
Factors Affecting Engagement and Talent Development in a School- Based Sports Program

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by

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CERTIFICATE OF AUTHORSHIP AND ORIGINALITY OF THESIS

I certify that the work contained in this thesis has not been previously submitted either in whole or in part for a degree at the University of Technology Sydney or any other tertiary institution.

I also certify that the thesis has been written by me, Thomas Lovell. Any help that I have received in my research work and in the preparation of this thesis has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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PREFACE

This thesis for the degree of Doctor of Philosophy is in the format of published or submitted manuscripts and abides by the ‘Procedures for Presentation and Submission of Theses for Higher Degrees – University of Technology Sydney; Policies and Directions of the University’. All manuscripts included in this thesis are closely related in subject matter and form a cohesive research narrative.

Based on the research design and data collected by the candidate, four manuscripts have been submitted for publication, and are currently either published or under review in peer-reviewed journals. These papers are initially brought together by an Introduction, which provides background information, defines the research problem and the aim of each study. A Literature Review then follows to provide an overview of previous knowledge regarding the factors influencing sports involvement and talent development in youth sport.

The body of the research is presented in manuscript form (Chapter 3 to Chapter 6), in a logical sequence following the development of research ideas in this thesis. Each manuscript outlines and discusses the individual methodology and the findings of each study separately. The General Discussion chapter provides an interpretation of the collective findings and practical applications from the series of investigations conducted. Finally, a Summary chapter provides a synopsis of the research hypothesis tested and conclusions from each project. Based on these findings, directions for future research are suggested. APA 6th reference format has been used throughout the document and a reference list included at the end of the thesis.

LIST OF PUBLICATIONS

Journal Publications

Lovell, T.W.J., Fransen, J., Bocking, C.J. & Coutts, A.J. (*under review*). Factors affecting sports involvement in a school-based youth cohort: implications for long term athletic development. *Journal of Sports Sciences*.

Lovell, T.W.J., Fransen, J., Bocking, C.J. & Coutts, A.J. (*under review*). A multidimensional approach to factors influencing playing level and position in a school-based soccer program. *Science and Medicine in Football*.

Lovell, T.W.J., Bocking, C.J., Kempton, T., Fransen, J. & Coutts, A.J. (2017). Factors affecting physical match activity and skill involvement in youth soccer. *Science and Medicine in Football*. DOI: 10.1080/24733938.2017.1395062.

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Book Chapters

Lovell, T.W.J., Bocking, C.J., Fransen, J. & Coutts, A.J. (2015). “The Influence of Maturation, Physical Capacity, Technical Ability and Motor Competence on Playing Level and Position in Youth Soccer Players”. In T. Favero, B. Drust & B. Dawson (Eds.) *International Research in Science and Soccer II*. Routledge.

Conference Proceedings

Lovell, T., Bocking, C., Fransen, J. & Coutts, A. (2014). *Influence of Maturation, Coordination and Physical Capacity on Selection and Match Performance in Youth Soccer*. 4th World Conference on Science & Soccer, Portland OR, USA.

Lovell, T., Bocking, C., Fransen, J. & Coutts, A. (2014). *The Influence of Anthropometry, Maturation and Physical Capacity on Playing Position and Match Involvement in Youth Soccer Players*. 1st Asia-Pacific Football & Futsal Seminar, Melbourne, AUS.

Lovell, T., Bocking, C., Fransen, J. & Coutts, A. (2013). *The Influence of Motor Ability and Physical Capacity on Team Selection and Physical Match Performance in Youth Soccer Players*. 18th annual Congress of the European College of Sport Sciences, Barcelona, ESP.

Additional Relevant Publications

Fransen, J., **Lovell, T.W.J.**, Bennett, K.J.M., Deprez, D., Deconinck, F.J.A., Lenoir, M. & Coutts, A.J. (2017). The influence of restricted visual feedback on dribbling performance in youth soccer players. *Journal of Sports Sciences*, 21(2), 158-167.

ABSTRACT

School-based sports programs provide important early sports experiences for children and young athletes, with opportunities to participate in recreational sport, or invest in developing skills required to achieve excellence. However, the suitability of school programs to balance long-term sports engagement with opportunities to develop excellence is not yet known. Four related studies were used to investigate the factors influencing sports participation and talent development in a school-based sports program. Firstly, in a cohort of 501 adolescent sport participants from 25 different sports, Study 1 showed physical and motor competence profiles to be very similar between sports in young athletes, before becoming more heterogeneous with increasing age. Participants at higher levels of competition also reported a delayed engagement in their primary sport. Study 2 employed a multidimensional approach to examine the factors influencing talent selection in adolescent soccer players (N=214), revealing fitness, technical ability and motor competence to be important for talent selection, while players seemed to be guided into playing positions based on maturation, anthropometry and physical performance. Study 3 employed a mixed model approach to examine the factors influencing match activity in youth soccer, showing playing level, playing position and individual fitness characteristics to all influence both match running and skill involvements during match-play. Finally, Study 4 employed a two-year cohort-longitudinal design (N=172), showing players selected into lower playing levels to be more likely to drop out of the school-based soccer program. Additionally, the program did not seem to support retention of motor competence. Collectively, these studies suggest development opportunities may be confounded by the talent selection process, and the school environment may not be suitable for the retention of motor

competence. However, schools may also provide an ideal setting to implement a sampling pathway, which may be the most suitable for early sports involvement, improving motor competence, long-term engagement, and development of excellence.

KEYWORDS

Talent identification

Talent selection

Multidimensional

Sports participation

Adolescence

Maturity

Motor competence

Sampling

Excellence

Soccer

Developmental Model of Sports Participation

ABBREVIATIONS

α	Cronbach's alpha
ANCOVA	analysis of covariance
ANOVA	analysis of variance
APA	American Psychological Association
APHV	age at peak height velocity
CI	confidence interval
cm	centimetres
CV	coefficient of variation
df	degrees of freedom
DMSP	Developmental Model of Sports Participation
DMSSP	Developmental Model of School Sports Participation
F	F-value
FFA	Football Federation Australia
GPS	global positioning system
h	hours
HSR	high-speed running
ICC	intra-class correlation
kg	kilograms
km	kilometres
$\text{km}\cdot\text{h}^{-1}$	kilometres per hour
KTK	Körperkoordinationstest für Kinder
m	metres
$\text{m}\cdot\text{min}^{-1}$	metres per minute
MANCOVA	multivariate analysis of covariance

MANOVA	multivariate analysis of variance
min	minutes
mm	millimetres
MQ	motor quotient
MSFT	multi-stage fitness test
N	number
NS	non-significant
η^2	eta-squared effect size
p	statistical significance
PE	physical education
s	seconds
SD	standard deviation
TD	total distance
UGent	Ghent University, Belgium
UTS	University of Technology Sydney
χ^2	chi-square
y	years
YYIR1	Yo-Yo Intermittent Recovery Test Level 1

DEFINITIONS

Talent

A combination of innate attributes and developed abilities pertaining to performance in a particular sport

Talent identification

The process of recognising participants with the potential to become elite performers in a particular sport

Talent development

Providing sport participants with a suitable learning environment so that they have the opportunity to realise their potential

Talent selection

The ongoing process of identifying players who demonstrate the performance required for inclusion in a given squad or team, choosing the most appropriate individual to carry out the task within a specific context

Excellence

The pinnacle of performance in a particular domain, which may be interchangeable with expertise or elite performance

Deselection

The inevitable occurrence of young participants not retained throughout the talent identification and talent selection process

Dropout

The withdrawal of a participant from a particular sport or activity

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Level 1, KTK; Körperkoordinationstest für Kinder, MQ; motor quotient, **; Interaction effect ($p < 0.001$), †; Time effect, a; Between-subjects effect. 131

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1 INTRODUCTION

1.1 BACKGROUND

School-based sports programs in both primary (5-11 y) and secondary (12-18 y) schools are an essential component of early sporting experiences. As children often receive their first sporting experience in a schooling environment, it is hoped that this early engagement provides the first step towards a lifelong affinity with sport and physical activity. Therefore, it is a priority for school-based sports programs to provide all children with adequate opportunities for successful engagement in sport and physical activity which may continue throughout life. Additionally, many school sports programs also aim to identify talent and develop sporting excellence, with the tangible success of a sports program often more related to the school's ability to produce good athletes within specific sporting disciplines. It is therefore important for school-based sports programs to carefully balance two aims: 1) providing opportunities to develop excellence, and 2) promoting long-term sports engagement.

Providing a balance between these two objectives is not a simple task for school-based sports programs. The transition through adolescence is characterised by high rates of sports disengagement, reducing the likelihood for long-term sports participation (Fraser-Thomas, Côté, & Deakin, 2008). Additionally, the development of talent is exclusive by nature, often prescribing an early specialisation approach in the pursuit of excellence (Burgess & Naughton, 2010). The Developmental Model of Sports Participation (DMSP) was proposed as a framework for young athletes to engage in developmentally appropriate sports activities in the pursuit of elite performance (Côté, Lidor, & Hackfort, 2009). Indeed, the DMSP may be the most appropriate framework for school-based sports programs to provide young athletes with an opportunity to pursue elite performance, while also promoting long-term engagement. However, no previous

research has investigated successful sports engagement within a school context, and therefore the extent to which schools are equipped to implement the DMSP, or provide optimal development environments is unknown.

1.2 RESEARCH PROBLEM

Despite school-based sports programs being an important stage in the early sporting experiences of children and young athletes, no previous research has investigated the development opportunities provided to children and young athletes in a school environment. This thesis therefore aims to observe sports involvement and talent development in a school-based sports program to provide new information on developmental pathways in a school environment. Specifically, the suitability of a school-based sports program to balance the promotion of long-term engagement with the development of excellence will be investigated.

The sports program observed in this thesis belonged to an independent boys' school in Sydney, Australia, who enrol approximately 2500 students across both primary (5-11 y) and secondary (12-18 y) cohorts. The school encourages all students to participate in sport, with a range of 15 and 25 different sports offered for primary and secondary students respectively. From eight years of age, students are afforded the opportunity to train and compete in their chosen sport across a range of competitive and recreational playing levels. In the school's high-participation sports (e.g. basketball, cricket, rugby, soccer), team coaches employ a thorough selection process, whereby players identified as talented are included in the highest playing levels, while those not selected are encouraged to continue participation in lower-level teams. Whilst each sport and playing level require different levels of time commitment from participating students,

team coaches require students to attend a minimum of two structured 60-min training sessions per week, scheduled in the afternoons following their school academic commitments. Depending on the sport, some students in the highest playing levels may participate in up to four structured 60-min training sessions per week. All sports coaches employed by the school are required to be qualified with their respective national sporting organisations (e.g. soccer coaches require minimum 'C' licence accreditation with Football Federation Australia). The majority of competitive sports also engage in a 16-week competition period, comprising of 10 matches against rival Sydney-based independent boys' schools.

Whilst the school's sports program aims to provide successful sports involvement for all students, the suitability of a school environment to provide adequate developmental opportunities is not known. Furthermore, the most appropriate pathways for young athletes to achieve lifelong sports engagement, while also receiving opportunities to develop expertise remains unclear. Regardless of outcome, all sport participants share common experiences including entry into sport, talent identification and athletic development pathways, and subsequent development outcomes (Figure 1.1). The present thesis therefore aims to understand the most appropriate pathway through these stages by observing the factors influencing sport involvement and talent development in the school-based sports program.

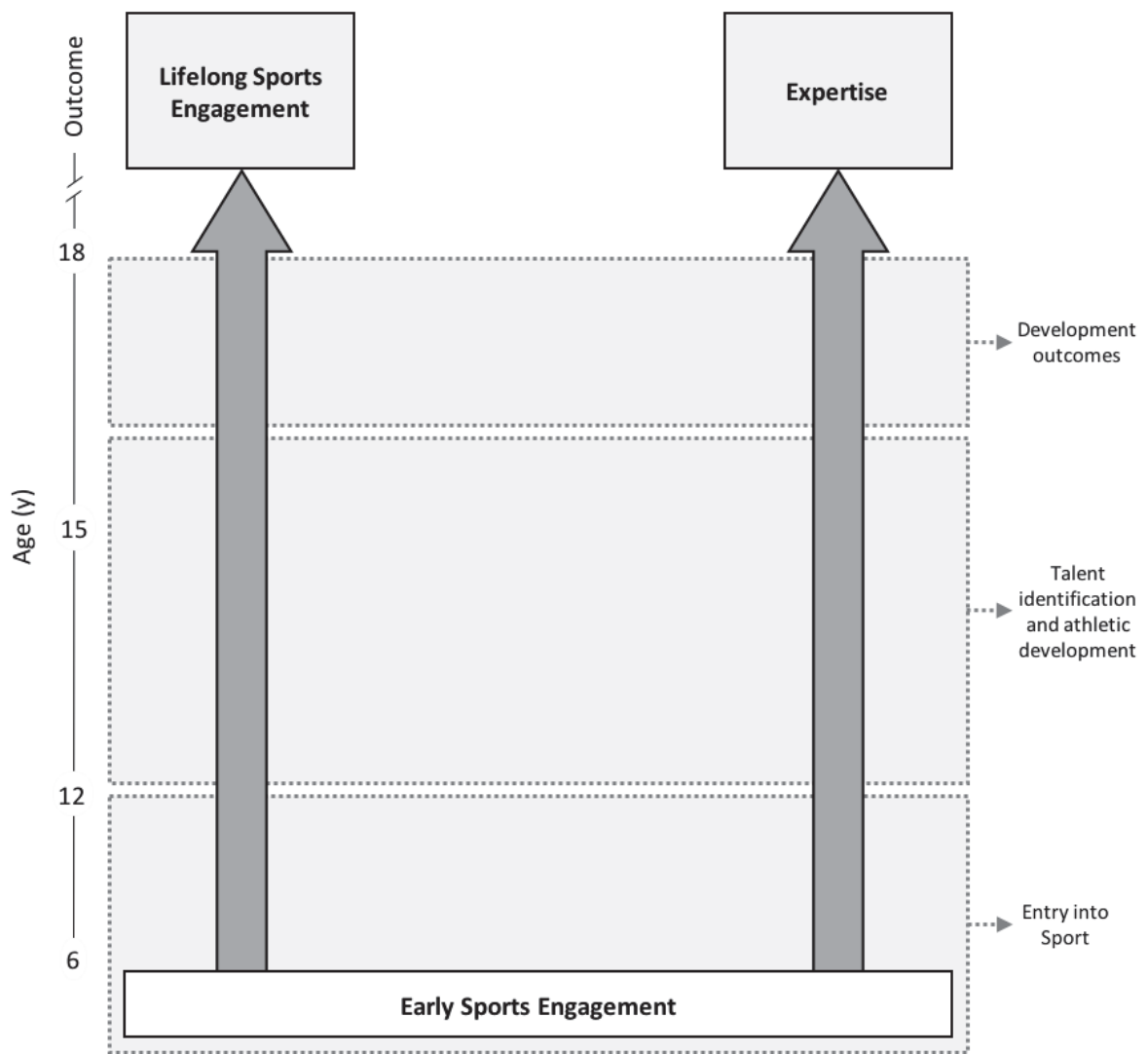


Figure 1.1 The pathway to successful sports participation in school-based sports programs.

1.3 STUDY OBJECTIVES

The aim of the present thesis is to observe the suitability of a school-based sports program for providing children with successful sports involvement and opportunities for talent development. A series of four related studies were therefore designed to investigate the factors influencing sports engagement and talent identification in children and young athletes throughout the schooling years. All four studies employed a multidimensional approach, assessing a range of attributes and performances to provide an understanding of the factors which may influence sports involvement and development opportunities. The multidimensional battery included the assessment of sports participation history, anthropometry, maturity, physical fitness, motor competence, technical ability, subjective coach ratings, and match activity profiles. Firstly, an observation of sports participants over a range of sports, age-groups and playing levels was undertaken to provide an understanding of the factors influencing sports orientation and successful sports involvement. This is particularly relevant for youth sports programs aiming to guide children through their early sporting years. The following three studies then focused on the school's soccer program, observing the talent identification and development pathways within one of the school's most popular sports. Within the school's soccer program, these studies firstly aimed to observe the factors influencing talent identification and selection; i.e. how young players are guided by coaches into specific playing levels and playing positions. Next, the third study aimed to understand the subsequent talent development opportunities provided to players based on these selections. Finally, the development and retention of young soccer players participating in the program was assessed longitudinally to observe the ability of the program to develop talent and promote successful sports involvement. It

was anticipated that the results of these studies would provide a holistic insight into the factors influencing sports engagement and talent development in a school environment.

Study One

Factors affecting sports involvement in a school-based youth cohort: implications for long term athletic development (Chapter 3).

Aim

To determine the factors affecting sports orientation and participation in a school-based adolescent population involved in a wide variety of sports and competitive playing levels.

Hypothesis

Young athletes would be orientated towards different sports based on anthropometrical and physical performance profiles, while both physical fitness and sports participation history would be positively related to playing level.

Significance

Understanding the factors influencing sport orientation, sport participation and talent development is important to maximise the effectiveness of youth sport programs. Indeed, this is especially important throughout the early years at a recreational level, where all children are first exposed to developmental pathways. Whilst previous studies have investigated the characteristics of young athletes in different sports and how these characteristics may be developed, no research to date has considered the factors influencing sport involvement in a recreational, school-based population.

Study Two

A multidimensional approach to factors influencing playing level and position in a school-based soccer program (Chapter 4).

Aim

To investigate the factors influencing selection into playing levels and playing positions in a school-based youth soccer program.

Hypothesis

A range of physical- and coordination-related performance measures will be different between both playing levels and playing positions, and reflect the performance profiles observed in elite soccer players.

Significance

Whilst the factors influencing talent identification and selection have been examined in youth soccer players at both elite and sub-elite levels, no research to date has investigated this at a recreational level. Talent identification and selection at a recreational level is especially important as this is the point at which all young players are first exposed to talent development pathways. Indeed, the selection process throughout the early years may determine the subsequent athletic development opportunities provided to these players.

Study Three

Factors affecting physical match activity and skill involvement in youth soccer (Chapter 5).

Aim

To examine how physical and technical match activity profiles may be influenced by playing level, playing position and individual fitness characteristics in youth soccer players.

Hypothesis

Both physical and technical match activity levels will be influenced by playing level, playing position and individual fitness characteristics.

Significance

To the author's knowledge, no previous research has focused on the factors affecting talent development at a recreational level. These findings are particularly important for youth coaches who aim to provide opportunities for young athletes to develop talent, as contextual factors such as playing level and position may have a significant influence of the development opportunities provided to young players. Additionally, due to the statistical limitations in previous studies, the extent to which individual physical characteristics influence match activity is largely unknown.

Study Four

Factors influencing retention and development trajectories in a school-based youth soccer program (Chapter 6).

Aim

1) To investigate the determinants of player retention in a school-based sports program, and 2) to map the age-related development trajectories of young soccer players retained in the program for a range of fitness and motor competence characteristics.

Hypothesis

Youth soccer players from higher playing levels would be more likely to be retained in the program, and a range of fitness and motor competence characteristics would improve throughout the duration of the study.

Significance

An improved understanding of whether school-based sports programs provide successful sports involvement and suitable development environments is required. Furthermore, an improved knowledge of the factors influencing retention in the program is important for youth sports programs to maximise long-term engagement, which is required for both health and development outcomes.

Collectively, these four studies were designed to investigate the factors influencing sports engagement and talent identification in children and young athletes throughout the schooling years. The studies aim to span the common pathways experienced by all young sport participants regardless of outcome, including entry into sport, talent identification and athletic development, and development outcomes (Figure 1.2). As the chronological age associated with each of these stages is not fixed, all studies aimed to examine a school-based cohort across a range of playing levels and age groups.

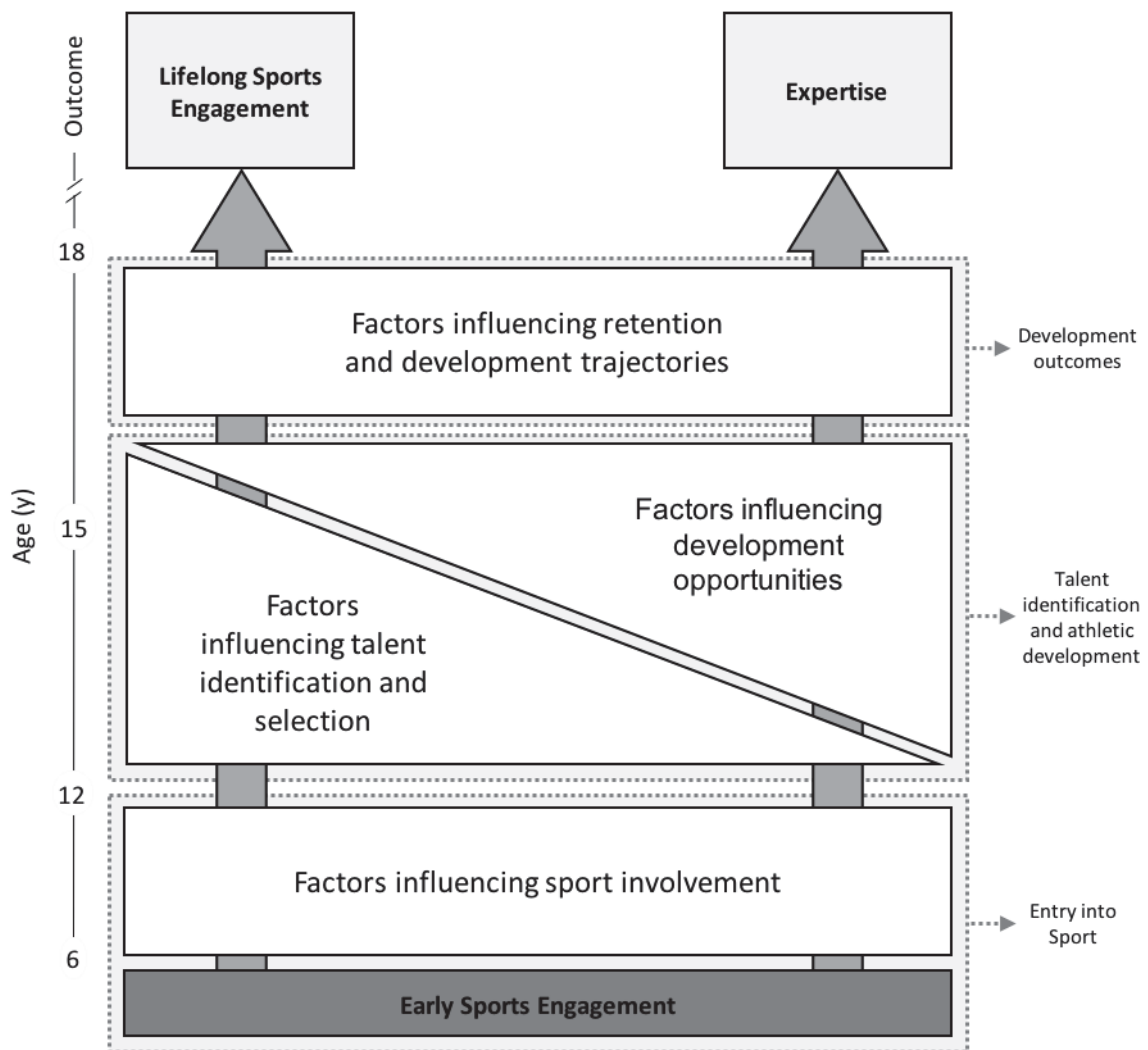


Figure 1.2 Four studies aimed at investigating successful sports participation pathways for school-based sports programs.

2 REVIEW OF LITERATURE

2.1 CHAPTER OVERVIEW

The following chapter is comprised of three main sections, providing a detailed review of sports participation and talent development in youth sport. Firstly, key literature pertaining to participation in youth sport is reviewed. This section includes the key benefits of sport and physical activity, dropout and disengagement, and factors influencing engagement in youth sport. Secondly, a review of the Development Model of Sports Participation (DMSP) is undertaken to provide a framework for the development of talent in youth sport. Specifically, the implications of the DMSP framework are reviewed in the context of two common goals for sports programs; 1) the development of excellence, and 2) providing sport for all. The third section highlights the importance of school-based sports, and how these programs may balance the goals of long-term sports engagement with opportunities for talent development. Finally, this chapter is concluded with recommended directions for future research and rationale for the framework of the subsequent chapters.

2.2 YOUTH SPORT PARTICIPATION

2.2.1 Benefits of Youth Sport Participation

Sport is regarded as a key component of Australia's culture and identity (Ward, 2013). From participating in competitive sport, to spectating high performance athletes in national and international competitions, many Australians enjoy sport as a form of physical activity, recreation and entertainment. The popularity of sport is particularly evident in Australia's youth population, with an estimated 60% of children participating in organised sport outside of school hours (ABS, 2012). Whilst children tend to engage in sport for enjoyment and peer interaction (Fraser-Thomas et al., 2008), there is also an abundance of associated health and developmental benefits. For example, physical fitness, weight control, self-esteem, and social skills are all positively associated with youth sport involvement (Fraser-Thomas, Côté, & Deakin, 2005). Throughout the schooling years (5-17 y), Australian children are therefore encouraged to engage in organised sport and physical activity to realise the many associated health and developmental benefits, while also developing activity habits which may continue into adulthood (Department of Education and Training, 2008).

Involvement in sport and physical recreation plays an important role in the health and development of children and youth. In a systematic review of youth physical activity literature, Janssen and Leblanc (2010) observed an extensive range of biological and psychosocial benefits in children, showing physical activity to positively affect a range of health indicators, including cholesterol levels, bone mineral density, blood pressure, metabolic syndrome, obesity and depression. Despite the abundance of health benefits associated with physical activity, there is a growing number of children with insufficient participation levels, coupled with a rise of obesity rates in young people (Goran &

Treuth, 2001). Indeed, these children are less likely to remain engaged in sport (Stodden, Goodway, Langendorfer, Robertson, Rudisill, Garcia, & Garcia, 2008), with negative health outcomes further decreasing physical activity levels. Health professionals and policy makers therefore aim to promote positive behaviours in young people which may result in lasting health outcomes. Accordingly, optimising physical activity and sport involvement in youth populations is a priority for the onset of lifelong healthy activity patterns (Vanreusel, Renson, Beunen, Claessens, Lefevre, Lysens, & Eynde, 1997).

Whilst the health benefits associated with physical activity are important, overall health in children also requires adequate physical, social, psychological and intellectual development (Fraser-Thomas et al., 2005). Although fitness and weight control are often the most evident physical outcomes, sport and physical activity also facilitate normal growth and development in children and adolescents (Bar-Or, 1983), providing opportunities to improve a range of physical capacities such as cardiovascular fitness, skill, strength, muscular endurance and flexibility (Côté & Hay, 2002). The development of fitness characteristics through participation also leads to higher physical competence, promoting engagement in everyday activities (Stodden et al., 2008), and subsequently increasing the likelihood of long-term sports involvement (Weiss, Smith, & Stuntz, 2002). Sport participation also promotes psychological development, with children experiencing challenge and enjoyment, increasing self-esteem and decreasing stress levels (Csikszentmihalyi, 1975), while also enhancing life satisfaction (Gilman, 2001) and happiness (Fraser-Thomas & Côté, 2004). Sport experiences also allow youth to enjoy social success, build positive peer relationships, and develop a range of social skills (Côté, 2002; Evans & Roberts, 1987; Wright & Côté, 2003). Finally, sport involvement and physical activity play an important role in cognitive development

during these early years, and have been positively correlated with academic performance (Dwyer, Sallis, Blizzard, Lazarus, & Dean, 2001) and adult career achievement (Larson & Verma, 1999). Collectively, these studies confirm that there is an important role for organised sport and physical activity in enhancing health outcomes and development in youth.

A comprehensive range of positive health and development outcomes are possible for children to experience through sport participation. However, as many of these positive outcomes only become possible with long-term sports engagement, maximising retention in sports programs is essential. Creating an inclusive and supportive sport environment is therefore important for youth sports programs to improve the likelihood of long-term sports engagement. This is particularly significant throughout adolescence when young athletes are at an increased risk of dropout, or complete disengagement from sport (Fraser-Thomas et al., 2008). Indeed, the risk of dropout may be linked to negative sport experiences, such as injury or athletic burnout from intensive training (DiFiori, Benjamin, Brenner, Gregory, Jayanthi, Landry, & Luke, 2014). Therefore, providing positive sport experiences to children may promote retention in sports programs, improving the likelihood for young athletes to experience positive development, and possibly even embark on talent development pathways towards elite performance.

2.2.2 Risks Associated with Dropout and Disengagement from Sport

Youth sport participation reaches its peak in late childhood, with approximately two-thirds (66%) of Australian children aged 9-11 years involved in organised sport outside of school hours (ABS, 2012). Throughout these years, sports participation is promoted

by schools and associations, aiming to encourage the onset of healthy lifelong habits. Despite this, a steady decline seems to follow, with the greatest decline in sports participation (Caspersen, Pereira, & Curran, 2000; Telama & Yang, 2000; Van Mechelen, Twisk, Post, Snel, & Kemper, 2000) and highest dropout rates (Petlichkoff, 1996) consistently observed during adolescence. Unsurprisingly, this time coincides with important milestones in physical and emotional development, as well as significant changes in social environments and influences (Eccles, Barber, Stone, & Hunt, 2003). The decline in sport engagement is viewed as a pressing public health issue, as a lack of physical activity is related to disease outcomes such as cardiovascular disease, type 2 diabetes, osteoporosis and depression (Haskell, Lee, Pate, Powell, Blair, Franklin, Macera, Heath, Thompson, & Bauman, 2007). Moreover, sport dropout may also be of detriment to self-concept, increasing the likelihood of depression and a detachment from school and peers (Eccles et al., 2003). Additionally, youth dropouts may also miss out on important physical and social developmental opportunities associated with sport participation, and are more likely to continue inactivity habits into adulthood (Robertson-Wilson, Baker, Derbyshire, & Côté, 2003; Telama, Yang, Viikari, Välimäki, Wanne, & Raitakari, 2005; Vanreusel et al., 1997).

In recent times, considerable research has explored the causes for youth sport participation and withdrawal. Youth sport dropout research has primarily focused on motivation theories, with common reasons for withdrawal including lack of enjoyment, the pursuit of another interest, coach conflict, or lack of playing time (Weiss & Williams, 2004). Indeed, a withdrawal from youth sport may be initiated by any combination of negative physical, psychological or social experiences. For example, sports injury, an excessive pressure to win, and athletic burnout are common negative outcomes which may lead to dropout in youth sport (DiFiori et al., 2014). Poor program

design or negative adult influences also have the ability to hinder rather than enhance development experiences (Fraser-Thomas et al., 2005). Despite the clear relationship between positive experiences and successful engagement in sporting activities, a complete understanding is lacking. It is therefore important to explore the multitude of factors which underpin positive and negative experiences in youth sport, allowing a further understanding of retention and dropout in youth athletes. Ensuring young athletes are retained in programs, or even guided into alternative sports, is essential to prevent disengagement and allow health and developmental benefits to be realised through long-term engagement.

2.2.3 Factors Influencing Engagement

The primary goal for school-based sports programs is to provide all children with adequate opportunities for successful long-term engagement in physical activity. Successful engagement allows children to enjoy participation, develop skills, and experience progression, improving the likelihood of long-term sports participation. While the health outcomes of physical activity are a key influence for schools and policy makers, children are often motivated to participate in sport for a range of other reasons. Most children participate in sport to have fun, to do something they are good at, improve their skills, exercise and become fit, be with their friends, make new friends, and be involved in competition (Weinberg & Gould, 2014). Children also choose to pursue activities in which they have experienced a positive coach interaction, encouragement from peers, early success, or simple enjoyment (Côté, 1999). Ensuring sports programs provide these experiences therefore seems crucial for fostering positive experiences and subsequently reducing sports dropout. In addition to program related

factors, there are a multitude of additional factors which may influence sports engagement throughout childhood and adolescence, such as individual characteristics of physical fitness and motor competence.

Physical Fitness

The development of physical fitness is a key outcome for young people participating in sport and physical activity. Consistent sports engagement allows children and adolescents to develop a range of physical capacities such as cardiovascular fitness, strength, muscular endurance and flexibility (Côté & Hay, 2002). The improvement of fitness characteristics through participation subsequently promotes engagement in everyday activities (Stodden et al., 2008) and increases the likelihood of long-term sports involvement (Weiss et al., 2002). Conversely, children with low levels of physical fitness are more likely to disengage from sporting opportunities, preventing any further improvement of physical fitness. Providing positive sports experiences during the early years is therefore essential to ensure children develop an affinity towards sport and enjoy the resulting benefits of enhanced physical fitness.

Increased fitness levels also improve the likelihood for young athletes to progress through talent development pathways in the pursuit of elite performance (Figueiredo, Coelho e Silva, & Malina, 2011). Throughout the talent identification process, coaches and scouts search for youth who demonstrate high levels of athletic talent, including physical characteristics of strength, speed and endurance. However, advanced athletic qualities in young athletes do not always translate to future potential. For example, older athletes may possess a 'relative age' advantage of up to 11 months on their counterparts in the same annual age-group (Barnsley & Thompson, 1988), whilst early maturing individuals are often taller, heavier and faster than their late maturing peers (Segers, De

Clercq, Janssens, Bourgois, & Philippaerts, 2008). These confounding factors often lead coaches to mistake physical maturation with athletic talent (Wattie, Copley, Macpherson, Howard, Montelpare, & Baker, 2007). Subsequently, athletes who are not viewed as talented may not be provided with adequate opportunities to develop the skills and fitness level required for future selection (Helsen, Starkes, & Van Winckel, 1998b). Despite this, elite performance may be achieved in many unique ways through different combinations of skills, attributes and capacities (Vaeyens, Lenoir, Williams, & Philippaerts, 2008a), making it vital for youth sports programs to overlook the influence of early maturation, while promoting a diverse range of skills and motor competencies to improve the likelihood of talent development and long-term sports engagement.

Motor Competence

Motor competence is defined as the ability to confidently perform a wide range of motor actions in everyday life (Magill & Anderson, 2007). As motor competence also requires adequate levels of motor coordination and physical fitness, it is a key indicator for sports engagement and physical activity levels in young people. Children with low motor competence are at risk of physical inactivity (Cairney, Hay, Faught, Corna, & Flouris, 2006; Cairney, Hay, Faught, Flouris, & Klentrou, 2007; Okely, Booth, & Patterson, 2001) and low physical fitness (Hands, 2008; Stodden, Langendorfer, & Robertson, 2009), while often experiencing reduced self-worth and motivation towards sport (Rose, Larkin, & Berger, 1997, 1998; Vedul-Kjelsås, Sigmundsson, Stensdotter, & Haga, 2012). Children with low motor competence are also more often overweight (D'hondt, Deforche, Vaeyens, Vandorpe, Vandendriessche, Pion, Philippaerts, Bourdeaudhuij, & Lenoir, 2011) and perform below average on tests of flexibility, cardiovascular endurance, speed, agility and strength (Cairney et al., 2007; Cantell & Crawford, 2008; Hands & Larkin, 2006; Sääkslahti, Numminen, Niinikoski, Rask-

Nissilä, Viikari, Tuominen, & Välimäki, 1999). In contrast, motor competence is positively associated with physical fitness throughout childhood and adolescence (Haga, 2008; Stodden et al., 2009; Vedul-Kjelsås et al., 2012). Motor competence has also been shown to be an important determinant of progression in talent development programs, predicting future performance in young gymnasts (Vandorpe, Vandendriessche, Vaeyens, Pion, Lefevre, Philippaerts, & Lenoir, 2011b), and discriminating between those who dropout and progress in an elite youth soccer program (Deprez, Fransen, Lenoir, Philippaerts, & Vaeyens, 2015). Collectively, these studies suggest the development of motor competence to be an important factor for young athletes to engage in sport and physical activity throughout the development years.

Whilst motor competence and physical fitness characteristics are clearly associated (Stodden et al., 2009), the relationship is mediated by physical activity levels (Okely et al., 2001). For example, physically active children are likely to develop both physical fitness and motor competence as a result of high participation levels, which in turn leads to further engagement in sport and physical activity. Children with low motor competence may instead show decreased participation in physical activity over time, resulting in a further decrease of physical fitness levels (Stodden et al., 2008). These ‘spirals of engagement’ refer to the snowballing effect of either positive or negative physical activity outcomes. For instance, sedentary behaviour may arise in children with low motor competence, leading to compromised health and further inactivity (Figure 2.1) (Stodden et al., 2008). Conversely, increased motor competence may lead to further investment in sport, resulting in improved physical fitness, likelihood of long-term engagement, and progression towards elite performance (Deprez et al., 2015; Vandorpe et al., 2011b). The development of motor competence is therefore essential to encourage physical activity, physical fitness and sports participation throughout childhood.

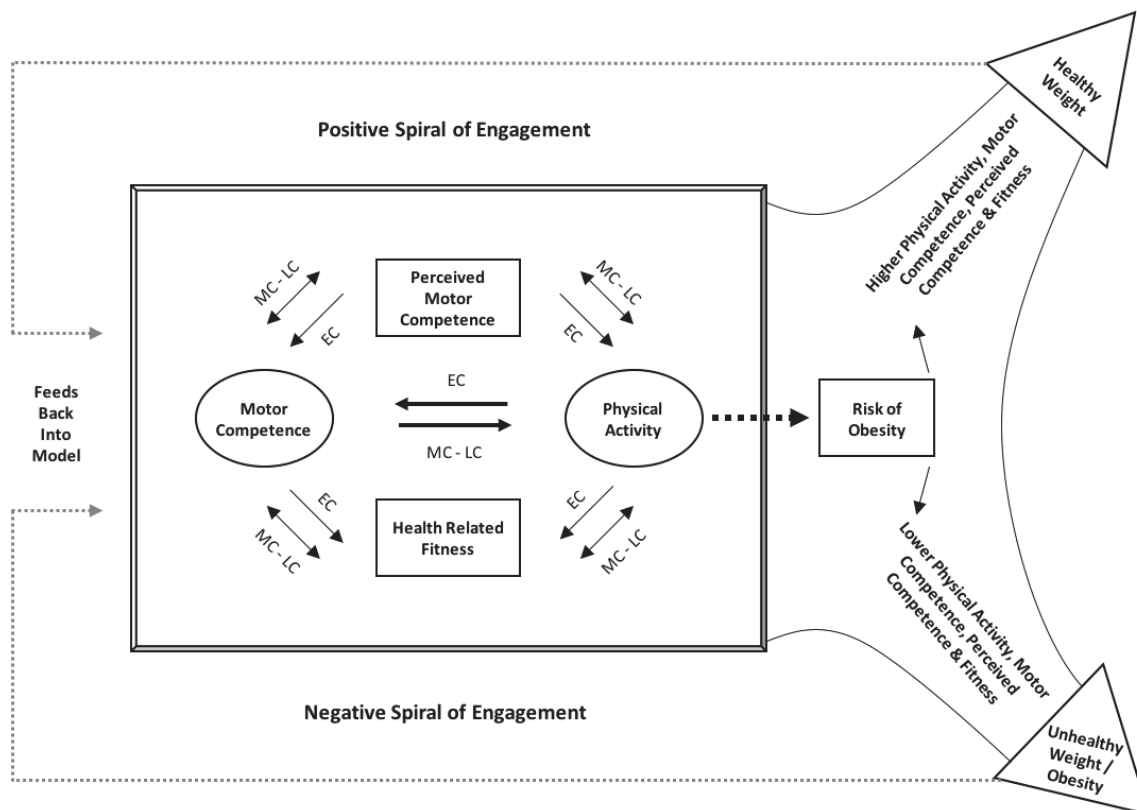


Figure 2.1 The ‘Negative/positive spiral of (dis)engagement’ shows the relationship between motor (in)competence, physical (in)activity and (lack of) physical fitness (Stodden et al., 2008). EC; early childhood, MC; middle childhood, LC; late childhood.

Perceived Competence

An individual’s self-perception of competence may also influence sport and physical activity engagement levels in youth sport. Harter (1978) theorised that children with high perceptions of their own ability are more likely to accept challenging tasks, enjoy the learning process, exhibit higher self-esteem, exert greater effort to master skills, and persist in the face of difficulty. Conversely, children who underestimate their own ability to learn and perform sport skills are more likely to disengage and drop out of sport participation (Weiss & Ferrer-Caja, 2002). Perceived competence may also be

influenced by actual motor competence, subsequently affecting physical activity participation levels (Griffin & Keogh, 1982). For example, higher levels of motor proficiency may result in an increased perception of competence, leading to greater participation in physical activity and further opportunities for the development of motor competence and physical fitness (Barnett, Morgan, van Beurden, & Beard, 2008). Children with poor skill proficiency may instead develop low perceived competence resulting in less engagement in physical activity throughout adolescence (Barnett et al., 2008). Therefore, providing early sport experiences which enhance the perceived and actual ability of young participants may be crucial to encourage positive developmental outcomes and increase the likelihood of long-term sports involvement (Weiss et al., 2002). However, for successful sports involvement to be experienced, youth athletes must be exposed to a suitable sporting environment and program design.

Program Design

Program design is recognised as an important mediator of development in youth sport (Côté, 1999; Côté et al., 2009; Orlick, 1974). For example, in a series of interviews with 60 youth dropouts aged 7-19 y, 50% of participants indicated that sports programs were too serious, focused only on winning, and lacked enjoyment (Orlick, 1974). Indeed, whilst talent programs often aim to accelerate development through specialised, competitive environments, this approach may be counter-productive for the aim of long-term sports engagement (Côté et al., 2009). Early specialisation allows young athletes to invest many hours of deliberate practice in their primary sport from a young age (Ericsson, Krampe, & Tesch-Römer, 1993), however this path is often synonymous with decreased intrinsic motivation and enjoyment in training (Wall & Côté, 2007), heightening the risk of social isolation, burnout and overuse injury (Malina, 2010). Alternatively, a more diversified approach to youth sport participation has been

suggested by Côté et al. (2009), where young athletes are afforded the opportunity to sample different sports and engage in deliberate play designed to maximise enjoyment. As young athletes reach adolescence, they may then decide to continue sports participation with a focus on enjoyment and health benefits, or invest time into a single sport with the goal of pursuing elite performance (Côté et al., 2009). Indeed, many athletic development programs, including those in schools, are required to balance the development of excellence with programs offering sport for all. However, as talent development programs are exclusive by nature (Burgess & Naughton, 2010), catering for both aims is not a simple task. Accordingly, the DMSP approach may be an appropriate framework to maximise the likelihood for long-term engagement, which provides young athletes with the opportunity to develop skills over a long period of time, and reap the benefits associated with long-term sports engagement. The diverse approach recommended by Côté et al. (2009) may therefore be able to effectively offer sports for all, while providing opportunities to develop excellence.

The Pursuit of Excellence

Successful sports involvement also entails the attainment of excellence. In fact, many young athletes report that the achievement of excellent performance standards is a major motivation for participating in sport (Recours, Souville, & Griffet, 2004). For this ambition to be realised, a long-term approach to sports involvement is essential, as many years of engagement allows youth athletes to accumulate skills over an extended period of time, which may ultimately result in expert performance (Ericsson et al., 1993). Children are often first exposed to sport in a schooling environment between 4-6 years of age. For some children who experience early success or enjoyment in a particular sport, this may motivate them towards increased sport participation, leading to many hours of investment into deliberate practice in the pursuit of elite performance.

A series of talent development pathways are also vital to realise the transition from early engagement to elite performance. Indeed, coaches and scouts search for talented youngsters who possess the potential for future sports performance, with the hope of developing expert performers. However, as this process often involves a strict emphasis on early selection, it may eliminate children who do not yet possess athletic ability, even if it may later develop with growth, maturation and training (Wiersma, 2000). Unfortunately, this problem has a confounding effect, with deselected athletes more likely to miss out on high quality coaching and training opportunities, limiting the chance of future selection (Helsen et al., 1998b). Furthermore, many talent development programs promote early sport specialisation, prescribing intense, year-round training in a single sport with the exclusion of other sports (Jayanthi, Pinkham, Dugas, Patrick, & LaBella, 2012). While this approach may allow children to invest time into many hours of deliberate practice, it may decrease enjoyment and constrain opportunities for intrinsically motivated, play-like activities, compromising the likelihood of long-term engagement in sport (Côté & Fraser-Thomas, 2008).

In summary, a range of considerations need to be made to maximise opportunities for children and adolescents to enjoy long-term engagement in sport. Regardless of whether young athletes seek to develop excellence, or continue participation at a recreational level, promoting health and development benefits through long-term engagement is a priority for youth sport programs. This may be achieved by enabling the development of physical fitness, motor competence and perceived competence in children and young athletes. Providing a suitable development environment through appropriate program design is therefore key to reducing dropout and deselection in sporting pathways. However, practitioners and researchers have strived for decades to determine what constitutes a suitable environment, with countless models and frameworks suggested for

the identification and development of gifted and talented young athletes (Baker, Cobley, Schorer, & Wattie, 2017). Indeed, comprehensive reviews of talent development literature have been undertaken elsewhere, which provide an insight into the efficacy (Güllich & Cobley, 2017), international best-practice (Weissensteiner, 2017), and implementation (Ford & Williams, 2017) of development programs. Whilst many perspectives on the processes behind attaining peak performance remain, the DMSP is one approach that consistently meets this criteria, providing a framework for different pathways to elite performance through long-term sports engagement (Côté et al., 2009). Specifically, the ability of the DMSP to aim for the development of expertise, while simultaneously promoting lifelong engagement through age-appropriate development opportunities, makes this particular framework an important consideration for school-based sports programs.

2.3 DEVELOPMENTAL MODEL OF SPORTS PARTICIPATION

2.3.1 Developmental Model of Sports Participation

The DMSP is a prominent and commonly adopted framework outlining different pathways through multiple stages of childhood and adolescent development. In recent times, a number of national sporting organisations have adopted the DMSP framework to improve talent development outcomes (International Council for Coaching Excellence, 2013; National Rugby League, 2017; United States Olympic Committee, 2016). Unlike most talent development frameworks, the DMSP accommodates two important objectives for young athletes: 1) the pursuit of excellence, and 2) lifelong engagement in sport. Despite many young athletes aspiring to reach the professional level, relatively few will attain elite performance. Therefore, striking a balance between

these two aims is essential for development programs to retain youth athletes in sport, regardless of whether elite performance is attained or not.

In their DMSP, Côté et al. (2009) propose two pathways to sporting excellence: early specialisation and early diversification. The DMSP suggests elite sports performance may be achieved by specialising in one sport at an early age followed by the accumulation of many hours of deliberate practice through early specialisation, or through early diversification, where many sports are sampled at a young age before later specialising in a chosen sport. Whilst a specialised approach to attaining elite sports performance is common in many talent development settings, the DMSP proposes early diversification as an alternative path to elite performance, involving three stages of athlete development, including the sampling (6-12 y), specialising (12-15 y), and investment years (+15 y) (Figure 2.2). In fact, Côté et al. (2009) suggest a sampling approach may be preferential to maximise engagement throughout the development years, providing young athletes with opportunities to either pursue a pathway to elite performance, or continue recreational involvement throughout adolescence. For these reasons, this model may be an ideal framework to promote long-term engagement in sport participation. Indeed, a recreational pathway is essential to prevent the complete disengagement of young athletes if elite performance is not attained. Prioritising long-term sports engagement also allows young athletes to realise a range of health benefits and developmental opportunities, while also accumulating the skills required to pursue sporting excellence.

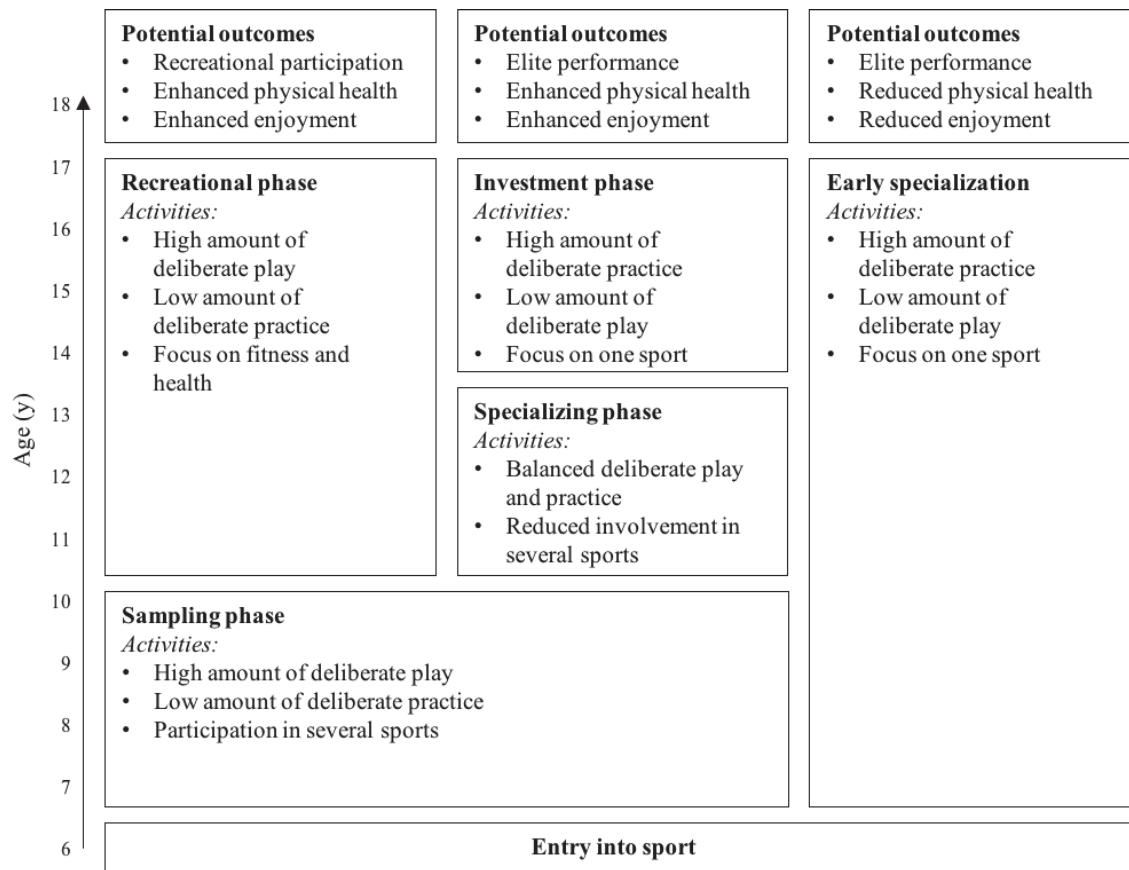


Figure 2.2 The Developmental Model of Sports Participation (DMSP) (Côté, 1999; Côté, Baker, & Abernethy, 2003, 2007; Côté & Fraser-Thomas, 2007; Côté et al., 2009).

2.3.2 The Pursuit of Excellence

The first sporting experience for most children is in a schooling environment between 4-6 years of age. These early sport experiences are often created through fun and playful games, taking the form of modified rules and environments adapted from standard sports. For some children who experience early success and enjoyment in sports activities, this early engagement may motivate them towards increased sport participation, and even the pursuit of excellence in a particular sport. However, for

young athletes to realise the transition from early sports engagement to elite performance, they must embark on a series of talent development stages, including a long-term commitment to high-quality training. In a sporting context, talent is often viewed as a combination of innate attributes and developed abilities pertaining to performance in a particular sport. Coaches and selectors therefore aim to identify potential at an early age to provide these athletes with a suitable learning environment (Williams & Reilly, 2000), with the hope of developing these talented individuals into expert performers. Whilst the definition of a suitable environment remains unclear, the DMSP described two pathways which may lead to the attainment of expertise: early specialisation and early diversification.

The DMSP recognises early specialisation as one of the pathways to elite performance, involving the investment of high amounts of deliberate practice into a single sport. This pathway supports early research on expertise, which highlighted the importance of experience (Chase & Simon, 1973) and deliberate practice (Ericsson et al., 1993) for the attainment of excellence. Therefore, while play-like activities may initially motivate a child towards sport participation, the pursuit of excellence often leads to many hours of investment into deliberate practice throughout childhood. Deliberate practice is described as structured activity aimed at improving performance, requiring deep, focused learning, with maximal effort and complete concentration from the performer (Ericsson et al., 1993). Having observed the close relationship between expert performance and a history of domain-specific practice, Ericsson et al. (1993) suggested early exposure, training specificity, and deliberate practice to be vital for children to have a chance of future success. Accordingly, talent development programs often adopt an early specialisation approach, where children are encouraged to specialise at a young age and invest many hours of deliberate practice into a single sport. An early focus on

specialisation allows young athletes to accumulate many hours in their sport of choice, bringing them closer to the attainment of expertise (Ericsson et al., 1993). Single-sport specialisation is especially important for sports with early ages of peak performance, such as women's gymnastics (Law, Côté, & Ericsson, 2007). However, the early specialisation approach downplays the importance of appropriate personal and social development during the early years of an athlete's involvement in sport (Côté et al., 2009). Excessive training demands and pressure to perform may lead to injury, burnout or even dropout from development programs (Fraser-Thomas et al., 2005). The strict emphasis on early selection may also eliminate young players who do not possess advanced athletic ability, even though these characteristics may later develop with growth, maturation and training (Wiersma, 2000). Collectively, these studies indicate that early specialisation may be an uncertain pathway to elite performance, and as few studies have conclusively shown specialisation at a young age to be a prerequisite for expert performance, alternative paths to success have been proposed.

The early diversification approach was proposed by Côté (1999) as an alternative trajectory to elite performance. In contrast to early specialisation, the early diversification approach encourages young athletes to sample a variety of sports and activities during the early years to maximise enjoyment through less structured play and age-adapted rules (Côté, 1999). Côté (1999) defined these activities as deliberate play, which are predominantly self-guided by children rather than structured activities coached by adults. It is suggested that deliberate play innately promotes intrinsic motivation, immediate gratification and enjoyment, allowing children the freedom to experiment with different movements and tactics in environments which would not be provided in organised situations (Côté et al., 2007). Côté et al. (2003) argued that a sole focus on deliberate practice at a young age is not essential, with play-like activities

preferential for the development of skills and intrinsic motivation towards sport engagement. Furthermore, the sampling of multiple sports exposes young athletes to a range of different physical, cognitive and psycho-social environments, reinforcing personal and mental skills needed for future success (Côté et al., 2009). This is supported with evidence at the elite level, with many elite athletes having spent considerable time in non-organised play during childhood (Rees, Hardy, Güllich, Abernethy, Côté, Woodman, Montgomery, Laing, & Warr, 2016). Following the sampling years, the DMSP encourages young athletes who wish to pursue elite performance to reduce involvement in several sports and continue with a balanced involvement in both deliberate practice and deliberate play, known as the specialising years (12–15 y). Finally, the investment years (+15 y) subsequently focus on deliberate practice in a single sport. While early diversifying athletes may reach peak target performance at a slower rate and at a later age (Baker, Côté, & Abernethy, 2003a), the gradual physical and psychological development reduces the likelihood of injury and dropout during the transition through adolescence (Fraser-Thomas et al., 2005).

Despite the clear advantages of a sampling approach to early sport participation, Ericsson et al. (1993) suggested that it would be near impossible to overcome the advantage provided to those who begin deliberate practice at a young age and maintain high amounts of deliberate practice hours over time. However, the main assumption of this theory is that practice must be deliberate in order to be beneficial, with structured activity superior to play or involvement in other sporting activities (Côté et al., 2007). Whilst sports with an early peak performance age (e.g. women's gymnastics) require early training specificity, comparisons between elite and non-elite performers in soccer (Helsen, Starkes, & Hodges, 1998a), field hockey (Helsen et al., 1998a), and triathlon (Baker, Côté, & Deakin, 2005) revealed training-based differences not to occur until 13,

15 and 20 years of age respectively. These findings suggest that the specialised training necessary for elite performance is not usually required until adolescence. Despite sport-specific practice commonly prescribed from a young age (Ericsson et al., 1993), it is clear that any number of movement, perceptual, conceptual or physical conditioning elements may be transferred between sports (Schmidt & Wrisberg, 2008). Indeed, athletes with diverse sporting backgrounds have frequently been shown to be capable of attaining elite performance (Baker, Côté, & Abernethy, 2003b; Baker et al., 2005; Bloom, 1985; Carlson, 1988; Vaeyens, Güllich, Warr, & Philippaerts, 2009). The multi-faceted nature of many sports allows learning through diverse settings to be beneficial, rather than relying solely on deliberate, task-specific practice. For example, aerobic conditioning may be enhanced during childhood with activities such as running or cycling, but later be beneficial for a range of sporting activities, such as field-based team sports (Côté et al., 2007). Similarly, exposure to a range of sport settings may be important for the development of decision-making skill, especially in team sports where dynamic pattern recognition is required (Baker et al., 2003b). Accordingly, athletes involved in additional sporting activities throughout the early years may circumvent some of the many hours of sport-specific training required for the achievement of expertise (Baker et al., 2003b).

In summary, the DMSP provides a framework to explain different pathways to expert performance. Early sport specialisation allows young athletes to accumulate many hours of deliberate practice from a young age, however, the focus on early selection and pressure to perform may not be ideal. Indeed, the potential negative experiences associated with early specialisation may prevent long-term engagement, which is essential for the development of excellence. Instead, a sampling approach may be more suitable to promote an intrinsically motivating environment and maximise long-term

sports engagement. This approach may also be ideal to ensure young athletes are provided with opportunities to continue engagement in recreational sport if elite performance is not achieved.

2.3.3 Lifelong Sports Engagement

Elite sports performance is a popular goal for young athletes, however few aspiring athletes will ever attain sporting expertise. Indeed, while 10% of the population may possess innate “giftedness” in a certain field, even fewer will translate this to talent or expert performance (Gagné, 2004). Therefore, when youngsters are inevitably deselected from talent development programs, or decide to discontinue the pursuit of elite performance, it is important that pathways are provided to allow a transfer between sports or continue participation at a recreational level. Recreational programs provide young athletes with an opportunity to continue sports participation, and enjoy the health benefits associated with lifelong engagement. Accordingly, the diversified approach proposed by the DMSP may provide suitable development pathways to all young athletes, allowing a recreational transition if elite performance is not achieved (Côté et al., 2009).

Despite early diversification proposed as a suitable approach to youth sport involvement, many sports programs persist with early specialisation, encouraging young athletes to pursue performance in a single sport. This approach allows youth coaches to focus on the early selection of talented youngsters, guiding them into elite programs and aiming to accelerate their development. However, this also leads to the systematic dropout of young athletes who are not retained in elite programs (Helsen et al., 1998b), becoming problematic for both talent development (Burgess & Naughton, 2010) and

recreational sports programs alike. For example, the early specialisation approach is solely focused on the pursuit of expertise until it is achieved, with no consideration for continued engagement at a lower-level if elite performance is not attained (Côté et al., 2009). As the early specialisation approach often requires an extrinsically motivated environment, these athletes may lack the intrinsic motivation to continue recreational participation if elite performance is not reached (Côté et al., 2009). Similarly, young athletes who specialise earlier are more likely to experience shorter sporting careers (Barynina & Vaitsekhovskii, 1992) and suffer an increased risk of burnout (Gould, Tuffey, Udry, & Loehr, 1996), indicating that an emphasis on deliberate practice and sport-specific training at a young age may not be suitable for the promotion of long-term sports participation in young athletes.

In contrast, a diverse approach to early sports participation may be a viable option for the promotion of long-term sports engagement. The sampling pathway proposed in the DMSP encourages young athletes to participate in a variety of sports and activities to maximise enjoyment through less structured play and age-adapted rules (Côté, 1999). Allowing children the freedom to experiment in unstructured, play-like environments allows immediate gratification and enjoyment, promoting intrinsic motivation towards sport engagement (Côté et al., 2009). Following the sampling years, sports participants may subsequently choose to either stay involved in sport at a recreational level, or embark on a path that focuses primarily on performance. Regardless of the chosen path, the intrinsically motivating experiences of the sampling years are thought to have a lasting positive effect. These experiences may help children become more self-determined and committed to future participation in sport (Côté et al., 2009), resulting in an increased motivation and willingness to engage in externally controlled activities such as deliberate practice, or simply a long-term involvement in recreational sport.

Whilst a diverse learning environment seems to be important for the promotion of long-term engagement from an early age, the sampling approach also assists a transition between sports in the later years. Young athletes who engage in multiple sporting disciplines throughout the sampling years may be more prepared for a future transfer between sports, having developed a diverse range of motor and cognitive skills. Participation in multiple sports throughout the early years promotes the development of diverse sporting profiles, with any number of movement, perceptual, conceptual or physical conditioning elements assisting a future transfer to performance in another sport (Baker, 2003; Schmidt & Wrisberg, 2000). Accordingly, exposure to a wide range of sport experiences during the early years reduces the likelihood of complete disengagement from sport. A recreational pathway also permits a transfer between sports, preventing complete disengagement if a young athlete experiences dropout or deselection from a sports program.

The recreational outcome of the DMSP has also been supported by research describing the type of early sports involvement which may lead to long-term sports engagement (Robertson-Wilson et al., 2003). In support of the diverse sampling pathways proposed in the DMSP, a retrospective study of active and inactive women reported differences in sporting participation from as early as 6 years of age (Robertson-Wilson et al., 2003). Active women recalled participation in a variety of sports during their sampling years (6-12 y), primarily involving play-like activities, whilst inactive women participated in less activities throughout childhood. Similarly, high amounts of deliberate play across a variety of sports during the sampling years has been suggested to expose children to an abundance of motor and cognitive experiences, improving the likelihood for positive development outcomes (Fraser-Thomas et al., 2005). Furthermore, a study of triathletes also showed that sampling a range of sports during childhood was associated with

participation that extended into late adulthood (Baker et al., 2005). Accordingly, these studies show that sport sampling may provide essential building blocks for lifelong sports participation, and should therefore be encouraged throughout the schooling years.

Collectively, these findings suggest that a diverse, sampling approach to early sport participation may be an appropriate pathway for the promotion of long-term sports engagement. Regardless, few talent development programs or sporting academies would consider a diverse approach to sports participation. Rather, young athletes are often encouraged to specialise earlier and accumulate many hours of deliberate practice, which leaves little room for coaches to encourage their athletes to sample other sports or participate in deliberate play (Côté & Fraser-Thomas, 2008). School-based sports programs may therefore be especially important in providing young athletes with a diverse learning environment throughout the early sporting years.

2.4 SCHOOL-BASED SPORTS PROGRAMS

During schooling years, Australian children and adolescents are encouraged, and even obligated, to engage in organised sport and physical activity (Department of Education and Training, 2008). Indeed, health experts and policy makers drive the promotion of sport and physical activity in schools to ensure children are exposed to a range of metabolic, physiological and mental health benefits (Fraser-Thomas et al., 2005). It is hoped that the schooling environment provides the first step towards a lifelong affinity with sport, encouraging healthy habits which may last into adulthood. The primary goal of school-based sports programs is to therefore provide all children with adequate opportunities for successful engagement in sport, with the aim of promoting long-term participation. However, school sports programs also aim to identify talent and develop

sporting excellence, as the tangible success of a sports program is often more related to the school's ability to produce good athletes within specific sporting disciplines. This has become evident with an increased investment into sports programs, particularly in Australia's elite private schools (Duncan, 2013; Munro, 2013; Robertson, 2013). It is therefore important for school-based sports programs to carefully balance the aims of providing opportunities to develop excellence, while promoting long-term sports engagement. Suitable program design with appropriate pathways for athletic development is therefore essential to achieve this goal.

The DMSP provides a framework for young athletes to engage in developmentally appropriate sports activities in the pursuit of elite performance. Most importantly, the sampling pathway may be suitable for school-based sports programs to balance the development of excellence, while providing sport for all. Following the sampling years (6-12 y), young athletes may choose to either continue recreational involvement, or enter the specialising years where they are encouraged to invest more time into their sport of choice. While the specialisation pathway is guided towards developing elite performance, the DMSP framework encourages a transition back to recreational participation if expertise is not attained, improving the likelihood for all young athletes to achieve long-term engagement regardless of playing level. Indeed, the schooling environment may be an ideal setting for sampling multiple sports, with schools commonly offering opportunities to participate in many sports across a range of competitive and recreational playing levels. The sampling of multiple sports may be easily facilitated in a school environment, with a range of sports often organised in close proximity during allocated sport training times. Therefore, if a young athlete decides to dropout from a sport, school-based sports programs should be able to accommodate a

transfer to another sport, protecting against complete disengagement during the transition through adolescence.

Whilst the two primary goals of school-based sports programs seem conflicting, both outcomes require a long-term engagement in sport. For example, if prolonged sports engagement is achieved, this also increases the likelihood for young athletes to invest time and develop skill proficiency which could ultimately result in expert performance (Ericsson et al., 1993). However, the transition through adolescence is characterised by high rates of sports disengagement, making long-term engagement difficult to guarantee. Moreover, a focus on providing specialised training to elite performers could result in the deselection of children from sports programs if they are not yet viewed as talented. Adolescent dropout poses a significant risk to youth sport programs, both reducing the likelihood of long-term sport engagement, and preventing the attainment of high-level sports performance. School-based sports programs should therefore focus on reducing dropout to maximise each student's potential for successful sports engagement.

In summary, school-based sports programs are an important component of early sporting experiences for children. As most talent development programs prescribe an early specialisation approach in the pursuit of excellence, the school environment is an ideal setting to provide an alternative approach to sports participation. The diverse, sampling pathway of the DMSP seems to be the most appropriate framework to provide young athletes with an opportunity to pursue elite performance, while promoting lifelong engagement through the recreational pathway. However, the extent to which schools are equipped to provide optimal development environments is unknown.

2.5 DIRECTIONS FOR FUTURE RESEARCH

Despite considerable research focusing on talent development at an elite youth level, to the authors' knowledge no previous studies have observed the factors influencing sports involvement and talent development in a school-based sports program. The recreational pathway is particularly important, as this is where all young athletes receive early exposure to sport. Indeed, throughout the early years of engagement, successful sports orientation and talent identification may have a significant effect on long-term sports engagement, and the opportunities to develop the skills required for elite performance. In retrospect, the sampling pathway of the DMSP seems to be the most appropriate framework to balance long-term engagement with an opportunity to pursue elite performance. However, the extent to which schools are equipped to provide optimal development environments for early diversification is unknown. Future research should therefore consider the factors influencing sport involvement in a recreational, school-based population. An improved understanding of the factors influencing talent identification and talent development in a school-based sports program is also required. Finally, a new framework should be considered to provide schools with a guided approach to sports participation, balancing lifelong sports engagement with the pursuit of excellence.

2.6 SUMMARY

School-based sports programs are a prominent fixture in the physical, social and cognitive development of all children. Involvement in these programs is therefore essential to provide children with positive sporting experiences, allowing youth to

realise a range of important health and developmental benefits, while promoting the accumulation of skills which may lead to elite performance. Despite many young athletes aspiring to attain elite performance, relatively few will reach the professional level. Striking a balance between the pursuit of expertise and lifelong engagement is therefore important for development programs to retain youth athletes in sport, regardless of whether elite performance is attained or not. The DMSP may be a suitable framework for school-based programs, as it aims to provide opportunities to develop excellence, while promoting lifelong engagement in sport. However, the extent to which schools are capable of adopting the DMSP framework for their sports programs is unknown, and it is not clear whether these programs are able to provide young athletes with suitable development opportunities across a range of age groups and playing levels. Whilst the factors influencing engagement in sport throughout childhood and adolescence are widely acknowledged, further work is required to understand the determinants of successful sports involvement at a recreational level. Furthermore, an improved understanding of the factors influencing sports participation and talent development is also required to maximise the effectiveness of school-based sports programs.

3 STUDY ONE

Lovell, T.W.J., Fransen, J., Bocking, C.J. & Coutts, A.J. (*under review*). Factors affecting sports involvement in a school-based youth cohort: implications for long term athletic development. *Journal of Sports Sciences*.

ABSTRACT

The aim of the present study was to determine the factors affecting sports involvement in a school-based adolescent population. A cohort of 501 sport participants (aged 10-16 y) was assessed for anthropometry, physical capacities, motor competence and sports participation history. For the purpose of analysis, participants were divided into junior (10-12 y) and senior (13-16 y) cohorts. Multivariate analyses of covariance (MANCOVA) and stepwise discriminant analyses were used to observe differences in maturation, anthropometry, physical capacity and motor competence between both sports and playing levels. A MANCOVA was also used to analyse differences between playing levels for a range of sports participation milestones and training history. Moderate differences were found between sports for a combination of maturation, anthropometry, physical capacity and motor competence in the senior cohort ($F=2.616$, $p<0.001$, $\eta^2=0.08$). No differences between sports in the junior cohort were observed. Additionally, both physical characteristics and sports participation history differentiated between playing levels in the junior cohort. Participants at a representative level possessed enhanced fitness qualities, engaged in a higher volume of structured training hours, and started competitive level match-play and organised competition at a later age. This study's findings are twofold: 1) physical and motor competence profiles for participants in different sports become more heterogeneous with increasing age, and 2) those who participate at a higher level of competition report delayed engagement in their main sport. This suggests that schools provide an ideal opportunity to sample different sports and delayed engagement might relate to better future performance in school athletes from a variety of sports.

INTRODUCTION

The metabolic, physiological and mental health benefits associated with physical activity in children and youth are wide-ranging (Fraser-Thomas et al., 2005). During schooling years, Australian children and adolescents are therefore encouraged, and even obligated, to engage in organised sport and physical activity (Department of Education and Training, 2008). As these formative years are strongly linked to activity patterns throughout adulthood, the promotion of sport and physical activity in children is hoped to encourage the onset of healthy lifelong habits (Vanreusel et al., 1997). Côté et al. (2003) suggest that a diverse and playful introduction to sport is the best approach to promote long-term participation. Furthermore, children often choose to pursue activities in which they have experienced a positive coach interaction, encouragement from peers, early success, or simple enjoyment (Côté, 1999). It is therefore important for developmental sports programs to maximise fun and excitement through a variety of sports to improve the likelihood of long-term sports participation. Indeed, the schooling environment often provides children with their first experiences in organised sport, making these experiences especially important. Furthermore, positive early experiences allow children to develop motor competence (Fransen, Pion, Vandendriessche, Vandorpe, Vaeyens, Lenoir, & Philippaerts, 2012; Vandorpe, Vandendriessche, Lefevre, Pion, Vaeyens, Matthys, Philippaerts, & Lenoir, 2011a), improving the likelihood for long-term engagement (Stodden et al., 2008). However, the extent to which schools are equipped to provide an optimal environment to develop talent are often limited (Elferink-Gemser, 2013), and the effectiveness of these school-based programs is poorly researched. Nevertheless, the school context seems to be the ideal

setting for children to sample sports across a range of recreational and competitive playing levels which are considered vital in developing lifelong adherence to sport.

In their Developmental Model of Sports Participation (DMSP), Côté et al. (2009) propose that there are two pathways to sporting excellence: early specialisation and early diversification. The DMSP suggests elite sports performance may be achieved by specialising in one sport at an early age followed by the accumulation of many hours of deliberate practice, or through early diversification, where many sports are sampled at a young age before later specialising in a chosen sport (Côté et al., 2009). Whilst early specialisation allows young athletes to invest many hours of deliberate practice in their primary sport from a young age, this path is often synonymous with decreased intrinsic motivation and enjoyment in training (Wall & Côté, 2007), heightening the risk of social isolation, burnout and overuse injury (Malina, 2010). The strict emphasis on early selection may also eliminate children who do not yet demonstrate the athletic ability which may later develop with growth, maturation and training (Wiersma, 2000). Conversely, the DMSP's early diversification approach involves three stages of athlete development, including the sampling (6-12 y), specialising (12-15 y), and investment years (+15 y). In contrast to early specialisation, young athletes are encouraged to participate in a variety of sports and activities to maximise enjoyment through less structured play and age-adapted rules (Côté, 1999). While early diversifying athletes may reach peak target performance at a slower rate and at a later age (Baker et al., 2003a), sampling exposes young athletes to a range of different physical, cognitive and psycho-social environments, reinforcing personal and mental skills needed for future success (Côté et al., 2009). Moreover, the gradual physical and psychological

development associated with early diversifying athletes reduces the likelihood of injury and dropout during the transition through adolescence (Fraser-Thomas et al., 2005).

An inclusive and well-rounded physical and sporting education is clearly important for the development of young athletes (Fransen et al., 2012). Indeed, the involvement in school-based sports programs may be critical in guiding children towards sports that foster successful long-term sports involvement (Pion, Segers, Fransen, Debuyck, Deprez, Haerens, Vaeyens, Philippaerts, & Lenoir, 2015), improving the likelihood for young athletes to invest time and accumulate skills which might ultimately result in sporting excellence. It is therefore important to understand the determinants of successful sporting involvement to maximise the effectiveness of sports orientation, talent identification and talent development in school-based sports programs. Whilst previous studies have investigated the characteristics of young athletes in different sports (Opstoel, Pion, Elferink-Gemser, Hartman, Willemse, Philippaerts, Visscher, & Lenoir, 2015; Pion et al., 2015) and how these characteristics may be developed (Fransen et al., 2012), no research to date has considered the factors influencing sport involvement in a recreational, school-based population with an emphasis on using a diversification approach (Côté et al., 2009) to long-term athletic development. The aim of the present study is therefore to determine the factors affecting sports orientation and participation in a school-based adolescent population involved in a wide variety of sports and competitive playing levels.

METHODS

Participants

A school-based cohort of 501 sport participants (boys aged 10-16 y) participated in the study (age: 13.4 ± 2.2 y; height: 161.7 ± 15.7 cm; body mass: 53.0 ± 15.1 kg). For the purpose of analysis, participants were divided into junior (10-12 y; N = 188) and senior (13-16 y; N = 313) cohorts. The 10-12 and 13-16 y age-groups were selected as these stages represent late childhood and early-to-mid adolescence respectively, which correspond to the sampling and specialisation stage transition periods suggested in the DMSP framework (Côté et al., 2009). All boys participated in at least one organised sport, with their main sport defined by the sport in which they spent most of their time. Twenty-five different main sports were reported, with participants divided into six sporting categories for further analysis: basketball (N=113), cricket (N=59), rugby (N=84), soccer (N=105), swimming (N=31) and tennis (N=38). The remaining 71 participants engaged in sports yielding fewer than ten members, and were therefore excluded from the analysis. Following application of the exclusion criteria, 430 participants were retained for analysis (155 junior, 275 senior). The school sporting program provided all students with the opportunity to compete in their chosen sport across a range of competitive and recreational playing levels. A written consent form was obtained from the parent/guardian of each subject prior to the commencement of this study. Ethical approval was granted by the UTS Human Research Ethics Committee (UTSHREC: 2012000199).

Study Design

This cross-sectional cohort study involved the assessment of each participant's anthropometry (stature, body mass and estimated somatic maturity), physical capacity (explosive leg power, sprint speed, flexibility and aerobic capacity) and motor competence. The data was collected during two 50-minute physical education classes, with each class of 25-30 students scheduled within their existing school timetable. Each participant in the junior cohort also completed a sports participation questionnaire used to elicit retrospective information on the developmental activities undertaken in structured sport practice or play (Ford, Low, McRobert, & Williams, 2010). Sports participation data was collected in this age cohort as these participants were between the sampling and specialisation stages outlined in the DMSP (Côté et al., 2009), and therefore had not yet moved into the specialisation years. Based on questionnaire responses, the junior participants ranged from recreational (N=133) to regional representative level (N=52) in their respective sports, with three participants failing to complete the questionnaire.

Procedures

Anthropometry

Stature and sitting height were recorded to the nearest millimetre using a wall-mounted stadiometer following the guidelines of Lohman, Martorell, and Roche (1988). Leg length was estimated by subtracting sitting height from stature. Body mass was measured by means of electrical scales (Universal Weight Enterprise, Taiwan). Somatic maturity was assessed by means of a gender-specific regression equation to estimate maturity offset, using measures of stature, body mass and leg length measurements

(Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). Estimated age at peak height velocity (APHV) was then derived by subtracting maturity offset from chronological age, to provide an indication of an individual's maturity status within a given age group. The limitations of this method are acknowledged, with a reported error of one year 95% of the time (Mirwald et al., 2002). Whilst an individual's maturity status can also be estimated by using x-rays, assessment of secondary sex characteristics, or the parent's adult stature (Khamis & Roche, 1994; Malina, Reyes, Eisenmann, Horta, Rodrigues, & Miller, 2000; Tanner & Whitehouse, 1976), these methods entail ethical, practical, and financial issues.

Physical Capacity

Standing broad and vertical jumps were used to assess explosive leg power, as these are commonly used measures of lower-body power (Faigenbaum, Kraemer, Blimkie, Jeffreys, Micheli, Nitka, & Rowland, 2009). Vertical jump was performed with swinging arms and measured to the nearest centimetre using a Yardstick apparatus (Swift Performance Equipment, Australia) and standing broad jump was measured to the nearest centimetre using a tape measure. Young, Macdonald, Heggen, and Fitzpatrick (1997) reported a high reproducibility for the vertical jump test in 17 male subjects with a coefficient of variation (CV) of 3.8%. An typical error for standing broad jump was reported as 6.3% in a European school-based cohort of 58 children and 80 adolescents (España-Romero, Artero, Jimenez-Pavon, Cuenca-Garcia, Ortega, Castro-Pinero, Sjöstrom, Castillo-Garzon, & Ruiz, 2010). Sprint speed was assessed with participants performing two maximal sprints of 20 m, recorded with speed timing lights (0.01 s) (Swift Performance Equipment, Australia). A study in 34 youth soccer players reported an intra-class correlation coefficient (ICC) of 0.97 for three 20 m sprints measured with timing gates (Comfort, Stewart, Bloom, & Clarkson, 2014). The

sit and reach test was used to assess flexibility, specifically the lower back and hamstring muscles (Castro-Pinero, Chillón, Ortega, Montesinos, Sjostrom, & Ruiz, 2009), with a CV for this test reported as 8.7% in young adults (Ayala, de Baranda, Croix, & Santonja, 2012). Finally, aerobic capacity was assessed using the Multi-Stage Fitness Test (MSFT) which requires players to run 20 m shuttles at incremental running speeds until the running speed cannot be sustained for two consecutive shuttles (Léger, Mercier, Gadoury, & Lambert, 1988). España-Romero et al. (2010) reported a typical error of 9.8% for the MSFT administered twice, one week apart, in a European school-based cohort of 58 children and 80 adolescents.

Motor Competence

Motor competence was assessed using the Körperkoordinationstest für Kinder (KTK) (Kiphard & Schilling, 2007). Three items from the original Kiphard and Schilling (2007) battery were used in this study according to the methods of Novak, Bennett, Beavan, Pion, Spiteri, Fransen, and Lenoir (2016): jumping sideways across a wooden slat, moving sideways on boxes, and walking backwards on balance beams (Figure 3.1). Jumping sideways consists of jumping laterally as many times as possible over a wooden slat (60 cm x 4 cm x 2 cm) in 15 s. The number of jumps over two trials is summed. Moving sideways consists of moving across the floor in 20 s by stepping from one box (25 cm x 25 cm x 5.7 cm) to the next, transferring the first plate, stepping on it, and so on. The number of relocations was counted and summed over two trials. Finally, walking backwards consists of walking backwards three times along each of three balance beams (3 m long; 6, 4.5, and 3 cm wide, respectively; 5 cm high). A maximum of 24 steps (eight per trial) are counted for each balance beam, which comprises a maximum of 72 steps (24 steps x 3 beams) for this test. An ICC of 0.97 was reported

(Kiphard & Schilling, 2007). Raw test scores were transformed into motor quotients (MQ), which represent an age and gender-specific score according to reference values from a cohort of 1228 normally developing German children in 1974 (Kiphard & Schilling, 1974). More recently, reference values for the KTK have been reported in a cohort of 2470 school children aged 6-12 years (Vandorpe et al., 2011a).

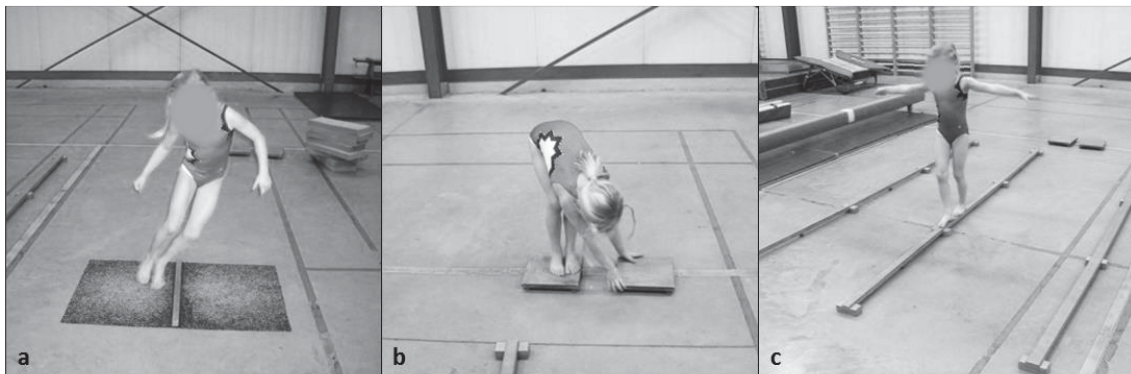


Figure 3.1 Körperkoordinationstest für Kinder (KTK): a) jumping sideways, b) moving sideways, and c) walking backwards.

Testing Procedures

Testing sessions were organised in the following order: Class 1) anthropometrics and KTK, warm-up, followed by the YYIR1; Class 2) warm-up, followed by circuit of physical capacity tests. The standardised warm-up consisted of 5 minutes of jogging and movement, followed by 5 minutes of dynamic stretches. All participants were familiarised with the testing procedures and performed the tests with running shoes, except for the KTK tests, which were conducted with bare feet according to the guidelines.

Sports Participation History

Finally, a questionnaire was used to elicit retrospective information on the developmental activities undertaken in structured sport practice or play (Appendix 9.1). The questionnaire was based on that used in previous research (Ward, Hodges, Starkes, & Williams, 2007) and had more recently been updated to match the consensus on development pathways in youth sport (Ford et al., 2010). As the present study involved young athletes from a variety of sports, participants were initially required to indicate their main sport, defined by the sport in which they spend most of their time. The questionnaire then contained three sections: main sport milestones, main sport participation, and additional sport participation. Firstly, participants were asked to recall their age for a series of milestones in their main sport: first participation, supervised training, regular training, organised competition, non-sport training (e.g. strength and conditioning), and competitive level match-play. Participants were also asked to identify the highest competitive standard attained in their main sport (e.g. recreational, regional representative, state/national). Participants were then asked to detail the amount of time (hours per week and weeks per year) spent in each of the following activities in their main sport: structured training (match-play, deliberate team practice, deliberate individual practice) and unstructured training (deliberate play). Finally, participants were asked to identify any additional sports they had previously engaged in regularly for a period of more than three months. For each additional sport, they were required to provide the age at which they started each sport, and the amount of time (hours per week and weeks per year) they had spent participating in each sport. To ensure accurate recall, participants were encouraged to be assisted by parents when completing questionnaire (Ford et al., 2010).

Statistical Analyses

All data are presented as means \pm standard deviation (SD) unless stated otherwise. As participants were divided into age cohorts for analysis and chronological age remained significantly different between sports and playing levels, this was included as a covariate throughout. Firstly, multivariate analysis of covariance (MANCOVA) was used to observe differences in maturation, anthropometry, physical capacity and motor competence between sports, with chronological age as a covariate. Similarly, MANCOVA was used to observe differences in maturation, anthropometry, physical capacity and motor competence between playing levels, with chronological age as a covariate. Stepwise discriminant analyses were used as a follow-up to each of these analyses to classify participants into their respective sports and playing levels. A homogenous variance and multivariate normal within-group distribution was assumed (Lachenbruch, 1975). Based on a Wilks' lambda significance level of 0.05, a stepwise selection method with a 0.15 selection probability criterion was used (Everitt, Everitt, & Dunn, 1991). Lastly, MANCOVA was used to analyse differences between playing levels for a range of sports participation milestones and training history. All statistical analyses were conducted using the SPSS statistical software package (Version 24). Significance levels were set at $p < 0.05$. Effect sizes (η^2) were also calculated, and values of 0.01, 0.06, and above 0.15 were considered small, moderate, and large, respectively.

RESULTS

Multivariate analysis of covariance revealed moderate differences between sports for a combination of maturation, anthropometry, physical capacity, and motor competence when adjusted for chronological age in the senior cohort ($F=2.616$, $p < 0.001$, $\eta^2=0.08$;

Table 3.1). No differences were shown between sports in the junior cohort (Table 3.2). For senior students, moderate differences between sports were found for sprint speed ($\eta^2=0.09$; $p<0.001$), standing broad jump ($\eta^2=0.08$, $p=0.001$) and motor competence ($\eta^2=0.06$, $p=0.004$), in addition to small differences for aerobic fitness ($\eta^2=0.05$, $p=0.013$) and vertical jump ($\eta^2=0.05$, $p=0.019$). Pairwise comparisons revealed swimmers to possess slower sprint speed when compared with basketball, cricket, rugby and soccer players, vertical jump performance to be higher for soccer players compared with tennis participants, standing broad jump to be higher in rugby players compared with swimmers and tennis players, and finally, soccer players to possess higher motor competence to basketballers and tennis players. Subsequent stepwise discriminant analysis revealed only 31.3% of students could be correctly classified into sports in the senior cohort, with standing broad jump and motor competence retained in the discriminant function (both $p<0.001$; Table 3.3).

Table 3.1 Senior cohort sport differences in maturation, anthropometry, physical capacity, and motor competence.

	Sport						Covariate	MANCOVA		
	Basketball	Cricket	Rugby	Soccer	Swimming	Tennis	Age	η^2	F	<i>p</i>
	<i>N=92</i>	<i>N=44</i>	<i>N=36</i>	<i>N=57</i>	<i>N=16</i>	<i>N=30</i>				
Chronological Age (y)	15.1 ±0.7	14.8 ±0.7	15.1 ±0.6	14.4 ±0.8	15.0 ±0.7	14.9 ±0.7	-	-	-	-
APHV (y)	13.7 ±0.7	14.0 ±0.7	13.8 ±0.7	13.9 ±0.7	13.7 ±0.7	14.1 ±0.7	-	0.04	1.981	0.082
Anthropometry										
Stature (cm)	173.7 ±8.5	171.8 ±7.2	172.9 ±7.2	166.9 ±9.5	171.4 ±8.0	170.2 ±10.1	**	0.03	1.527	0.181
Body Mass (kg)	63.7 ±11.7	60.8 ±10.1	65.7 ±11.2	55.4 ±11.5	64.9 ±14.9	58.9 ±8.4	**	0.04	2.012	0.077
Physical Capacity										
Sit and Reach (cm)	-1.8 ±8.8	-1.7 ±6.8	2.8 ±9.0	-1.3 ±8.3	0.9 ±7.7	0.7 ±7.9	*	0.04	2.095	0.066
Vertical Jump (cm)	50 ±8	47 ±8	50 ±9	49 ±8	48 ±10	45 ±8	**	0.05	2.769	0.019
Standing Broad Jump (cm)	211 ±27	202 ±22	220 ±24	200 ±25	193 ±36	196 ±21	**	0.08	4.514	0.001
20 m Sprint (s)	3.32 ±0.20	3.38 ±0.24	3.26 ±0.20	3.36 ±0.21	3.56 ±0.48	3.44 ±0.23	**	0.09	5.526	<0.001
MSFT (m)	1622 ±406	1588 ±401	1753 ±453	1766 ±344	1490 ±600	1519 ±354		0.05	2.969	0.013
Motor Competence										
KTK (MQ)	100 ±15	102 ±10	105 ±13	106 ±15	97 ±15	96 ±11		0.06	3.603	0.004

Data are means ± standard deviations; * = $p < 0.05$; ** = $p < 0.001$

APHV; age at peak height velocity, MSFT; Multi-Stage Fitness Test, KTK; Körperkoordinationstest für Kinder, MQ; motor quotient

Table 3.2 Junior cohort sport differences in maturation, anthropometry, physical capacity, technical ability and motor competence.

	Sport						Covariate	MANCOVA		
	Basketball	Cricket	Rugby	Soccer	Swimming	Tennis	Age	η^2	F	<i>p</i>
	<i>N=21</i>	<i>N=15</i>	<i>N=48</i>	<i>N=48</i>	<i>N=15</i>	<i>N=8</i>				
Chronological Age (y)	11.2 ±1.3	10.4 ±1.3	10.9 ±1.3	10.8 ±1.5	11.1 ±0.9	10.6 ±1.4	-	-	-	-
APHV (y)	14.2 ±0.8	14.4 ±0.5	14.3 ±0.8	14.4 ±0.8	14.8 ±0.6	14.4 ±0.5	-	0.05	1.401	0.227
Anthropometry										
Stature (cm)	150.5 ±12.8	143.3 ±7.8	146.6 ±10.8	143.5 ±9.9	145.8 ±8.5	143.7 ±8.0	**	0.06	1.768	0.123
Body Mass (kg)	43.1 ±11.2	37.0 ±5.8	41.0 ±10.3	37.3 ±7.9	37.6 ±6.1	37.3 ±10.3	**	0.06	1.798	0.117
Physical Capacity										
Sit and Reach (cm)	-4.8 ±5.9	-2.8 ±7.0	-0.1 ±6.5	-1.2 ±5.3	0.5 ±6.8	-1.8 ±6.7		0.07	2.146	0.063
Vertical Jump (cm)	35 ±7	29 ±7	32 ±6	31 ±7	32 ±6	29 ±6	**	0.04	1.281	0.275
Standing Broad Jump (cm)	159 ±25	156 ±23	160 ±24	153 ±23	163 ±23	144 ±21	**	0.05	1.380	0.235
20 m Sprint (s)	3.92 ±0.29	3.95 ±0.27	3.92 ±0.34	3.93 ±0.45	3.95 ±0.33	4.12 ±0.46	**	0.02	0.646	0.665
MSFT (m)	1067 ±517	1007 ±412	1024 ±455	990 ±509	1063 ±439	758 ±499	**	0.02	0.624	0.682
Motor Competence										
KTK (MQ)	102 ±11	104 ±16	105 ±13	106 ±15	111 ±13	93 ±9		0.06	1.996	0.082

Data are means ± standard deviations; * = $p < 0.05$; ** = $p < 0.001$

APHV; age at peak height velocity, MSFT; Multi-Stage Fitness Test, KTK; Körperkoordinationstest für Kinder, MQ; motor quotient

Table 3.3 Discriminant function structure coefficients and tests of statistical significance.

Variable	Function	
	1	2
Standing Broad Jump (cm)	0.81	0.59
Vertical Jump (cm) ^a	0.64	0.40
20 m Sprint (s) ^a	-0.53	-0.47
KTK (MQ)	-0.13	0.99
Multi-Stage Fitness Test (m) ^a	0.18	0.47
Wilks' Lambda	0.836	0.943
Chi-square	48.4	15.8
<i>p</i>	<0.001	0.003
Eigenvalue	0.13	0.06
Relative percentage	68.1	31.9
Canonical correlation	0.34	0.24

^a Variable not retained in the discriminant function

KTK; Körperkoordinationstest für Kinder, MQ; motor quotient

Moderate differences were also found between playing levels for a combination of maturation, anthropometry, physical capacity, and motor competence when adjusted for chronological age ($F=3.016$, $p=0.002$, $\eta^2=0.14$; Table 3.4). Univariate analysis revealed students participating at a representative level to possess superior aerobic fitness ($\eta^2=0.09$; $p<0.001$), vertical jump ($\eta^2=0.04$, $p=0.004$), sprint speed ($\eta^2=0.03$, $p=0.012$) and standing broad jump ($\eta^2=0.02$, $p=0.023$). Stepwise discriminant analysis revealed 73.0% of participants could be classified into playing levels with measures of aerobic fitness and vertical jump (both $p<0.001$).

Multivariate analysis of covariance revealed differences between playing levels for a combination of sports participation milestones and training history when adjusted for chronological age ($F=4.332$, $p<0.001$, $\eta^2=0.21$; Table 3.4). Univariate analysis revealed students participating at a representative level to have engaged in more structured training hours in both their main sport ($\eta^2=0.07$, $p<0.001$) and additional sports ($\eta^2=0.04$, $p=0.014$), despite non-sport training ($\eta^2=0.03$, $p=0.039$) and competitive level match-play ($\eta^2=0.05$, $p=0.002$) ages to be younger in their recreational counterparts. Stepwise discriminant analysis revealed 70.8% of participants could be classified into playing levels with a combination of structured training hours and competitive-level match play age (both $p<0.001$).

Table 3.4 Junior cohort playing level differences in maturation, anthropometry, physical capacity, motor competence and sport participation history.

	Playing Level		Covariate	MANCOVA		
	Recreational	Representative		η^2	F	p
	N=133	N=52	Age			
Chronological Age (y)	10.6 ±1.3	11.6 ±1.1	-	-	-	-
APHV (y)	14.5 ±0.7	14.4 ±0.8	-	0.01	1.969	0.162
Anthropometry						
Stature (cm)	143.8 ±9.7	149.3 ±10.6	**	0.00	0.132	0.717
Body Mass (kg)	38.2 ±8.9	41.4 ±8.4	**	0.00	0.096	0.756
Physical Capacity						
Sit and Reach (cm)	-1.5 ±5.9	-0.3 ±7.3	*	0.02	3.394	0.067
Vertical Jump (cm)	30 ±6	35 ±6	**	0.04	8.361	0.004
Standing Broad Jump (cm)	151 ±23	168 ±23	**	0.03	5.244	0.023
20 m Sprint (s)	4.03 ±0.38	3.77 ±0.27	**	0.03	6.402	0.012
MSFT (m)	868 ±384	1287 ±493	**	0.09	17.654	<0.001
Motor Competence						
KTK (MQ)	102.7 ±14.3	105.7 ±13.1		0.01	2.189	0.141
Sports Participation History						
First participation (y)	6.1 ±2.1	5.7 ±2.3		0.01	1.594	0.209
Supervised training (y)	6.6 ±2.0	6.3 ±2.2		0.00	0.497	0.482
Regular training (y)	6.9 ±2.0	6.4 ±2.1		0.01	1.874	0.173
Organised competition (y)	7.0 ±2.2	7.7 ±2.1	*	0.02	2.912	0.090
Non-sport training (y)	6.6 ±3.6	8.5 ±2.5	**	0.03	4.309	0.039
Competitive level match-play (y)	7.0 ±2.9	8.6 ±1.8	*	0.05	9.662	0.002
Structured training (h)	564 ±564	1094 ±827	**	0.07	13.008	<0.001
Unstructured training (h)	160 ±217	194 ±303		0.00	0.048	0.827
Additional sports (N)	2.7 ±1.9	3.2 ±2.0		0.02	2.728	0.100
Additional sport training (h)	711 ±785	1241 ±1326	*	0.04	6.118	0.014

Data are means ± standard deviations; * = $p < 0.05$; ** = $p < 0.001$

APHV; age at peak height velocity, MSFT; Multi-Stage Fitness Test, KTK; Körperkoordinationstest für Kinder, MQ; motor quotient

DISCUSSION

The present study aimed to determine the factors affecting sports orientation and participation in an adolescent school-based cohort. The main findings of the present study were that moderate differences were found between sports for a combination of anthropometry, physical capacity and motor competence in the senior cohort, with no differences shown between sports in junior participants. While these characteristics were generally unable to discriminate between sports, both physical characteristics and sports participation history were able to differentiate between participants at a recreational and representative playing level in the junior cohort observed in this study. These findings provide new information on the factors that may affect successful sports involvement in an Australian school context.

The primary goal for school-based sports programs is to provide all children with adequate opportunities for successful engagement in physical activity. Indeed, successful engagement in sport and physical activity increases the opportunity to develop motor competence, translating to an increased likelihood for long-term participation (Stodden et al., 2008). However, the reputation of a school's sports program is often more tangible and directly related to the school's ability to produce good athletes within specific sporting disciplines. Attaining excellence within a sporting discipline requires a combination of natural abilities and performance characteristics that are unique to the requirements of each sport (Ericsson et al., 1993). These specific attributes are often pursued by coaches and scouts in talent identification settings, manifesting in specialised physical profiles in youth sport populations (Pion et al., 2015). The present study supported this precedent, revealing moderate differences between sports for a combination of anthropometrical, physical and coordination related

characteristics in the senior cohort. Despite these findings, there were no differences observed between sports in the junior cohort, and physical characteristics were generally a poor predictor of sporting discipline, with only 31.3% of the senior cohort correctly classified into their sport. These findings are in direct contrast to those of Pion et al. (2015), who classified 96.4% of elite adolescent participants into nine different sports with a series of similar anthropometric, physical fitness and motor coordination measurements. Whilst the methodological differences (physical fitness variables and statistical analyses) between the present study and that of Pion et al. (2015) partially contribute to these findings, a more likely explanation is the vast difference in playing standards between the two cohorts. For example, highly active children are more likely to exhibit unique sporting profiles compared with their less active peers (Opstoel et al., 2015), making the elite youth athletes observed by Pion et al. (2015) more likely to possess specialised sporting profiles. It could also be expected that the inclusive nature of the present school-based sports program resulted in a primarily homogenous group, with a range of playing levels accommodated within each sport. This is particularly evident in the junior cohort, which appears to provide a suitable setting for children to transfer between sports before specialisation is required.

While an inclusive, diversified approach to sports participation seems appropriate in a school-based setting, successful sports involvement is likely to improve the chances of long-term engagement. The present study therefore aimed to observe the characteristics of those participants who had progressed to an advanced playing level before entering the specialisation years. Indeed, physical attributes appear to be a reasonably good indicator of playing level, with 73% of participants correctly classified as either recreational or representative using measures of aerobic fitness and explosive leg power. These results are not surprising, as advanced fitness levels are often a result of

specialised training, a prerequisite for sporting excellence (Bompa & Haff, 2009). Indeed, in a vast array of sports, physical fitness characteristics have been shown to be important determinants of talent identification (Elferink-Gemser, Visscher, Lemmink, & Mulder, 2007; Till, Coble, O'Hara, Brightmore, Cooke, & Chapman, 2011; Torres-Unda, Zarrasquin, Gil, Ruiz, Irazusta, Kortajarena, Seco, & Irazusta, 2013; Vaeyens, Malina, Janssens, Van Renterghem, Bourgois, Vrijens, & Philippaerts, 2006), career progression (Burr, Jamnik, Baker, Macpherson, Gledhill, & McGuire, 2008; Deprez et al., 2015; Figueiredo, Goncalves, Coelho, & Malina, 2009; Pyne, Gardner, Sheehan, & Hopkins, 2005; Till, Coble, O'Hara, Morley, Chapman, & Cooke, 2015) and match performance (Castagna, Impellizzeri, Cecchini, Rampinini, & Alvarez, 2009; Mooney, O'Brien, Cormack, Coutts, Berry, & Young, 2011). Accordingly, coaches and selectors tend to place an emphasis on physical characteristics throughout the talent selection process. However, this approach may favour early maturing individuals, who may possess favourable physical attributes (Coble, Baker, Wattie, & McKenna, 2009). Whilst the disparities in fitness shown in the present study may have resulted from either coach selections or training effects, the reliance on physical characteristics in a talent identification setting may be detrimental to long-term sports participation. For example, deselected athletes become more likely to miss out on high quality coaching and training opportunities, and may suffer from reduced motivation or perceived competence, limiting the likelihood for future selection (Helsen, van Winckel, & Williams, 2005). Importantly, the sports program in the present study aimed to maximise participation by promoting sports participation across a range of different sports and playing levels. However, whether the developmental opportunities provided to these young athletes selected at lower levels is ideal to ensure future selection remains unclear.

Similar to physical characteristics, sports participation history was a reasonably strong indicator of playing level, with a combination of sporting milestones and training history able to predict 72% of athletes who compete at a representative level in their chosen sport. In particular, the volume of structured training hours was most important when classifying participants into playing levels, highlighting the significance of long-term involvement for sports performance. It is well established that an extended training history is related to improved physical fitness, motor coordination and perceptual-cognitive qualities (Ford et al., 2010; Fransen et al., 2012). For example, Fransen et al. (2012) reported a positive relationship between the amount of training hours per week and the level of physical fitness and motor competence in 10 to 12 year old boys, while Ford et al. (2010) showed young cricketers with an extended training history to possess superior anticipatory skills. While these findings suggest early engagement is essential for attaining sports performance, the importance of early specialisation is questionable, with the sampling of sports throughout childhood suggested as a more appropriate development path to promote long-term sports engagement (Côté et al., 2009). Indeed, sampling multiple sports before pursuing a path to elite performance may be required to develop a well-rounded athletic profile (Fransen et al., 2012). In agreement, the present study revealed participants at a representative level to have higher participation in additional sports outside of their main sport, and even commenced organised competition and competitive level match-play from a later age in their main sport. These results highlight that early engagement is not a pre-requisite for successful sports involvement in a school context. Therefore, a schooling environment could be suitable to promote the sampling of a variety of sports for long-term athlete development.

The present study also has its limitations. In particular, the present results are specific to this young male, school-based cohort. Due to the nature of the school program, it is

possible that the differences in physical profiles observed between sports could simply be highlighting the school's most popular sports. For example, the high popularity of sports such as rugby and soccer are likely to attract the school's best athletes, while in contrast, minority sports such as tennis may attract students with less athletic ability. Regardless, the multidimensional nature of the present study provides an important insight into these factors which may influence development opportunities in a school-based talent development system. It is suggested that future research uses a long-term approach to investigate the development opportunities provided to young athletes engaging in different sports and playing levels, and how this may influence their opportunities for future sporting success.

In summary, the present findings highlight that within a school context, physical and motor competence profiles for participants in different sports are relatively similar, but become more heterogeneous with increasing age. Additionally, those who participate at a higher level of competition within school sports possess enhanced fitness qualities and engage in a higher volume of structured training hours in both their main sport and additional sports compared with participants at a recreational level, despite starting organised competition and competitive game play at a later age. These findings suggest that high schools provide a suitable opportunity to sample different sports due to the similarity in anthropometrical, physical and motor competence profiles at a younger age, which allow students to sample a variety of sports before entering the specialisation years. Additionally, this inclusive approach might well be an avenue to develop talent in gifted athletes through the schooling system, without ignoring the needs of the less-gifted. School-based programs have the ability to provide all children with opportunities for long-term athlete development, whilst challenging gifted youngsters to develop their talents through the promotion of involvement in a wide range of sports. Indeed, a sport

policy which strikes a balance between recreational and elite programs may help prevent dropout and promote long-term sports engagement through sampling a variety of sports and promoting high levels of sports participation.

4 STUDY TWO

Lovell, T.W.J., Fransen, J., Bocking, C.J. & Coutts, A.J. (under review). A multidimensional approach to factors influencing playing level and position in a school-based soccer program. *Science and Medicine in Football*.

ABSTRACT

The aim of this study was to use a multidimensional approach to examine the factors influencing selection into playing levels and playing positions in a school-based soccer program. The talent identification and development opportunities provided to young soccer players in recreational programs largely unknown. Two hundred and fourteen adolescent soccer players (aged 10-16 y) in a school-based soccer program participated in the study. Anthropometry, maturation, physical capacity, technical ability and motor competence were assessed. Team coaches selected players into playing levels, playing positions and also provided subjective ratings of player ability. Multivariate analyses of covariance showed significant large and moderate differences between playing levels ($F=5.336$, $p<0.001$, $\eta^2=0.30$) and playing positions ($F=1.974$, $p=0.002$, $\eta^2=0.14$) respectively, for a combination of maturation, anthropometry, physical capacity, technical ability and motor competence, when adjusted for chronological age. Univariate analysis revealed measures of fitness, technical ability and motor competence to be important determinants for selection into playing level. In contrast, maturation, anthropometry and physical performance characteristics were different between playing positions. Discriminant analysis revealed 64.8% of cases could be correctly classified into playing level with a combination of sprint speed, agility, aerobic fitness, technical ability and motor competence. Large differences in subjective coach ratings were found between positions in the highest playing level (Team 1; $F=2.598$, $p=0.001$, $\eta^2=0.16$). These findings contribute new evidence to highlight how both innate attributes and physical fitness characteristics influence the selection process in recreational youth soccer, which have important implications for talent development pathways in schools, clubs and academies.

INTRODUCTION

Since the publication of Football Federation Australia's (FFA) National Football Curriculum (Football Federation Australia, 2013), the pathways for talent development in Australian soccer have received considerable attention (O'Connor, Larkin, & Mark Williams, 2016). Aiming to develop players for future success at an international level, FFA have highlighted the importance for all tiers of Australian soccer to embrace a long-term approach to youth development, where clubs, schools and academies provide the foundation for talented player pathways. Indeed, the contribution of school-based programs may be especially important, as this is where young players likely receive most exposure to the game at an early age, providing excellent opportunities for early engagement and talent identification. Whilst training programs at this level focus on engagement and skill development, it is also important to recognise individuals with the potential for future success and ensure opportunities are provided for these young athletes to realise their potential (Williams & Reilly, 2000). However, the extent to which schools are equipped to detect athletically gifted youngsters and provide optimal development environments is often limited (Elferink-Gemser, 2013). Further attention is therefore required to improve our understanding of the talent identification and development process for young players through school-based soccer programs.

The process of talent identification typically involves a range of anthropometrical, physical or performance-based assessments aimed at recognising individuals with the capacity for future sporting success. However, the development of talent is complex, especially for multidimensional sports such as soccer, making future performance difficult to predict during the transition through maturation (Philippaerts, Coutts, & Vaeyens, 2008). Whilst becoming more common in elite youth soccer (Unnithan,

White, Georgiou, Iga, & Drust, 2012), talent identification is often undertaken with little attempt to account for maturation status, making it common for early maturation to be mistaken for athletic talent (Helsen et al., 1998b). Consequently, relatively older, earlier maturing individuals are more frequently selected into talented soccer programs during adolescence (Helsen et al., 1998b), and even guided towards key positional roles where certain physical attributes may be advantageous (Gil, Gil, Ruiz, Irazusta, & Irazusta, 2007). For example, at the elite level, taller players may be most suited to central defensive positions which require height for aerial duels, whilst attacking players require speed and power to create space from defenders (Boone, Vaeyens, Steyaert, Vanden Bossche, & Bourgois, 2012). Accordingly, these favourable attributes are often used as performance criteria when selecting young talent. A mixed-longitudinal study of elite U17 soccer players reported defenders to be the tallest, midfielders to possess the best aerobic fitness and technical ability, and attackers to be the fastest, most explosive and agile players (Deprez, Franssen, Boone, Lenoir, Philippaerts, & Vaeyens, 2014b). A combination of anthropometrical and performance measures were also shown to discriminate between goalkeepers and field positions from as young as 8 years of age (Deprez et al., 2014b). Indeed, guiding young players towards specific positions based on these requirements may not be appropriate at a youth level, as physical attributes will not necessarily be retained throughout the maturational process and may have no bearing on future sports performance (Vaeyens, Lenoir, Williams, & Philippaerts, 2008b). Accordingly, a multidimensional approach to talent identification, including measures of maturation, motor competence and technical ability, may be the most appropriate means to assess performance potential in young soccer players (Vaeyens et al., 2006).

Whilst the factors influencing talent identification and selection have been examined in youth soccer players at both elite (Deprez et al., 2014b) and sub-elite levels (Lovell, Towlson, Parkin, Portas, Vaeyens, & Cogley, 2015), no research to date has investigated this at a recreational level where all young players are first exposed to talent development pathways. The present study therefore aims to investigate the factors influencing talent identification and selection in a school-based youth soccer program. A multidimensional approach will be used to examine the influence of maturation, anthropometry, physical capacity, technical ability and motor competence on subjective coach ratings, and subsequent selection into playing levels and positions. Based on existing literature in youth soccer, it was hypothesised that there will be a range of differences in physical- and coordination-related variables between both playing levels and playing positions in the current cohort.

METHODS

Participants

Two hundred and fourteen adolescent soccer players (aged 10-16 y) from the same school-based soccer program participated in the study. The participants ranged from a recreational to regional representative playing level across five age-groups (U13; N=56, U14; N=44, U15; N=43, U16; N=48, U18; N=23), and possessed the following characteristics: age: 14.0 ± 1.5 y; stature: 165.4 ± 10.5 cm; body mass: 53.7 ± 11.1 kg. The soccer program formed part of a school sports academy focused on long-term development, providing all students with the opportunity to compete in their chosen sport across a range of competitive and recreational playing levels. The program used a systematic approach to talent development, starting with a thorough selection process

within each age group, whereby players who were identified as talented were included in the highest playing level (Team 1), while those not selected were encouraged to continue participation in lower-level teams (Team 2 and Team 3). All players trained within their respective age groups and competed within their age-group playing levels. One hundred and sixty participants also engaged in competitive soccer outside of the school-based program, with 42 competing at a regional representative level. Ethical approval was granted by the UTS Human Research Ethics Committee (UTSHREC: 2012000199) and a written consent form was obtained from the parent/guardian of each participant prior to the commencement of this study.

Study Design

This cross-sectional cohort study employed a multidimensional approach by assessing each participant's estimated maturation, anthropometry, physical capacity, motor competence and technical ability during a 90-minute testing session prior to the start of the school competition period. Team coaches also arranged a further two 90-minute training sessions as a talent selection process, with participants in each of the five age-groups competing in various small- and large-sided games (5v5, 7v7, 11v11). Three coaches per age group subjectively and collaboratively assessed performance during both sessions and subsequently divided participants into playing levels (Team 1, Team 2 and Team 3) and playing positions (attackers, midfielders, fullbacks, and central defenders). Whilst some previous research has highlighted the importance for differentiating between central and lateral midfield players (Towlson, Copley, Midgley, Garrett, Parkin, & Lovell, 2017), the "1-4-3-3" tactical formation employed by the teams in this study did not warrant this approach, with all three midfield positions

located centrally (Figure 4.1). All 42 participants who engaged in regional representative level soccer outside of the school-based program were selected to play in Team 1 in their respective age-group. Coach selections were made without any knowledge of physical or performance test outcomes. Following the selection process, coaches also recorded subjective ratings of each player. Goalkeepers were excluded from the analysis, as these positions were primarily self-selected by players. All coaches were accredited by the FFA (minimum 'C' licence) and were also engaged in coaching commitments at external clubs, ranging from regional representative to sub-elite level competition (i.e. age-group state level).

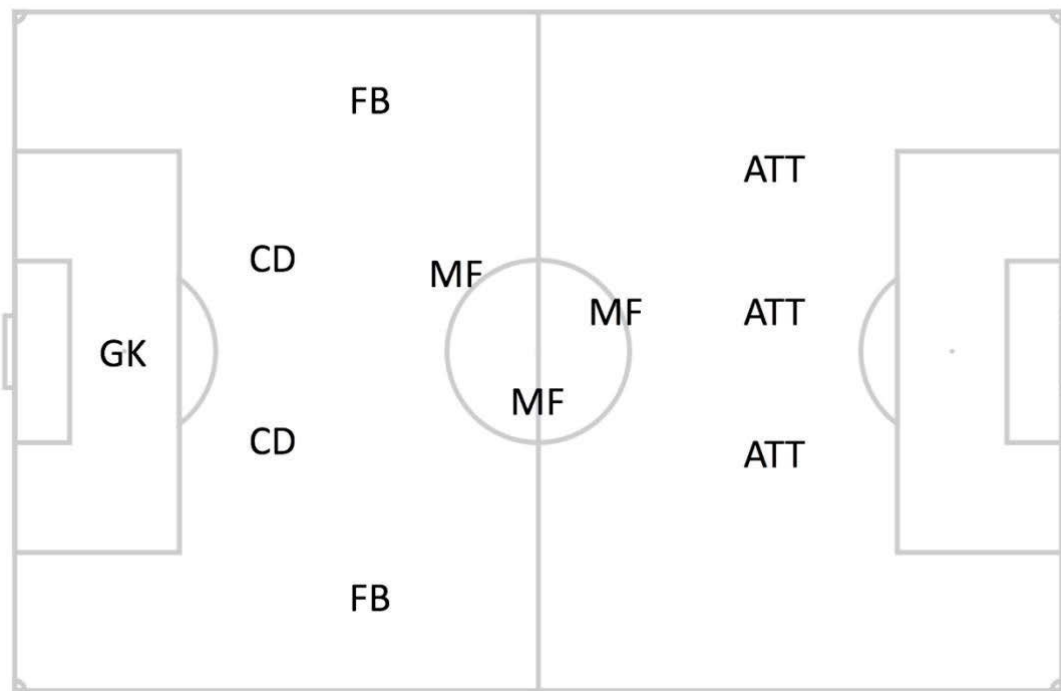


Figure 4.1 1-4-3-3 tactical formation employed by all teams in the present study; ATT; attacker, MF; midfielder, FB; fullback, CD; central defender

Procedures

Anthropometry

Stature and sitting height were recorded to the nearest millimetre using a wall-mounted stadiometer following the guidelines of Lohman et al. (1988). Leg length was estimated by subtracting sitting height from stature. Body mass was measured by means of electrical scales (Universal Weight Enterprise, Taiwan). Somatic maturity was assessed by means of a gender-specific regression equation to estimate maturity offset, using measures of stature, body mass and leg length measurements (Mirwald et al., 2002). Estimated age at peak height velocity (APHV) was then derived by subtracting maturity offset from chronological age, to provide an indication of an individual's maturity status within a given age group. The limitations of this method are acknowledged, with a reported error of 1 year 95% of the time (Mirwald et al., 2002). Whilst an individual's maturity status can also be estimated by using x-rays, assessment of secondary sex characteristics, or the parent's adult stature (Khamis & Roche, 1994; Malina et al., 2000; Tanner & Whitehouse, 1976), these methods entail ethical, practical, and financial issues.

Physical Capacity

Explosive leg power was assessed using a vertical jump test, performed with swinging arms and measured to the nearest centimetre using a Yardstick apparatus (Swift Performance Equipment, Australia), with the best of three jumps retained for analysis. Young et al. (1997) reported a high reproducibility for the vertical jump test in 17 male subjects with a coefficient of variation (CV) of 3.8%. A modified T-test was used to assess agility according to the methods of Deprez et al. (2014b), with participants required to run 5 m straight, turn 90° and run 5 m towards the next turn of 180°, run 10

m towards the third turn (180°), run a further 5 m towards the last turn of 90°, then 5 m to finish at the initial starting point (Figure 4.2). The test was performed once in each direction, with an aggregate score used for analysis. A similar modified T-test was shown to be reliable in 52 male physical education students (22.4 ± 1.5 y), with a CV of 2.7% (Sassi, Dardouri, Yahmed, Gmada, Mahfoudhi, & Gharbi, 2009). Sprint speed was assessed with participants performing three maximal linear sprints of 30 m. A test-retest reliability study in 19 youth athletes reported a coefficient of variation (CV) of 1.4% for two 30 m sprints measured with timing gates (Waldron, Worsfold, Twist, & Lamb, 2011). Both the agility and sprint tests were recorded with speed timing lights (0.01s) (Swift Performance Equipment, Australia), with the fastest trials used for further analysis.

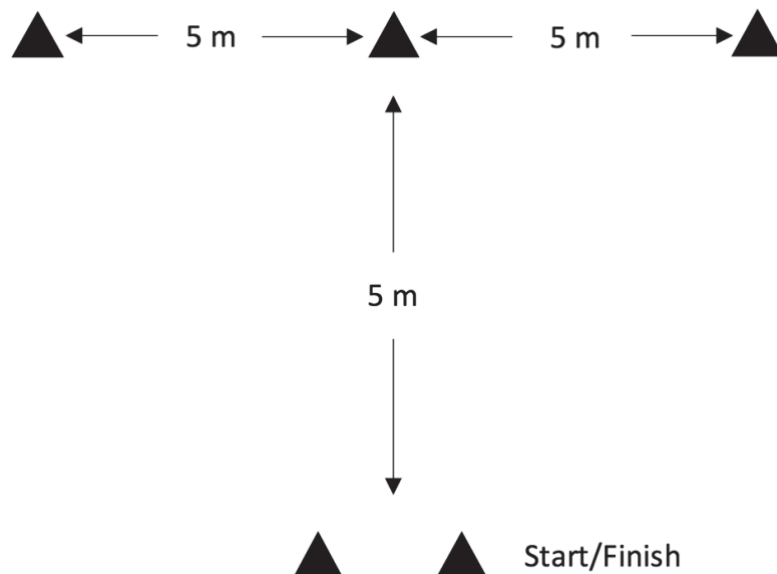


Figure 4.2 Modified T-test dimensions, according to the methods of Deprez et al. (2014b)

The Sit and Reach test was used to assess flexibility, specifically the lower back and hamstring muscles (Castro-Pinero et al., 2009), with a CV for this test previously reported as 8.7% in young adults (Ayala et al., 2012). Aerobic fitness was assessed using the Yo-Yo Intermittent Recovery Test Level 1 (YYIR1) according to the methods of Bangsbo, Iaia, and Krstrup (2008), with participants required to run 20 m shuttles of increasing speeds, interspersed with short recovery periods, until the speed was unable to be maintained. Recently, a test-retest reliability study reported CVs of 17.3, 16.7 and 7.9% in U13 (N=35), U15 (N=32) and U17 (N=11) non-elite youth soccer players, respectively, showing adequate to high reproducibility of the YYIR1 (Deprez, Coutts, Lenoir, Fransen, Pion, Philippaerts, & Vaeyens, 2014a). In contrast to the previous chapter, the YYIR1 was employed to assess intermittent aerobic capacity, deemed to be more applicable for the present soccer cohort.

Motor Competence

Motor competence was assessed using the Körperkoordinationstest für Kinder (KTK) (Kiphard & Schilling, 2007). Three items in the battery were used in this study according to the methods of Novak et al. (2016): 1) jumping sideways: jumping laterally as many times as possible over a wooden slat (60 cm x 4 cm x 2 cm) in 15 s, with the number of jumps over the two trials summed; 2) moving sideways: moving across the floor by stepping from one plate (25 cm x 25 cm x 5.7 cm) to the next, transferring the first plate, stepping on it, and repeating as many times as possible in 20 s, with the number of relocations summed over two trials; and 3) walking backwards: walking backwards three times along each of three balance beams (3 m length; 6, 4.5 and 3 cm width respectively; 5 cm height) for a maximum of 24 steps (eight per trial) on

each balance beam, aiming for a maximum of 72 steps (24 steps x 3 beams) (Figure 3.1). An intra-class correlation (ICC) of 0.97 was reported (Kiphard & Schilling, 2007). Raw test scores were transformed into motor quotients (MQ), which represent an age and gender-specific score according to reference values from a cohort of 1228 normally developing German children in 1974 (Kiphard & Schilling, 2007). More recently, reference values for the KTK have been reported in a cohort of 2470 school children aged 6-12 years (Vandorpe et al., 2011a).

Technical Ability

The UGent Dribble Test was used to measure technical ability according to the methods of Vandendriessche, Vaeyens, Vandorpe, Lenoir, Lefevre, and Philippaerts (2012). The test requires participants to complete the short course as fast as possible, maintaining control of a soccer ball whilst changing direction around eight cones in a particular sequence (Figure 4.3). An ICC of 0.81 indicated high reliability for dribble times (Vandendriessche et al., 2012).

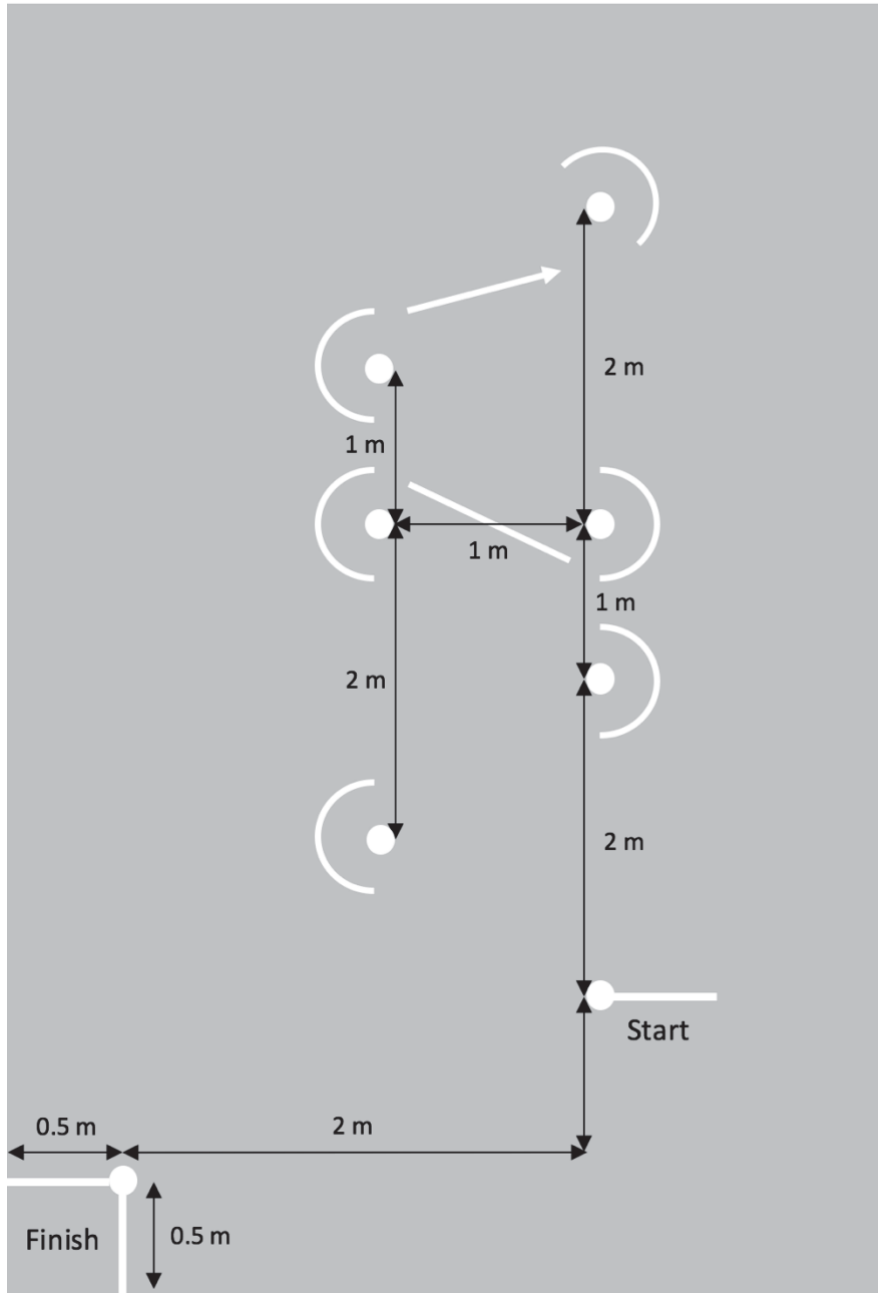


Figure 4.3 UGent Dribble Test dimensions, according to the methods of Vandendriessche et al. (2012)

Testing Procedures

Testing sessions were organised in the following order: anthropometrics and KTK, warm-up, physical capacity tests, followed by the YYIR1 after completing all other tests. The standardised warm-up consisted of 5 minutes of jogging and movement,

followed by 5 minutes of dynamic stretches. All participants were familiarised with the testing procedures and performed the tests with running shoes, except for the KTK tests, which were conducted with bare feet according to the guidelines.

Subjective Coach Ratings

Following the selection process, coaches of each team provided a subjective rating of each player's technical, tactical, physical, psychological and overall ability. All ratings were recorded by coaches on a 100-point visual analogue scale (Figure 4.4). For the purpose of analysis, subjective coach ratings were converted to within-team ranks to account for inter-coach variation. Subjective coach ratings of technical and overall ability have been shown to possess a valid association with objective physical measures, and have previously been used to examine talent selection in elite youth sports such as rugby (Cupples & O'Connor, 2011), volleyball (Gabbett, Georgieff, & Domrow, 2007) and basketball (Hoare, 2000).

Note each player's ability levels on the line below:



Figure 4.4 Visual analogue scale (0-100 point) used to measure coach subjective ratings of player ability

Statistical Analyses

All data are presented as means \pm standard deviation (SD) unless stated otherwise. Multivariate analyses of covariance (MANCOVA) were used to observe differences in maturation, anthropometry, physical capacity, motor competence and technical ability between playing levels and playing positions. Chronological age was used as a covariate to account for the differences in age that existed across all age groups, which may confound measures of anthropometry or physical performance.

A linear discriminant analysis was used as a follow-up analysis to indicate how well a multidimensional set of performance variables could classify participants into their respective playing levels. For this analysis, a homogenous variance and multivariate normal within-group distribution was assumed (Lachenbruch, 1975).

Pearson's correlation coefficients were calculated to provide an indication of the agreement between coach ratings and objectively measured performance characteristics. Additionally, a further multivariate analysis of variance (MANOVA) was used to analyse differences between playing positions for a range of subjective coach ratings. For all multivariate analyses, partial eta squared effect sizes (η^2) were used to analyse the magnitude of effects using cut-off scores of set as small (0.01), moderate (0.06) and strong (0.14) effects (Cohen, 1992).

All statistical analyses were conducted using the SPSS statistical software package (Version 23). The criterion alpha level for significance was set at $p < 0.05$.

RESULTS

Multivariate analysis of covariance showed large differences between playing levels for a combination of maturation, anthropometry, physical capacity, technical ability and motor competence when adjusted for chronological age ($F=5.336$, $p<0.001$, $\eta^2=0.30$) (Table 4.1). Univariate analysis revealed large differences between playing levels for technical ability ($\eta^2=0.37$, $p<0.001$) and aerobic fitness ($\eta^2=0.15$, $p<0.001$), in addition to moderate differences in agility ($\eta^2=0.14$, $p<0.001$), sprint speed ($\eta^2=0.09$, $p=0.002$) and motor competence ($\eta^2=0.08$, $p=0.004$). Pairwise comparisons revealed both Team 1 and 2 players to possess faster sprint speed and aerobic fitness compared with Team 3 players. Team 1 also exhibited superior agility and motor competence compared with both Team 2 and 3 players. Finally, technical ability was indicative of playing level, with dribble test times faster for each ascending level.

These five variables were then entered into a follow-up discriminant analysis to classify players into playing levels with a combination of sprint speed, agility, aerobic fitness, technical ability and motor competence. Table 4.2 describes the contribution of the two discriminant functions and respective structure coefficients for each variable entered into the analysis. The structure coefficients quantify the potential of each variable to maximise differences between means amongst playing levels. The larger the magnitude of the coefficients, the greater the contribution of that variable to the discriminant function. The discriminant analysis correctly classified 64.8% of cases into their respective playing level (Figure 4.5), representing an improved prediction of 35.9, 13.7 and 47.4% above chance levels for Team 1, 2 and 3, respectively (Table 4.3). The variate scores are shown in the combined-groups plot (Figure 4.5), where each group is

plotted against the discriminant functions to highlight how each variate discriminates between groups.

Table 4.1 Playing level differences in maturation, anthropometry, physical capacity, technical ability and motor competence.

	Playing Level			Covariate	MANCOVA			
	1	2	3	Age	η^2	F	<i>p</i>	Post-hoc
	<i>N</i> =48	<i>N</i> =53	<i>N</i> =39					
Chronological Age (y)	14.0 ±1.7	14.1 ±1.6	14.0 ±1.4	-	-	-	-	-
Maturity Offset (y)	0.4 ±1.7	0.5 ±1.5	-0.2 ±1.3	-	0.00	0.253	0.777	
Anthropometry								
Stature (cm)	165.1 ±10.7	166.9 ±10.7	163.5 ±10.1	**	0.02	1.323	0.270	
Body Mass (kg)	54.0 ±11.8	54.6 ±10.8	51.9 ±10.7	**	0.01	0.701	0.498	
Physical Capacity								
Sit and Reach (cm)	3.5 ±8.2	1.2 ±7.9	-0.6 ±8.8	**	0.02	1.521	0.222	
Vertical Jump (cm)	49 ±9	47 ±8	43 ±9	**	0.03	2.156	0.120	
30 m Sprint (s)	4.76 ±0.39	4.77 ±0.32	5.08 ±0.43	**	0.09	6.586	0.002	1=2 < 3
T-Test (s)	8.15 ±0.91	8.58 ±0.51	8.87 ±0.53	**	0.14	10.627	<0.001	1 < 2=3
YYIR1 (m)	1368 ±530	1252 ±449	833 ±372	**	0.15	12.255	<0.001	1=2 > 3
Technical Ability								
UGent Dribble Test (s)	21.9 ±2.2	24.8 ±3.5	27.9 ±3.3	*	0.37	39.685	<0.001	1 < 2 < 3
Motor Competence								
KTK (MQ)	106.7 ±10.9	98.4 ±16.0	98.8 ±15.3		0.08	5.668	0.004	1 > 2=3

Data are means ± standard deviations; * = $p < 0.05$; ** = $p < 0.001$

YYIR1; Yo-Yo Intermittent Recovery Test Level 1, KTK; Körperkoordinationstest für Kinder, MQ; motor quotient

Table 4.2 Discriminant function structure coefficients and tests of statistical significance.

Variable	Function	
	1	2
30 m Sprint (s)	-0.03	0.78
T-Test (s)	0.23	-0.81
YYIR1 (m)	-0.19	-0.46
UGent Dribble Test (s)	0.83	0.04
KTK (MQ)	-0.08	0.50
Wilks' Lambda	0.528	0.905
Chi-square	98.4	15.4
<i>p</i>	<0.001	0.004
Eigenvalue	0.71	0.11
Relative percentage	87.2	12.8
Canonical correlation	0.65	0.31

YYIR1; Yo-Yo Intermittent Recovery Test Level 1, KTK; Körperkoordinationstest für Kinder, MQ; motor quotient

Table 4.3 Classification matrix for the players' actual and predicted playing levels according to discriminant functions.

Actual Group	Predicted Group		
	Team 1	Team 2	Team 3
Team 1 (<i>N</i> =58)	71%	24%	5%
Team 2 (<i>N</i> =59)	27%	59%	14%
Team 3 (<i>N</i> =42)	10%	21%	69%

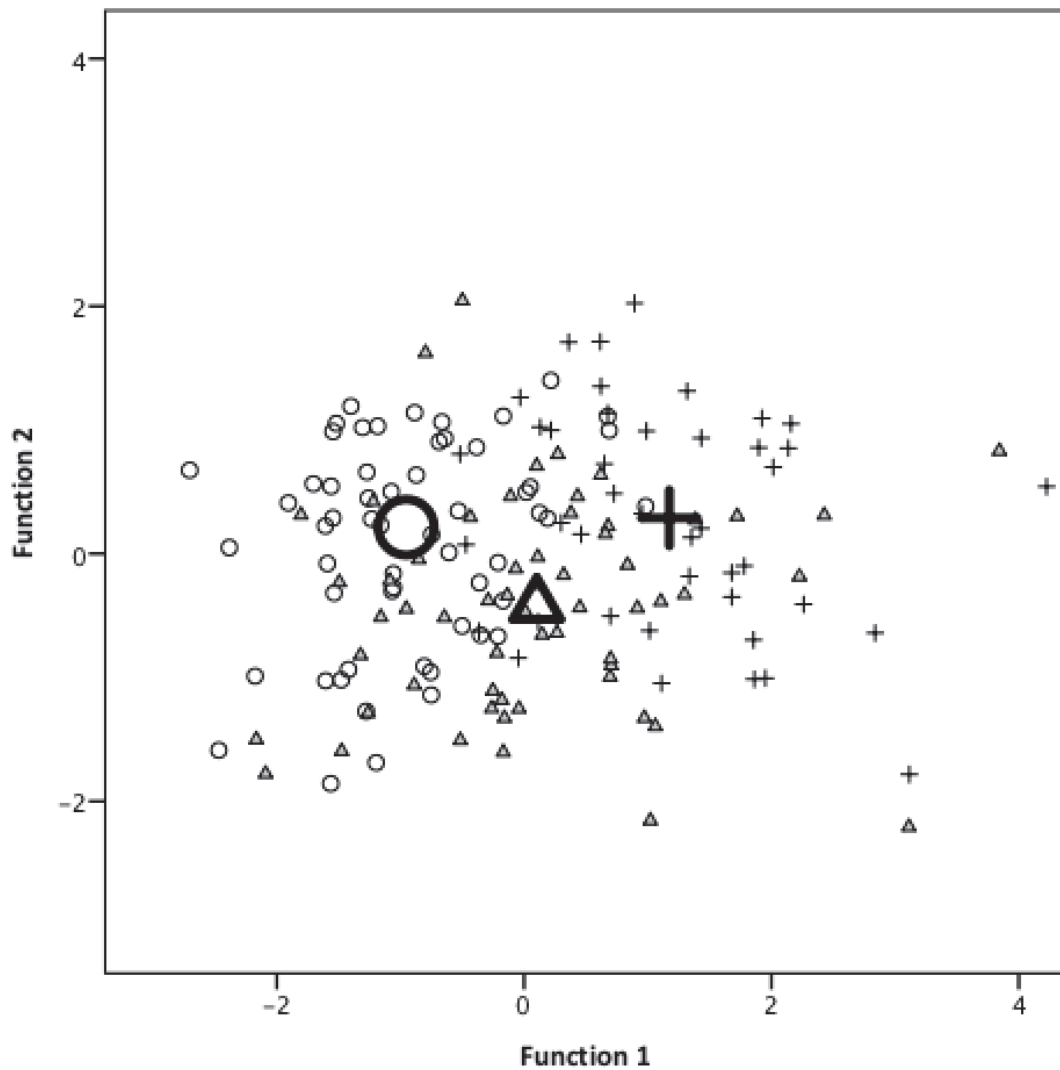


Figure 4.5 Territorial map of the players relative to playing level (Team 1; ○, Team 2; △, Team 3; +) according to canonical discriminant functions. Centroids represent the mean variate scores for each group.

Moderate differences between playing positions were found for a combination of maturation, anthropometry, physical capacity, motor competence and technical ability when adjusted for chronological age ($F=1.974$, $p=0.002$, $\eta^2=0.14$) (Table 4.4). Univariate analysis revealed large differences between playing positions for body mass ($\eta^2=0.16$, $p<0.001$), in addition to moderate differences in maturity offset ($\eta^2=0.08$,

$p=0.008$), vertical jump ($\eta^2=0.06$, $p=0.039$) and sprint speed ($\eta^2=0.07$, $p=0.018$). Pairwise comparisons revealed central defenders to be heavier than all other positions, and earlier maturing than midfielders (Table 4.4). Attackers possessed a faster sprint speed than midfielders.

Table 4.4 Playing position differences in maturation, anthropometry, physical capacity, technical ability and motor competence.

	Playing Position				Covariate	MANCOVA				
	Attackers	Midfielders	Fullbacks	Central Defenders		Age	η^2	F	p	Post-hoc
	N=39	N=32	N=26	N=43						
Chronological Age (y)	14.1 ±1.6	14.0 ±1.5	14.0 ±1.6	14.2 ±1.5	-	-	-	-	-	
Maturity Offset (y)	0.4 ±1.6	0.0 ±1.4	0.0 ±1.4	0.8 ±1.7	-	0.08	4.151	0.008	CD > MF	
Anthropometry										
Stature (cm)	165.5 ±11.1	163.0 ±10.5	164.5 ±9.7	169.0 ±10.1	**	0.05	2.499	0.062		
Body Mass (kg)	53.8 ±10.5	50.3 ±9.9	51.3 ±10.0	60.1 ±12.0	**	0.16	8.412	<0.001	CD > ATT=MF=FB	
Physical Capacity										
Sit and Reach (cm)	3.7 ±7.5	2.0 ±8.6	-1.0 ±8.5	0.0 ±8.6	**	0.04	1.958	0.123		
Vertical Jump (cm)	49 ±8	44 ±8	45 ±8	49 ±10	**	0.06	2.859	0.039		
30 m Sprint (s)	4.71 ±0.33	4.98 ±0.44	4.93 ±0.33	4.80 ±0.44	**	0.07	3.488	0.018	ATT < MF	
T-Test (s)	8.42 ±0.51	8.64 ±0.66	8.58 ±0.55	8.39 ±1.09	**	0.01	0.488	0.691		
YYIR1 (m)	1257 ±468	1136 ±515	1117 ±563	1175 ±503	**	0.01	0.215	0.886		
Technical Ability										
UGent Dribble Test (s)	24.7 ±3.6	24.4 ±3.9	24.8 ±4.5	24.8 ±3.7	**	0.01	0.278	0.841		
Motor Competence										
KTK (MQ)	102.4 ±15.2	101.4 ±15.7	102.9 ±15.2	98.7 ±12.4		0.01	0.451	0.717		

Data are means ± standard deviations; * = $p < 0.05$; ** = $p < 0.001$

YYIR1; Yo-Yo Intermittent Recovery Test Level 1, KTK; Körperkoordinationstest für Kinder, MQ; motor quotient

Multivariate analysis of variance revealed differences in subjective coach ratings between playing positions. Whilst no differences between playing positions were shown in Team 2 or Team 3 players, large differences were found between positions in Team 1 players for a combination of technical, tactical, physical, psychological and overall subjective coach ratings ($F=2.598$, $p=0.001$, $\eta^2=0.16$). Pairwise comparisons revealed midfielders to be rated higher than fullbacks in tactical ability, technical ability and overall ability, while central defenders were rated higher than fullbacks in physical ability (Table 4.5). Pearson's correlations also revealed midfield players with higher coach ratings to possess faster sprint speed ($r=0.437$, $p=0.010$) and agility ($r=0.444$, $p=0.008$). Technical ability was also shown to correlate positively with coach ratings in both attackers ($r=0.383$, $p=0.021$) and midfielders ($r=0.521$, $p=0.002$).

Table 4.5 Playing position differences in subjective coach ratings

	Playing Position				MANOVA		
	Attackers	Midfielders	Fullbacks	Central Defenders	η^2	F	<i>p</i>
Selected	<i>N=25</i>	<i>N=16</i>	<i>N=16</i>	<i>N=18</i>			
Overall Rank	5.0 ±3.2	3.2 ±2.8	7.0 ±3.7	4.8 ±2.5	0.15	4.296	0.008
Tactical Rank	4.8 ±3.8	2.9 ±2.5	7.3 ±3.3	4.8 ±2.6	0.19	5.486	0.002
Technical Rank	5.4 ±3.5	2.9 ±2.2	6.8 ±3.4	5.6 ±2.7	0.17	4.875	0.004
Physical Rank	5.0 ±3.2	4.3 ±3.7	6.8 ±2.7	3.7 ±2.5	0.11	2.897	0.041
Psychological Rank	5.5 ±3.2	3.4 ±3.0	5.3 ±3.1	3.7 ±2.4	0.09	2.310	0.084
Non-Selected	<i>N=44</i>	<i>N=43</i>	<i>N=26</i>	<i>N=26</i>			
Overall Rank	4.9 ±3.6	5.6 ±3.6	5.5 ±4.7	5.9 ±3.9	0.01	0.380	0.767
Tactical Rank	5.2 ±3.5	4.6 ±3.6	6.0 ±4.7	5.7 ±4.1	0.02	0.756	0.521
Technical Rank	5.3 ±3.2	4.7 ±3.7	5.1 ±3.3	6.2 ±4.1	0.02	1.008	0.391
Physical Rank	4.7 ±3.6	6.2 ±3.9	6.0 ±3.3	5.1 ±4.3	0.03	1.381	0.251
Psychological Rank	5.9 ±4.2	5.4 ±4.3	5.2 ±4.9	4.7 ±4.4	0.01	0.434	0.729

Data are means ± standard deviations; * = $p < 0.05$; ** = $p < 0.001$

Selected; Team 1 players, Non-Selected; Team 2/3 players, Rank; subjective coach rating expressed as within-team rank

DISCUSSION

The main purpose of the present study was to employ a multidimensional approach to examine factors influencing playing level and position selection in a cohort of recreational youth soccer players. The main finding of this study was the different characteristics observed between playing levels, with measures of fitness, technical ability and motor competence shown to be important determinants for selection. In contrast, measures of maturation, anthropometry and physical performance were shown to be different between playing positions. These findings contribute new evidence to highlight how individual characteristics influence the selection process in recreational youth soccer, which have important implications for talent development pathways in schools, clubs and academies.

In agreement with previous research in elite youth soccer (Deprez et al., 2015; Vaeyens et al., 2006; Vandendriessche et al., 2012), the present study revealed differences in both physical- and coordination-related characteristics between playing levels. Whilst a combination of all factors was shown to be different between playing levels, these differences could primarily be attributed measures of aerobic fitness, agility, technical ability and motor competence. Similar findings have previously been reported in elite youth soccer (Deprez et al., 2015), with fitness, technical ability and motor competence distinguishing players who persisted or dropped out of a high-level talent development program. Vaeyens et al. (2006) also reported differences between elite, sub-elite and non-elite youth soccer players in both technical ability and a vast range of physical performance characteristics. The present findings agree with existing literature, and also extend current understanding to show that physical characteristics may underlie selection bias at a recreational level. These are important observations, as unlike the

elite development programs assessed in previous studies (Deprez et al., 2015; Vaeyens et al., 2006), the school-based development program in the present study aimed to minimise drop out and the subsequent effects of deselection. This was achieved by maximising participation, regardless of the sport or playing standard. Despite this, those selected in lower teams become more likely to miss out on the high-quality coaching and training opportunities provided for higher-level teams. Subsequently, this may further limit the athlete's chance of future selection, guide an individual towards a different sport, or increase the chance of drop out after high school (Helsen et al., 1998b).

The present study also revealed moderate differences between playing positions for a combination of maturation, anthropometry and physical performance characteristics. Central defenders were characterised by advanced maturation (maturity offset: 0.8 ± 1.7 y; $CD > ATT=MF=FB$) and greater body mass (60.1 ± 12.0 kg; $CD > MF$), while attackers possessed the fastest sprint speed (30 m sprint: 4.71 ± 0.33 s; $ATT < MF$). Similar positional traits have been reported in both professional (Boone et al., 2012) and elite youth soccer players (Deprez et al., 2014b), and are almost certainly due to the tactical requirements of each position. For example, central defenders require body size and strength to win defensive duels, while attackers require speed and explosiveness to pass defenders and create goal-scoring opportunities (Reilly, Bangsbo, & Franks, 2000). Similar to previous research in elite youth soccer (Deprez et al., 2014b), these findings show that coaches may be selecting young players into positions based on the physical profiles required for success at a professional level. However, this approach may not be efficient, as favourable physical characteristics will not necessarily be retained throughout the maturational process and may have no bearing on future sports performance (Vaeyens et al., 2008b). Selection based on physical attributes may be

especially counter-productive at a grassroots level, where maximising engagement, participation and diversity is recommended for long term participation and enjoyment in sport (Côté et al., 2009).

Burgess and Naughton (2010) reported that selection bias in elite youth sport may be perpetuated by a coach's short-term mindset on team success, rather than sustaining a long-term vision to develop talent. Indeed, to minimise this bias, coaches may need to ignore enhanced physical qualities which are often favoured in a pursuit of short-term performance. Team selection in the present study could primarily be attributed to measures of technical ability, motor competence and fitness. Whilst it is likely these differences may be attributed to coach selections, these performance characteristics may also have been developed as a result of an exposure to enhanced coaching and training effects (Helsen et al., 2005). In contrast, selection into playing positions was more influenced by measures of maturity, anthropometry and physical performance, which appear to be important characteristics for guiding individuals into specific playing positions. Despite the recreational level of the present study, and the school's intent to maximise participation, it seems coaches are still inclined to look for desirable physical characteristics when selecting youngsters into playing positions. However, as young players may not retain these physical attributes into adulthood, early specialisation in recreational youth soccer players may limit the development opportunities that could be provided through a wide variety of training and match exposure in a number of different positional roles.

Finally, large differences were shown between positions in Team 1 players for a combination of tactical, technical, physical, psychological and overall subjective coach ratings. Whilst coach ratings are subjective in nature, they allow a valuable insight into

the criterion underpinning talent selection, and may provide more construct validity than more objectively measured characteristics. Midfielders were rated highest in tactical, technical and overall ability, while central defenders were rated highest in physical ability. These findings are not surprising when considering the physical and technical requirements of each position. For example, players in central defensive positions are expected to be physically dominant in order to win duels in defensive areas against opposing attackers (Reilly et al., 2000). In contrast, midfield players are required to participate in both defensive and offensive situations in all areas of the pitch, demanding highly developed technical and tactical ability. Performance in the UGent Dribble Test was also shown to correlate positively with coach rankings in midfield positions, highlighting the importance of technical ability for players selected into these positions. Furthermore, despite physical performance not being fundamental for midfield selection in the present study, sprint speed and agility were both shown to improve coach ratings for midfielders, emphasising the importance of these physical attributes in the selection process. Whilst a coach's subjective assessment may be important in the talent selection process, guiding individuals into specific positions based on overall perceived playing ability may merely accentuate disparities in performance. For example, as midfielders are important for controlling the game, players with higher playing ability may be preferentially selected in these positions, providing an enhanced opportunity to further develop their advanced levels of technical and tactical ability. Accordingly, the early specialisation of young players into positions may narrow development opportunities provided during match-play, and negatively impact an individual's ability to change positions in the future (Matthys, Fransen, Vaeyens, Lenoir, & Philippaerts, 2013).

The present study also has its limitations. Firstly, not all potential predictors of talent, such as training history or psychological factors, were included in the analysis. There was also an inability to subdivide into age groups for further analysis without compromising the sample size of the study. Despite this, the present study used a multidimensional approach to include a considerable range of physical- and coordination-related characteristics, which contribute important findings to the existing literature. Furthermore, the present findings are specific to this particular cohort, and provide a cross-sectional snapshot of a male, school-based soccer program. It is therefore suggested that future research should use a longitudinal, multidimensional approach to talent identification and development across a range of age groups and playing levels in youth soccer. Indeed, a longitudinal approach would provide important context to the individual development trajectories experienced by young athletes to further investigate factors influencing talent identification, selection and development across the performance spectrum.

In summary, the present findings extend previous observations from elite youth soccer showing both physical- and coordination-related characteristics to be different between playing levels and positions in recreational youth soccer players. These results also revealed a combination of motor competence, technical ability and aerobic fitness to distinguish players of different playing levels. In contrast, maturity status and physical characteristics were the major factors to determine an individual's playing position. Whilst it is unclear whether some of these differences resulted from coach selections or training effects, the reliance on physical characteristics to guide individuals towards playing levels and specific playing positions in youth soccer may be detrimental to the development opportunities provided by training and match experience. As young

players may not retain physical attributes into adulthood, selection based on physical characteristics is not recommended. It is also suggested that coaches provide all young players with the opportunity to sample different playing positions to improve exposure to a diverse learning environment throughout development.

5 STUDY THREE

Lovell, T.W.J., Bocking, C.J., Kempton, T., Fransen, J. & Coutts, A.J. (2017). Factors affecting physical match activity and skill involvement in youth soccer. *Science and Medicine in Football*. DOI: 10.1080/24733938.2017.1395062.

ABSTRACT

The aim of this study was to examine the factors affecting physical match activity and technical performance (skill involvements) in youth soccer. Physical activity profiles and skill involvements were collected from 160 adolescent soccer players (aged 11-17 y) across one season in a recreational, school-based soccer program. Team coaches selected players into playing levels and playing positions, and individual characteristics of aerobic fitness and sprint performance were obtained prior to the season. Three separate linear mixed models were constructed to examine the influence of playing level, playing position and individual player characteristics on both physical (relative total distance; TD; $\text{m}\cdot\text{min}^{-1}$, relative high-speed running distance; HSR; $\text{m}\cdot\text{min}^{-1}$) and technical match activity (relative skill involvements; $\text{involvements}\cdot\text{min}^{-1}$). Midfielders performed higher TD (attackers: -5.6% , fullbacks: -7.6% , central defenders: -13.6%) and skill involvements (attackers: -25.4% , fullbacks: -21.8% , central defenders: -27.3%) during match-play compared to all other positions. Attacking players performed more HSR distance (11.3%) than other positions, whilst central defenders performed the least HSR distance (-22.2%). Aerobic fitness and sprint performance were both positively associated with TD and HSR. Skill involvement was also increased by TD during match-play. These findings provide new evidence to understand the complex interaction of factors influencing developmental opportunities during soccer match play. Specifically, the present study showed playing position to influence both the match running demands and skill involvements for young players in a recreational cohort. Varying playing positions is therefore important to maximise skill and physical development opportunities in young soccer players.

INTRODUCTION

Through the talent development process, coaches continually strive to provide young athletes with a suitable learning environment to develop the physical, technical, tactical and psychological skills required for sports performance (Williams & Reilly, 2000). The learning environment provided to young players at a recreational level may be particularly important, as this is where all young soccer players are initially exposed to developmental pathways. While identifying young players with potential may be important to ensure they are exposed to specific training and higher levels of competition, the prediction of future talent is a difficult process. Indeed, many of the qualities that distinguish elite athletic performance in adults might not be apparent until late adolescence (Vaeyens et al., 2008b). Furthermore, vast differences in age and maturity may be present within youth sport age groups, causing coaches and selectors to mistake early maturation with athletic talent. For example, relatively older, earlier maturing individuals are more frequently selected into talented soccer programs during adolescence (Helsen et al., 1998b), and even guided towards key positional roles where certain physical attributes may be advantageous (Gil et al., 2007). This selection bias has a confounding effect, with development opportunities narrowed, and those athletes selected at lower levels more likely to fall behind and miss out future selection (Helsen et al., 1998b). However, the extent to which selection or position specialisation influences development opportunities in youth soccer is largely unknown.

Soccer match-play forms a primary opportunity for young players to develop a range of physical, perceptual, technical and tactical skills required to progress to an elite level. Competitive matches are particularly important for providing task-specific development opportunities for the unique requirements of performance (Williams, Ward, Ward, &

Smeeton, 2008). However, the opportunity to develop such skills during match-play may be dependent on situational factors such as playing level and playing position (Williams et al., 2008). For example, young players who are selected into elite playing levels often receive higher quality coaching (Helsen et al., 1998b) and are exposed to increased physical and technical intensity during match-play (Waldron & Murphy, 2013). Playing position is also an important determinant of physical and technical match activity, with positional differences reported in both professional (Bangsbo, Mohr, & Krustup, 2006; Mohr, Krustup, & Bangsbo, 2003) and youth soccer (Buchheit, Mendez-Villanueva, Simpson, & Bourdon, 2010). There is also evidence to suggest the development of perceptual-cognitive skills, such as anticipation, is specific to playing position in soccer (Williams et al., 2008). Accordingly, if young players spend several years in a specific playing position or competing at a lower playing level, important learning opportunities such as match running and skill involvement may be constrained, limiting the improvement of tactical, technical or physical abilities (Stroyer, Hansen, & Klausen, 2004). However, whilst several previous studies have described the factors affecting talent identification and development pathways in youth soccer (Helsen, Hodges, van Winckel, & Starkes, 2000; Vaeyens et al., 2006; Williams & Reilly, 2000), no research to date has examined the influence of both playing level and playing position on technical and physical match activity. Moreover, to the author's knowledge, no previous research has focused on the factors affecting talent development at a recreational level, where all young soccer players are initially exposed to developmental pathways.

The present study therefore aims to provide an improved understanding of the factors affecting match activity in a recreational, school-based youth soccer cohort.

Additionally, a mixed model approach aims to overcome the statistical limitations reported in previous studies (i.e. the analysis of independent effects is not permitted with many statistical approaches), as the extent to which individual characteristics (i.e. aerobic capacity and sprint performance) influence match activity is largely unknown (Buchheit et al., 2010). Therefore, the independent effects of playing level, playing position and individual player factors on both physical and technical match activity will be examined in a recreational, school-based youth soccer cohort.

METHODS

Participants

A school-based cohort of 160 adolescent, male recreational level soccer players (aged 11-17 y) were invited to participate in the study. The participants possessed the following characteristics: age: 14.2 ± 1.5 y; height: 165.3 ± 11.8 cm; body mass: 53.9 ± 12.3 kg. All participants engaged in the school-based soccer program, competing within one of the school's five age-based cohorts (Year 7; 11-12 y; N=38, Year 8; 12-13 y; N=42, Year 9; 13-14 y; N=41, Year 10; 14-15 y; N=37, Year 11/12; 15-17 y; N=41). Within each age-based cohort, participants had been selected by team coaches into three playing levels (Team 1; N=67, Team 2; N=62, and Team 3; N=71), with Team 1 defined as the highest playing level. Informed consent from the parent/guardian of each participant and ethics approval was obtained from the UTS Human Research Ethics Committee (UTSHREC: 2012000199).

Study Design

This longitudinal cohort study involved the collection of physical and technical match activity data throughout a season in a school-based soccer program. Prior to the season, each participant's anthropometry and physical fitness characteristics (aerobic fitness and linear speed) were assessed (Table 5.1). Match activity data was collected during each team's five home games, which spanned a 16-week period. All matches were played on the same field (dimensions: 90 m x 50 m) and consisted of two 25-minute halves, with the exception of Year 11/12 matches which consisted of two 40-minute halves. Participants who completed all testing procedures and participated in at least one entire match were retained for analysis (N=127). Only complete match samples (where the participant was not substituted) qualified for analysis to negate the influence of pacing strategies on physical match activity (Waldron & Highton, 2014), totalling 257 individual matches (2.0 ± 1.1 match samples per participant). While playing position may have changed during the season, participants were mostly selected into the same position for each match (attacker; N=38, midfielder; N=37, fullback; N=23, central defender; N=29). Although some previous research has highlighted the importance for differentiating between central and lateral midfield players (Towilson et al., 2017), the "1-4-3-3" tactical formation employed by the teams in this study did not warrant this approach, with all three midfield positions located centrally (Figure 4.1).

Procedures

Anthropometry

Stature and sitting height were recorded to the nearest millimetre using a wall-mounted stadiometer following the guidelines of Lohman et al. (1988). Leg length was estimated

by subtracting sitting height from stature. Body mass was measured by means of electrical scales (Universal Weight Enterprise, Taiwan). Somatic maturity was assessed by means of a gender-specific regression equation to estimate maturity offset, using measures of stature, body mass and leg length measurements (Mirwald et al., 2002). Estimated age at peak height velocity (APHV) was then derived by subtracting maturity offset from chronological age, to provide an indication of an individual's maturity status within a given age group. The limitations of this method are acknowledged, with a reported error of 1 year 95% of the time (Mirwald et al., 2002).

Physical Capacity

Physical characteristics were measured during an existing training session prior to the commencement of the season. Sprint performance was measured using a linear 30-m sprint, with the fastest of three sprint trials retained as the final result. The sprint was measured with photo cell timing lights (0.01 s) (Swift Performance Equipment, Australia), with a starting distance 0.5 m behind the triggering photo cell. A test-retest reliability study in 19 youth athletes reported a coefficient of variation (CV) of 1.4% for two 30-m sprints measured with timing gates (Waldron et al., 2011). Aerobic fitness was assessed using the Yo-Yo Intermittent Recovery Test Level 1 (YYIR1) according to the methods of Bangsbo et al. (2008). Recently, a test-retest reliability study reported CVs of 17.3, 16.7 and 7.9% in U13 (N=35), U15 (N=32) and U17 (N=11) non-elite youth soccer players, respectively, showing adequate to high reproducibility of the YYIR1 (Deprez et al., 2014a). All testing was conducted at an indoor sporting complex on multi-purpose, synthetic flooring.

Physical Match Activity

Physical activity data was collected concurrently during each match using 15 Hz GPS devices (SPI Pro X, GPSports, Canberra, Australia). The data was then downloaded and analysed using the manufacturer's proprietary software (TeamAMS 2014, GPSports, Canberra, Australia). Data-exclusion was undertaken according to the criteria outlined by Weston, Siegler, Bahnert, McBrien, and Lovell (2015). Global Positioning System devices have been shown to provide an acceptable level of accuracy and reliability for distance and speed measures during high-intensity, intermittent exercise (Johnston, Watsford, Kelly, Pine, & Spurrs, 2014). Measures of total distance and high-speed running (HSR; $>13 \text{ km}\cdot\text{h}^{-1}$) were recorded, according to previously used speed thresholds for match activity analysis in youth soccer players (Buchheit et al., 2010). An interunit reliability study of 15 Hz GPS devices has previously reported CVs of 1.9 and 7.6% for total distance and HSR, respectively (Johnston et al., 2014).

Technical Match Activity

Technical match activity was assessed as the absolute number of skill involvements during matches. This measure was chosen to reflect each player's magnitude of involvement, which may be representative of the skill learning opportunities received during soccer match-play. Skill involvements during matches were assessed via retrospective video analysis. All matches were filmed using a digital camcorder (Sony HDR-CX405, Sony, Australia) and then downloaded to a computer using video editing software (iMovie 10.0, Apple, California, USA). Skill involvements were defined as any action resulting in a player intentionally controlling or striking the ball, with the exception of "dead-ball" situations such as goal-kicks, throw-ins, free-kicks and penalties. Each possession was recorded as one involvement, regardless of the duration

or number of actions per possession (e.g. dribble vs. pass). All matches were coded by the same analyst, with 51 individual player samples analysed twice to assess intra-rater reliability for the coding of skill involvements. The Cronbach's alpha (α) for internal consistency reliability of the coding used in this study was 0.996.

Statistical Analyses

Given the complex nature of team sport match-play, it is likely that a variety of situational factors (i.e. playing position) and individual player characteristics (i.e. fitness) contribute to the variation in match activity profiles. Multilevel mixed modelling represents a statistical method with the ability to examine the independent effects of a variable on an outcome whilst accounting for all other variables. Therefore, the present study employed a mixed models approach to examine the independent effects of playing level, playing position and individual characteristics on match activity profiles in youth soccer.

Three separate linear mixed models were constructed using a combination of level 1 (individual participants' match activity data) and level 2 covariates (individual participants' characteristics) to investigate the effect of playing level, playing position and individual fitness characteristics on TD (Model 1), HSR (Model 2), and skill involvements (Model 3). All three response variables are expressed as a function of time, and referred to as relative total distance (TD; $\text{m}\cdot\text{min}^{-1}$), relative HSR distance (HSR; $\text{m}\cdot\text{min}^{-1}$), and relative skill involvements ($\text{involvements}\cdot\text{min}^{-1}$) respectively. Response variables were log transformed prior to analysis to provide differences as a percentage of the mean (Hopkins, Marshall, Batterham, & Hanin, 2009). Random

factors were included in the model to investigate deviations for players and playing levels from the overall fixed intercept and fixed coefficients (Table 5.2).

A ‘step-up’ model construction strategy was employed, beginning with an “unconditional” null-model containing only a fixed intercept and level 2 and 3 random factors (West, Welch, & Galecki, 2014). The model was then developed by adding each single level 1 fixed effect, followed by level 2 fixed effects. Each fixed effect was retained if it demonstrated statistical significance ($p < 0.05$) and improved the model information criteria compared to the previous model as determined by a likelihood ratio test. Level 1 and 2 fixed effects were also tested for random coefficient effects by comparing a model containing the random effect to that containing the fixed effect for each covariate. The intra-class correlation coefficient (ICC) was used to determine the similarity of observed responses within both the playing level and individual player clusters. The t statistics from the mixed models were converted to partial effect size (η^2) correlations and associated 90% confidence interval (CI) (Rosnow, Rosenthal, & Rubin, 2000). Effect sizes were interpreted as < 0.1 , trivial; 0.1–0.3, small; 0.3–0.5, moderate; 0.5–0.7, large; 0.7–0.9, very large; 0.9–0.99, almost perfect; 1.0, perfect (Hopkins, 2002). All statistical analyses were conducted using the lme4 and psychometric packages in R statistical software (R.3.1.0, R Foundation for Statistical Computing).

Table 5.1 Maturity, anthropometry and physical capacity by school year cohort.

	School Year Cohort				
	7	8	9	10	11/12
	<i>N=26</i>	<i>N=34</i>	<i>N=27</i>	<i>N=19</i>	<i>N=21</i>
Chronological Age (y)	12.6 ±0.3	13.6 ±0.3	14.5 ±0.3	15.6 ±0.3	16.9 ±0.8
Maturity Offset (y)	-1.4 ±0.7	-0.3 ±0.7	0.4 ±0.6	1.6 ±0.5	2.7 ±0.9
Anthropometry					
Height (cm)	153.8 ±8.9	162.8 ±7.5	167.0 ±6.7	173.8 ±6.1	177.1 ±8.2
Body Mass (kg)	42.8 ±6.8	50.8 ±7.7	53.8 ±6.0	61.1 ±6.9	67.8 ±9.6
Physical Capacity					
YYIR1 (m)	897 ±351	925 ±388	1339 ±423	1467 ±305	1800 ±400
30 m Sprint (s)	5.04 ±0.28	5.11 ±0.34	4.78 ±0.26	4.59 ±0.25	4.35 ±0.11

Data are means ± standard deviations

YYIR1; Yo-Yo Intermittent Recovery Test Level 1

Table 5.2 Covariates included in model specification.

Level of Data	Factors	Type	Classification
Level 3	Cluster of clusters (random factor)	<i>Team</i>	
Level 2	Cluster of units (random factor)	<i>Player</i>	
	Covariates	Aerobic fitness	Continuous YYIR1 (m)
		Sprint performance	Continuous 30 m sprint (s)
		Total distance (Model 3)	Continuous $\text{m} \cdot \text{min}^{-1}$
Level 1	Unit of analysis	<i>Individual match sample</i>	
	Dependent variables	Total distance (Model 1)	Continuous $\text{m} \cdot \text{min}^{-1}$
		High-speed distance (Model 2)	Continuous $\text{m} \cdot \text{min}^{-1}$
		Skill involvements (Model 3)	Continuous involvements $\cdot \text{min}^{-1}$
	Covariate	Position	Categorical ATT, MF, FB, CD

YYIR1; Yo-Yo Intermittent Recovery Test Level 1, ATT; attacker, MF; midfielder, FB; fullback, CD; central defender

RESULTS

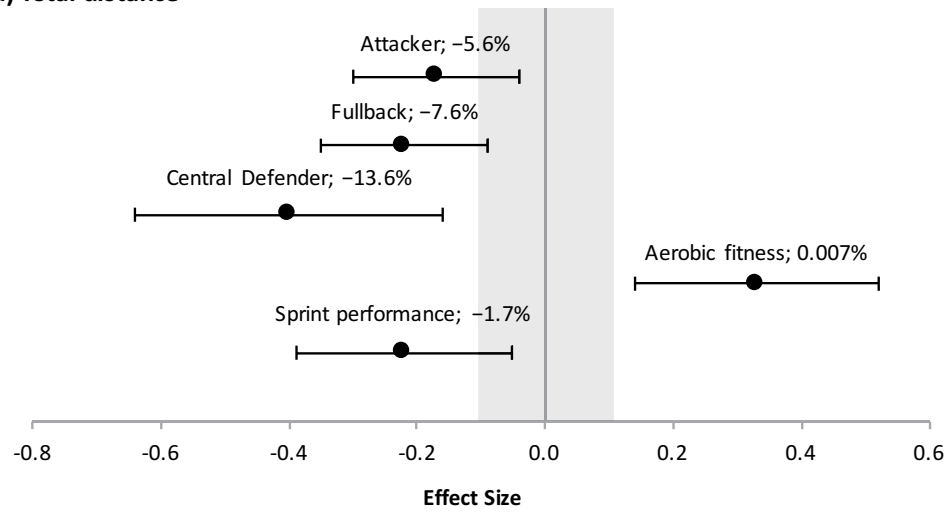
Playing position influenced the TD, HSR and the amount of skill involvements in each of the separate models (Table 5.3). Midfield positions ran the furthest during games, while attackers (-5.6% , $\eta^2=0.17$), fullbacks (-7.6% , $\eta^2=0.22$) and central defenders (-13.6% , $\eta^2=0.40$) ran less (Figure 1). Central defenders also performed less HSR (-22.2% , $\eta^2=0.29$), whilst attackers performed more HSR than all other positions (11.3% , $\eta^2=0.13$). TD and HSR were both positively associated with individual characteristics of aerobic fitness (TD: 7.0% , $\eta^2=0.33$; HSR: 26.0% , $\eta^2=0.44$) and sprint performance (TD: -1.7% , $\eta^2=0.22$; HSR: -5.2% , $\eta^2=0.25$). Skill involvements were highest in midfielders, and lower in all other positions (central defenders: -27.3% , $\eta^2=0.36$; attackers -25.4% , $\eta^2=0.33$; fullbacks -21.8% , $\eta^2=0.28$). Furthermore, the results revealed that skill involvements increased as more total distance was covered during a game (0.8% , $\eta^2=0.31$). The random intercept effects for TD (Model 1) were 2.5% , 1.4% and -3.8% for playing levels 1, 2 and 3 respectively, indicating that level 1 players covered higher TD during games than their lower level counterparts. There were no random effects for HSR for playing level (Model 2). The random intercept effects for skill involvements (Model 3) were -0.02% , 0.02% and 0.01% for playing level 1, 2 and 3 respectively.

Table 5.3 Percentage effects of covariates on log transformed relative total distance, high-speed running distance and skill involvements (90% CI).

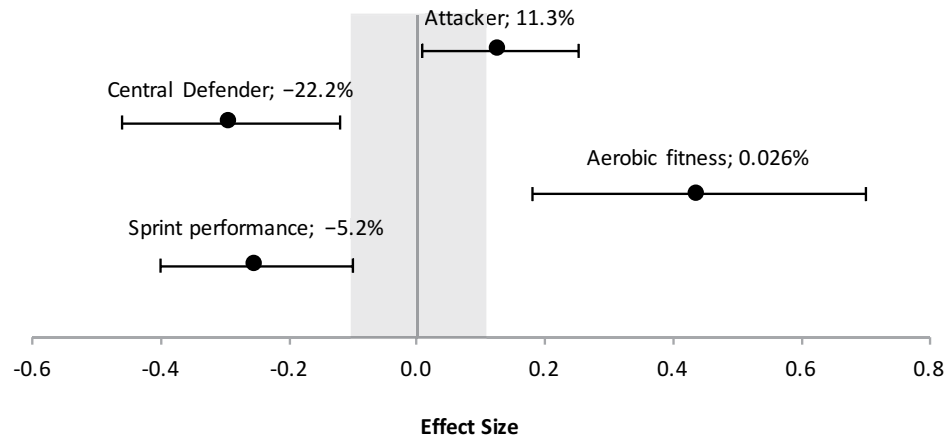
Total Distance (Model 1)					
	Coefficient	90% CI	df	t Value	Effect size
<i>Fixed effects</i>					
Intercept ($\text{m}\cdot\text{min}^{-1}$)	98.8	92.8, 105.1	5	122.1	
Attacker	-5.6	-8.9, -2.2	247	-2.7	0.17
Fullback	-7.6	-10.9, -4.1	237	-3.5	0.22
Central Defender	-13.6	-16.8, -10.2	207	-6.3	0.40
Aerobic fitness (m)	0.007	0.004, 0.010	107	3.7	0.33
Sprint performance (s)	-1.7	-2.7, -0.6	128	-2.5	0.22
HSR Distance (Model 2)					
	Coefficient	90% CI	df	t Value	Effect size
<i>Fixed effects</i>					
Intercept ($\text{m}\cdot\text{min}^{-1}$)	17.5	15.5, 19.8	8	38.4	
Attacker	11.3	2.2, 21.1	250	2.1	0.13
Central Defender	-22.2	-28.9, -14.8	226	-4.6	0.29
Aerobic fitness (m)	0.026	0.018, 0.034	114	5.3	0.44
Sprint performance (s)	-5.2	-7.9, -2.4	133	-3.0	0.25
Skill Involvements (Model 3)					
	Coefficient	90% CI	df	t Value	Effect size
<i>Fixed effects</i>					
Intercept ($\text{involvements}\cdot\text{min}^{-1}$)	0.37	0.28, 0.50	157	-5.6	
Attacker	-25.4	-31.8, -18.4	240	-5.4	0.33
Fullback	-21.8	-28.7, -14.2	219	-4.4	0.28
Central Defender	-27.3	-34.1, -19.7	191	-5.3	0.36
Total distance ($\text{m}\cdot\text{min}^{-1}$)	0.76	0.48, 1.04	195	4.5	0.31

CI; confidence interval, df; degrees of freedom, NS; covariate non-significant in final model.

a) Total distance



b) HSR distance



c) Skill involvements

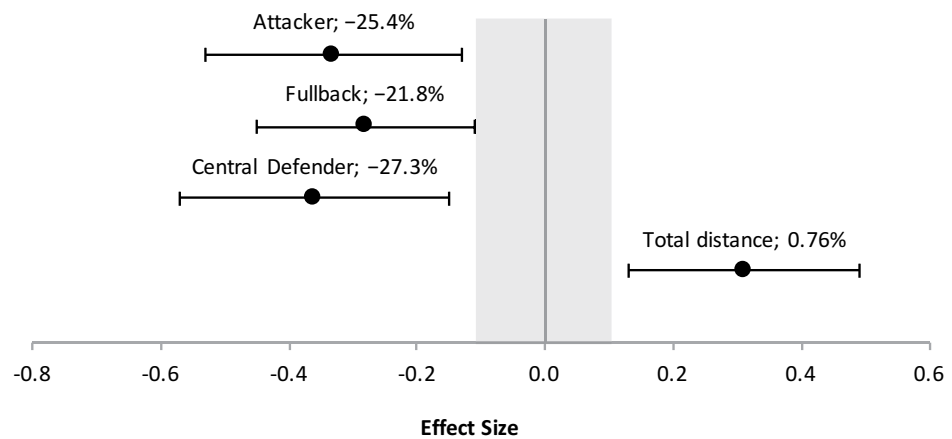


Figure 5.1 Percentage effects of covariates on log transformed data for relative a) total distance, b) high-speed running distance and c) skill involvements (90% CI).

DISCUSSION

The present study used a mixed models approach to determine the independent effects of various match-related and individual player factors on both physical and technical match activity in a school-based youth soccer cohort. The main finding of this study was the different physical and technical match activity profiles observed between playing positions at a recreational level. Players in midfield positions were associated with higher TD and skill involvements when compared to all other position groups. Furthermore, individual physical characteristics of aerobic capacity and sprint performance were associated with increases in TD and HSR. These findings provide new information on the factors influencing physical and technical match activity in a recreational, school-based cohort, which have important implications for coaches to better understand talent development in youth soccer.

The influence of playing position on physical match activity profile has received considerable attention in both professional and youth soccer research (Stølen, Chamari, Castagna, & Wisløff, 2005), with midfield players consistently shown to cover the most distance, and central defenders the least distance during match-play. In agreement with existing literature, the present study demonstrated that midfielders cover more distance than all other positions (attackers: -5.6%, fullbacks: -7.6%, central defenders -13.6%). Indeed, the effects of playing position on physical match activity are likely explained by specific tactical requirements (Stølen et al., 2005), with midfielders typically required to participate in both offensive and defensive tasks in all areas of the pitch. The present study also revealed central defenders to be associated with less HSR (-22.2%), in contrast to small increases shown in HSR for attacking positions (11.3%). These findings also agree with previous research in youth soccer, with attackers reported to

cover more distance at high speed than any other position (Stølen et al., 2005). These specialised running patterns have been suggested to indicate a mature understanding of position-specific tasks (Buchheit et al., 2010), and therefore limited to elite level players. However, a new finding of the present study is that position-specific physical activity profiles are apparent at a recreational level, where all young players are first introduced to talent development opportunities. These observations suggest that early specialisation into playing positions may limit the important developmental opportunities of young players. Since sports participation at a recreational level should promote a diverse, inclusive learning environment (Côté et al., 2009), it is recommended that players at lower levels of youth soccer be afforded the opportunity to sample playing in a variety of positions and tactical roles to not limit their football development.

In addition to playing position, match activity profile may also be influenced by individual characteristics such as age, maturation or fitness (Bangsbo et al., 2006; Buchheit & Mendez-Villanueva, 2014; Castagna et al., 2009; Helgerud, Engen, Wisloff, & Hoff, 2001; Impellizzeri, Marcora, Castagna, Reilly, Sassi, Iaia, & Rampinini, 2006). For example, enhanced aerobic fitness has been shown to increase distance covered and high-speed running during soccer match-play in both professional (Impellizzeri et al., 2006) and elite youth soccer players (Castagna et al., 2009). However, Buchheit et al. (2010) recently suggested that the contribution of a player's physical capacities on match activity profile in highly trained youth soccer is not as large as initially expected, with positional and tactical constraints likely to dictate most variation in physical activity. While the positional differences shown in the present results agree with Buchheit et al. (2010), both aerobic capacity and sprint performance were also shown to be independently associated with moderate increases in both TD and HSR during

match-play. A likely explanation for the differences between the present results and the suggestions of Buchheit et al. (2010) are the playing standard and fitness disparities between the two cohorts investigated. Furthermore, the statistical approach in the present study allows for the independent effect of player characteristics to be observed while controlling for confounding factors such as playing position. Based on these findings, it is suggested that fitness characteristics may be important mediators of match activity profile for players of lower fitness and playing standard, however, the importance of these characteristics are diminished as they are developed and the level of competition is increased.

The current model shows that when accounting for the effect of playing position, players with greater physical qualities also have increased match activity profiles. For example, whilst midfielders already cover the greatest distances, enhanced aerobic capacities further increase match speed, with each additional YYIR1 shuttle (40 m) associated with an increase of $0.27 \text{ m}\cdot\text{min}^{-1}$ in TD. Likewise, whilst attackers perform more HSR than other playing positions, sprint capacity further accentuates HSR during match play, with a reduction of 0.1 s sprint time associated with an increase of $0.09 \text{ m}\cdot\text{min}^{-1}$ in HSR distance. Collectively, these results highlight the vast differences in match activity which may arise through a combination of playing position and fitness characteristics in youth soccer. The development of specific fitness qualities for certain positional roles is also supported by existing studies showing midfield positions to be characterised by superior aerobic capacity, and attackers to possess greater explosive speed and power (Deprez et al., 2014b). These findings could also be interpreted as support for early specialisation of playing position, especially considering both aerobic capacity and sprint speed are known to contribute to retention in elite soccer programs (Deprez et al., 2015). However, when these results are viewed in the context of talent

development, the early specialisation of playing position is not recommended, as it is likely that youth players will not retain physical characteristics throughout maturation (Vaeyens et al., 2008b). Indeed, if physical characteristics have been used to guide young players towards playing positions, early specialisation may foster the development of unidimensional performance profiles, making future position relocation difficult. The findings of the present study therefore contribute new evidence to highlight the significant role of position selection in the development of young players. Position specialisation should be delayed to maximise the development opportunities provided to youth soccer players, particularly at a recreational level.

The current analysis also revealed differences in technical match activity between positions, with midfielders associated with more involvements during match-play. Moderate reductions in involvements were attributed to both central defensive (-27.3%) and attacking positions (-25.4%), while small reductions in involvements were observed in fullback positions (-21.8%). These findings agree with existing literature in professional soccer match-play (Bloomfield, Polman, & O'Donoghue, 2007), and are also likely to result from the tactical constraints of each playing position. For example, midfielders engage in both offensive and defensive situations in all areas of the pitch, whereas territorial advantage often dictates the magnitude of involvement for both attackers and central defenders. Accordingly, as young players with advanced technical ability are more often selected into midfield positions (Deprez et al., 2014b), less skilled players may find it difficult to catch up, receiving fewer learning opportunities and skill exposure during match-play. It may also be expected that midfield positions would benefit from ball possession as a direct result of superior fitness or work rate, as aerobic capacity has been reported to increase ball possessions during soccer match-play

(Helgerud et al., 2001). These findings are supported in the present study, with TD associated with moderate increases in skill involvements. Collectively, these observations demonstrate the influence of both playing position and work rate on match involvement in recreational youth soccer, highlighting the potential for physical characteristics to confound this measure of match performance. Furthermore, whilst only small to moderate effect sizes were reported between positions, these differences still have important implications for long-term development, based on the cumulative effect of more (or less) involvement throughout one or more seasons of position specialisation. The selection of young players into specific playing positions may therefore limit developmental opportunities in recreational youth soccer players and should be carefully considered.

Whilst the present findings have important implications for coaches to better understand talent development in youth soccer, there are some limitations. Firstly, only the absolute number of skill involvements was recorded during match-play, with no further analysis of the nature or quality of involvement. It could be expected that different playing positions experience a range of position-specific skills (Mohr et al., 2003), while a measure of successful ball retentions may be able to discriminate between players of different playing standards (Waldron & Murphy, 2013). A detailed analysis of skill involvements may therefore provide a more suitable performance measure and elaborate on the positional differences in technical match activity. Despite this, the present study used total involvements to reflect the magnitude of skill learning opportunities received by each player during match-play. Secondly, as physical fitness characteristics were measured prior to the season, they may not reflect acute changes in fitness which are likely to follow maturation in an adolescent cohort. Finally, match results may also provide important contextual information to better understand the factors affecting

match activity profiles. It is also important to note that the present findings are specific to this particular cohort and provide a cross-sectional analysis of a school-based, recreational youth soccer program. It is suggested that future research should examine a longitudinal, multidimensional approach to talent development across a range of age groups and playing levels to further investigate talent development in youth soccer. Despite these limitations, the findings from this study have important implications for coaches to better understand the factors affecting talent development in recreational youth soccer.

To our knowledge, this is the first study to investigate the independent effects of playing position and individual player characteristics on physical and technical match activity in a recreational, school-based youth soccer cohort. Playing level, playing position, and individual characteristics were all shown to influence physical and technical match activity, contributing new evidence to understand the complex interaction of factors influencing talent development in youth soccer. Indeed, if players are guided towards specific positions at a young age, the opportunities provided to develop a range of physical and technical skills may be restricted. The selection process in youth soccer often guides young players towards suitable positions based on individual characteristics, with midfielders reported to possess superior technical ability and aerobic fitness (Deprez et al., 2014b). The findings of the present study suggest that enhanced developmental opportunities will be provided to such players, accentuating any physical or technical differences between these individuals and their counterparts. Accordingly, it is recommended that youth soccer players are afforded the opportunity to sample playing in a variety of positions and tactical roles to not limit their football development. This is especially important during early development pathways, such as recreational programs, where a diverse learning environment exposes young athletes to

a range of physical and cognitive experiences, maximising enjoyment and intrinsic motivation towards sport (Côté et al., 2009). Lastly, a more holistic approach (e.g. evaluations of technical, tactical and perceptual-cognitive skills) should be used by coaches to evaluate performance in youth soccer, rather than unidimensional measures of physical or technical match activity which may be influenced by individual and contextual factors such as fitness and playing position.

6 STUDY FOUR

Lovell, T.W.J., Fransen, J., Bocking, C.J. & Coutts, A.J. (*under review*). Factors influencing retention and development trajectories in a school-based youth soccer program.

ABSTRACT

The present study employed a two-year cohort-longitudinal design to determine the factors influencing retention in a school-based soccer program, and the subsequent development trajectories of players retained in the program. One hundred and seventy-two adolescent soccer players (aged 10-16 y) across five age groups were invited to participate in the study at baseline. Anthropometry, maturity, physical capacity, motor competence and technical ability were assessed prior to the start of three consecutive seasons. Team coaches divided players into three playing levels within each age group (Team 1, Team 2 and Team 3). Crosstabs revealed a strong association between player retention and baseline playing level, with 61%, 21% and 18% of retained players originating from Team 1, Team 2 and Team 3 respectively ($\chi^2=36.453$, $p<0.001$). Multivariate analysis of covariance revealed large differences between retained and dropout players for a range of anthropometry, physical capacity, motor competence and technical ability when adjusted for chronological age ($F=5.883$, $p<0.001$, $\eta^2=0.28$). Repeated measures analysis observed age-related changes in two age cohorts, revealing junior players to develop motor competence at a faster rate than their senior counterparts. While the present findings suggest the school-based sports program could be valuable in developing some performance characteristics, the program did not seem to benefit aerobic fitness, or the long-term retention of motor competence. Furthermore, successful participation was shown to be important for program adherence in youth athletes, with players initially selected into lower playing levels more likely to drop out of the program before the end of the two-year period.

INTRODUCTION

An important goal for school-based sports programs is to provide all children with adequate opportunities for successful engagement in physical activity. Indeed, as children often receive their first sporting experience in a schooling environment, it is hoped that this early engagement provides the first step towards a lifelong affinity with sport and physical activity. Additionally, many school sports programs also aim to develop sporting excellence, with the tangible success of a sports program often more related to the school's ability to produce good athletes within specific sporting disciplines. While lifelong sports engagement and the pursuit of elite performance seem to be conflicting goals, they are not mutually exclusive, as prolonged sports engagement increases the likelihood for young athletes to invest time and develop skill proficiency which could ultimately lead to expertise (Ericsson et al., 1993). However, as the transition through adolescence is characterised by high rates of sports disengagement (Fraser-Thomas et al., 2008), the likelihood of long-term sport engagement is reduced. Therefore, for school-based sports programs to be successful, they should aim to reduce dropout and maximise each student's potential for long-term sports engagement. To the authors' knowledge, no previous research has investigated dropout and successful sports engagement within a school context.

While sports participation is important for a range of health outcomes, it is also critical for the development of motor competence in youth populations (Fransen et al., 2012). Motor competence is strongly related to both physical activity (Okely et al., 2001) and physical fitness in adolescents (Stodden et al., 2009), and plays an important role in both long-term physical activity engagement (Stodden et al., 2008) and the attainment of sporting excellence (Vandorpe et al., 2011b). For example, Deprez et al. (2015)

reported motor competence to improve the likelihood of young players being retained in a high-level soccer program. Conversely, children with poor motor competence may continue to decrease participation in physical activity over time, resulting in a further impairment of physical fitness levels (Stodden et al., 2008). Accordingly, the development of motor competence is an important consideration for school-based sports programs that aim to both improve sports engagement and develop excellence. Similarly, the development of physical attributes also appears to be of importance for progression youth soccer players. Figueiredo et al. (2009) demonstrated that players who moved up to the elite level in a soccer program were chronologically older, larger in body size, and performed better in functional performance and skill tests. Collectively, these studies demonstrate that the factors contributing to sustained engagement and talent development in youth programs are multifactorial. Therefore, similar protocols could be applied to better understand how motor competence and physical attributes are developed within the unique constraints of school-based sports programs.

Physical attributes are reported a peak in youth soccer players around the time of the adolescent growth spurt (Philippaerts, Vaeyens, Janssens, Van Renterghem, Matthys, Craen, Bourgois, Vrijens, Beunen, & Malina, 2006). However, changes in growth and performance are highly individualised and may also be influenced by the nature and volume of specific training (Philippaerts et al., 2006). Sports coaches therefore strive to provide young athletes with an optimal learning environment to maximise the development of the physical attributes and skills required for elite performance (Williams & Reilly, 2000). While the definition of an ideal environment remains unclear (Burgess & Naughton, 2010), the DMSP provides a viable developmental

model that can be applied across a broad range of sports and contexts (Côté et al., 2009). The DMSP argues the importance of sampling multiple sports prior to specialising or investing in one single sport. This approach provides young athletes with a well-rounded development aimed at improving motor competence and increasing the likelihood of long-term sports engagement. However, despite the recent popularity of the DMSP (Côté et al., 2009), the extent to which youth sport programs such as schools or academies have adopted such development frameworks is relatively unknown. Furthermore, few previous studies have used a longitudinal approach to describe development trajectories in youth sport, particularly at a school level, where all children are first exposed to development pathways.

Therefore, to investigate the potential for the DMSP as a theoretical framework for youth athlete development in schools, an improved understanding of school-based programs is essential. Accordingly, the aims of the present study are two-fold: 1) to investigate the determinants of player retention in a school-based sports program, and 2) to map the age-related development trajectories of young soccer players retained in the program for a range of fitness and motor competence characteristics.

METHODS

Participants & Study Design

The present study involved a two-year longitudinal design to describe retention and developmental trajectories in a cohort of adolescent soccer players participating in a school-based soccer program across three consecutive seasons. The soccer program formed part of a school sports academy which competed annually against five other

schools over a 10-match competition period, providing all students with the opportunity to compete across a range of competitive playing levels. At the time of baseline measurement, 172 adolescent soccer players (aged 10-16 y) were invited to participate in the study. All participants engaged in the school-based soccer program and competed within one of the school's five age-based cohorts (Year 6; 10-11 y; N=30, Year 7; 11-12 y; N=33, Year 8; 12-13 y; N=34, Year 9; 13-14 y; N=40, Year 10; 14-16 y; N=35). These players possessed the following characteristics at baseline: age: 14.1 \pm 1.5 y; stature: 165.1 \pm 11.7 cm; body mass: 53.9 \pm 12.3 kg.

At baseline, participants were selected by team coaches into playing levels within each age-group (Team 1; N=56, Team 2; N=62, and Team 3; N=54), whereby players who were deemed talented were included in the highest playing level (Team 1), while those not selected were encouraged to continue participation in lower level teams (Team 2 and Team 3). Each participant's anthropometry, maturity, physical capacity, motor competence and technical ability was assessed prior to each season. A total of 62 players were retained in the program for all three seasons. Dropout occurred when athletes chose to participate in a different sport. For the purpose of analysis, retained participants were divided into junior (Year 6 – Year 8; 10-13 y; N=45) and senior (Year 9 – Year 10; 13-16 y; N=17) cohorts. Retention rates for junior and senior cohorts were 46% (45 of 97) and 23% (17 of 75) respectively. The subdivision into age-based cohorts allows for a mixed longitudinal assessment of players' developmental trajectories with the junior cohort approximately two years younger than the senior cohort at baseline.

Ethical approval was granted by the UTS Human Research Ethics Committee (UTSHREC: 2012000199) and a written consent form was obtained from the parent/guardian of each participant prior to the commencement of this study.

Procedures

Anthropometry

Stature and sitting height were recorded to the nearest millimetre using a wall-mounted stadiometer following the guidelines of Lohman et al. (1988). Leg length was estimated by subtracting sitting height from stature. Body mass was measured by means of electrical scales (Universal Weight Enterprise, Taiwan). Somatic maturity was estimated by means of a gender-specific regression equation to predict maturity offset, using measures of stature, body mass and leg length measurements (Mirwald et al., 2002). Estimated age at peak height velocity (APHV) was then derived by subtracting estimated maturity offset from chronological age, to provide an estimation of an individual's maturity within a given age group. The limitations of this method are acknowledged, with a reported error of one year 95% of the time (Mirwald et al., 2002).

Physical Capacity

Sprint performance was assessed with a linear 30-m sprint, with the fastest of three sprint trials retained as the final result. A test-retest reliability study in 19 youth athletes reported a coefficient of variation (CV) of 1.4% for two 30-m sprints measured with timing gates (Waldron et al., 2011). The sprint was measured with photo cell timing lights (0.01 s) (Swift Performance Equipment, Australia), with a starting distance 0.5 m behind the triggering photo cell. Explosive leg power was assessed using a standing broad jump, measured to the nearest centimetre using a tape measure, with typical error for this test previously reported as 6.3% in a European school-based cohort of 58 children and 80 adolescents (España-Romero et al., 2010). The sit and reach test was used to assess flexibility, specifically the lower back and hamstring muscles (Castro-

Pinero et al., 2009), with a CV for this test previously reported as 8.74% in young adults (Ayala et al., 2012). Aerobic fitness was assessed using the Yo-Yo Intermittent Recovery Test Level 1 (YYIR1) according to the methods of Bangsbo et al. (2008). Recently, a test-retest reliability study reported CVs of 17.3, 16.7 and 7.9% in U13 (N=35), U15 (N=32) and U17 (N=11) non-elite youth soccer players respectively, showing adequate to high reproducibility of the YYIR1 (Deprez et al., 2014a). All testing was conducted at an indoor sporting complex on multi-purpose, synthetic flooring.

Motor Competence

Motor competence was assessed using the Körperkoordinationstest für Kinder (KTK) (Kiphard & Schilling, 2007). Three items in the battery were used in this study according to the methods of Novak et al. (2016): jumping sideways across a wooden slat, moving sideways on boxes, and walking backwards on balance beams (Figure 3.1). An intra-class correlation (ICC) of 0.97 was reported (Kiphard & Schilling, 2007). Raw test scores were transformed into motor quotients (MQ), which represent an age and gender-specific score according to reference values from a cohort of 1228 normally developing German children in 1974 (Kiphard & Schilling, 1974). More recently, reference values for the KTK have been reported in a cohort of 2470 school children aged 6-12 years (Vandorpe et al., 2011a).

Technical Ability

The UGent Dribble Test was used to measure technical ability according to the methods of Vandendriessche et al. (2012). The test requires participants to complete the short course as fast as possible, maintaining control of a soccer ball whilst changing direction

around eight cones in a particular sequence (Figure 4.3). An ICC of 0.81 indicated high inter-trial reliability for dribble times (Vandendriessche et al., 2012).

Statistical Analyses

Descriptive statistics were computed and cross tabs (χ^2) were used to investigate the association between playing level and retention in the soccer program. Multivariate analysis of covariance (MANCOVA) was used to observe differences in anthropometry, maturation, physical capacity, motor competence and technical ability (dependent variables) between players who were retained or dropped out of the soccer program (between-subjects factor). Chronological age was used as a covariate. Subsequent repeated measures multivariate analyses of variance (separate analyses with anthropometry, physical capacity, motor competence and technical ability as dependent variables) were used to examine changes in the dependent variables over time. The three repeated measurements were entered as within-subject factors, while the age group at baseline (junior or senior) was entered as a between-subjects factor in each analysis. Chronological age was not entered as a covariate due to the interest in age-related changes in the dependent variables. For all multivariate analyses, partial eta squared effect sizes (η^2) were used to analyse the magnitude of effects using cut-off scores set as small (0.01), moderate (0.06) and large (0.14) effects (Cohen, 1992). All statistical analyses were conducted using the SPSS statistical software package (Version 23). The criterion alpha level for significance was set at $p < 0.05$. All data are presented as means \pm standard deviation (SD) unless stated otherwise.

RESULTS

Crosstabs revealed a strong association between player retention and the playing level at baseline, with 61%, 21% and 18% of retained players coming from Team 1, Team 2 and Team 3 respectively. In contrast, of the 110 participants not retained in the program, 16%, 45% and 39% were from Team 1, Team 2 and Team 3 respectively ($\chi^2=36.453$, $p<0.001$).

Multivariate analysis of covariance showed large differences between players retained in the soccer program compared with dropouts for a range of anthropometry, physical capacity, motor competence and technical ability when adjusted for chronological age ($F=5.883$, $p<0.001$, $\eta^2=0.28$; Table 6.1). Univariate analysis revealed large differences between groups for technical ability ($\eta^2=0.23$, $p<0.001$), in addition to moderate differences in sprint performance ($\eta^2=0.07$, $p=0.001$) and aerobic fitness ($\eta^2=0.07$, $p=0.001$), and small differences in explosive leg power ($\eta^2=0.05$, $p=0.008$) and motor competence ($\eta^2=0.03$, $p=0.046$).

Table 6.1 Differences in anthropometry, physical capacity, technical ability and motor competence between retained and dropout players.

	Retention		Covariate	MANCOVA	
	Retained	Dropout	Age	η^2	F
	<i>N</i> =62	<i>N</i> =110			
Chronological Age (y)	13.8 ±1.3	14.2 ±1.5	-	-	-
Maturity Offset (y)	-0.1 ±1.3	0.2 ±1.5	-	0.00	0.067
Anthropometry					
Stature (cm)	162.7 ±10.0	165.6 ±12.9	**	0.00	0.612
Body Mass (kg)	51.7 ±11.1	53.8 ±12.2	**	0.00	0.092
Physical Capacity					
Sit and Reach (cm)	1.8 ±7.5	0.7 ±7.2	*	0.01	1.254
Standing Broad Jump (cm)	200 ±30	192 ±29	**	0.05	7.178 *
30 m Sprint (s)	4.82 ±0.39	4.94 ±0.38	**	0.07	11.099 *
YYIR1 (m)	1279 ±482	1084 ±488	**	0.07	11.289 *
Technical Ability					
Dribble Test (s)	24.2 ±3.6	28.3 ±4.2	*	0.23	42.804 **
Motor Competence					
KTK (MQ)	103.9 ±14.0	99.0 ±15.0		0.03	4.064 *

Data are means ± standard deviations; * = $p < 0.05$; ** = $p < 0.001$

YYIR1; Yo-Yo Intermittent Recovery Test Level 1, KTK; Körperkoordinationstest für Kinder, MQ; motor quotient

Repeated measures of anthropometry, physical capacity, motor competence and technical ability relative to player age at baseline are presented in Table 6.2, using means \pm standard deviations, F-values, *p*-values and effect sizes. A repeated measures MANOVA revealed a significant multivariate time*age cohort interaction ($F=14.299$, $p<0.001$, $\eta^2=0.27$) and a significant main effect of time ($F=77.690$, $p<0.001$, $\eta^2=0.67$) and age cohort ($F=71.032$, $p<0.001$, $\eta^2=0.55$) on anthropometrical assessments. Subsequent univariate analysis demonstrated a significant time*age cohort interaction for stature ($F=43.302$, $p<0.001$, $\eta^2=0.42$), body mass ($F=14.057$, $p<0.001$, $\eta^2=0.19$) and estimated maturity offset ($F=6.735$, $p=0.002$, $\eta^2=0.10$). Visual interpretation of these interaction effects revealed anthropometric changes to be more pronounced in younger players compared with the older cohort (Figure 6.1a, 6.1b). Additionally, the univariate main effects of time and age cohort revealed that stature, body mass and estimated maturity offset increased significantly over time and the senior age cohort were characterised by advanced stature, body mass and maturity compared with the junior age cohort.

A second repeated measures MANOVA demonstrated a significant multivariate time*age cohort interaction ($F=2.757$, $p=0.019$, $\eta^2=0.41$) and a significant main effect of time ($F=16.698$, $p<0.001$, $\eta^2=0.81$) and age cohort ($F=6.521$, $p<0.001$, $\eta^2=0.42$) on measures of physical fitness. Univariate analysis showed a significant time*age cohort interaction for sprint performance ($F=3.635$, $p=0.031$, $\eta^2=0.09$) and explosive leg power ($F=3.439$, $p=0.037$, $\eta^2=0.08$). Visual interpretation of these interaction effects revealed that improvements in sprint performance were gradual throughout the three measurements in the senior cohort, while there appeared to be no change between baseline and measurement two in the junior cohort (Figure 1c). A similar trend was found for explosive leg power (Figure 6.1d). The univariate main effects of time and

age cohort revealed explosive leg power and sprint performance to generally improve over time, while aerobic fitness (Figure 6.1e) and flexibility (Figure 6.1f) showed no time effect (Figure 6.1e). The senior cohort possessed more advanced physical fitness and flexibility than the junior cohort throughout.

Finally, two repeated measures ANOVAs revealed a significant time*age cohort interaction effect on motor competence ($F=10.522$, $p<0.001$, $\eta^2=0.30$) but not on technical ability assessed by dribbling performance ($F=0.017$, $p=0.983$, $\eta^2<0.001$). Specifically, motor competence scores improved over time in the junior cohort but plateaued in the senior cohort (Figure 6.1g). Main effects of time ($F=9.106$, $p<0.001$, $\eta^2=0.271$) and age cohort ($F=4.985$, $p=0.030$, $\eta^2=0.09$) were observed for technical ability, but not for motor competence. Technical ability improved over time in both cohorts and the senior cohort had faster dribbling times than the junior cohort (Figure 6.1h).

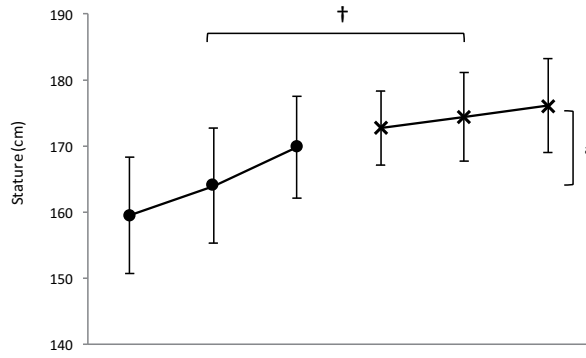
Table 6.2 Repeated measures for anthropometry, physical capacity, technical ability and motor competence across three testing periods in junior and senior cohorts.

	Junior			Senior			Between-Subjects		Time		Interaction	
	Baseline	Year 1	Year 2	Baseline	Year 1	Year 2	η^2	F	η^2	F	η^2	F
	<i>N=45</i>	<i>N=45</i>	<i>N=45</i>	<i>N=17</i>	<i>N=17</i>	<i>N=17</i>						
Maturity Offset (y)	-0.7 ±0.9	-0.1 ±0.7	0.8 ±1.0	1.6 ±0.7	2.1 ±0.6	2.8 ±0.6	0.55	71.032 **	0.90	508.302 **	0.13	8.488 *
Anthropometry												
Stature (cm)	159.5 ±8.8	164.0 ±8.7	169.8 ±7.7	172.7 ±5.6	174.4 ±6.7	176.1 ±7.1	0.24	19.061 **	0.77	194.569 **	0.46	50.672 **
Body Mass (kg)	47.7 ±8.3	51.5 ±9.0	57.5 ±9.3	64.7 ±12.6	65.6 ±11.2	70.3 ±11.8	0.32	27.398 **	0.80	242.340 **	0.24	18.483 **
Physical Capacity												
Sit and Reach (cm)	0.4 ±6.7	-0.7 ±7.6	-1.1 ±7.3	4.9 ±8.1	5.8 ±8.3	4.4 ±9.5	0.11	4.894 *	0.05	1.941	0.01	0.398
Standing Broad Jump (cm)	191 ±32	184 ±23	201 ±27	215 ±19	222 ±19	234 ±18	0.29	15.709 **	0.39	25.344 **	0.05	2.059
30 m Sprint (s)	5.03 ±0.39	5.06 ±0.38	4.82 ±0.39	4.54 ±0.20	4.42 ±0.14	4.30 ±0.11	0.40	25.981 **	0.53	44.336 **	0.00	0.088
YYIR1 (m)	1129 ±462	1089 ±399	927 ±758	1612 ±488	1883 ±389	1425 ±532	0.29	15.528 **	0.09	3.616	0.00	0.005
Technical Ability												
Dribble Test (s)	24.8 ±3.8	23.0 ±2.9	23.6 ±3.2	22.8 ±3.1	21.1 ±2.1	21.8 ±3.1	0.09	4.985 *	0.14	8.390 *	0.00	0.035
Motor Competence												
KTK (MQ)	103.0 ±14.3	106.1 ±13.2	113.4 ±11.6	109.2 ±12.5	103.7 ±10.6	102.8 ±14.1	0.01	0.418	0.02	1.252	0.30	21.387 **

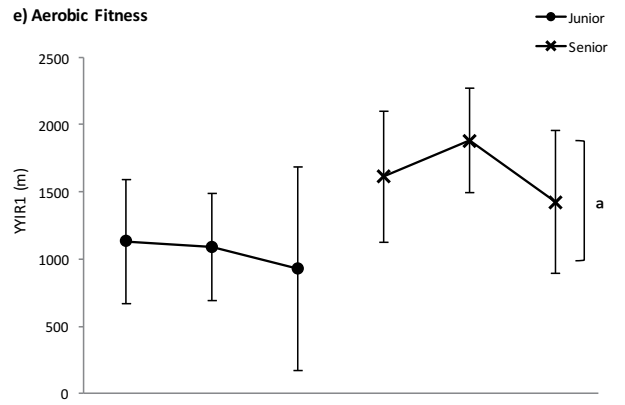
Data are means ± standard deviations; * = $p < 0.05$; ** = $p < 0.001$

YYIR1; Yo-Yo Intermittent Recovery Test Level 1, KTK; Körperkoordinationstest für Kinder, MQ; motor quotient

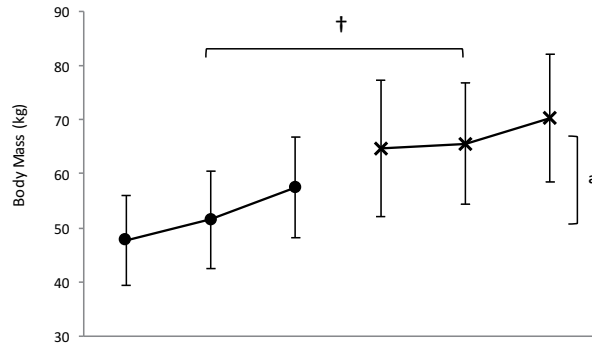
a) Stature **



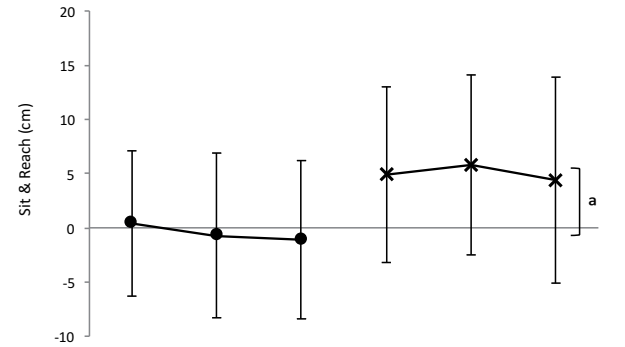
e) Aerobic Fitness



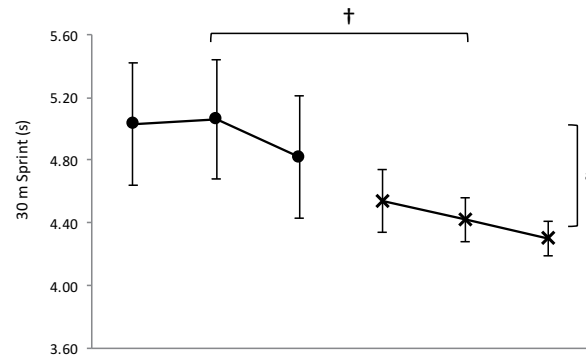
b) Body Mass **



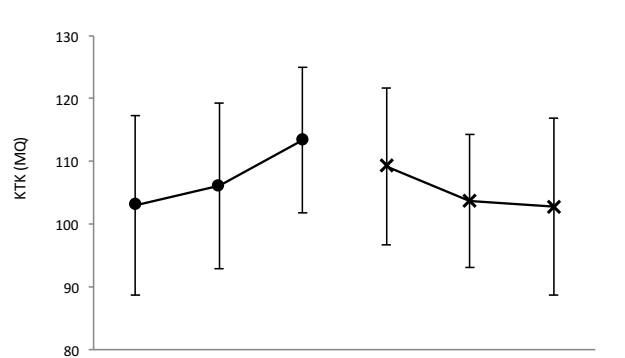
f) Flexibility



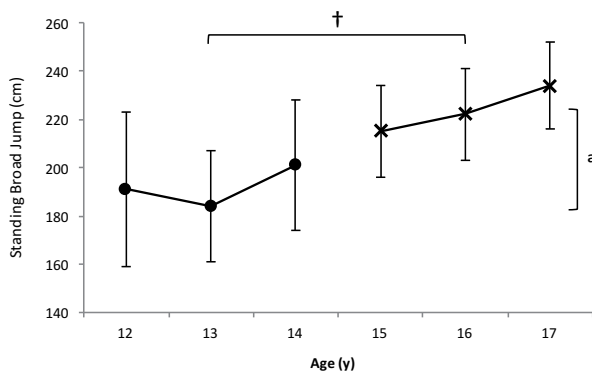
c) Sprint Performance



g) Motor Competence **



d) Explosive Leg Power



h) Technical Ability

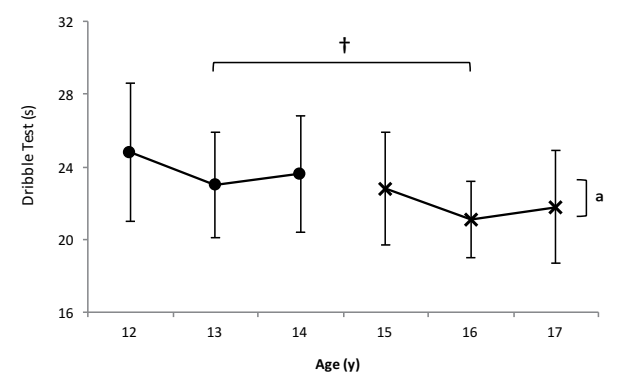


Figure 6.1 Age-related development trajectories of a) stature, b) body mass, c) sprint performance, d) explosive leg power, e) aerobic fitness, f) flexibility, g) motor competence and h) technical ability in youth soccer players. YYIR1; Yo-Yo Intermittent Recovery Test Level 1, KTK; Körperkoordinationstest für Kinder, MQ; motor quotient, **; Interaction effect ($p < 0.001$), †; Time effect, a; Between-subjects effect.

DISCUSSION

The purpose of the present study was to employ a two-year longitudinal design to describe the factors influencing retention and dropout in a school-based soccer program. The second aim was to analyse the developmental trajectories of anthropometry, physical fitness, motor competence and technical ability in adolescent soccer players from a junior and senior cohort retained in the soccer program. The main findings of this study indicate that players initially selected into lower playing levels were more likely to drop out of the program before the end of the two-year period. Additionally, for those players retained in the program, junior players developed motor competence at a faster rate than their senior counterparts. It appears as though adolescents in the senior cohort experienced a plateau, or even a regression in motor competence at around 15 years of age.

Attaining excellence within a sporting discipline requires a combination of both natural abilities and performance characteristics that are unique to the requirements of each sport (Ericsson et al., 1993). Accordingly, prolonged sports engagement is essential to allow young athletes to invest time and accumulate the skills necessary for sporting

excellence (Ericsson et al., 1993). However, throughout adolescence, when young athletes are driven to invest more time in their chosen sport, dropout is inevitable (Côté et al., 2009). In the present school-based soccer cohort, only 62 of the 172 participants at baseline were retained in the program until the conclusion of the study. The present study also revealed that young soccer players who were selected into the highest playing level in this study were more likely to persist in the sport, with 68% of players selected into Team 1 at baseline remaining in the sport throughout the two-year period. In contrast, only 21% of both Team 2 and Team 3 players were retained in the program, while 79% dropped out to participate in other sports. While the exact cause of dropout is not clear, these findings suggest the importance of successful sports involvement for long-term sports engagement. It is certainly questionable whether children and adolescents who disengage from their sport of choice are provided with adequate opportunities to participate at lower levels or develop talent in other sporting domains. While the magnitude of dropout shown in the present cohort appears substantial, it is likely that the school-based sports program has accommodated a transition for these athletes towards participation in other sports. Regardless, these findings highlight the importance of sampling a variety of sports throughout childhood to protect against complete disengagement from sport and physical activity. This is supported by Côté et al. (2009), who argues that sampling a variety of sports at a young age allows youths who drop out of their primary sport to transition into other sports. Indeed, the school environment may be the ideal sampling environment, as a wide variety of sports may be accessed by students prior to the investment years (15+ years), where highly specialised practice becomes a prerequisite for domain-specific excellence (Côté et al., 2009).

While retained players were more likely to have experienced successful sports performance, they also possessed superior performance capabilities. Players retained in the soccer program were shown to possess higher levels of physical fitness (e.g. YYIR1: 1279 ± 482 m vs. 1084 ± 488 m; 30 m sprint: 4.82 ± 0.39 s vs. 4.94 ± 0.38 s), technical ability (dribble test: 24.2 ± 3.6 s vs. 28.3 ± 4.2 s) and motor competence (KTK: 103.9 ± 14.0 vs. 99.0 ± 15.0), compared with those who dropped out. These findings agree with Deprez et al. (2015), who demonstrated the importance of motor competence and sprint speed for preventing dropout from a high-level soccer program. Similarly, young soccer players who progress to an elite level have been shown to perform better in a range of functional performance and skill tests (Figueiredo et al., 2009; Vaeyens et al., 2006). As physical and technical ability are essential for elite sports performance, the present findings are unsurprising. However, it is possible that young players who do not possess advanced athletic ability may be dropping out of sport, even though these characteristics may later develop with growth, maturation and training. This may be exacerbated by coaches who choose to deselect children who are less physically developed than their peers. Regardless, deselected athletes are more likely to miss out on opportunities to develop sports performance, causing them to fall behind and decrease their chances of future selection (Helsen et al., 1998b). As talent identification in youth sport is exclusive by nature, reducing systematic dropout is essential to maximise engagement and long-term participation in youth sport. Indeed, this may require coaches to adopt a mindset of long-term development, ignoring physical qualities which may enhance current performance, but not necessarily reflect future potential (Burgess & Naughton, 2010).

Finally, over the two-year time span of this study, a range of functional performance characteristics was tracked in retained players for both junior and senior cohorts across the three assessment periods. As expected, the senior cohort displayed advanced anthropometry, physical fitness and technical ability characteristics when compared with their junior counterparts. Repeated measures also demonstrated the temporal advancement of stature and body mass, along with improvements in explosive leg power, sprint performance and technical ability. While these capacities seemed to increase in both age groups, interaction effects indicated a more rapid development of anthropometry and motor competence in the junior cohort. As the three testing periods spanned APHV in the junior cohort (maturity offset: -1, 0 and +1 years at each testing point respectively), these findings partly support Philippaerts et al. (2006), who reported an accelerated development of functional performance characteristics to align with the APHV in youth soccer players. While these findings suggest schools may be valuable in developing a range of performance characteristics, further results revealed that the present school-based sports program did not seem to benefit aerobic fitness, or the long-term retention of motor competence. Indeed, motor competence was shown to plateau, or even regress in the senior cohort. As adequate motor competence augments both adherence in sporting programs and the pursuit of excellence, schools need to ensure that ample opportunities are provided to develop and retain this attribute. Fransen et al. (2012) suggested a diverse, playful sporting environment at a young age is important in developing motor competence, emphasising the long-term benefits of a sampling approach. This recommendation aligns with the DMSP, which highlights the importance of sampling sports prior to the specialisation years to maximise the development of motor competence in youth athletes (Côté et al., 2009). Accordingly, while the present school-based sports program seemed to promote the development of

some physical capacities and soccer specific skill, efforts should be made to maximise opportunities for sport sampling, encouraging the development and retention of motor competence throughout adolescence.

The present study has its limitations. Firstly, a mixed longitudinal design was employed, rather than purely longitudinal, which somewhat limits the interpretability of the results. Additionally, the present study did not undertake follow-up tracking of dropped out participants. A follow-up of drop outs would provide an insight into the different sports these participants chose to pursue and the development trajectories for those not retained in the soccer program. Despite these limitations, the present study provides a new insight into the factors influencing retention and development trajectories in a school context, which have important implications for school-based sports and talent development programs alike.

In summary, the present findings highlighted the importance of successful sports participation for reducing the likelihood of dropout in youth sport. Additionally, levels of fitness, technical ability and motor competence were shown to improve retention in the present school-based soccer program. While dropout from youth sport during adolescence may be inevitable for some who do not experience early success, it is important that both gifted and less gifted players benefit from a sampling stage, albeit for different reasons. Gifted children are provided with an all-round physical and psychological development that minimises the risk of injury and burnout, while less gifted children may be exposed to different sports, which facilitates the transfer between sports throughout their athletic careers (Côté et al., 2009). Furthermore, while most fitness characteristics were shown to improve throughout the study, adolescents in the senior cohort experienced a plateau, or even a regression in motor competence at around

15 years of age. These findings suggest that efforts should be made in school-based sports programs to maximise opportunities for sport sampling and subsequent retention of motor competence throughout adolescence. Indeed, the DMSP may be an ideal framework for school-based sports programs, as it promotes the sampling of sports before the specialisation years, catering for both the development of excellence and sport for all.

7 DISCUSSION

7.1 MAIN FINDINGS

School-based sports programs provide children and adolescents with important opportunities to engage in sport from a young age. These early experiences are particularly important to promote a lifelong affinity with sport, while also providing early exposure to talent development pathways. However, the ability for school-based programs to provide suitable development opportunities to young athletes has not been investigated. Therefore, a series of studies were conducted to investigate the factors influencing sports involvement and talent development in a school-based sports program. The main findings of the studies were threefold, and are discussed below.

School-based sports programs are an ideal environment for sampling different sports

The sampling pathway outlined in the DMSP is viewed as the most appropriate framework for early sport participation in youth athletes (Côté et al., 2007). Despite the recent popularity of the DMSP (Côté et al., 2009), the extent to which schools have adopted such development programs is unknown. Furthermore, the suitability of a school environment to encourage a sampling approach had not previously been investigated. However, the findings of Study 1 provide new evidence to suggest that school-based programs may in fact be the ideal setting for this approach. After assessing the anthropometrical, physical and coordination related characteristics of young athletes aged 10-12 years, Study 1 revealed no differences between groups of participants from a range of sports. These findings are in direct contrast to those of Pion et al. (2015), who successfully classified 96.4% of elite adolescent participants into nine different sports

with a series of similar measurements. Indeed, the vast difference in playing standards between the two cohorts may explain the different findings, with Pion et al. (2015) observing athletes approaching late adolescence (post age at peak height velocity) and engaged in elite level training. In contrast, it appears as though the inclusive nature of the present school-based sports program resulted in a primarily homogenous cohort, with a range of playing levels accommodated within each sport. Although Study 1 also reported performance profiles to become more heterogeneous with increasing age, these young athletes had passed the suggested sampling years (6-12 y), where young athletes are encouraged to pursue a more specialised training environment.

The findings of Study 1 suggest that school-based sport programs provide a suitable setting to promote sport sampling throughout the early years. Indeed, the similarity in anthropometrical, physical and motor competence profiles exhibited in the present cohort allows young people to sample a variety of sports before entering the specialisation years. Additionally, Study 1 revealed participants who had attained representative level competition had started organised competition and competitive game play in their primary sport at a later age than their recreational counterparts. These findings provide further evidence to suggest sampling to be the most appropriate approach for youth development programs, with sports performance not reliant on early engagement or specialisation in a particular sport. The early diversification approach might well be an avenue to develop talent in gifted athletes through the schooling system, without ignoring the needs of the less-gifted. School-based programs have the ability to provide all children with opportunities for long-term athlete development, whilst challenging gifted youngsters to develop their talents through the promotion of involvement in a wide range of sports. A sport policy which strikes a balance between

recreational and elite programs may therefore assist with dropout prevention and promote long-term sports engagement through sampling a variety of sports and promoting high levels of sports participation. Furthermore, to achieve long-term sports engagement, school programs must embrace the recreational pathway, and promote a transition between sports for young athletes who are deselected or dropout of their primary sport.

Opportunities to develop talent are confounded by identification and selection processes in school-based sports programs

The primary aim for developmental programs, such as school-based sport, is to provide all children with opportunities for successful engagement in sport. However, the findings of the present studies suggest that the development opportunities provided to young players may be confounded by the talent identification and selection process. Coaches are tasked with guiding young athletes into a range of playing levels, and even playing positions within sports, which may subsequently influence, and potentially limit developmental opportunities. For example, in a longitudinal observation of youth soccer players, Study 4 revealed the playing level participants were selected into at baseline significantly influenced the likelihood of dropout. Specifically, 68% of players selected into the highest playing level (Team 1) were retained in the program, while only 21% of players in the lower playing levels (Team 2 and Team 3) were retained over the two-year period. Whilst it is likely the school environment has accommodated a transition for these athletes into other sports, it is unknown whether children and adolescents who dropout from their sport of choice were provided with adequate opportunities to participate at lower levels or develop talent in other sporting domains. Regardless, a history of sport sampling would certainly assist a transfer between sports for young

athletes who decide to drop out of their primary sport, rather than experience complete disengagement.

Further to these findings, the present studies revealed a range of factors, including physical- and coordination-related attributes, to influence the identification and selection of talent in the school's sports programs. Specifically, Study 2 revealed a combination of motor competence, technical ability and aerobic fitness to distinguish players of different playing levels, in addition to Study 1 observing enhanced fitness qualities in young athletes participating at a representative level compared with their recreational counterparts. As fitness, motor competence and technical ability are all important attributes for sporting performance (Deprez et al., 2015), these findings may be unsurprising. However, as the development of athletic talent is highly individualised and dependent on growth, maturation and training (Wiersma, 2000), coaches should not rely on fitness characteristics alone, which may negatively bias the selection process for youth athletes who experience late development. The findings of Study 2 revealed physical characteristics to also determine an individual's playing position within the soccer cohort, with the selection process seeming to reflect the physical characteristics required for performance at an elite level. Guiding young players towards specific positions based on these requirements may not be appropriate at a youth level, as physical attributes will not necessarily be retained throughout the maturational process and may have no bearing on future sports performance (Vaeyens et al., 2008b).

Whilst it is unclear whether these individual differences resulted from coach selections or training effects, a reliance on physical characteristics for selection in youth soccer may be detrimental to the development opportunities provided by training and match experience. This was confirmed by the findings of Study 3, which highlighted the

different match activity profiles for young players based on these situational factors. The findings of Study 3 revealed playing level, playing position and individual fitness characteristics to all influence both physical and technical match activity. For example, midfielders were involved in increased match running and skill involvements during match-play compared with all other playing positions. If players are guided towards specific positions at a young age, these findings suggest that the opportunities to develop a range of physical and technical skills may be restricted. It is recommended that players at lower levels of youth soccer be afforded the opportunity to sample playing in a variety of positions and tactical roles to not limit their football development. Accordingly, the sampling approach recommended for early sports participation is also relevant for task-specificity within a single sport, where developmental opportunities may be narrowed if position specialisation occurs at an early age.

School-based sports programs may not currently provide adequate opportunities for young athletes to develop fitness characteristics and retain motor competence throughout adolescence

A suitable sporting environment must be provided to young athletes to make successful sporting involvement possible. An optimal learning environment allows the development of motor competence and fitness characteristics, increasing the likelihood of long-term sports engagement, and even the progression through athletic development pathways. However, while Study 4 revealed most fitness characteristics to improve over the two-year longitudinal study design, participants were shown to experience a plateau, or even a regression in motor competence at around 15 years of age. Similarly, the

program did not seem to benefit the development of aerobic fitness. These findings suggest that the schooling environment may not provide sufficient exposure to improve or retain these particular qualities throughout adolescence. Therefore, efforts should be made in school-based sports programs to maximise opportunities for the development of motor competence throughout childhood and adolescence.

Developing motor skills throughout childhood and adolescence is crucial to promote physical activity engagement and sports participation in children, and to provide a foundation for the more complex skills required for sports performance (Rudd, Barnett, Farrow, Berry, Borkoles, & Polman, 2017). The school environment provides the ideal setting to improve and retain motor skills, with children and adolescents allowed to sample a variety of sports and participate in physical education (PE) classes on a regular basis. Interventions to improve motor skills should include all aspects of motor competence, promoting a wide range of locomotor (e.g. running and hopping), stability (e.g. balance) and object control skills (e.g. kicking and throwing) (Bardid, Lenoir, Huyben, De Martelaer, Seghers, Goodway, & Deconinck, 2017; Rudd et al., 2017). However, for the successful implementation of these PE programs, schools need to ensure teachers are appropriately supported in terms of resources, skills and environments (Morgan & Hansen, 2008). Furthermore, school-based sports programs should provide all children with opportunities to sample a variety of sports during the early years (Fransen et al., 2012), and allow lateral development trajectories throughout the specialisation stage, with sports transfer encouraged for those who dropout or are deselected from their primary sport.

7.2 LIMITATIONS

Despite the novel findings of this thesis, the present results are specific to this young male, school-based cohort. It is assumed that the findings are representative of other male, school-based populations, however, as the present studies are limited to a single cohort with a modest sample size, these findings may be unique to the current cohort. An increased sample size would improve the power of the present findings, however, both multidimensional and longitudinal study designs in a sporting context lend themselves to a reduced sample size with a high likelihood for missing data points and participant dropout. Consequently, the sample size of the present studies are comparable with similar studies published in the talent development domain (Elferink-Gemser et al., 2007; Opstoel et al., 2015; Pion et al., 2015; Vaeyens et al., 2006). Furthermore, the relatively short observation period in Study 4 (3 time points over 2 years) resulted in a mixed-longitudinal study design, rather than purely longitudinal, somewhat limiting the interpretability of the results. Given the practical difficulties in undertaking longitudinal, multidimensional research in the talent development domain, a multi-centre approach is suggested for future research.

Second, some methodological limitations in the present studies should be noted. All studies employed an indirect estimation of biological maturity, with estimated age at peak height velocity (APHV) derived through a series of anthropometrical measures according to the methods of Mirwald et al. (2002). The limitations of this method are acknowledged by the study's authors, with a reported error of 1 year 95% of the time (Mirwald et al., 2002). An individual's maturity status may also be estimated by using x-rays, assessment of secondary sex characteristics, or the parent's adult stature (Khamis & Roche, 1994; Malina et al., 2000; Tanner & Whitehouse, 1976), however

these methods entail ethical, practical, and financial issues which prevented them from being used in the present studies. Additionally, due to methodological constraints, not all potential predictors of talent were included in the study design. For example, whilst psychological factors such as resilience, motivation and perceived competence have previously been identified as important traits for sports success (Rees et al., 2016), these measures were not assessed in the present studies. Finally, the testing batteries employed in this thesis primarily assessed current performance through measures of an individual's physical- or coordination-related characteristics. Whilst these measures provided useful information to understand the talent identification and development process in the school's sports program, few outcome measures were assessed, preventing a thorough analysis of findings through observing career trajectories and development outcomes. It is suggested future research undertake longitudinal research to overcome this limitation.

Finally, the school sports program observed in the thesis did not allow the tracking of participants who dropped out of the study. For example, Study 4 aimed to observe the development trajectories of soccer players who were retained in the sport across a two-year period. Alongside this aim, it would have provided important context to understand the development trajectories of those players who dropped out of the soccer program, which sports they gravitated towards, and the success of their subsequent sports involvement. Despite these limitations, the multidimensional nature of the present studies provides a new and important insight into the factors which may influence sports participation and talent development opportunities in a school-based sports program. Most importantly, this thesis provides an important platform for future research to be conducted in a recreational youth population, such as school sporting programs.

7.3 PRACTICAL APPLICATIONS

The findings of this thesis have identified practical applications which may be applied by schools to maximise successful sports participation and talent development opportunities throughout childhood and adolescence. Specifically, a modified DMSP is proposed as a new framework for schools to maximise long-term sports engagement, reducing the risk of disengagement, promoting lifelong affinity with sport, and assisting with the pursuit of excellence.

The new sports participation framework consists of four key recommendations:

1. Invest in early sampling

All children should be afforded the opportunity to sample a diverse range of sports in the early years (6-12 y), mostly through high amounts of deliberate play. The intrinsically motivating experiences of the sampling years may help children become more self-determined and committed to future participation in sport (Côté et al., 2009), resulting in an increased motivation and willingness to engage in externally controlled activities such as deliberate practice, or simply a long-term involvement in recreational sport. A sampling stage provides children with a vast range of motor and cognitive experiences, developing a diverse performance profile which may be transferred between sports, protecting against sports disengagement. The sampling focus also remains relevant within individual sports, with a diverse set of physical and technical skills only allowed to be developed if role and/or position specialisation is delayed.

2. Promote the development and retention of motor competence

The development of motor competence is an important focus for youth sports programs, increasing the likelihood of young people to engage in sport and physical activity. Motor competence is also essential for the development of excellence, with young athletes more likely to progress and be retained in talent development pathways. The development of motor competence should be maximised through unstructured activities across a range of sports and environments throughout childhood. Schools should allow all children the opportunity to sample a variety of sports, while also implementing PE programs designed to promote a wide range of locomotor, stability and object control skills. Furthermore, the retention of motor competence should be a focus in development programs after the sampling years (12-18 y) to prevent the regression of this attribute.

3. Delay the focus on sport and task specificity

Providing children and young athletes with a range of motor and cognitive experiences is essential for the development of diverse performance profiles, assisting position relocation within a sport, or a future transfer between sports. Players should avoid specialisation within a specific sport from a young age, as the opportunities to develop a range of motor skills may be restricted. This is also applicable for task-specificity within a single sport, where developmental opportunities may be narrowed if position specialisation occurs at an early age. Young sport participants should be afforded the opportunity to develop a diverse set of skills through sampling a variety of activities, positions and tactical roles to not limit their development. As young athletes progress into the investment years (15-18

y), the specialisation of sport and task should be encouraged, allowing the development of specific skills which may be required for elite performance.

4. Allow for lateral development trajectories and fluidity in specialisation stage

When young athletes are inevitably deselected from talent development programs, or decide to discontinue the pursuit of elite performance, pathways should be provided to allow a transfer between sports or continue participation at a recreational level. Providing children with a sampling approach in the early years exposes them to a diverse range of skills which may assist with a future transition between sports. School-based sports programs are an ideal environment to allow fluidity in the specialisation stage, with the relative proximity between sports accommodating a simple transition.

The summation of these recommendations form a new framework proposed for sports participation in schools. The Developmental Model of School Sports Participation (DMSSP) is a framework adapted from the DMSP (Côté et al., 2007), with the primary aim of balancing the development of excellence with the promotion of lifelong sports engagement in school-based sports programs (Figure 7.1).

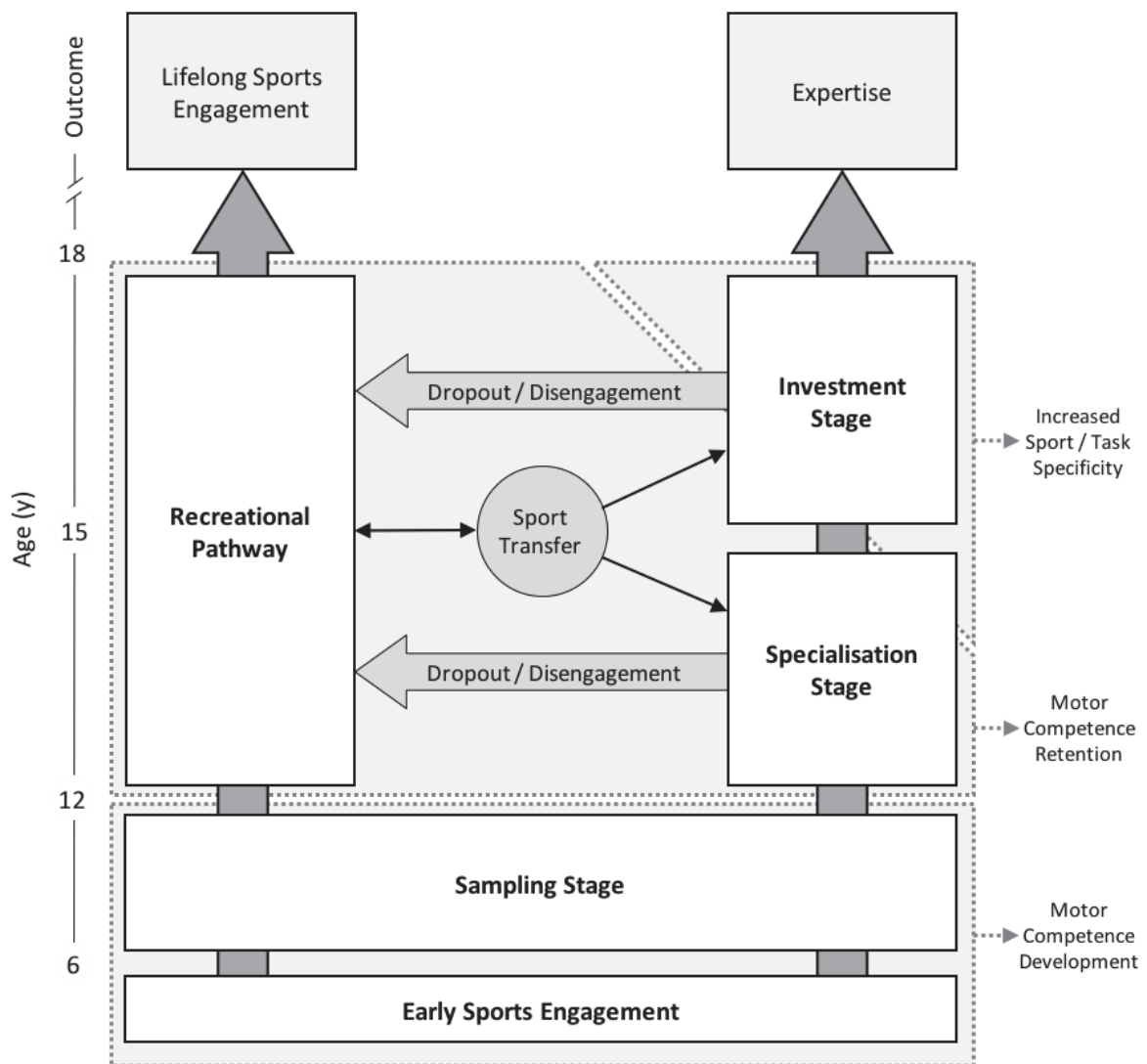


Figure 7.1 The proposed Developmental Model for School Sports Participation, adapted from Côté et al. (2007).

The proposed framework is adapted from the diverse, sampling pathway of the DMSP, which has been identified as a suitable approach to balance the objectives of school-based sports programs. Following early sports engagement, it is suggested that all children are guided into a sampling stage (6-12 y), involving high amounts of deliberate play and participation in several sports. These unstructured, play-like environments are necessary to promote the development of motor competence and increase intrinsic

motivation towards sport. It is important that both gifted and less gifted players benefit from a sampling stage, albeit for different reasons. Gifted children are provided with an all-round physical and psychological development that minimises the risk of injury and burnout, while less gifted children may be exposed to different sports, which facilitates the transfer between sports throughout their athletic careers (Côté et al., 2009).

Following the sampling stage, young people may choose to continue recreational participation or enter a specialising phase. The specialisation phase involves an increased performance focus with the introduction of deliberate play and a reduced involvement in several sports. Despite the specialisation focus, a balance of deliberate play remains an important component to ensure the retention of motor competence throughout this stage. At around 15 years of age, young athletes in the specialisation pathway may decide to continue the pursuit of elite performance in the investment stage (15-18 y), increasing the performance focus in a single sport. The investment stage involves high amounts of deliberate practice, increasing sport specificity, as well as specific roles or playing positions required for the development of elite performance. As young athletes are inevitably deselected from talent development programs, or decide to discontinue the pursuit of elite performance, the DMSSP highlights the importance of allowing lateral development trajectories in the specialisation stage. School-based sports programs should focus on accommodating transfer between sports or continued participation at a recreational level to prevent disengagement from sport throughout adolescence.

8 SUMMARY

8.1 THESIS SUMMARY

School-based sports programs are an important stage in the early sporting experiences of children and young athletes. The success of these programs relies on ability of the school to balance the promotion of long-term engagement with opportunities to develop talent in the pursuit of elite performance. Previous research in youth development primarily focused on elite youth programs, with few studies observing sports involvement or talent development at a recreational level. Despite this lack of research focus, the recreational level is especially important, as this is where all children are first exposed to developmental pathways. Furthermore, no previous research has investigated the suitability of a school program to provide an optimal development for young athletes. This thesis therefore aimed to provide new information to understand sports involvement and talent development in a school-based sports program. Specifically, a series of four studies aimed to observe the factors influencing sports participation and talent development in the school-based sports program (Study 1); the factors influencing talent selection in adolescent soccer players (Study 2); the factors influencing development opportunities in youth soccer match-play (Study 3); and the factors influencing program retention and the subsequent development of performance characteristics in youth soccer players (Study 4). A summary of the findings from the four studies are presented in Table 8.1.

Table 8.1 Summary of the studies conducted as part of the thesis

Study			Participants			Methods			Findings	
Number	Chapter	Title	Primary Sport	Age	Number	Study Design	Measurements	Statistical Analyses	Results	Practical Application
1	Chapter 3	Factors affecting sports involvement in a school-based youth cohort: implications for long term athletic development	25 different primary sports	10-16 years	501	Cross-sectional cohort	Anthropometry, maturation, physical capacity, motor competence, sports participation history	Multivariate analysis, discriminant analysis	Similar profiles between sports, ↑ diversity with age; ↑ levels of competition associated with delayed engagement in primary sport.	Schools suitable for sport sampling, early specialisation not essential for sports performance.
2	Chapter 4	A multidimensional approach to factors influencing playing level and position in a school-based soccer program	Soccer	10-16 years	214	Cross-sectional cohort	Anthropometry, maturation, physical capacity, motor competence, technical ability, subjective coach ratings	Multivariate analysis, discriminant analysis, correlations	Talent selection guided by fitness, technical ability and motor competence; playing position guided by maturation, anthropometry and physical performance.	Reliance on physical characteristics alone for talent selection may be of detriment, as these attributes may be later developed with growth, maturation and training.
3	Chapter 5	Factors affecting physical match activity and skill involvement in youth soccer	Soccer	11-17 years	160	Cross-sectional cohort	Anthropometry, maturation, physical capacity, physical/technical match activity	Linear mixed models	↑ physical/technical demands for midfielders; ↑ HSR for attackers; fitness increased physical/technical activity.	Position specialisation may constrain development opportunities in youth soccer match-play.
4	Chapter 6	Factors influencing retention and development trajectories in a school-based youth soccer program	Soccer	10-16 years	172	Two-year cohort-longitudinal	Anthropometry, maturation, physical capacity, motor competence, technical ability	Crosstabs, Repeated measures	Selection into lower playing levels ↑ risk of dropout; program did not benefit motor competence, with plateau or even regression at 15 years of age.	Successful sports involvement ↑ retention, allow sports transfer or recreational participation to ↓ disengagement, focus on development and retention of motor competence.

The findings of this thesis contribute to existing knowledge on sport participation and talent development in youth sport. Specifically, these findings provide a new insight into how development programs may be maximised in a school environment. The results of the thesis suggest that school-based programs are an ideal environment for the sampling different sports throughout the early years. Despite this, opportunities to develop talent may be confounded by identification and selection processes in school-based sports programs. Additionally, school-based sports programs may not provide adequate opportunities for young athletes to develop fitness characteristics and retain motor competence throughout adolescence. Based on these findings, a new framework has been proposed for schools to balance the promotion of long-term engagement with opportunities to develop talent. Specifically, the model suggests all children should be afforded an opportunity to sample a range of sports throughout the early years (6-12 y), programs should focus on the development and retention of motor competence, and lateral development trajectories should be allowed in the specialisation stage to prevent disengagement. Collectively, these suggestions are aimed at improving the success of school-based sports programs. However, further research in recreational and school environments is still required.

8.2 DIRECTIONS FOR FUTURE RESEARCH

To expand upon the findings of this thesis, it is recommended that further research is aimed at improving our understanding of sports engagement and talent development in recreational and school-based sports programs. In particular, the focus of future research should include:

- A multi-centre approach to increase sample size and investigate factors influencing talent development in a range of different sports across and range of age-groups and developmental stages.
- The replication of this research in a cohort of young females to investigate the influence of gender on sports engagement and talent development, with boys and girls often shown to participate in different types of activities subsequently develop different motor skills throughout childhood (Bardid et al., 2017).
- A longitudinal follow-up approach to talent development in youth sports, evaluating the implementation of the new Developmental Model of School Sports Participation as a framework for maximising sports participation and talent development in school-based sports programs.

9 APPENDIX

9.1 SPORTS PARTICIPATION HISTORY QUESTIONNAIRE

Sports Participation History

1. 'Main sport milestones'

What is your name? _____

What is your date of birth? _____

What is your main sport? _____

Sports specific milestones (main sport)

___ years old when you first started participation

___ years old when you first took part in supervised training by an adult _____ have never done it

___ years old when you first began training regularly _____ have never done it

___ years old when you first played in an organised competition _____ have never done it

___ years old when you first began non-sport training (e.g., running, strength, etc.) regularly _____ have never done it

___ years old when you first took part at a "competitive" level _____ have never done it

___ years old when first took part at a "regional-representative" level _____ have never done it

___ years old when first took part at a "state/national" level _____ have never done it

2. Engagement in main sport-related activities

The following section focuses on the main sport-related activities you have participated from when you began participating to the present day, the number of hours spent in these activities per week, and the number of months per year you spent in each of the activities. This will be done for each year you have participated.

Please group the activities you have participated in into the categories listed below:

- 1. Match-play:** organised competition in a group engaged in with the intention of winning and supervised by adult(s), e.g. competitive games.
- 2. Coach-led group practice:** organised group practice engaged in with the intention of performance improvement and supervised by coach(es) or adult(s), e.g. practice with team.
- 3. Individual practice:** practice alone engaged in with the intention of performance improvement, e.g. practicing skills alone.
- 4. Peer-led play:** play-type games with rules supervised by yourself/peers and engaged in with the intention of fun and enjoyment, e.g. game of football in park with friends.

Please complete the 'participation history' log, which lists these four categories and groups them into years. Please fill this in as accurately as possible, starting from this year and working downwards until you have completed the first year you participated in your main sport. Please do not fill in shaded areas.

For each year, please complete:

1. Main sport participation
 - a. The total number of hours per week spent taking part in activities related to each category.
 - b. The number of months of the year that you spent taking part in activities related to each category.
2. The number of weeks from the relevant year that you were injured and unable to take part in the activity. Leave blank if no injury.

Note. Please first write the name of the coach and team you played for in each season in the space provided.

Note. A school sport season equals 6 months, whereas a year equals 12 months.

Age group	Team and coach	Activities	Hours/week	Months/year	Injury weeks/y
e.g. Y10	John Smith Knox Grammar 10(1)	1. Match-play	2	9	3
		2. Coach-led practice	5	9	
		3. Individual practice - self	2	12	
		4. Peer-led play	5	12	
		1. Match-play			
		2. Coach-led practice			
		3. Individual practice - self			
		4. Peer-led play			
		1. Match-play			
		2. Coach-led practice			
		3. Individual practice - self			
		4. Peer-led play			
		1. Match-play			
		2. Coach-led practice			
		3. Individual practice - self			
		4. Peer-led play			
		1. Match-play			
		2. Coach-led practice			
		3. Individual practice - self			
		4. Peer-led play			

Categories:

- 1. Match-play:** organised competition in a group engaged in with the intention of winning and supervised by adult(s), e.g. competitive games.
- 2. Coach-led group practice:** organised group practice engaged in with the intention of performance improvement and supervised by coach(es) or adult(s), e.g. practice with team.
- 3. Individual practice:** practice alone engaged in with the intention of performance improvement, e.g. practicing skills alone.
- 4. Peer-led play:** play-type games with rules supervised by yourself/peers and engaged in with the intention of fun and enjoyment, e.g. game of football in park with friends.

Age group	Team and coach	Activities	Hours/ week	Months /year	Injury weeks/y
		1. Match-play			
		2. Coach-led practice			
		3. Individual practice - self			
		4. Peer-led play			
		1. Match-play			
		2. Coach-led practice			
		3. Individual practice - self			
		4. Peer-led play			
		1. Match-play			
		2. Coach-led practice			
		3. Individual practice - self			
		4. Peer-led play			
		1. Match-play			
		2. Coach-led practice			
		3. Individual practice - self			
		4. Peer-led play			
		1. Match-play			
		2. Coach-led practice			
		3. Individual practice - self			
		4. Peer-led play			

Categories:

- 1. Match-play:** organised competition in a group engaged in with the intention of winning and supervised by adult(s), e.g. competitive games.
- 2. Coach-led group practice:** organised group practice engaged in with the intention of performance improvement and supervised by coach(es) or adult(s), e.g. practice with team.
- 3. Individual practice:** practice alone engaged in with the intention of performance improvement, e.g. practicing skills alone.
- 4. Peer-led play:** play-type games with rules supervised by yourself/peers and engaged in with the intention of fun and enjoyment, e.g. game of football in park with friends.

3. Engagement in other sport activities

The following section focuses on the other sporting activities you have engaged in, the period of your life in which you took part in this activity, the number of hours per week, and months per year spent in these activities, and the standard of this activity. For each activity, please complete:

1. Please place a tick next to the other sports that you have participated in during your life, outside of timetabled school physical education classes.
2. Age of participation
 - a. The age you started taking part in each activity.
 - b. The age you finished taking part in each activity (if you are still participating in an activity then leave this section blank).
3. The total number of hours per week spent taking part in each activity.
4. The number of months of the year in which you took part in each activity.
5. The standard of the activity that you took part in for that sport (e.g., recreational, competitive, regional-representative, state/national).

Note. Please only record other sport activity that has lasted a total of three months of activity.

Other sport activities.	Please tick if yes	Please cross if no	Start age	Finish age	Hours/week	Months/year	Standard of participation
e.g. Cross country	/	x	7	12	2	8	Recreational
Athletics							
Australian Rules Football							
Badminton							
Baseball							
Basketball							
Canoeing/kayaking							
Cricket							
Cycling							
Cross country							
Dance							
Football (soccer)							
Gymnastics							
Golf							
Handball							
Hockey							
Martial arts/combat sports							
Mountain bike riding							
Rugby league/union							
Running or jogging							
Squash							
Swimming							
Skiing/snowboarding							
Stretching/yoga/Pilates							
Surf life saving							
Table tennis							
Tennis							
Volleyball							
Water polo							
Weights							
<i>Other:</i>							
<i>Other:</i>							
<i>Other:</i>							
<i>Other:</i>							
<i>Other:</i>							

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