of Amsterdam]. 2004, Young Researcher Award for best oral presentation at the Young Researcher Seminar 'Young elite athletes and education', University of Innsbruck, Austria. 2005, PhD [University of Groningen]. 2005, European Young Investigator by the European College of Sport Sciences.

Robert M. Malina
Born in 1937, September 19 [Brooklyn, New York]. 1959, BS Physical Education [Manhattan College, Riverdale, NY]. 1960, MS Physical Education [University of Wisconsin, Madison]. 1963, PhD Physical Education [University of Wisconsin, Madison]. 1968, PhD Anthropology [University of Pennsylvania, Philadelphia] 1989, Doctor Honoris Causa [Catholic University of Leuven, Faculty of Biomedical Sciences, Institute of Physical Education]. 2001, Doctor Honoris Causa [Bronislaw Czech University School of Physical Education in Cracow, Poland]. 2006, Doctor Honoris Causa [University School of Physical Education in Wroclaw, Poland]. 2008, Doctor Honoris Causa [University of Coimbra].

Série Investigação
•
Imprensa da Universidade de Coimbra
Coimbra University Press
2016

• U C •

IMPRENSA DA UNIVERSIDADE DE COIMBRA
COIMBRA UNIVERSITY PRESS