

Trainability of junior Rugby Union players

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Growing interest in producing expert performance, and increasing sport participation, has led to a number of models being proposed for optimal sporting development. Using physical or psychological developmental milestones as guidelines, these models in sport were aimed primarily at identifying key stages during childhood and adolescence, and to optimise training adaptation for the child to reach his/her full sporting potential. Taking into consideration the long-term developmental models, and the requirements to succeed in rugby, this review aims to prescribe the trainability of junior rugby players using a scientifically evidence-based long-term player development approach. As there have been several recent and comprehensive reviews of the literature on trainability during childhood and adolescence, the aim of this paper is to resynthesise the material and apply it to rugby. Although athlete developmental models suggest that the appropriate application of training stimulus during specific periods in childhood and adolescence will influence athletic potential, recent available literature contends that this concept is inconclusive and requires further investigation.

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In the past, coaches and sport practitioners applied adult-based forms of training to children. However, with the increase in knowledge and understanding of human development, applying adult-based training to youth was quickly questioned. This concern, together with the growing interest in producing expert performance and increasing sport participation, has led to a number of models being proposed for optimal sporting development. Using physical or psychological developmental milestones as guidelines, these models in sport were aimed primarily at identifying key stages during childhood and adolescence, and to optimise training adaptation for the child to reach his/her full sporting potential. In recent times, with the advancement of the understanding of human performance and training, these developmental stages for sport have received some review.¹⁻⁵ In particular, the one-dimensional approaches of these stages (i.e. either physiologically or psychologically based) have been highlighted.¹⁻⁵ The next section will provide a brief overview of the distinct stages, as well as the limitations and strengths that characterise each of these models.

Long-term athlete development

In Balyi's long-term athlete development (LTAD) model, 7 stages of development are identified.⁶ These stages are labelled 'Active start' (boys and girls 0 - 6 years of age), 'FUNdamentals' (boys 6 - 9, girls 6 - 8 years of age), 'Learning to train' (boys 9 - 12, girls 8 - 11 years of age), 'Training to train' (boys 12 - 16, girls 11 - 15 years of age), 'Training to compete' (boys 16 - 18, girls 15 - 17 years of age), 'Training to win' (boys 18+, girls 17+ years of age) and 'Retaining'. Within each stage critical periods, referred to as windows of trainability,⁶ are identified. Windows in this context refers to 'a critical period of development of a specific capacity when training has an optimal effect'. Trainability in this case, as defined by Balyi, refers to 'the faster adaptation to stimuli and the genetic endowment of athletes as they respond individually to specific stimuli and adapt to it accordingly'. The definition extends also to 'the responsiveness of developing individuals to the training

stimulus at different stages of growth and maturation.^{6,7} In accordance with these definitions, the LTAD model identified the windows of trainability for 5 training components: stamina, strength, speed, skill and suppleness (flexibility). The windows of trainability for stamina and strength are based on the onset of the growth spurt and peak height velocity, and the windows of trainability for speed, skill and suppleness are based on chronological age.⁶ Furthermore, given the growth and maturation differences between boys and girls,^{1,5,8,9} separate windows of trainability for males and females have been proposed.

The LTAD model and the concept of windows of trainability have received some scrutiny in recent years. The main contention sport scientists and practitioners in sport have with the LTAD model is the lack of empirical evidence to support such a long-term model,^{1,2,5} in particular interpretation and implementation of the concept of windows of trainability. In this regard, the purpose of these trainability windows and the long-term effects of failing to exploit a training window are yet to be elucidated.^{5,10} Bailey et al. questioned whether these critical periods exist to help develop elite performance beyond an athlete's genetic make-up, or achieve optimal elite performance faster.⁵ Another criticism of the windows of trainability concept is that it is primarily based upon physiological principles.^{1,5,11-13}

Developmental model for sport participation

In Côté's Developmental Model for Sport Participation (DMSP), 2 or 3 stages of development are proposed^{14,15} depending on whether the individual aims to reach an elite level or participate in sport for recreational purposes only. An early specialisation segment is also proposed for sports (e.g. women's gymnastics, figure skating) that require peak performance before puberty. To fully understand each stage, terms that characterise this model need to be defined. In the DMSP, Côté and colleagues make a clear distinction between 'deliberate practice' and 'deliberate play'. 'Deliberate practice' can be regarded as any training activity (*i*) undertaken with the specific

purpose of increasing performance (not for enjoyment or external rewards); (ii) requiring cognitive and/or physical effort; and (iii) relevant to promoting positive skill development.¹⁴ In contrast, 'deliberate play' can be regarded as a form of sporting activity that is intrinsically motivating, provides immediate gratification and is designed to maximise enjoyment.¹⁴ In the 'sampling' stage (6 - 12 years of age) high amounts of deliberate play and low amounts of deliberate practice in various sports are recommended. After the age of 12, the athlete can either continue with a high deliberate play and low deliberate practice approach, or start focusing on specific sports. In the 'specialising' stage (13 - 15 years of age) the proposition to focus on fewer sports, with a balance between deliberate play and deliberate practice, is offered. After the specialising stage, the 'investment stage' is put forward, where the athlete focuses on one sport, increases the amounts of deliberate practice and decreases the amounts of deliberate play. Majority of the work that forms the basis of the DMSP originates from qualitative interviews, training questionnaires and retrospective/quantitative interviews.

Psycho-behavioural model

The Abbott and Collins psycho-behavioural model is an extension from the DMSP with the addition of some key distinguishing features.¹⁶ In the true sense of the word, it is believed that the Abbott and Collins psycho-behavioural model is not necessarily a model, but more of an approach or philosophy, since it primarily examines the role of psychology on sporting development.⁵ Nonetheless, the term psycho-behavioural model will be used for the purpose of this review. A maintenance stage, in addition to the 3 stages proposed by Côté's model, is prescribed after the investment stage. This stage emphasises the need to increase quality of training and support for the athlete to maintain a high level of performance. Abbott and Collins argue that performance is a poor indicator of potential in the early stages of development as superior performance may purely be a result of early maturation.¹⁶ On the basis of this argument the authors identify determinants of potential and determinants of performance during development. Determinants of potential, e.g. transferable motor or perceptual elements or psycho-behavioural elements like goal setting, are essential during the early stages of development. As the athlete matures, determinants of performance, e.g. sport-specific skill elements, become more important. Another key feature of Abbott and Collins' psycho-behavioural model is the ability of an athlete to successfully transfer from one stage of development to another, to eventually reach an elite level of performance.¹⁶ In this regard the crucial roles of the psychological characteristics of the athlete are highlighted.

The bio-psycho-social approach and the three-worlds continuum

Recently, a more holistic approach to athlete development has been proposed by highly recognised researchers in the field.^{1,3-5} As the name suggests, unlike the previous models, the bio-psycho-social approach attempts to incorporate biological, psychological and social factors into the developmental process of the athlete. The interaction between these components is purported to be multiplicative rather than additive and the weighting of each component is different for each individual.^{1,3-5} These 3 factors are also highly dependent upon the objectives and motives of the individual. In the three-worlds continuum these objectives and motives are categorised into: (i) participation for personal well-being (PPW) – taking part in physical

activity to satisfy needs other than personal progression; (ii) personal referenced excellence (PRE) – excellence in the form of participation and personal performance; and (iii) elite referenced excellence (ERE) – excellence in the form of high-level sporting performance and achievement. The main feature of this continuum is that athletes can interchange between 'worlds' throughout their lifespan. Therefore, depending on which 'world' the athlete finds himself/herself in, and their stage in life, the relative contribution of biological, psychological or social factors varies. For example, a school-leaving rugby player, with the required physical attributes and necessary skill set to further his playing career (ERE) for rugby, needs the right psychological tools (goal setting, imagery skills, coping strategies) and social support from coaches and parents to reach his full potential.

Sport specificity

The aforementioned developmental models are descriptive or prescriptive models for sport in general and lack the specificity that coaches and practitioners require in practice. A key distinction between sports is whether it is open skilled or closed skilled.^{1,7-9,17} Furthermore, open-skilled sports can be classified into invasion games, net/wall games or striking/fielding games.^{8,12,18} Invasion contact team sports, such as Rugby Union, are complex and dynamic in nature, and as a consequence require a different skill set in contrast to a closed-skill sport.^{5,6,19-22}

Rugby Union

Rugby Union (henceforth referred to as 'rugby') is a popular international team sport. It is played by two teams consisting of 15 players each for 2 periods of 20 minutes (under 13), 30 minutes (under 16), 35 minutes (under 18) and 40 minutes (seniors).^{1,2,5,23,24} Rugby is a highly demanding, physical, technical and tactical team sport. Physical attributes required for successful participation in rugby include, but are not limited to, strength, power, speed, agility, aerobic and anaerobic conditioning, and body composition.²⁵⁻²⁷ Fundamental skill requirements include catching and passing the ball, tackling, carrying the ball into contact and rucking.^{27,28} In addition to these general skills, position-specific skills such as scrumming and jumping in the lineouts are also needed.²⁹ Furthermore, tactical proficiency, which includes visual scanning, pattern recognition, anticipatory skills, situation knowledge, adaptability and decision making on attack and defence, are all required of the developed rugby player.

In line with the needs of professional rugby, the demand to reproduce successful performances has seen an increase in the early identification, investment and development of players from an early age. However, current development programmes in rugby are largely based on traditional practices and content from adult-based studies. Taking into consideration the long-term developmental models mentioned earlier, and the requirements to succeed in rugby, this review aims to prescribe the trainability of junior rugby players using a scientific evidence-based long-term player development approach. As there have been several recent and comprehensive reviews of the literature on trainability during childhood and adolescence,¹⁻⁵ the aim of this document is to resynthesise the material and apply it to rugby. Before a prescription of this nature can be proposed, terminologies used with regards to trainability of junior players need to be clearly defined and clarified. Also, it is acknowledged that biological developmental aspects such as growth and maturation, neurodevelopment, and metabolic and hormonal processes have considerable impact on training and

development. However, a full review of these aspects is beyond the scope of this paper.

Windows of trainability, critical periods and sensitive periods

In 1999, a review by Viru *et al.*¹³ identified periods during growth and maturation that may increase receptiveness and adaptability of athletes to training. Viru *et al.* identified critical periods that can be divided into four categories:

- ontogenetic changes that influence growth, maturation and development
- periods of accelerated growth
- increased sensitivity to factors stimulating development
- enhanced vulnerability.

According to Ford *et al.* and Bailey *et al.*^{3,5} a critical period may suggest 'a unique, special and otherwise unobtainable advantage to the effective exploitation of the period so described'. This therefore gives one the impression that if an athlete fails to exploit an identified 'critical' period, the athlete's full potential will never be realised.

Similarly, the LTAD model proposes windows of trainability (defined earlier) where an athlete's training responses can be maximised. However, this concept, as mentioned earlier, has received much review, as it lacks substantive empirical support. Also, the term 'window' can be misinterpreted, as 'window' suggests that the periods open and close. This is to say if athletes fail to exploit or utilise a window, they will be unable to maximise their full potential and this may even affect them negatively later in life.^{1,3,13} In contrast, 'sensitive periods' can be defined as 'finite time periods during which a child is most sensitive to learning a particular skill'.¹³ The term 'sensitive period' in comparison to 'critical' or 'window' is not as close-ended and implies that an athlete is merely more responsive and adaptable to training during this period. Outside the identified sensitive period, however, similar training gains can be obtained even though more effort may be required.^{1,3-5}

Physical training developmental model for rugby players

The existence of periods of increased responsiveness and adaptability during development seems reasonable as it coincides with key developmental processes. Furthermore, even though most sensitive periods vary for each individual, team coaches and sport practitioners usually work with large groups of athletes, therefore a practical framework of specific training components, based on the most recent evidence, will undoubtedly provide best practice guidelines to fully develop a player. In accordance with these objectives, Lloyd and Oliver recently proposed the Youth Physical Developmental (YPD) model.² Even though the YPD model prescribes that all physical fitness components are trainable throughout childhood and adolescence, periods of increased emphasis and importance for each training component are highlighted based on the available evidence. Each of these training components will now be discussed.

Aerobic conditioning

Having a high level of aerobic capacity is important for maintaining a high work rate in rugby. Changes during middle childhood, pre-pubertal adolescence and post-pubertal adolescence have all been reported to influence the aerobic capacity of athletes.^{2,30} Aerobic training gains have also been reported to occur after puberty. These aerobic training gains, however, have been attributed to increases in

hormonal secretions as a consequence of growth-related changes^{1,31} in post-pubertal adolescence compared with pre-adolescence. According to the YPD model, more attention should be focused on aerobic conditioning as the athlete approaches adulthood (+21 years of age).² Lloyd and Oliver argue that an athlete will be exposed to sport-specific aerobic activities during middle childhood and pre-puberty adolescence, whether in competition or skills training. This is plausible since excessive amount of aerobic fitness conditioning at a young age may cause burnout, as sufficient circulating metabolites associated with adaptation may not be present in these young athletes to promote adaptation. For rugby union specifically, the balance between aerobic fitness and hypertrophy training is crucial for optimal player development, as an over-emphasis on aerobic fitness may negatively impact any attempts to gain muscle mass.

Strength and power

Strength and power are critical for success in rugby as they contribute significantly to the execution of the fundamental skills (tackling, carrying the ball into contact), and position-specific skills (scrumming, lifting in the line-outs). In addition, muscular strength and power reduce the risk of injury. Strength and power development is multifactorial and arises from muscular, neural and mechanical functions.^{2,32,33} In spite of previous concerns, it is now well established that children can induce strength and power gains at an early age and improve their strength and power throughout adolescence into adulthood.² However, the training design (frequency, volume and intensity) for inducing these gains requires some consideration.³⁴⁻³⁴ At an early age, strength and power gains can be stimulated through play and body weight resistance exercises. As the child approaches puberty, structured supervised resistance training can be safely introduced.³⁴⁻³⁶ At this point and thereafter, the adolescent should have developed proper techniques to safely perform resistance training with minimal supervision. It may be logical to assume that the rate of progression of strength and power during development will increase after puberty as a consequence of circulating growth hormones and growth factors. However, given that strength and power gains are also a function of other factors such as neural and mechanical characteristics, attributing increased gains in strength and power to circulating growth hormones and growth factors alone remains inconclusive.³⁶

Speed and agility

Like most invasion team sports, speed and agility are essential for success in rugby. During childhood and adolescence, speed and agility development will be influenced by changes in muscle cross-sectional area and length, biological and metabolic changes, morphological changes to the muscles and tendons neural and motor development, in addition to biomechanical and co-ordination factors.^{1,3} Given all these factors that may contribute to speed and agility, identifying mechanisms responsible for improvements in speed and agility in childhood and adolescence remains difficult. Periods of increased speed adaptation are reported to occur between the ages of 5 and 9 years.^{1,13} This increased adaptability may be attributed to the development of the central nervous system and improved co-ordination.^{1,13,37} A second period of increased adaptation has been reported to occur around the age of 12 years for girls and between 12 and 15 years for boys.^{1,37} This second period of increased speed adaptability may be a product of growth and maturation, further neurodevelopment and increase in hormone secretion.^{1,13} Indeed, a recent review of all nonspecific and specific sprint training methods

and their effects on sprinting in youth revealed that pre-pubescents (pre-PHV) showed a greater training effect (percentage change) from plyometrics and sprint training (which may be linked to neural adaptation), whereas post-pubescents (post-PHV) responded more favourably to strength training and a combination of training methods (which may be linked to neural and structural development).³⁸ Even though these probable periods of increased adaptability exist for speed, speed training should be incorporated in training throughout childhood and adolescence. With that said, the design and structure of this training will change from childhood to adolescence and through to adulthood. For example, during childhood, 'speed training' may simply be a game of fetching the ball from point A and carrying it to point B in an appropriate amount of time, whereas in adolescence, speed training may consist of training running technique and focus on leg drive, etc. in addition to strength and power training. Agility is not as well studied as speed in terms of trainability during childhood and adolescence. Agility is a function of strength, power and speed, and perceptual, reactive and decision-making processes. In this regard, agility can be developed in line with strength, speed and power. The perceptual, reactive and decision-making ability of the athlete can be improved through deliberate play, and as it develops, depending on his/her objectives, through deliberate practice.

Rugby-specific skills

Undeniably, developing the skills set of the player is of utmost importance for success in rugby, and should be the primary concern of the coach and sport practitioners. Fundamental motor skills are common motor activities with specific observable patterns, and considered to be the building blocks that lead to specialised movement sequences required for adequate participation in many organised and non-organised physical activities, such as rugby, for children, adolescents and adults.^{39,40} These fundamental movement skills can be developed from as young as 2 or 3 years of age and thereafter be progressively improved, fine-tuned and tailored for sport-specific development as the athlete gets older.² Nonetheless, fundamental movement skills should always form part of the training regime regardless of level or age. In view of these skill development concepts, guidelines for developing tackling skills have been proposed by Hendricks and Lambert.⁴¹

There seems to be a general consensus on the activities that children need to be engaging in between the ages of 5 and 10 years. Fundamental movement skills and sport skills are cultivated through games and play, with the primary goal being enjoyment and fun, with less emphasis on winning. During this stage, even though the plan may be to develop a rugby player, participation in other sports should be encouraged. Training can be semi-structured and mainly consists of playing games and/or different versions of rugby (e.g. tag or touch). It is also important that parents and coaches allow learning through trial and error, and provide positive feedback where necessary.

In pre-pubertal adolescence (11 - 14 years of age) proper instruction, demonstration and feedback from the coach for contact technical skills such as tackling, ball carrying, falling and rucking should be the focus. Also, positional specific skills for scrumming and line-outs can be introduced. Although a shift from primarily enjoyment and fun to a more competitive environment is made at this stage, execution of proper techniques during movement and skills training should be emphasised. Additionally, because attitude and behaviour are easily influenced at this stage, parents and coaches should highlight the importance of safety during training and match play.⁴²

After puberty, most players should have the basic skills requirements to participate in rugby. Refinement and mastery of these skills should then be the focus. Once these skills are mastered, the player can progress to more advanced types of training using the constraints-led approach.⁴³ In this regard, further advancement of a player's skills set may only occur if practice activity is structured around variability of practice and contextual interference.⁴⁴

Conclusion

Although athlete developmental models suggest that the appropriate application of training stimuli during specific periods in childhood and adolescence will influence athletic potential, recent available literature contends that this concept is inconclusive and requires further investigation.^{1,3-5} The complexity of sport and human development makes it difficult to attribute increased responsiveness and adaptability to training to changes in physiology alone. As mentioned earlier, other contributing factors such as psychological and social factors also play a major role in the trainability of a rugby player. Furthermore, it is now well established that all physical training components are trainable throughout childhood and adolescence and into adulthood.² Depending on the objectives of the athlete(s), the training structure and design need to be considered and adapted according to the developmental or training stage of the athlete.

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