Relative Age Effects

in Australian Junior Rugby Union

A thesis submitted for the degree

Master of Arts in Sport Studies (Research)

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Declaration

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

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

Peter Damian Fernley

Date Submitted

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Preface

This is a thesis submitted for the degree of Master of Arts in Sports Studies, at the University of Technology, Sydney. This thesis, titled ‘Relative Age Effects in Elite Junior Rugby Union in Australia’, contains four chapters. Firstly, an introduction is provided to describe the background of this thesis, state the research problem, and detail the aims of research. An extensive review of literature is then included, detailing all previous work relevant to this research area. Next, a research study chapter is provided, outlining the various parts of the study, together with an analysis and discussion of the data. Finally, a summary chapter reports all major findings and draws attention to suggested areas for future research.

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Keywords

Relative Age Effects

Maturation

Adolescence

Performance Potential

Nature

Nurture

Talent

Contextual Factors

Perceived Competence

List of Abbreviations

RAE	Relative Age Effects
ABS	Australian Bureau of Statistics
ARF	Australian Rules Football
IRB	International Rugby Board
N	Number
CI	Confidence Interval
p	Statistical significance
Jan	January
Mar	March
Apr	April
Jul	July
Sept	September
Oct	October
Dec	December
Q1 – Q4	Quartile 1 up to and including Quartile 4
H1	First half (6 months) of the year
H2	Second half (6 months) of the year
U16	Under 16 years
U20	Under 20 years
Rugby	Rugby Union
UTS	University of Technology, Sydney

Abstract

Each of the four codes of professional football played in Australia (i.e., Rugby Union, Rugby League, Australian Rules Football and Soccer) is faced with the dilemma of identifying and developing talented young athletes into elite senior players. One of the key difficulties faced by talent scouts, coaches and selectors is identifying talented young individuals during adolescence. Individual differences in the timing and tempo of the maturation process, which are most visible during puberty, can have a significant impact on all aspects of sporting performance and resultant judgements of talented players. With junior and youth teams organised according to chronological age-groupings, inequalities related to perceptions of playing ability are likely to emerge between individuals based on when in a calendar year they are born. These inequalities have become known as 'Relative Age Effects', with young players born earlier in a selection year gaining advantages over their later-born counterparts. These advantages include more playing time, a perception of possessing more talent and a subsequent increase in the probability of gaining selection in elite representative teams.

The purpose of the first part of this investigation was to examine whether a relative age effect was present in a cohort of elite junior rugby union players competing at the annual national U16 championships. Individual birth-date data and playing position was recorded for each participant at the championships over a seven-year period (2004 – 2010). Chi-square statistics were used to examine differences between observed and expected birth date distributions in all players and general playing positions (forwards and backs). Comparison of birth date distributions between players in the 1st (top 8 teams) and 2nd division (bottom 4 teams) was also conducted. Odds ratios (ORs) and 95% confidence intervals (CIs) were also calculated for both quartile and half-year distributions (H1 and H2). For the OR analyses, the relatively

youngest members, (i.e. quartile 4 and H2 respectively) of the annual age-groupings were assigned as referent groups.

The second part of the investigation examined whether increasing age and skill levels would act as moderators of relative age effects in talented Australian rugby union players. Individual birth-date data was obtained for Australian U20 teams from 2008 to 2011. Birth-date distributions for this group were then compared to distributions from the U16 national championships for the equivalent time period (i.e. 2004 - 2007). Chi-square statistics were again used to examine differences between observed and expected birth date distributions in all players to determine the size of the relative age effect in the U20's teams and to the compare these results with those from the U16 group. ORs and CIs were also calculated for both quartile and half-year distributions (H1 and H2). For the OR analyses, the relatively youngest members, (i.e. quartile 4 and H2, respectively) of the annual age-groupings were assigned as referent groups. Player retention along the development pathway was also examined, with selection to Australian schoolboys teams observed as the intermediate step from U16 championships to the Australian U20 team.

The main finding from the first part of the investigation was the presence of a strong relative age effect within the cohort of elite junior rugby union players. The birth-date distribution was significantly biased towards a higher number of births earlier in the selection year. There was also a significant underrepresentation from players born in the fourth quarter of the year. This study also found that birth date distributions were influenced by age and skill level, but not playing position. A stronger age bias was observed for players from the division one teams competing at the U16 championships, with a larger disparity between players born in the first and last quarters of the selection year than in division two. Playing position did not appear to impact on the birth date distribution. Even though there was a strong overrepresentation of players born in the first half of the year for both forward and backline playing positions, the percentage breakdown for each group were similar. The second part of the investigation showed there was a strong retention of players along the developmental pathway from the U16 age group through to the Australian U20 Junior World Cup team. These findings suggest that increasing age does not appear to act as a moderator of relative age effects in talented Australian rugby union players.

In conclusion, the results of this study demonstrated the presence of a strong relative age effect in a group of elite U16 rugby players. This biased birth date distribution also appeared along the developmental pathway until the Australian U20 team. On the basis of these findings, it is recommended that current selection processes require modification to assist with minimising and/or eliminating the various factors that have led to their development in elite junior rugby union teams.

Chapter 1

Introduction

Background

Every year, approximately 1.7 million Australian children participate in some form of organised sporting activity outside of school hours (ABS, 2008). For some children, these early years learning to play sport with their friends is the beginning of their journey to a successful career as an elite adult athlete. This journey is difficult and requires a combination of several important factors to facilitate transformation from talented junior athlete to successful adult performer.

Previous research has found that a combination of physical, psychological and socio-cultural variables impact on the development of sporting expertise (Baker, Horton, Robertson-Wilson, & Wall, 2003; Côté 1999; Helsen, Hodges, Van Winckel, & Starkes, 2000; Martindale, Collins, & Daubney, 2005; Vaeyens et al., 2006). Furthermore, the optimal balance between training and environmental factors is needed in order for a young athlete to develop the expertise required for success as an adult athlete (Baker, Horton, et al., 2003). Accordingly, it seems that each of these variables should be considered on an individual basis to augment the development of talented young athletes.

Talent Development Process

For approximately 60 years national sporting organisations, federations, clubs, schools and coaches have developed programs to assist with the identification and nurturing of young individuals who might then achieve excellence in future years in their chosen sport (Baker, Schorer, & Cobley, 2010; Vaeyens, Gullich, Warr, & Philippaerts, 2009). These programs were first developed in the former Eastern Bloc countries where their primary goal was to develop young athletes to become future Olympic and world champions. Additionally, with the rise in the popularity of professional sports such as soccer and ice hockey, this model was also embraced by professional sporting clubs to develop future elite senior players (Durand-Bush & Salmela, 2001; Vaeyens et al., 2009). In order to enter these programs, junior athletes aged 12–16, were identified as having the necessary 'talent' or 'potential' to succeed at the highest levels. These early talent identification methods primarily focussed on the development of physical attributes, and therefore identified those athletes with the best physical abilities as juniors as those who possessed more 'talent' than their peers (Philippaerts et al., 2006). Unfortunately, this 'traditional' approach largely overlooked psychological aspects of performance and unintentionally favoured early maturing athletes.

Early maturing athletes were more likely to have physical performance advantages such as greater strength, power and speed, compared to their less developed counterparts (Helsen, Hodges, et al., 2000; Vaeyens et al., 2006). Furthermore, because these selection protocols favoured early-maturing individuals, many later maturing athletes with talent for future athletic success were 'deselected' from talent development programs. Indeed, research has found that adolescents missing out on selection were more likely to be born towards the latter half of the selection year (Helsen, Hodges, et al., 2000; Vaeyens et al., 2006). This selection bias has led to the development of the 'Relative Age Effect', where those players who are born early in the selection year were provided a relative advantage over those players born towards the end of the selection year.

More recently there has been a change towards a multi-dimensional model of talent identification that accounts for an individual's ability to learn and develop, rather than basing selection on a battery of performance measures (Abbott, Button, Pepping, & Collins, 2005; Burgess & Naughton, 2010; Fraser-Thomas, Côté, & Deakin, 2005; Martindale, Collins, &

Abraham, 2007; Reilly, Williams, & Richardson, 2008; Strachan, MacDonald, Fraser-Thomas, & Cote, 2008; Vaeyens, Lenoir, Williams, & Philippaerts, 2008; Vaeyens et al., 2006). The adoption of this more holistic approach has shifted the focus to identifying the development potential of young athletes, with performance measures used to assist in the ongoing monitoring and direction of the development pathway (Brettschneider & Gerlach, 2008; Philippaerts, Coutts, & Vaeyens, 2008; Vaeyens, Lenoir, Williams, & Philippaerts, 2007; Vaeyens et al., 2008). Therefore, rather than adopting an unnatural process of identification and elimination (Abbott et al., 2005), contemporary talent development models seek to identify and include those individuals with the most potential for future success. While the older, more traditional models have achieved a modicum of success in identifying and developing players who had long successful sporting careers, they have ignored other, equally important factors that contribute significantly to talent development. For example, psycho-behavioural skills such as performance-evaluation and goal-setting have been shown to be important determinants of success in elite professional athletes (Abbott & Collins, 2002), but until recently had not been included in talent identification systems.

Influences on the Development of Sporting Expertise

Since the late 19th century, researchers have been investigating and debating the relative importance of 'nature' and 'nurture' in the development of talent. However, it is now widely accepted that excellence in human performance is the result of the interaction of elements from both nature and nurture (Baker & Horton, 2004; Davids & Baker, 2007). Indeed, the emergence of talent is thought to be contingent on the interplay between the physical, physiological, psychological and sociological attributes of each individual. These attributes include those factors each athlete contributes to their own performance (i.e. individual genetic, psychological and behavioural factors), together with a number of secondary influences (i.e. non-genetic environmental influences) that collectively affect the attainment of expertise (Baker & Horton, 2004; Collins & MacNamara, 2011; Johnson, Edmonds, Jain, & Cavazos Jr, 2010; Phillips, Davids, Renshaw, & Portus, 2010). These secondary influences are broadly grouped into socio-cultural and contextual factors that together make up the environmental constructs that affect each athlete's life on a continual basis (Baker & Horton, 2004; Côté , Baker, & Abernethy, 2007; Holt & Mitchell, 2006; Johnson et al., 2010; MacNamara, Button, & Collins, 2010).

As each athlete progresses along their own individual pathway towards sporting expertise, they have an impact on their environment and are in turn impacted by the environment in which they develop and mature. Socio-cultural factors include the cultural importance of a sport in any given society, instructional resources such as the quality of teaching and coaching available at each stage of an individual's sporting career, and the level of familial support offered to junior athletes by their parents and other family members (Baker & Horton, 2004; Collins & MacNamara, 2011; Côté et al., 2007; Johnson et al., 2010; Van-Yperen, 2009).

Contextual factors are related more to the specific demands placed on an athlete by the sport or sports in which they are participating. These include the maturity of the sport (which influences the amount and type of training required to become an expert) (Baker & Horton, 2004), and the degree of expertise required to become an elite athlete in their chosen sport. Both of these factors are directly influenced by the 10 year or 10,000 hours rule which has been suggested as being necessary for an individual to achieve a level of expert performance in their chosen sport (Ericsson, 1996). One further environmental factor that may impact on individual athlete development is the depth of competition in each sport. All of these factors have been identified as being instrumental in the development of relative age effects (Musch

& Grondin, 2001) as these effects are likely to encourage earlier exposure to sport and promote early entry into talent development programs (Côté et al., 2007).

Relative Age Effects

In most junior organised sporting competitions, athletes compete against opponents on the basis of chronological age groupings. Primarily designed to age-match participants, annual age groupings also aim to promote fair competition for all, facilitate instruction, promote safety in the playing environment, ensure children's development is age related and for each child to have an equal chance of success (Helsen, van Winckel, & Williams, 2005; Musch & Grondin, 2001; Schorer, Cobley, Busch, Brautigam, & Baker, 2009; Weir, Smith, Paterson, & Horton, 2010). Age groupings are typically arranged on a calendar year basis, so that a selection year is established for a twelve-month period. In Australia, for example, the selection year is usually between January 1 and December 31.

While grouping children according to their chronological age may make administration of sporting competitions simpler for adults, research has shown that such a structure invariably highlights the cognitive, physical and emotional differences between participants resultant from differences in birthdays throughout the selection year (Cobley, Baker, Wattie, & McKenna, 2009; Musch & Grondin, 2001; Weir et al., 2010). These differences have been described as a "relative age effect" and were first identified in the sports of ice hockey and volleyball in the early 1980's (Grondin, 1982). Since then there have been over 100 studies investigating this phenomenon, with the majority of this work investigating the sports of soccer and ice hockey (Cobley et al., 2009; Musch & Grondin, 2001). In recent times relative age effects have also been found in a number of other sports including baseball, basketball, handball, volleyball and rugby league (Cobley et al., 2009; Till et al., 2010).

Relative Age Effects in Australian Sports

Despite the large body of research investigating the phenomenon of birth-date effects across a broad spectrum of sports for nearly 30 years, from 16 countries, very little research has been conducted in Australia. Of the seven published studies (Abernethy & Farrow, 2005; Barnett, 2010; Barnsley, Thompson, & Legault, 1992; Hoare, 2000a; Musch & Hay, 1999; O'Donoghue, Edgar, & McLaughlin, 2004; Pyne, Gardner, Sheehan, & Hopkins, 2006), six have investigated relative age effects at the senior professional level (Abernethy & Farrow, 2005; Barnett, 2010; Barnsley et al., 1992; Musch & Hay, 1999; O'Donoghue et al., 2004; Pyne et al., 2006), with only one study specifically examining junior team sports (Hoare, 2000a).

The sports common in Australia which have been examined in the above studies include cricket, Australian Rules football, soccer, rugby league and rugby union, basketball and netball (Cobley et al., 2009). Notably however, none of these investigations have specifically set out to examine relative age effects, with many only reporting on birth date distribution effects as an artefact in the discussions of their findings (Pyne et al., 2006). Furthermore, most of the studies examining this phenomenon in the Australian context only used data from one year of competition (Abernethy & Côté 2007; Abernethy & Farrow, 2005; Barnett, 2010), or used data from a single world championship (Barnsley et al., 1992; Musch & Hay, 1999; O'Donoghue et al., 2004). Due to the relatively small data sets used in these studies, the conclusions drawn from this work may therefore not provide a true indication of birth date effects in these Australian sports.

Mechanisms that Underpin Relative Age Effects

Research has shown that relative age effects develop as the result of a mixture of physical, cognitive, emotional and motivational causes (Musch & Grondin, 2001). Specifically, the advantages gained by relatively older athletes during the early stages of development (i.e. <14 y) foster the perception that these athletes are more talented than their peers. The resultant bias affords relatively older children / adolescent athletes with a higher probability of gaining selection to junior representative teams. Consequently, relative age effects are now a pervasive phenomenon in junior team sports (Cobley et al., 2009; Côté et al., 2007; Helsen et al., 2005; Musch & Grondin, 2001; Weir et al., 2010). While the key causal mechanism appears to be the cut-off date to junior sporting competitions, there are a number of other mechanisms that underpin their existence. These are competition for selection, physical development, psychological development and playing experience of young athletes (Musch & Grondin, 2001; Mujika, 2009; Weir, 2010).

The popularity of a sport eventually leads to competition for team selection at all level of junior competition (Barnsley, Thompson, & Barnsley, 1985; Daniel & Janssen, 1987; Grondin, Deshaies, & Nault, 1984). This has been demonstrated in ice hockey and soccer, up until the age of 18 y (Barnsley & Thompson, 1988; Baxter-Jones, Helms, Baines-Preece, & Preece, 1994; Cobley et al., 2009; Grondin et al., 1984; Helsen et al., 2005; Lariviere & Lafond, 1986; Musch & Grondin, 2001; Wattie, Cobley, et al., 2007). In both of these sports, research has also reported a strong relationship between those athletes benefiting from a relative age advantage and advanced physical maturity (Helsen, Starkes, & Van Winckel, 2000; Lariviere & Lafond, 1986; Malina et al., 2000; Sherar, Baxter-Jones, Faulkner, & Russell, 2007). These findings have now been replicated in baseball (Hale, 1956; Krogman, 1959) and rugby league (Till et al., 2010). These results suggest that sports where advanced physical / physiological development (i.e. strength, power, speed, agility and aerobic power) is required, that relatively older athletes gain an advantage in physical precocity which may be mistaken for 'talent' (Baxter-Jones et al., 1994; Figueiredo, Goncalves, Coelho e Silva, & Malina, 2009b; Helsen, Starkes, et al., 2000; Malina, Chamorro, Serratosa, & Morate, 2007; Vaeyens et al., 2006). These physical advantages appear to be the primary basis for the observed selection biases, which tend to discriminate against athletes born later in the selection year, making fair competition for selection difficult to attain. Collectively, it appears that increased competition for selection and advanced physical maturity are instrumental in the evolution of biased birth-date distributions. To focus solely on these two factors, however, would be to ignore the very important contributions of playing experience and psychological development in the formation of relative age effects.

As children mature, their psychological skills and abilities are also developed. Just as the stature, mass, strength, speed and power develop in a non-linear fashion, psychological, or cognitive skills also display non-uniform rates of change (Diamond, 1983). For example, cognitive functions such as controlling attention and impulses are not fully developed until the mid to late teens (Wattie, Cobley, & Baker, 2008) whereas their perceived competence (how children see themselves compared to their peers), can be well developed as young as age ten (Musch & Grondin, 2001). Indeed educational researchers have found that there are significant differences in children's cognitive development resulting from relative age effects (Musch & Grondin, 2001). This research, demonstrated that children who were born just after the cut-off date achieved significantly better academic results in primary school than those children who were born in the last quarter of the school year (Thompson, 1971). Subsequent research also reported that children born earlier in the year displayed higher levels of self-esteem and perceived competence than their latter born peers (Fenzel, 1992). Similar findings have been observed in the sporting domain (Carpenter & Scanlan, 1998; Ebbeck & Weiss, 1998; Weiss, 2008). Therefore, children born in the first half of the year, who possess a relative age advantage over their later born counterparts, are more likely to play their sport with greater confidence in their own abilities. When this enhanced self-efficacy is coupled with their physical attributes, these relatively older are more likely to be perceived as being more talented than their peers, rather than less developed. However, these older athletes may not necessarily possess greater athletic potential than their peers.

The perception of an individual's playing ability is especially important during late childhood / early adolescence, when most talent identification occurs. Young athletes who are born early in the selection year have an advantage that can be up to 12 months of additional playing experience compared to their peers born in the last quarter of the year. This extra experience provides the additional opportunity for the relatively older athletes to further develop physical and technical skills, and accrue more training time. When combined with improved cognitive abilities, it provides the advantage of being able to participate more actively in games during competition (Musch & Grondin, 2001). Consequently these older athletes are more likely to be noticed by selectors and coaches, which may result in increased positive feedback, which further adds to their self-esteem. Moreover, these relatively older players are also more likely to be noticed by coaches and selectors when selections are being made for representative teams. Once selected, these players are then afforded further opportunities to play and practice, have access to better coaching and competition and subsequently may also develop better technical knowledge (Weir et al., 2010). This further reinforces their self-esteem and most likely acts as a powerful motivating tool, reinforcing their athletic esteem. The associated enhancement of their playing abilities further increases the likelihood of being selected for higher levels of competition and given additional coaching and support.

Moderators of Relative Age Effects

While the mechanisms responsible for the development of relative age effects have been widely researched (Cobley et al., 2009; Musch & Grondin, 2001), a smaller body of recent research has reported on the potential moderators of relative age effects (Cobley et al., 2009; Schorer et al., 2009; Till et al., 2010; Wattie et al., 2008; Weir et al., 2010). Potential moderators include sport context, the relationship between chronological age and stage of career, skill level, playing position and gender.

Research has found that sport contexts associated with higher relative age risks include basketball, soccer, handball, ice hockey and rugby league (Cobley et al., 2009; Schorer et al., 2009; Till et al., 2010). In these sports relative age risks were higher in mid – late adolescence (14 – 18 years) and increased with competition level, with the highest risk observed with selection to state and national teams. However, beyond 18 years of age, in elite adult competitions, there is a much lower risk, with an even distribution of births found in some sports (Schorer et al., 2009).

Gender also appears to act as a moderator of relative age effects, with generally lower relative age risks reported from the few investigations of female sports. However, a recent investigation from Canadian Under 18 and Under 22 women's ice hockey found a strong relative age effect (Weir et al., 2010).

Investigations from other sports have also suggested that playing position may act as a moderator of relative age effects. For example, back-row versus front-row forwards in rugby league (Till et al., 2010), goal keepers versus other defensive positions in male ice hockey (Grondin & Trudeau, 1991) and left-side backcourt players in handball (Schorer et al., 2009) were all found to have a higher risk for relative age effects than other playing positions in their respective sports. Either individually or collectively, these factors can each impact on the magnitude of relative age effects

Summary

The development of expertise in sport occurs as the result of the interaction between those factors inherent to each athlete and the impact of the environmental factors that help to shape and nurture each individual's potential. The impact of environmental factors increases during adolescence, especially when young athletes are being evaluated for selection into representative teams. Traditional models of talent development tend to favour early maturing athletes, who appear bigger, stronger and faster than their later-maturing counterparts. This bias in the selection process has given rise to the development of relative age effects. On average, the available research suggests that athletes born earlier in the selection year tend to be early maturers, and tend to be over represented in junior representative sports teams (Brewer, 1995; Sherar, 2007; Till et al, 2008). Relative age effects are now seen as a contextual factor that can affect the outcome of the careers of junior athletes, especially for those relatively younger players who fail to gain selection for higher levels of competition. These effects have been identified in both junior and senior team sports in Australia, albeit from only a handful of studies. There appear to be a number of factors that may act to moderate the risk of developing relative age effects, especially age, skill level and playing position, which warrant investigation in the context of Australian junior team sports.

Research Problem

At present there is limited research of relative age effects in junior team sports in Australia (Abernethy & Farrow, 2005; Hoare, 2000a; Pyne et al., 2006). Furthermore, these studies have investigated only a small number of junior sports, (i.e. basketball, Australian Rules football and soccer), and all, except for Australian Rules football, have based their findings on data gathered from only 1 or 2 national and / or world championships. The data from the ARF study was collected from a relatively small sample (n = 495) of players aged 17 to 18 years, over 5 years from the annual ARF draft camp (Pyne et al., 2006). To date there have been no studies that have investigated the presence of relative age effects at the junior level in either of the two rugby codes played in Australia.

Rugby Union is a popular sport in Australia and provides players the opportunity to compete for both state and country in national and international competitions. Competitions in junior rugby union are organised at both the school and local club level. Junior players may progress from playing for their school or local club team through to district and state representation. The first such national competition is the Australian U16 schools championships. From these championships potentially talented players then have an opportunity to gain selection in an Australian Schoolboys team, with the next step being selection in the Australian U20 team. From there, players progress to senior ranks and the possibility of playing for the ‘Wallabies’, the Australian National team. To the author’s best knowledge, there has been no research on the relative age effect in junior rugby union in Australia. Furthermore, there has been no research investigating whether increasing age and / or skill level acts as a moderator on the magnitude of any age effects that may be identified in junior rugby union.

Aims of the Research

The aims of this research are to initially determine if a relative age effect is present in a sample of elite U16 y rugby union players. Subsequent aims include determining if these effects are then moderated by playing position and/or by increasing age and skill level.

Objectives

Study 1: Determination of the presence of a Relative Age Effect in a group of elite U16 rugby union players

- Examine birth-date data from a cohort of U16 rugby union players competing at the Australian National U16 championships to determine the presence of a relative age effect.

Study 2: Determine if increasing age acts as a moderator of relative age effects

- Examine birth-date data from a cohort of Australian rugby union players competing at the International Rugby Board's Junior World Championships to determine the presence of a relative age effect.
- Compare these results to those from study 1 to determine if the relative age effect is affected with increasing age and skill level.

Hypotheses

Study 1:

- A relative age effect will be present in a cohort of elite junior rugby union players competing in a National U16 rugby union championship.
- A stronger relative age effect would be found in players of a higher ability/skill level competing in a National U16 rugby union championship.
- Playing position would act as a moderator of relative age effects, with a stronger effect to be found in a group of forwards as opposed to the backline positions.

Study 2:

- Age would act as a moderator of relative age effects, with a diminished effect found in a cohort of U20 Australian rugby union players competing at the Junior World Championships.

Contribution to Theory and Practice

Study 1:

The first study will attempt to determine if there is a bias in the distribution of birth dates among a group of elite junior rugby union players. From a practical perspective for coaches and selectors, identifying a bias in favour of players born earlier in the year, may encourage them to review their selection and player development criteria. As there tends to be a large percentage of relatively older junior athletes who are also early maturers, raising awareness of the existence of relative age effects may encourage coaches and selectors to more carefully consider their selection choices. Furthermore, knowledge of the factors associated with relative age effects may facilitate a shift from a focus of short-term goals to that of long-term development, where young players are provided with the opportunities to fully develop all aspects of their athletic potential.

Theoretically, the study may add to the body of knowledge further validating the need to control for individual variations in maturation during adolescence. This may then encourage the development of a model that would see selection into talent development programs based on an assessment of individual sporting potential rather than results from a series of discrete performance evaluations. Such a model would then include development of the psychological, emotional, motivational, and tactical skills and abilities of young athletes and not just the physical and technical aspects of their sport. Performance measures would still be an important part of the development process, but would be used to monitor and guide the direction of the overall training program rather than determining inclusion or exclusion to / from the talent development pathway.

Study 2:

This study will determine whether increasing age acts as a moderator of relative age effects in elite junior rugby union players. On a practical level, awareness of those factors that act to moderate any bias in the distribution of birth dates in sporting teams can be very useful to administrators, coaches and selectors. In the case of increasing age, a birth date distribution that still remains biased towards more births in the first half of the year may suggest that the most talented players are being retained along the pathway. Conversely, this could also suggest that selection into junior national teams is predicated by performances at the U16 national championships, rather than on performances in the time period immediately prior to selection of these teams. This latter scenario may be discouraging to young players and lead to the premature loss of many potentially gifted athletes (players).

Limitations and Assumptions

Subjects

Access to player records was restricted to the U16 age group. Fortunately these records were from the national U16 championships, and were therefore representative of the best U16 rugby union players in Australia, with every state and territory represented. Despite these records providing a good sample size, the investigation could have been improved by having access to data from U13y – U16y. Subsequent analysis of these younger age groups may have helped to clarify the earliest age at which a relative age effect occurs.

Sample size

The final size of the sample of players was restricted by the availability of suitable data from the Australian Rugby Union. Player records were only available for the period 2004 – 2010. While this allows for good statistical power to be obtained, in keeping with existing research, a full ten years of data would have been preferred (Mujika, 2009; Vaeyens, 2005).

Anthropometric measurements

Due to the retrospective nature of a large part of the data collection, consistent data for mass and stature was not possible to obtain. Consequently, the final analysis did not include a between-group comparison for each measure to determine if players born earlier in the year were taller and heavier than their latter born counterparts.

Delimitations

Subjects

The subjects used in the study represented the best U16 rugby union players from each state and territory in Australia. Each player had been selected to attend the national U16 championships after competing in a selection carnival in their home state/territory. These championships represent the highest level of junior schoolboy rugby union and have been seen as an important step in the player development pathway in this sport. These players play at the highest competition level for their age group, at either school and / or club level in their home state or territory.

Chapter 2

Literature Review

Introduction

Since colonisation, sport has been central to the Australian way of life. The Australian climate and lifestyle have led to an active, outdoor lifestyle with high levels of participation in sport and physical activity in children and adolescents. Indeed, the Australian Bureau of Statistics (ABS, 2008) has reported that during 2005-2006, 63.5 percent of children aged 5-14 (1.7 million) participated in a sport outside of school hours. Moreover, approximately two-thirds of 15 year olds participated in some form of recreation, sport or exercise. In a recent submission to the Commonwealth Government's Independent Review of Sport in Australia, the Australian Sports Commission (ASC) described sport as being an integral part of Australian life (ASC, 2008). Furthermore, the report suggested that Australia's sporting success at the international level is largely due to the active, outdoor life enjoyed by the majority of the population.

For many young Australians, the sporting journey progresses from unstructured play in their local park with family and friends, through to 'structured sport' as they make the transition into school and club sport between the ages of six and eighteen. During this period, young athletes are provided the opportunity to further their journey through involvement with pre-elite representative sport, in the first instance, and then, if selected, continue on to national / elite level competition or even a professional sporting career. In order to make the ultimate transition from 'playground to podium', young athletes need to be identified and selected to continue to move along the pathway to elite sporting competition.

This process of identifying and developing talent is difficult and does not always guarantee success (Malina, Ribeiro, Aroso, & Cumming, 2007). Most traditional methods for both talent identification and detection have used a combination of anthropometric, physical performance or discrete, basic skill measures (e.g. non-opposed dribbling and shooting tasks in soccer) to identify the abilities required to perform at the elite level in a chosen sport (Philippaerts et al., 2008). A battery of assessment instruments were then developed and used (Reilly, Bangsbo, & Franks, 2000) together with the subjective / objective opinions of coaches and selectors to determine if a young athlete had the required ‘talent’ to be selected (Abbott, Collins, Martindale, & Soweby, 2002; Reilly, Bangsbo, et al., 2000; Reilly, Williams, Nevill, & Franks, 2000).

A similar approach has often been used to identify and develop talented individuals in most team sports within Australia (Hoare, 2000a; Pyne, Gardner, Sheehan, & Hopkins, 2005; Young et al., 2005; Young & Pryor, 2007). There are however many difficulties associated with using this approach and it is now generally accepted that future sporting success is almost impossible to predict by taking a snapshot of a young person during the transition period from childhood to adult performer (Franks, Williams, Reilly, & Nevill, 1999; Philippaerts et al., 2008). During adolescence, maturation occurs at different rates and physiological qualities also develop in a non-linear manner (Figueiredo, Goncalves, et al., 2009b; Malina, Bouchard, & Bar-Or, 2004; Malina, Cumming, et al., 2005; Philippaerts et al., 2006). As a consequence of this, ‘athletic talent’ often times is confused with the increased performance provided as a consequence of early maturation.

Early maturers are, in most cases, taller, heavier and faster than their late maturing peers (Segers, De Clercq, Janssens, Bourgois, & Philippaerts, 2008) and too often coaches and scouts confuse maturation with talent (Reilly, Cabri, & Araujo, 2005; Wattie, Baker, Cobley, & Montelpare, 2007). For example, in some countries coaches in team sports specifically target early maturing athletes at ages as young as eleven years in their quest to find ‘new talent’(Taeymans, Clarys, Abidi, Hebbelinck, & Duquet, 2009). This misguided approach has a significant impact on the sporting careers of not only those young athletes who benefit as a result of selection, but also on those players who are consequently deselected (Musch & Hay, 1999; Sherar, Bruner, Munroe-Chandler, & Baxter-Jones, 2007; Vaeyens, Philippaerts, & Malina, 2005; Wattie et al., 2008). Young athletes whose birth dates fall early in the selection year are more likely to have a maturational advantage over their counterparts who are born later in the selection year. These relatively older individuals are more frequently represented among elite male youth teams during adolescence (Helsen et al, 2005; Perez Jiminez & Pain, 2008; Sherar et al, 2007).

This phenomenon, known as the ‘Relative Age Effect’, was first reported in education in the 1960’s (Wattie, Baker, et al., 2007) and first appeared in the sporting literature in the early 1980’s (Cobley et al., 2009; Musch & Grondin, 2001; Wattie, Baker, et al., 2007; Wattie, Cobley, et al., 2007). *Relative Age* refers to the difference in ages between children in the same age group resultant from differences in birth dates throughout the year (Barnsley & Thompson, 1988) and its consequence is known as the ‘Relative Age Effect’. For example, the age groupings in most team sports in Australia are organized on a calendar year from January 1 to December 31. Accordingly, a child born on January 1 is essentially twelve months older than his/her counterpart born on December 31 with whom they are competing for selection (Abernethy & Farrow, 2005). The resultant difference provides the earlier born child with a relative age advantage over their later born counterpart. One such advantage is an increased probability of gaining selection in a junior representative team.

Relative age effects will be discussed in more detail in ensuing sections of this review. Specifically, evidence will be presented outlining the history, causes and prevalence of relative age effects in adolescent sport. Evidence of relative age effects in the context of Australian Sport will also be presented, highlighting the need for an investigation of relative age effects in junior team sports in this country, as there have been few empirical investigations on this topic. The review will examine the process of talent identification and development, including an outline of the recent history of the talent identification process, as well as a discussion of current trends in talent identification and development. Finally the implications of relative age effects will be discussed, as will some possible solutions to lessen the impact or even eliminate this phenomenon in youth sport in Australia.

Studies investigating the development of sporting expertise have suggested that the type of experiences athletes have throughout their development strongly influences to what degree individual potential/talent is realised and expertise is attained (Côté et al., 2007). Furthermore, the conditions and context in which these experiences occur can have a remarkably enduring influence on the probability of expertise emerging (Abernethy, 2008; Durand-Bush & Salmela, 2001). For example, when and where an athlete is born, access and availability to quality coaching during their teenage years, and opportunities for elite competition can all have an impact on the development of expertise (Baker, Horton, et al., 2003). During the early years of development, contextual factors such as relative age effects may have an impact on the development of an individual's athletic potential. Relative age effects appear to develop as the result of a mixture of physical, cognitive, emotional, motivational, and social causes working together to produce the effect (Musch & Grondin, 2001). In the section below, the first of these causes is discussed, with a particular emphasis on the influence of growth and biological maturation on the development of relative age effects.

The articles referenced in this review were obtained by searching the electronic databases of *Ovid, SPORTDiscus, PubMed, Web of Knowledge* and *Google Scholar*. Keywords used were 'relative age effects', 'birth-date effects', 'season of birth', 'talent identification and development', 'junior team sports', 'adolescent sport', 'athlete development', 'maturation', 'growth and development'. Following this original search, bibliographies and / or reference lists were further examined to identify any other relevant articles.

Physical factors involved in the development of relative age effects

Growth and Biological Maturation

In the early stages of athletic development, it is difficult to forecast with a high degree of certainty, which young athletes possess all of the qualities required to be successful as an adult athlete. Even in an extreme case, where a young athlete displays all of the characteristics of greatness and is vastly superior to his or her peers, talent alone is a weak predictor of future success (Abbott & Collins, 2002; Vaeyens, 2009).

The journey to achieve expertise is such a long and unpredictable process. This is often due to non-linear variance in physical maturation rates. It is highly possible that the athlete, who is thought to be a sporting prodigy at 13 years could well prove otherwise by age 16 (Starkes & Ericsson, 2003). Indeed, there is some evidence that suggests some sports are rewarding early developing individuals with their talent identification programs. Malina (2004) has suggested that in those sports in which body size, strength and power are advantageous, early maturing individuals within an age group are likely to have an advantage over those who are late maturing (Malina, Bouchard, et al., 2004). This has gained further support, with several studies demonstrating similar findings (Coelho e Silva, Figueiredo, Carvalho, & Malina, 2008; Figueiredo, Goncalves, Coelho e Silva, & Malina, 2009a; Gil, Ruiz, Irazusta, Gil, & Irazusta, 2007; Gravina et al., 2008; Hansen, Klausen, Bangsbo, & Muller, 1999; Hirose, 2009b; Malina, Dompier, Powell, Barron, & Moore, 2007; Malina et al., 2000; Malina, Ribeiro, et al., 2007; Pearson, Naughton, & Torode, 2006; Segers et al., 2008; Taeymans et al., 2009). Furthermore, coaches tend to unwittingly favour early maturers when selecting the 'best' players (Cumming, Battista, Martyn, Ewing, & Malina, 2006; Dezan, Sarraf, Rodacki, & da Silva, 2004; Figueiredo, Coelho e Silva, & Malina, 2009; Gil et al., 2007; Gravina et al., 2008; Malina et al., 2000).

The processes of growth and maturation greatly impact on talent identification during adolescence. The process of growth refers to changes in size, physique and body composition, whereas that of maturation / development refers to progress toward the mature adult state (Baxter-Jones, 1995; Beunen & Malina, 2008; Malina, Bouchard, et al., 2004). During this transitional period from childhood to adulthood (typically 10 – 15 years for females and 11 – 17 years for males) the effects of each process are most evident, and there can be large differences between the Biological Age (BA) and Chronological Age (CA) between individuals (Bailey, Baxter-Jones, Mirwald, & Faulkner, 2003; Baxter-Jones, Eisenmann, & Sherar, 2005).

With the onset of puberty a multitude of hormonal changes facilitates the development of physical and physiological characteristics important for sporting performance (Fairclough, Boddy, Ridgers, & Stratton, 2009; Leone & Comtois, 2007; Pearson et al., 2006). Significant changes in each of these characteristics during puberty make the prediction of adult performance difficult from adolescent data (Ackland & Bloomfield, 1996). Indeed, the timing and tempo of the maturational process is different for each individual and for each of the individual bodily systems.

During childhood and adolescence there can be considerable differences in overall body dimensions between individuals (Bale, Mayhew, Piper, Ball, & Willman, 1992). For example, during puberty, teenagers gain approximately 50% of their adult weight, and skeletal mass, and twenty percent of their adult height. Additionally the lean body mass is doubled for boys during puberty and girls undergo large increases in sex-specific fat deposition (Wahl, 1999). However, these changes are non-linear and the extent of change varies between individuals. For example, within the same chronological age grouping, biologic maturity, body composition, physical performance, cognitive development and sport-specific skill levels can vary dramatically (Ackland & Bloomfield, 1996; Beunen, 1992; Philippaerts, 2006).

Each of these factors can be affected by an individual’s maturational status, which is referred to as their BA (Malina, 1994). BA may be very different from an individual’s CA (Beunen & Malina, 2008). Therefore, both growth and maturation can have an impact on physical performance with early maturing athletes, or those having an advanced BA for their CA thought to possess an advantage over later maturers (Rotch, 1908). Therefore, using CA to index physical potential accurately can cause problems, as it does not take into account maturational age. This is particularly true during puberty when maturity-related differences in strength, speed and endurance are evident among children of the same CA (Caine & Brockhoff, 1987; Mirwald, Baxter-Jones, Bailey, & Beunen, 2002).

Historical research into the effects of maturation on athletic performance

CA and gender are typically used to organise children and adolescents into sporting teams. However, due to the potential for earlier maturation, this approach has created unfair advantages for children born earlier within the selection year. The influences of maturation on athletic performance have been studied since the mid 1800’s (Table 2.1).

Table 2.1 Time-line of landmark studies that have examined the effect of maturation on athletic performance.

Year	Description
1840's	Quetelet, M.A (1842). Investigated the Lifetime Growth of Man. Identified specific ages when key physiological performance measures, such as strength and speed were at their peak.
1890's	Boas, F. (1892). Investigated the growth of children. Identified the importance of interpreting physical changes around the adolescent growth spurt to Peak Height Velocity and not Chronological Age
1900's	Crampton, C. (1908). Investigated the most appropriate age for the commencement of "child labour". Highlighted the importance of using 'physiological age' instead of chronological age during puberty. Rotch, T. (1908). Also investigated maturation in relation to "child labour". Stressed the importance of determining 'anatomical age', especially during the pubertal years. First researcher to use X-Rays of left wrist to determine anatomical age of adolescent boys.
1930's	1932, Jones, H.E. – commences the California Adolescent Growth Study. 1934, Espenschade, A – commences study investigating motor performance in adolescence.
1940's	Espenschade, A. (1940), Longitudinal study investigating motor performance in adolescence; suggests that classification on a skill level into team sports is essential for fair competition. Bayley, N. (1943), Investigated relationships between rate of maturation and growth in body size in a group of adolescent children, found gender differences between early and late maturing individuals. Jones, H. (1946, 1949), Adolescent growth study using children from 6 Californian schools, age range 11-18yrs. Found PSV to occur slightly after PHV.
1950 's	Hale, C. (1956), Investigated the physiological age of Little League baseball players at the 1955 World Series. Found the greater majority of boys who had a CA 0f 12yrs, were in fact post-pubescent, BA = 14 yrs; Krogman, W. (1959), Investigated the skeletal age of players at the 1955 Little League Baseball World Series; found that 83% of players had a SA > CA.
1980's	Ostyn et al, (1980), Leuven Growth Study (commenced 1969) – investigated the effect of CA and BA on a range of body measures, plus evaluated the variability in motor performance as a function of CA, BA and overall body size. Beunen et al, (1981), investigated CA and BA as related to physical fitness in boys 12 to 19yrs. Strongly recommend that classification for team sports should be a function of BA and not merely by CA Mirwald et al, (1981), investigated impact of adolescence on maximal aerobic power. Found adolescence to be a critical period for determining maximal aerobic power as an adult. (Used data from the Saskatchewan Growth Study (1964 – 1973)
1990's	Lefevre et al, (1990), Investigated motor performance in a group of Flemish boys from the age of 13 and 18yrs and then again at age 30. Found that late maturing adolescents perform better on functional and explosive strength tests at age 30 when compared to early maturing individuals. Beunen at al, (1992), Investigated the effects of physical activity on physical growth, maturation and performance. No significant effects of increased physical activity were observed in any of the

	three parameters Baxter-Jones et al, (1995, 1996), investigated elite young British athletes. Found soccer players, swimmers and tennis players tended to be early maturers and gymnasts were late maturers. Findings drawn from 'TOYA' Study, which commenced in 1988. Katzmarzyk, P. (1997), found that in children aged 7-12 yrs, SA influenced motor fitness more so than muscular strength Little et al, (1997), Investigated the relationship between physical performance and maturation in perimenarchal girls. Found more mature females aged 11, 12 and 13 yrs have a greater physical performance advantage.
2000's	Gasser et al, (2001), investigated growth from infancy until adulthood. Main findings include early maturers start their growth spurt up to 2 years earlier than late maturers, late maturing children of either gender have, on average, longer legs as adults than their early maturing counterparts Philippaerts et al, (2006) Ghent Youth Soccer Project – investigated longitudinal changes in height, weight and physical performance in a group of adolescent soccer players. Found most key performance measures to be coincident with PHV. In many tasks, performances continued to improve after PHV. Erlandson et al, (2008), Investigated 3 female sports using data from the TOYA study (1988). Found that female swimmers and tennis players were early maturers and gymnasts late maturers. Ortega et al, (2008) AVENA study on a sample of Spanish Adolescents. Investigated a number of health-related physical components. Found that BA had an influence on muscular fitness in both genders and CRF in females. Taeymans, et al, (2009), found that handgrip is a fair predictor of adult static strength in early and late maturing females and for average maturing males is a predictor at age 11.

The first studies were designed to determine the appropriate age for "child labour" rather than sporting performance. They identified that the timing and magnitude of adolescent growth spurts in various body dimensions should be interpreted relative to Peak Height Velocity and not CA (Boas, 1892). These early studies reported that physiological / anatomic age provided a much fairer classification system than CA during the formative period of early life until late adolescence (Crampton, 1908; Rotch, 1908). Indeed, it was recommended that a system that would more accurately reflect the developmental age of each child, especially during adolescence, was required. Crampton (1908) advocated estimating physiological age based on the development of pubic hair while Rotch (1908) estimated physiologic / anatomic age based on X-rays of the carpals. The technique originally advocated by Rotch (1908) was not that dissimilar to current methodologies which are either the Tanner-Whitehouse, Fels, or Greulich-Pyle techniques for assessing skeletal age. This approach is now considered the gold standard for assessing physiological / anatomic age (Beunen & Malina, 2008). Additionally, both Crampton (1908) and Rotch (1908) recognized that differences in maturation could be related to the variable rates of change in body mass, stature, strength, and / or motor performance at a specific CA (Anderson & Ward, 2002). Following these findings, several longitudinal research studies, which commenced during the 1930's, reported on the effect of maturation on physical performance (Bayley, 1943; Espenschade, 1940; Jones, 1946). Results from these studies showed that early maturers had significant strength and motor performance advantages over late maturers. Furthermore, these studies suggested that when classifying adolescent athletes for team sports, a system which allowed for consideration of the BA of participants might be useful in providing fairer competition and therefore reducing any relative age effects.

More recently, two major longitudinal studies that examined the growth and development of adolescent schoolboys and a group of young athletes were conducted in Europe. The Leuven Growth Study followed a large group of Flemish boys aged 12 -19 years for six years commencing in 1969 (Beunen, Ostyn, Simons, Renson, & Van Gerven, 1981; Lefevre, Beunen, Steens, Claessens, & Renson, 1990). The 'Training of Young Athletes' (TOYA) study investigated a group of elite young British athletes over a three-year span from 1988-1990 (Baxter-Jones & Helms, 1996; Baxter-Jones, Helms, Maffulli, Baines-Preece, & Preece, 1995). The results from the Leuven Growth Study demonstrated that early maturers performed significantly better than late maturers on three motor performance tasks involving speed of limb movement, explosive strength and static strength (Beunen et al., 1981; Lefevre et al., 1990). The British TOYA study found that in sports where large physiques provided an advantage for performance success (e.g. swimming and tennis), these athletes tended to have advanced sexual maturation. This study also observed that gymnasts demonstrated characteristics of late-maturing individuals, suggesting that in some sports, early maturation is actually disadvantageous. Both studies supported the earlier research in finding that biological age is a much better predictor of performance than chronological age (Baxter-Jones et al., 1995; Beunen et al., 1981).

Research has clearly established that advanced skeletal maturity is associated with larger body size, greater muscular strength, power and speed, as well as greater absolute, but not relative, VO_2max in adolescent males (Figueiredo, Coelho e Silva, et al., 2009; Forbes, Bullers, et al., 2009; Jones, Hitchen, & Stratton, 2000; Malina et al., 2000; Segers et al., 2008). These increased physiological capacities resultant of a higher BA can provide advantages in many sports, especially those that require high strength and power. Many studies have shown that the majority of talented adolescent athletes, between the ages of 12 and 15 from a variety of sports (baseball, basketball, American football, soccer and ice hockey), are early maturers (Baxter-Jones et al., 1994; Coelho e Silva et al., 2008; Hale, 1956; Krogman, 1959; Lariviere & Lafond, 1986; Malina, 1994; Malina, Cumming, et al., 2005; Malina, Eisenman, Cumming, Ribeiro, & Aroso, 2004; Malina et al., 2000; Malina, Ribeiro, et al., 2007). Indeed, the evidence from baseball, ice hockey and soccer among boys 12 years of age suggests that in addition to maturity associated variation in body size; there is variation in maturity status by position within a given sport (Hale, 1956; Lariviere & Lafond, 1986; Malina, 1994; Malina, Eisenman, et al., 2004). For example, forwards and defenders in soccer, pitchers, first basemen, left-fielders and 'clean-up' batters in baseball, and defenders in ice-hockey all tend to be advanced in BA.

Following on from the pioneering work of Espenschade, (1940) and Jones,(1946), the effects of maturation on a range of performance parameters used in talent identification programs have recently been investigated (Chuman, Hoshikawa, & Iida, 2009; Pearson et al., 2006). The greater majority of this research has once again focused on the sport of soccer (Capela et al., 2004; Chuman et al., 2009; Cumming et al., 2006; Figueiredo, Coelho e Silva, & Malina, 2004; Figueiredo, Coelho e Silva, et al., 2009; Figueiredo, Goncalves, et al., 2009a; Figueiredo, Goncalves, et al., 2009b; Fragoso et al., 2004; Gil, Gil, Irazusta, Ruiz, & Irazusta, 2004; Gravina et al., 2008; Guschelbauer, Oberhammer, & Tschan, 2009; le Gall, Carling, & Reilly, 2008; Malina, Chamorro, et al., 2007; Malina, Cumming, et al., 2005; Malina, Eisenman, et al., 2004; Malina et al., 2000; Mendez-Villanueva, Kuitenen, Peltola, Poon, & Simpson, 2009; Philippaerts et al., 2006; Tschopp, Held, & Marti, 2004; Vaeyens et al., 2006; Vanttinen, 2009), with a variety of other sports investigated including, gymnastics, swimming, tennis (Erlandson, Sherar, Mirwald, Maffulli, & Baxter-Jones, 2008), basketball (Coelho e Silva et al., 2008), and roller-skate hockey (Dos Santos et al., 2009). For example, the Ghent Youth Soccer Project (Vaeyens et al., 2006) specifically attempted to identify significant predictors of talent in Flemish youth players of different playing levels in several age groups across adolescence. This mixed-longitudinal study found that among youth players (13-18 yr) the variation in discriminating factors in performance might be associated with differential timing of the adolescent growth spurt and sexual maturation. Consequently this was found to have an effect on the timing of each of the various physical components' trainability (Vaeyens et al., 2006). Despite this large body of international evidence examining the role of maturation on athletic performance, there is a relative paucity of similar studies in Australian junior sports.

Variation in physiological changes and their impact on athletic performance

The main physiological qualities associated with athletic performance change dramatically during puberty and adolescence. During adolescence, boys firstly experience a growth spurt in stature followed by spurts in muscle mass, body weight, and muscular strength (Beunen & Malina, 2008). However, each physical attribute develops at different rates and each is intrinsically linked to maturity or the attainment of ‘Peak Height Velocity’ (PHV) (Baxter-Jones, 1995; Beunen & Malina, 1988; Beunen & Malina, 2008; Malina, 1994; Pearson et al., 2006; Roemmich & Rogol, 1995). Therefore, to account for the variable rate of development amongst individuals, most physiological measures are expressed relative to the timing of PHV rather than to CA (see Figure 2.1 over page). The expression of physiological development relative to PHV provides more specific information about the timing and magnitude of adolescent spurts in each of these physical attributes, rather than focusing only on changes in height and physical performance (Beunen & Malina, 2008; Boas, 1892).

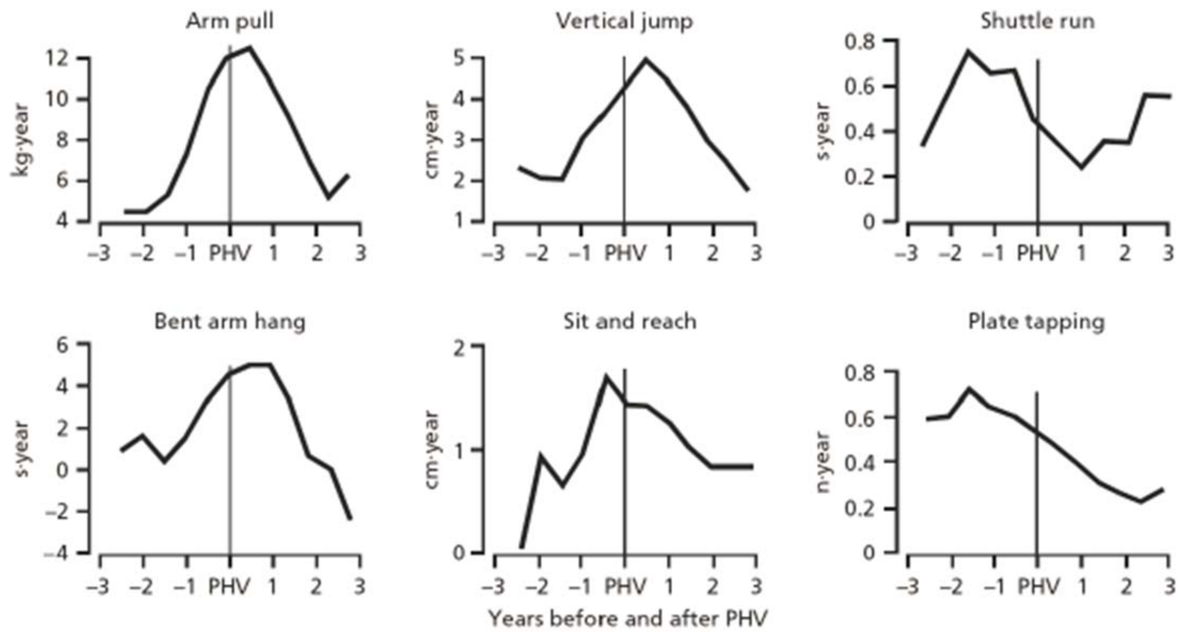

Figure 2.1 Median velocities of several tests of strength and motor performance aligned on peak height velocity (PHV) in the Leuven Growth Study of Belgian Boys. Velocities for the performance items are plotted as years before and after PHV. Drawn from data reported by Beunen *et al*. (1988).

Peak Height Velocity (PHV) – The adolescent growth spurt commences at about 10 years in girls and 12 years in boys, reaching a peak at about 12 years in girls and 14 years in boys and then gradually declining and eventually ceasing with the attainment of adult stature.

Peak Weight Velocity (PWV) – Substantial weight gain accompanies the adolescent growth spurt, with PWV generally occurring after PHV (Beunen & Malina, 1988; Pearson et al., 2006; Roemmich & Rogol, 1995). This may not always be the case as, Philippaerts et al (2006), found PWV to be coincident with PHV in trained, adolescent soccer players. On average PWV occurs between 0.2 and 0.4 years after PHV in boys and 0.3 and 0.9 years after PHV for girls.

Strength / Peak Strength Velocity (PSV) – Strength development is related to body size and muscle mass (Beunen & Malina, 2008; Jones, 1946). PSV, therefore, is closely related to PWV and PHV. This relationship was first noted by Quetelet (1842) who observed that strength related abilities displayed a significant increase during puberty, slightly after increases in stature and mass of adolescent males. Several studies have shown that PSV follows PHV, with maximum velocities in strength and endurance following PWV. The adolescent spurt (peak velocities) in static strength (arm pull), explosive strength (vertical jump), and muscular endurance (bent arm hang), appears to begin about 1.5 years prior to PHV and reaches a peak 0.5-1.2 years after PHV and 0.8 years after PWV (Beunen & Malina, 2008; Espenschade, 1940; Jones, 1946; Roemmich & Rogol, 1995). However, sport specific strength training may affect the timing of PSV, as Philippaerts et al (2006), found each of the major strength variables to be coincident with PHV in trained, adolescent soccer players, when compared to non-trained adolescent males..

Speed – In contrast to PSV, maximum velocities in speed tests (shuttle run and plate tapping) are achieved about 1.5 years prior to PHV (Beunen & Malina, 1988; Katzmarzyk, Malina, & Beunen, 1997). Recently, Philippaerts et al (2006), found that maximum velocities in speed tests were also coincident with PHV in trained, adolescent soccer players. Improvements in speed during adolescence appear to be related more to changes in skeletal and neuromuscular maturation (Beunen & Malina, 1988; Espenschade, 1940; Katzmarzyk et al., 1997).

Flexibility – Flexibility achieves peak velocity prior to PHV and then displays a gradual decline, which continues through to maturation. Maximum velocities for flexibility also appear to be closely related to the adolescent spurt in leg length (Beunen & Malina, 1988). Results from the TOYA study indicated that between the ages of 13 and 16, girls are more flexible than boys (Baxter-Jones & Helms, 1996). Of all of the performance measures, flexibility is perhaps the only one that does not improve significantly during adolescence (Beunen et al., 2001; Little, Day, & Steinke, 1997; Ortega et al., 2008). In contrast, Philippaerts et al (2006) found that maximum velocities for flexibility, as measured by a sit and reach test, peaked approximately 12 months post-PHV in trained, adolescent soccer players.

Aerobic Capacity / Power - Aerobic power is dependent on body size during growth, (as indicated by the growth curve of relative aerobic power). Typically, VO_2max begins to increase several years before PHV and continues to increase after PHV. On the other hand, relative VO_2max generally begins to decline one year before PHV and continues to decline after PHV. The decline reflects the rapid changes in stature and body mass so that, per unit of body mass, oxygen uptake declines during the growth spurt. Changes in relative aerobic power during adolescence probably reflect changes in body composition and not changes in aerobic function (Beunen & Malina, 2008; Beunen et al., 1992; Kobayashi et al., 1978; Mirwald, Bailey, Cameron, & Rasmussen, 1981; Pearson et al., 2006). Skeletal maturation and absolute aerobic power are significantly related, with early maturing boys demonstrating a higher absolute VO_2max than late maturing boys except in late adolescence (Beunen et al, 1988). A similar trend is evident between early and late maturing girls, but the differences are smaller (Beunen et al, 1988). On the other hand, relative VO_2max is higher in late maturers of both sexes (Beunen & Malina, 2008).

Anaerobic Power – Anaerobic Power increases at a steady rate during childhood. There is an increased rate of improvement with the onset of puberty (Espenschade, 1940; Falk & Bar-Or, 1993; Inbar & Bar-Or, 1986; Roemmich & Rogol, 1995). Sprint speed and jumping ability improve dramatically during adolescence, with the highest rate of improvement occurring between the ages of 13 and 15 years (le Gall, Beillot, & Rochongar, 2002; Pearson et al., 2006). Improvements in anaerobic power with maturation appear to be related to a number of factors to do with an increase in muscle mass. These include changes to muscle architecture, an enhanced neuromuscular ability, and an increase in peak power production (Falk & Bar-Or, 1993; Pearson et al., 2006; Roemmich & Rogol, 1995).

The greatest physiologic differences exist between individuals during adolescence, mainly because of the wide variation in the timing and tempo of the pubertal growth spurt in normally growing boys and girls. However, when adjusted to PHV, there appears to be a consistent pattern. For non-athletic adolescents' peak rate of development of flexibility, endurance and motor control appear to occur in the years prior to PHV, whilst strength and power qualities tend to develop at their fastest rates following PHV. However, a recent investigation has suggested that for trained, adolescent athletes, estimated velocities for most performance measures reached a peak around the time of PHV (Philippaerts et al., 2006). Whilst these differences tend to be small they may, in part, be influenced by sport-specific training. For either of the two groups above, coaches and administrators need to be aware of the characteristics of the adolescent growth spurt. These have an important impact on the development of physical qualities and may also be related to injury risk.

Maturity status and injury

Several authors have suggested that there is a link between maturational status of adolescent athletes and the risk of injury (Anderson & Ward, 2002; Baxter-Jones, 1995; Caine & Brockhoff, 1987; Hirose, 2009a; le Gall et al., 2006; Malina, Dompier, et al., 2007; Malina, Morano, Barron, Miller, & Cumming, 2005; Mirwald et al., 2002; Roemmich & Rogol, 1995; Stricker, 2002). Roemmich (1995) has suggested that due to the differences in the timing and tempo of the adolescent growth spurt, grouping young athletes by chronological age may place athletes who are late to mature at an increased risk of injury (Roemmich & Rogol, 1995). In addition, Haffner (1975) demonstrated a significantly reduced injury rate among boys aged 12 to 19 years who were matched by genital maturation prior to participation in various sports and reported that approximately two percent of participants incurred a significant injury over the course of a regular high-school football season (Haffner, 1975). In contrast, a recent study of elite French youth football players demonstrated that biological maturity status did not significantly affect the overall incidence of injury, although there were differences between maturity groups when patterns of injury location, type, severity and re-injury were analysed (le Gall et al., 2006). For example, early maturers tended to incur a greater number of acute, traumatic injuries, whereas late maturing players had a higher occurrence of more serious overuse injuries (le Gall et al., 2006). Additionally, Hirose (2009) has also demonstrated that amongst adolescent soccer players the rate of injury increased with age, with players entering their growth spurt particularly vulnerable to overuse injuries (Hirose, 2009a).

The path to maturity is variable and unique for each individual (Mirwald et al., 2002). The effect of the tempo of growth during adolescence can result in significant performance differences between individuals of the same chronological age. Therefore, an awareness of the biological maturity status of each individual may allow coaches and athletic trainers to structure the training load of young athletes and potentially predict and prevent certain kinds of injury (Caine & Brockhoff, 1987; Hirose, 2009a). Regardless of maturational status (early, on time, late), it is important from a developmental perspective that adolescent athletes are not treated as mature athletes. Talent identification programs need to allow for differences in the timing and tempo of the maturational process, especially around the time of the adolescent growth spurt (Caine & Brockhoff, 1987; Hirose, 2009a; Malina, Dompier, et al., 2007; Philippaerts et al., 2006; Roemmich & Rogol, 1995).

Summary of physical factors and the effects of growth and maturation

With few exceptions, high-level young athletes of different competitive levels in various sports are characterized by average or advanced biologic maturity status (Baxter-Jones, 1995; Beunen & Malina, 2008; Jones et al., 2000; Leone & Comtois, 2007). The changes in maturity that occur during adolescence result in an increased physical size capacity such as increased fat-free mass, muscular performance (strength, power, speed) and aerobic capacity. These physical changes are manifest in early maturers seeming to possess a performance advantage over their later maturing counterparts.

Despite these early advantages, these early physical gains are transient and dissipate with age. Nonetheless, youth who are successful in sport during puberty tend to differ in maturity status and rate compared with the general population. Specifically, early maturers have a much shorter growth period (~1.5 - 2 years), than late maturers (Gasser, Sheehy, Molinari, & Largo, 2001) but with a higher growth velocity level during childhood and in pre-adolescence. Early maturers also tend to be taller around their pubertal growth spurt, when compared to late maturers at the same CA. Early maturing children start their pubertal growth spurt about 1.5 (girls) or almost 2 years (boys) earlier than late maturers (Gasser et al., 2001). Given that early maturers have essentially completed their growth spurt before late maturers have even commenced theirs, it is hardly surprising that this group is perceived as possessing performance advantages and subsequently over-represented in junior representative sporting teams.

In sports where stature, body mass, strength and power are an advantage, the early maturer at any given CA is likely to have a biological advantage (Baxter-Jones, 1995; Forbes, Sutcliffe, Lovell, McNaughton, & Siegler, 2009; Ortega et al., 2008). This advantage is reduced as boys approach late adolescence or early adulthood when late maturers tend to have equal or greater performance capacities than the early maturers (Beunen & Malina, 2008; Lefevre et al., 1990; Philippaerts et al., 2006). Coincidentally, the majority of studies investigating Relative Age Effects have suggested that athletes born earlier in the year tend to be taller, stronger and heavier than their later-born peers (Gravina et al., 2008; Hansen et al., 1999; Helsen et al., 2005; Musch & Grondin, 2001; Perez Jimenez & Pain, 2008; Vaeyens et al., 2005). These athletes may also then be selected into key decision-making positions in their sport, primarily because they are perceived as being more talented, where they continue to benefit from more opportunities for playing and practice.

On their own, therefore, maturational changes could be perceived as being the sole cause of 'Relative Age Effects'. Certainly young athletes classified as 'early maturers' tend to be over represented in elite junior sporting teams. However, maturational changes are but one of the factors that contribute to the development of relative age effects in junior sporting programs. In the following sections, cognitive, emotional/motivational and social factors will be reviewed to provide a more complete understanding of this pervasive phenomenon.

Cognitive, emotional and motivational factors that influence the development of relative age effects

As a function of their chronological age, children differ both in their physical and psychological maturity (Musch & Grondin, 2001). As they become older, children continue to learn, mature and develop, and for most of them increases in chronological age are related to increased physical and mental development (Barnsley, 1988; Barnsley et al., 1992). Recent research has suggested that certain cognitive functions such as controlling attention and impulses, engaging in behaviour when a goal is remote and control of gross motor performance are not fully developed until late adolescence (Wattie et al., 2008). Furthermore, these functions appear to be important prerequisites for complex tactical team sports such as Australian Rules football, soccer and ice hockey. Relatively older adolescent athletes may therefore benefit from enhanced cognitive development, which further reinforces their relative age advantage. For example, Barnsley (1988) and Cobley et al (2008), have demonstrated that children born earlier in the school year are over represented in programs for gifted children. Conversely, Diamond (1983) has found that children with relative age disadvantages were over represented in programs for children with learning disabilities. Furthermore, when compared to younger, less physically and cognitively mature members of a peer group, this advantage resulted in added psychological enhancements such as greater confidence, adventurousness and self-esteem (Bell, Massey, & Dexter, 1997). Cognitive, emotional and motivational factors therefore need to be considered not only in their role in the development of relative age effects but also as part of the talent development process.

Several studies have demonstrated that often the perception of talent by coaches and selectors may indeed be explained by an enhanced physical precocity associated with a relative age advantage (Helsen, Hodges, et al., 2000; Malina et al., 2000; Musch & Grondin, 2001; Sherar, Baxter-Jones, et al., 2007). Early selection into representative teams then provides these young athletes with more opportunities for play and practice. Furthermore, because of their early success, these athletes may receive more encouragement, feedback and support from parents, coaches and peers (Côté et al., 2007; Helsen, Hodges, et al., 2000; Johnson & Tenenbaum, 2006). Therefore, a young person may be motivated to play and practice with more intensity, both physically and mentally, because of this positive feedback and encouragement. This may then result in an enhanced self-efficacy for those individuals benefiting from this relative age advantage (Côté et al., 2007; Johnson & Tenenbaum, 2006; Thompson, Barnsley, & Battle, 2004).

Perceived competence is well established as a powerful determinant of sport participation. According to Harter's (1978) theory of competence motivation, those high in perceived physical, academic, or social competence are more likely to participate in their respective activities. With age, children become more accurate with their perceptions of their own abilities. For example, a child between 10 and 13 years of age has a much better perception of their competence levels than a child of 8 to 9 years (Musch & Grondin, 2001; Weiss, 2008). Furthermore, around 13 years of age children begin to appreciate how effort, practice and ability impact on their sporting performance (Fraser-Thomas & Côté, 2006). Consequently, relatively older children may possess a performance advantage, which provides them with potential selection benefits, as a direct result of this increased awareness of their skills and abilities.

Children benefiting most from an initial relative age advantage are likely to be erroneously perceived as the most talented in their age group. Referred to as a 'Pygmalion Effect', this may enhance a relative age advantage if the behaviours of parents, coaches, and peers encourage and support the initial perception of children's abilities. Parents and coaches should therefore understand fully the potential influence of the relative age effect (Musch & Grondin, 2001).

Very little is known about the affective, cognitive, and motivational effects of a relative age disadvantage. For example, one negative consequence of relative age effects is the development of low self-esteem in relatively younger children (Thompson, Barnsley, & Dyck, 1999). This may lead to early drop-out from organised sport (Barnsley & Thompson, 1988; Delorme, Boiche, & Raspaud, 2009; Helsen, Starkes, & van Winckel, 1998; Wilson, 1999). There is also some evidence that a relative age disadvantage at school is associated with a higher incidence of youth suicide (Thompson et al., 1999).

Even though chronological age differences are related to discrepancies in a range of physical attributes during adolescence, careful consideration should also be given to psychological variables. Several studies have demonstrated that a child's continued involvement in youth sport is linked to the perceived benefits of participation, including the opportunity for social interaction and the development of social relationships, enjoyment, and perceived competence (Carpenter & Scanlan, 1998; Ebbeck & Weiss, 1998; Wilson, 1999). Therefore, creating a competitive environment where children feel competent has been suggested to increase commitment to the sport, and also have a significant impact on a child's self-esteem (Anderson & Ward, 2002; Carpenter & Scanlan, 1998; Ebbeck & Weiss, 1998; Weiss, 2008).

In sports such as ice hockey and soccer where representative teams are first selected as young as age ten years (Barnsley & Thompson, 1988; Barnsley et al., 1985; Helsen et al., 1998), this type of competitive environment would appear to be lacking. Selection policies that favour bigger, stronger, faster and potentially more mature athletes certainly provide favourable opportunities to these athletes to gain access to better coaching, competition, and playing time, as well as increased motivation and commitment to their sport. On the other hand, young players who miss out on selection may have more difficulties in developing a strong commitment to their sport. Traditional models for identifying and detecting talent have certainly placed an over-emphasis on anthropometric and physical performance measures, at the expense of psychological skills (Vaeyens et al., 2008).

Previous research has shown that elite athletes possess significantly higher levels of mental skills than do less elite athletes (Durand-Bush & Salmela, 2001; French, Spurgeon, & Nevett, 1995; Gould & Maynard, 2009; Simonton, 1999). The development and maintenance of psychological skills in sport is obviously important for the development of talent (Elferink-Gemser, Starkes, Medic, & Visscher, 2009). It is noteworthy that commitment and self-confidence have consistently been found to be associated with high-level performance. For example, a recent study of elite Norwegian athletes demonstrated that higher psycho-physiological growth underlies higher performance (Harung et al., 2011). Athletes should be given help in developing adequate levels of commitment and self-confidence that could enhance the process of talent development. Several authors have suggested that this should occur in the earliest stages of athletic development (Durand-Bush & Salmela, 2001; Martindale et al., 2007; Martindale et al., 2005; Reilly, Williams, et al., 2000; Williams & Reilly, 2000b).

Summary of cognitive, emotional and motivational factors

Psychological skills are therefore vitally important in the identification and development of talented young athletes (Harwood, Cumming, & Hall, 2003). Indeed, there is evidence they should be included as part of an overall training schedule to allow young athletes to realise their full potential (Baker & Horton, 2004; Gould, Dieffenbach, & Moffett, 2002; Holt & Dunn, 2004). The development of sporting expertise is a multi-faceted process, in which physical, cognitive, emotional and motivational skills all need to be practised from an early age (Durand-Bush & Salmela, 2002; Williams & Reilly, 2000b). For example, Abbott & Button, (2004), Button & Abbott, (2007) and Durand-Bush & Salmela, (2002) have reported that for Olympic and World Champion athletes the most important personal characteristics related to the successful development of their sporting expertise were self-confidence, commitment to training, goal-setting and motivation.

Furthermore, based on findings from a study of elite adolescent Canadian and English soccer players, Holt & Dunn, (2004) identified four key psychological competencies associated with elite soccer success. These were discipline, commitment, resilience and social support. The authors suggested that young players possessing these competencies could be identified for selection into talent development programs. They also suggested that development of these competencies could be incorporated into the overall talent development process to assist young players in making the transition from talented junior to elite adult player (Holt & Dunn, 2004).

Holt & Mitchell, (2006) have since refined these competencies and proposed a model based on three competencies and environmental conditions associated with soccer success. These are hope, resilience and social support. Hope combines discipline and commitment from their previous model and includes pathways for achieving goals. This new model is based on findings from an investigation into sub-elite players contracted to play with an English third division soccer team. The authors demonstrated that these players, who were ultimately released from their contracts, were lacking in strategies to achieve their stated goals, were not as resilient as elite players and lacked emotional, informational and tangible support. Therefore, high-hope players who are resilient and receive high social support have a much greater likelihood of ultimately making the transition to successful elite adult player (Holt & Mitchell, 2006).

Relative age effects can be viewed as a construct of a talent identification process that has placed too much emphasis on the physical prowess of young male athletes. The psychological development of those athletes deselected at a young age has been shown to be adversely affected with a resultant diminishment of their self-efficacy (Thompson et al., 2004). For example, Barnsley & Thompson (1988) found that young ice hockey players disadvantaged by a relative age effect were more likely to drop-out of their chosen sport as a consequence of lowered self-confidence and self-esteem. Those relatively older, and possibly more mature athletes who benefit from early selection, initially experience an enhanced self-esteem. However, studies have suggested that for some of these early-maturing individuals, once they lose their physical advantages and technical and tactical skills become more important, they may also suffer from issues of negative self-esteem (Cobley et al., 2009; Wattie et al., 2008; Williams, 2009). Therefore regardless of whether a young athlete gains an advantage or a disadvantage as the result of a relative age effect, their cognitive, emotional and motivational development is still likely to be affected.

The process of initial talent identification and selection into elite junior representative teams therefore warrants investigation. In the following section, factors involved with the development of expertise and how they have contributed to the formation of relative age effects will be discussed. The concept of talent and the roles of nature and nurture in the development of talented individuals will be presented, along with the influence each have had in the evolution of talent identification and development models. Both traditional and current talent identification and development models will also be discussed. In the case of more traditional models, evidence will be presented demonstrating the clear link with the formation and development of relative age effects. Finally, current talent identification and development models will be presented, illustrating how a different approach to this process may in fact provide some solutions to reduce, or possibly even eliminate relative age effects in junior team sports.

Factors underlying effective talent development - The roles of nature and nurture in the development of expertise

The process of identifying talented individuals in sport is a challenge for most coaches, clubs and national sporting bodies. The primary objective of talent identification programs is to recognize current participants with the greatest potential to excel in a given sport (Vaeyens et al., 2008). Through early identification, sporting bodies are able to allocate scarce resources to the potentially most talented athletes (Button & Abbott, 2007; Mohamed et al., 2009). Historically, most talent identification models have examined the physiological and anthropometric characteristics of senior ‘elite’ performers in a given sport and then evaluated junior athletes in at attempt to identify those athletes that had the necessary ‘markers’ of talent to allow them to make the next step in their playing career (Abbott & Collins, 2002).

These models have, for the most part, erroneously ascribed ‘talent’ to those young athletes who benefit from a relative age advantage afforded by early maturation (Starkes, Helsen, & Jack, 2001). One factor driving the use of such models has been the lack of consensus for a definition of talent. This, coupled with the ongoing debate regarding the relative contributions of nature and nurture in its development, has distracted focus away from the main issue of how talent can be identified and promoted (Vaeyens et al., 2008).

The terms nature and nurture, were first introduced by Sir Francis Galton (1874) in the specific context of a debate about which of these two factors contributed most to talent development in ‘men of science’ in the United Kingdom (Galton, 1874). Initially drawing from classical literature he reminded his readers that:

> "It is maintained by Helvetius and his set, that an infant of genius is quite the same as any other infant, only that certain surprisingly favourable influences accompany him through life, especially through childhood, and expand him, while others lie close folded and continue dunces" (Galton, 1874)

> "The phrase 'nature and nurture' is a convenient jingle of words, for it separates under two distinct heads the innumerable elements of which personality is composed. Nature is all that a man brings with himself into the world; nurture is every influence from without that affects him after his birth. The distinction is clear: the one produces the infant such as it actually is, including its latent faculties of growth of body and mind; the other affords the environment amid which natural tendencies may be strengthened or thwarted, or wholly new ones implanted. Neither of the terms implies any theory; natural gifts may or may not be hereditary; nurture does not especially consist of food, clothing, education or tradition, but it includes all these and similar influences whether known or unknown." (p 12)

As Galton (1874) recognized over a century ago, talent provides a critical research site for addressing one of the biggest enigmas in the behavioural sciences (Simonton, 1999).

A complete picture of talent and its development demands that the effects of nature be integrated with the effects of nurture. The debate has evolved from determining whether genetic or environmental behaviours influence behaviour to understanding how they interact. Talent appears to depend on genetics, environment, opportunity, encouragement, and the effect of these variables on physical and psychological traits. It is therefore much more likely that environmental and contextual factors, including deliberate practice, deliberate play, social support and relative age effects account for far more variance in performance than does innate capacity in every salient talent domain (Abbott et al., 2002; Abernethy & Côté 2007; Simonton, 1999). For example, Ward & Williams, (2003) concluded that eight year old footballers selected into elite junior development squads had better skills due to extra opportunities rather than any genetic advantage. Talent may undoubtedly be found in young children, but their early life experiences play an important role in developing any potential they may possess.

For over a century, scholars have been debating the exact definition of 'Talent'. This debate continues to this day with professional sporting clubs and national sports organizations investing significant quantities of both human and financial resources each year in an attempt to identify and develop athletes who possess 'talent' (Durand-Bush & Salmela, 2001; Mohamed et al., 2009). A working definition of 'Talent' is presented below, which very succinctly defines the concept.

Talent Defined

'Talent' is defined as: "any innate capacity that enables an individual to display exceptionally high performance in a domain that requires special skills and training" (Simonton, 1999). Included in these talent domains may be activities from the creative arts, competitive chess, individual and team sports, entrepreneurial leadership, and concert performance. The development of talent has come to be seen as a highly dynamic process; a complex interplay of the psychological, physiological and somatic components that constitute each individual's talent (Abbott et al., 2005).

Infancy, childhood, adolescence and even adulthood will see the components of latent potential undergoing various transformations. A youth's talent potential, therefore, is not a stable innate trait but rather is undergoing constant transformation during the maturation process. A teenager is not likely to possess the same talent they may have displayed as a child, nor will an adult necessarily exhibit the full scope of talents manifest during their teenage years. Not only may talent be lost or never recognized due to lack of opportunities, but in addition one talent may metamorphose into another talent (Simonton, 1999). For example, Vaeyens et al, (2009) have found a low to moderate success ratio from talent identification and promotion programs which were used in former soviet-bloc countries. Furthermore, their findings have shown that only a very small percentage, in some cases less than one percent, of children identified at a very young age ever became successful senior athletes. In addition, their study also found that many successful senior athletes had not been supported by a national sport academy as a young athlete.

Expertise in sport is so highly prized and usually requires significant time and resources in order to attain. Because of this, any means that can be found to accelerate the acquisition of expertise and to make skill learning more efficient will be exceptionally valuable to athletes, coaches, officials and administrators alike (Abernethy, 2008). Converting athletic potential into expertise requires a rare blend of genetics, environment, good planning and luck. Many young athletes display sporting potential, but only a few ever achieve and sustain expertise in their chosen domain. An expert athlete is characterized as someone who possesses the ability to move within a defined space, in a defined way, within a defined time frame with the aim of producing a defined level of performance. Therefore predicting how an adolescent athlete will likely perform all of the skills expected of an expert adult performer under the pressure of competition, is an unrealistic expectation (Gulbin, 2008).

Talent identification and development process

The process of identifying and then developing talent is far from foolproof. Despite the vast sums of money spent each year on recognizing young athletes with the potential to excel in a particular sport, there is still a lack of scientific support for most talent identification programs (Vaeyens et al., 2008).

Until recently, most talent identification studies have used a combination of anthropometrical, physical & performance measures to predict performance potential in adolescent athletes. For example, Aitken & Jenkins (1998) found that selected anthropometric measurements could not be used to predict future sprint kayak performance potential in a small group of specially trained young children. Furthermore, no evidence was found linking performance on physical and physiological tests during adolescence and subsequent success in soccer (Franks et al., 1999). Indeed, much previous research has focused on comparisons between professional and youth players and players classified by competitive level of expertise at a certain stage of development (Helsen et al., 2005; Musch & Grondin, 2001; Vaeyens et al., 2006; Wattie et al., 2008). However, there is now a growing body of research that suggests that most of the physiological tests traditionally used on adolescents were in reality of little or no value in accurately determining future athletic success.

While research in this area may have come a long way from humble beginnings in the mid 19th century (Thomas & Nelson, 1996), researchers are still seeking ways to objectively quantify talent. The methods employed have evolved from collecting anthropometric and simple performance measures for physical achievement tests (Thomas & Nelson, 1996), to the multivariate, multidisciplinary methods which the latest research is proposing as a more effective way of identifying athletic ‘potential’ (Mohamed et al., 2009; Vaeyens et al., 2008).

One of the earliest examples of scientific research in this area was conducted with a group of American college athletes (Di Giovanna, 1943). This study attempted to determine the relationships between selected structural measures and sporting success from a sample of 836 American college athletes who competed in baseball, basketball, football, gymnastics, tennis and track and field. The results demonstrated that athletes with distinct anthropometric, strength, power and physical capacities tended to be suited to specific sports. For example, male gymnasts were found to be significantly smaller in height, leg length, and hip breadth, but capable of much greater explosive power when compared to other athletes such as backfield players in football (DiGiovanna, 1943). These results were used to assist the 'physical director' to guide individuals into activities in which they were more apt to find success and enjoyment. This study is one of the earliest scientific investigations of talent identification and the author suggested that coaches could use this approach as a rudimentary screening process for their athletic squads (DiGiovanna, 1943).

During the next two decades interest in identifying and nurturing young athletes who were perceived to possess the necessary talent to excel in sport became the focus of many national governing bodies, federations, clubs and coaches (Vaeyens et al., 2009). This approach was further refined in the 1970's by sports scientists from East Germany and the Soviet Bloc countries (Durand-Bush & Salmela, 2001). Under this system, children in primary schools were evaluated to determine if they possessed the necessary aptitudes and skills, which would lead to success in sport. For example, in the German Tennis Federation, children as young as age six were selected for developmental training based on results from mini tournaments and motor ability tests (Martindale et al., 2005).

Interest in effectively identifying and developing sporting talent continued to evolve, with many countries adopting a nationally coordinated approach (Abbott et al., 2002). For example, in 1994, the *Talent Search* scheme was launched in Australia to assist with the identification and development of talented athletes prior to the 2000 Sydney Olympics. However, it appears that many such programs have focused primarily on the early identification of talent, selecting the 'best' junior athletes in the hope they would then become elite adult performers (Martindale et al., 2005). This approach, which primarily focused on "sport talent detection" (Abbott et al., 2002; Durand-Bush & Salmela, 2001; Mohamed et al., 2009), formed the basis of traditional talent development models.

Traditional models used in sport for talent identification and development

Traditional models for identifying and developing talented adolescent athletes used a combination of anthropometric and physiological tests to identify / distinguish between talented youngsters (Vaeyens et al., 2008). Most often, these tests were adopted directly from profiles of elite adult performers and were more concerned with 'detecting' young athletes deemed to possess the most talent. The majority of these studies were conducted on young athletes between 10 and 18 years with the results often being used to determine which athletes had the "talent" required to "succeed" as an adult athlete (Abbott et al., 2002; Durand-Bush & Salmela, 2001; Gil et al., 2007; Gravina et al., 2008; Mohamed et al., 2009; Vincent & Glamser, 2006). The testing protocols in these studies favoured early maturing individuals, who displayed greater size, strength and speed (Malina et al., 2000; Naughton, Farpour-Lambert, Carlson, Bradney, & Van Praagh, 2000; Nedeljkovic, Mirkov, Kukolj, Ugarkovic, & Jaric, 2007; Pearson et al., 2006; Reilly, Bangsbo, et al., 2000; Reilly & Gilbourne, 2003; Reilly, Williams, et al., 2000; Williams & Reilly, 2000a, 2000b). These athletes were then 'selected' into representative teams on the false assumption that they possessed more 'talent' than those not selected. The flaw in this approach was that the best performing athletes on the selective tests were commonly those with a more advanced biological age than their counterparts.

Bloom (1985) has demonstrated that successful development into the upper echelons of sport was not necessarily predicated by top performances at junior levels. Indeed, only ten per cent of successful adult athletes demonstrated sufficient sporting prowess at age twelve to indicate their future level of achievement (Martindale et al., 2005). Findings such as this question the validity of focusing on and rewarding the explicit development of highly successful adolescent athletes. For example, international hockey players have been reported to not reach their peak until their late twenties (Helsen et al., 1998). Therefore rewarding athletes who possess a relative age advantage, and in the process placing too much emphasis on winning and early specialisation in junior sport, can have negative repercussions in the long term. For example, Nieuwenhuis, Spamer, & van Rossum (2002) have found that between 22% and 37% of children between the ages of 13 and 15 drop out of sport each year because they experience a lack of sufficient skills. Indeed, relative age effects have also been shown to be associated with early drop out and wasted talent (Figueiredo, Goncalves, et al., 2009a; Gould, 2009; Helsen et al., 1998; Perez Jimenez & Pain, 2008).

While these traditional models may have over-emphasized physical and performance characteristics of young athletes, they still included a measure of psychological qualities (Abbott & Collins, 2004; Abbott et al., 2002; Durand-Bush & Salmela, 2001). However, this was usually a measure of the psychological aptitudes required to achieve future sporting success (Durand-Bush & Salmela, 2001). Subsequent research has clearly demonstrated that there is more than one personality trait observable in successful world-class performers in both individual and team sports (Abbott et al., 2005; Holt, 2008; Morris, 2000; Reilly, Williams, et al., 2000; Williams & Reilly, 2000a, 2000b). Furthermore, in the context of elite sport, there is no reported evidence that psychological variables remain stable from adolescence to adulthood (Holt, 2008; Morris, 2000). Therefore, a variable that is important for success in elite adult competition, may be very different from what is required at 10 to 15 years of age (Abbott & Collins, 2004; Morris, 2000; Reilly et al., 2008; Williams & Reilly, 2000b).

These findings formed the genesis of a new, integrated approach to the identification and development of talent. This new approach encompassed a more holistic philosophy, in which multiple determinants of performance exist and each variable contributes to the ultimate fulfilment of an individual's athletic potential (Abbott & Collins, 2004; Durand-Bush & Salmela, 2001; Holt, 2008; Malina, 2008; Reilly et al., 2008).

Current models used in sport for talent identification and development

The concept of talent and its development has come to be viewed as a complex, dynamic system in which future behaviours emerge from an interaction of key performance determinants. These include psychological behaviours, motor abilities and physical characteristics. The search for young athletes with the talent to excel at the elite senior level has subsequently been divided into four key stages: (1) detection, (2) identification, (3) development and (4) selection (Williams & Franks, 1998; Williams & Reilly, 2000b). This process has been focused on recognizing young athletes with the necessary potential to become elite performers. Rather than basing their future performance capabilities on the results of discrete anthropometric and physiological tests, future performance is predicted by an ongoing assessment of physical, physiological, psychological and sociological attributes. The most appropriate learning environments are then provided to assist with the realization of this potential. This process is ongoing and rather than deselecting individuals, allows each athlete a greater opportunity to achieve excellence in their sporting domain.

The current trend in the identification and development of talented young performers is to identify 'athletic potential' using a multidimensional methodology (Abbott et al., 2002; Holt, 2008; Philippaerts et al., 2006; Reilly et al., 2008; Vaeyens et al., 2008; Vaeyens et al., 2006). With this approach, anthropometric and physiological assessment protocols are still used, but only as tools to monitor the progress of junior athletes. Recent studies have used tests that evaluate technical, tactical and decision-making abilities as well as physical and performance measures of young athletes. This approach displays the potential to more effectively discriminate between athletes of different playing abilities (Wattie et al., 2008). This dynamic, multi-dimensional approach to talent identification, will hopefully allow more young athletes to be provided with the opportunities to fully develop their 'athletic potential' (Brettschneider & Gerlach, 2008; Philippaerts et al., 2008; Vaeyens, Lenoir, Williams, Mazyn, & Philippaerts, 2007; Vaeyens, Lenoir, Williams, & Philippaerts, 2007).

An effective developmental program will therefore allow young athletes the capacity to develop their sporting potential while also providing opportunities for them to develop the requisite psychomotor and physical performance skills needed to achieve elite levels of performance (Abbott et al., 2005). This method will by necessity require a long-term approach to the development of sporting expertise. Furthermore, because of the dynamic epigenesis of talent, the timing and tempo of talent development will be different for each individual athlete (Abbott & Collins, 2004; Malina, 2008; Simonton, 1999; Vaeyens et al., 2008). For example, Simonton, (1999) has suggested that many characteristics of a trait may take years, or even decades, to emerge. On the other hand, for some individuals, they may display adequate values of all components of talent at an early age. This process therefore necessitates the provision of multiple pathways to achieving excellence (Abbott et al., 2005). As talent emerges, young athletes will pass through different stages of development and their individual needs will change as a function of their physical, cognitive and social maturation.

Originally developed by Bloom (1985) and later refined by Côté (1999) is the premise that athletes move through several distinct stages of development. The process of evolving from novice to elite athlete requires years of commitment to learning and training. Central to this process is the amount and quality of support and instruction children receive from parents, teachers or coaches (Durand-Bush & Salmela, 2001; Holt, 2008). Based on findings from retrospective interviews with elite athletes, both researchers proposed that talent development occurred through distinct phases, or stages across the life span. For Bloom, these phases were the initiation stage during the early years of development, followed by the Stage of Development during the middle years, and then in later years, the final stage, the Stage of Perfection (Durand-Bush & Salmela, 2001; Holt, 2008).

Côté has described a ‘Differentiated Model of Sport Participation’, which proposes three main stages of development. These are, the sampling years (age 6-13 years), the specialising years (age 13-15 years) and then the investment years (age 15 years and over). Unlike Bloom’s model which is primarily focused on performance, Côté’s model is based on sampling, deliberate play and deliberate practice (Strachan et al., 2008). Côté also included a fourth stage, the recreational years, which can be entered at any time, and is independent of the experiential outcomes at any of the other stages (Durand-Bush & Salmela, 2001).

These models were developed based on findings from middle-class North American athletes (Holt, 2008). An alternative view was proposed by Salmela & Moraes, (2003) who interviewed a group of youth soccer players (aged 16-18years), that were members of junior professional teams in Brazil. These young athletes were from lower-class backgrounds and had achieved ‘pre-elite’ status with little family or formal coaching support. However, they had devoted inordinate amounts of time during their childhood to playing and practicing soccer. Together with the lure of potential financial rewards, this large volume of practice had apparently compensated for the lack of coaching. Regardless of the pathway, the development of talent involves many years of learning, training and commitment in order to attain excellence. Therefore it would seem that a long term focus is required to become an expert (Ericsson, 1996; Starkes & Ericsson, 2003), but what seems less clear is the nature of this focus throughout development.

Role of deliberate practice

The results of investigations in the early 1990’s suggested that many years of deliberate practice were essential for anyone to become an expert performer in most performance domains. This research demonstrated that approximately ten years, or 10,000 hours of training was required for a talented athlete to achieve expert performance (Ericsson, 1996). Furthermore, the level of expertise attained was directly and monotonically related to the accumulated amount of deliberate practice in each specific domain (Ericsson, Krampe, & Tesch-Romer, 1993). As a consequence of these findings, talent identification initiatives in many sports have attempted to identify the ‘talented’ as early as possible in order to provide the necessary period of time required in order to excel (Ericsson, 1996; Starkes & Ericsson, 2003). Traditional methods of talent development have supported this concept, and according to Vaeyens et al, (2009) this approach was principally based on economic motives such as time and finances. Early identification of talented individuals therefore became increasingly more important across many performance domains. In doing so, limited resources could be directed more efficiently to a select group of ‘talented’ junior athletes who would hopefully progress to become an elite adult performer in their chosen domain.

With the development of Bloom’s stages of talent development and more recently of Côté’s differentiated model of sports participation, many researchers are now questioning the efficacy of Ericsson’s notion of deliberate practice (Abbott & Collins, 2004; Abernethy & Côté 2007; Baker, 2003; Côté et al., 2007; Côté & Fraser-Thomas, 2008; Fraser-Thomas & Côté, 2006; Gulbin, 2006; Martindale et al., 2005; Soberlak & Cote, 2003; Vaeyens et al., 2009; Vaeyens et al., 2008; van Rossum, 2000; Ward, Hodges, Starkes, & Williams, 2007). This more current research suggests that expertise in a sporting domain can be achieved in 3,000 to 5,000 hours. For example, van Rossum (2000) in a study of elite Dutch field-hockey players found that adult national and international players had spent 4,100 and 4,600 hours respectively participating in training and playing. Furthermore Gulbin, (2006) reported that 28% of athletes at the Australian Institute of Sport had achieved national representation in their sport, in less than four years of involvement, and that 70% of athletes required significantly less than 10 years to achieve expertise. This data reinforces the current belief that between 3,000 and 4,000 hours of sport-specific training is sufficient to allow for expert levels of performance to be achieved in those sports where peak performance occurs after 20 years of age (Côté & Fraser-Thomas, 2008). Rather than focusing on the necessity of accruing 10,000 hours of deliberate practice in the one sporting domain, a better measure of expertise in sport appears to be the accumulation of 10,000 hours of total involvement in sport.

Summary of factors underlying effective talent development

The need for a multi-dimensional approach to talent identification has therefore evolved from the shortcomings of the older, traditional approaches (Vaeyens et al., 2008). These earlier models had attempted to identify talent by focusing on a limited range of physical parameters and basing selection on "one-off" proficiency measures. However, they failed to acknowledge the role of both physical maturity and previous experience in influencing performance (Vaeyens et al., 2008). In doing so, those young athletes who displayed some / all of these same characteristics were incorrectly deemed to possess the necessary talent to progress and possibly become an elite athlete. Due to these limitations, current best practice sets out to identify, evaluate and nurture athletic potential rather than performance abilities at a young age.

Contemporary research into the development of sporting expertise is therefore focused on more than simply attempting to understand the control processes that distinguish elite from non-elite performers. There is also an attempt to understand the processes through which expertise is acquired (Lidor et al., 2005). There appear to be many influences that may have a crucial and lasting impact on the development and eventual success of a talented athlete (Gould et al., 2002). For example, profiles of elite athletes have shown a pattern of training that changes throughout development (Baker, Côté & Abernethy, 2003). Important development changes that occur include the number of sporting activities athletes are involved in and the number of hours invested in deliberate play, structured practice, and deliberate practice. Certainly the dynamic nature of talent warrants an approach that is sympathetic to both 'early' and 'late' bloomers. Such an approach would include long-term aims and methods; wide ranging coherent messages and support; emphasis on appropriate development rather than early success; individualised and ongoing development; and finally integrated, holistic and systematic development (Fraser-Thomas, Côté , & Deakin, 2008; Martindale et al., 2005; Strachan, Cote, & Deakin, 2009).

Relative age effects

In this final section, relative age effects will be discussed in more detail. Firstly, evidence will be presented outlining the history and prevalence of relative age effects on a global basis and then in the context of Australian sports. Social / environmental factors will then be discussed, illustrating how such seemingly innocuous influences as chronological age groupings, degree of playing experience and an individual's place of birth impact on the development of relative age effects. These factors highlight the importance of the early years of a child's involvement in sport as a foundation for the development of motivation, skill, and talent. Also, it demonstrates the remarkably enduring effect that early sport experiences may have on the likelihood of expertise being ultimately achieved. A number of possible solutions to help eliminate/reduce relative age effects will then be presented. The potential of fundamental movement skills, decision-making, technical and tactical skill development as part of a potential strategy to assist this process will also be discussed. Several authors have suggested that the inclusion of these skills in development programs will not only help to reduce relative age effects, but also enhance the overall talent development process (Fisher, 2008; Gould, 2009; Martindale et al., 2007; Musch & Grondin, 2001; Starkes & Ericsson, 2003).

History and prevalence of relative age effects in adolescent sport

The earliest studies that investigated the relative age effect were from junior and minor Canadian Ice Hockey leagues (Barnsley & Thompson, 1988; Barnsley et al., 1985; Grondin, 1982; Grondin et al., 1984). Grondin et al (1982, 1984), initially examined birth-date distributions of Canadian ice hockey and volleyball players who competed in three different levels of competition ranging from recreational to the professional level. The results from ice hockey leagues identified repeated over-representation of players born in the first three months of the competitive season for each age-group category and across all three levels of competition, while in volleyball a relative age effect was observed for elite representative players (Cobley et al., 2009). Following on from this work, Barnsley et al, (1985); Barnsley et al, (1992); Cobley et al, (2008); Lariviere & Lafond, (1986); Musch & Grondin, (2001); Wattie, Cobley et al, (2007) also identified a skewed trend in ice hockey player birth dates with an over-representation of players in junior representative provincial teams and national leagues being born in the first three months of the year.

The majority of studies examining relative age effects have been conducted in Europe and North America within the major sports of soccer (Barnsley et al., 1992; Baxter-Jones & Helms, 1994; Brewer, Balsom, & Davis, 1995; Brewer, Balsom, Davis, & Ekblom, 1992; Dudink, 1994; Gil et al., 2007; Helsen et al., 1998; Helsen, Starkes, et al., 2000; Helsen et al., 2005; Jullien, Turpin, & Carling, 2008; le Gall, Carling, Williams, & Reilly, 2009; Malina, Cumming, et al., 2005; Musch & Hay, 1999; Nedeljkovic et al., 2007; Peterson, 2003; Richardson & Stratton, 1999; Simmons & Paull, 2001; Vaeyens et al., 2005; Verhulst, 1992; Vincent & Glamser, 2006; Williams & Reilly, 2000b), ice hockey (Barnsley & Thompson, 1988; Barnsley et al., 1985; Boucher & Mutimer, 1994; Daniel & Janssen, 1987; Grondin, 1982; Grondin et al., 1984; Grondin & Trudeau, 1991; Lariviere & Lafond, 1986; Sherar, Baxter-Jones, et al., 2007), baseball (Grondin & Koren, 2000; Thompson, Barnsley, & Stebelsky, 1991) investigated. More recently, athletics (Johnstone & Doyle, 2007; J. G. Morris, Sedgwick, & Nevill, 2007), professional basketball (Esteva & Drobnic, 2006), French junior basketball (Delorme & Raspaud, 2009), English rugby league (Till et al., 2010; Till, O'Hara, Cobley, Cooke, & Chapman, 2008), European handball (Cobley, Schorer, et al., 2008; Mohamed et al., 2009), rugby union (Spamer & Winsley, 2003), swimming (Baxter-Jones et al., 1995; Dunman, Morris, Peyrebrune, Warr, & Nevill, 2005; Morris et al., 2007), and tennis (Baxter-Jones et al., 1995; Dudink, 1994; Edgar & O'Donoghue, 2005; Giacomini, 1999) have also shown evidence of relative age effects. Taken together these studies have confirmed that players born early in the competitive season are over-represented in junior development squads when compared with players who are born late in the competition year (October – December) (Carling, le Gall, Reilly, & Williams, 2009; Helsen et al., 2005; le Gall et al., 2008; le Gall et al., 2009; Lefevre et al., 1990; Musch & Grondin, 2001; Vaeyens et al., 2005; Williams & Reilly, 2000b) An overview of the findings of each of these studies can be found in Appendix B.

To date, there appears to be only a few studies that have specifically examined relative age effects in Australian sports at the senior, professional level (Abernethy & Farrow, 2005; Barnett, 2010; Musch & Hay, 1999; O'Donoghue et al., 2004; Pyne et al., 2006). For example, O'Donoghue et al. (2004) described the relative age effect in elite cricket and netball from players at the 2003 World Cup (cricket) and the 1999 World Championships (netball). The results indicated a significant season of birth bias only for players from the northern hemisphere netball squads.

Abernethy and Farrow (2005) examined the distribution of birth dates of current and past elite male Australian athletes in a sample of major winter and summer sports to determine whether a relative age effect was evident at this level of professional ARF, rugby league and rugby union, cricket & basketball. Their results demonstrated that a relative age effect existed for senior ARF players, elite junior soccer players (U17 and U23 national teams), senior rugby league players, and Australian cricket players but not in the Australian national soccer (The Socceroos), or rugby union teams. Barnsley et al, (1992) also found evidence of a relative age effect in the Australian Under-17 soccer team that attended the 1989 FIFA Under-17 world tournament. These findings support earlier research that demonstrated an over-representation of early maturers in sports that require players to have physical size, strength and speed (Vaeyens et al., 2005). Evidence of a relative age effect was also found in both male (U16 and U18) and female (U16), state junior representative basketball teams in Australia (Hoare, 2000a). It was suggested that the relative age effect might be related to the developmental pathway for young basketball players in Australia.

Relatively few studies have specifically examined the relative age effect in Australian junior team sports (Abernethy & Farrow, 2005; Hoare, 2000a, 2000b; Pyne et al., 2006). Based on the growing evidence from international studies, there appears to be a solid justification for investigating the relative age effect in elite junior team sports in Australia. For example, recent research has suggested that the continued presence of a strong relative age effect in elite junior sport is counter-productive to effective talent promotion programs. Coaches should instead focus on the future potential of young athletes rather than on short-term success (Augste & Lames, 2011; Baker, et al, 2010; Del Campo et al, 2010).

Social/Environmental Factors

Chronological age groupings and competition

The popularity of youth sport could in fact be contributing to the continued existence of relative age effects in most sports. Musch and Grondin (2001) have suggested that the popularity of a sport (i.e. the number of people desiring to play) increases the competition for available positions on a sports team (Musch & Grondin, 2001), which produces an environment conducive to the development of the relative age effect. Other factors such as grouping players in sports according to chronological age and beginning a process of selecting players for junior representative teams at early ages are also considered to foster the relative age effect (Barnsley & Thompson, 1988; Barnsley et al., 1985; Cobley, Schorer, et al., 2008; Helsen et al., 2005; Perez Jimenez & Pain, 2008; Wattie, Baker, et al., 2007). This combination of chronological age groupings and competition beginning at an early age provides a distinct advantage for those children whose birthdate falls in the first few months of the competition year, which can provide a considerable maturational advantage (Helsen, Hodges, et al., 2000). For these reasons, coaches may inadvertently ascribe talent to early physical maturation and deselect late maturers.

Experience

In addition to the physical and psychological factors involved in age differences, a young athlete's experience with a particular sport is an important contributing factor to the relative age effect. For example, among 10-year-old children, an 11-month difference in age may provide considerable advantages in terms of stature, mass, strength, and cognitive development (Reilly et al., 2008; Ward & Williams, 2003). In addition, relatively older athletes also have the advantage of approximately an extra 10% of total life experience. Maybe more importantly, this difference represents an extra year of experience in a given sport. Additionally this may provide more training and playing time. Furthermore, because of their early success, athletes that are born in the first quarter of their sport year may receive more encouragement, feedback, and support from parents, coaches and peers. This type of social environment further enhances their advantage by providing the added motivation needed to play and train with greater focus and intensity.

The relative age effect, therefore, is a phenomenon that favours athletes born early in their selection year by providing them with additional time on task (Côté et al., 2007). For relatively older athletes this may also provide a greater chance of being selected in TID programs. These programs then provide important development opportunities, which may also increase an athlete's motivation. In contrast, the relatively younger child is likely to be frustrated by his or her limited ability to compete, which will likely lead to a decrease in motivation, and increase the likelihood of dropping out of competitive sport (Musch & Grondin, 2001). Therefore, an important consideration in the process of developing elite-level athletes is balancing the acquisition of all the necessary performance skills, while optimising the mental, physical, social and emotional health of young athletes through continued participation in sport (Côté et al., 2007).

Birthplace effects on development of athletic talent

An athlete's place of birth has also been shown to influence sporting success (Baker & Logan, 2007; Carlson, 1988; Côté , Macdonald, Baker, & Abernethy, 2006; Curtis & Birch, 1987; D. MacDonald, Cheung, Côté , & Abernethy, 2009; D. J. Macdonald, King, Côté , & Abernethy, 2009), with the size of the town or region in which an athlete is born and the place where an athlete spends a significant amount of their early years being shown to have a significant bearing on their chances of playing professional sport.

Several studies have demonstrated a link between birth place and success in professional sports, including American football (NFL), Major League Baseball (MLB), National Basketball Association (NBA) and Ice Hockey (NHL) (Baker & Logan, 2007; Côté et al., 2006; Curtis & Birch, 1987; MacDonald et al., 2009). Specifically, living in a town or region with a population of between either 100,000-250,000, or 500,000-999,999 people provided a much greater chance of being selected to play professional sport. For example, MacDonald et al (2009) reported that female professional soccer players who were born in cities of less than 1,000,000 were over-represented, whilst female professional golfers were more likely to come from cities of less than 250,000 (Macdonald et al., 2009). These findings were consistent with those of the studies of male professional athletes. In the only study to date using Australian data, Abernethy and Farrow, (2005) also demonstrated a greater majority of professional rugby league and cricket players were born in cities with a population between 100 000 and 999,999 inhabitants (Abernethy & Farrow, 2005).

The consensus from these studies is that being born in a relatively small town / city affords young people with more opportunities for both deliberate and spontaneous play. It is possible that athletes from these smaller cities can engage in activities / behaviours that allow them to safely explore their sporting environment in a manner neither found nor available in larger cities (Baker, 2007; Baker et al, 2009; Côté et al, 2006). Furthermore, athletes from smaller cities may also benefit from exposure to multiple sports from a much younger age and for a longer time (Curtis & Birch, 1987; MacDonald et al, 2009; Soberlak & Côté, 2003). These athletes might also benefit from earlier exposure to competing against much older sporting opponents in either a social or competitive environment (Carlson, 1988; Abernethy & Farrow, 2005).

Summary of social/environmental factors influencing the development of relative age effects

The relative age effect is now seen as an artificial consequence of the competitive structure and creates waste of potential (Perez Jimenez & Pain, 2008). Rather than contributing to the development of elite success, traditional models are more likely to have excluded many late maturing, potentially talented children from developmental programs. It is now widely believed that selecting players purely on the basis of physical characteristics may in fact deselect many younger players, even though they may be more technically gifted. These players may then be denied access to professional training and the opportunity to fulfil their potential in the long term (Helsen et al., 2005; Peterson, 2003). Moreover, Verhulst (1992) has suggested that this type of juvenile competition stress can result in early discouragement of an important cohort of talented youngsters, forcing many of them to drop out of sport at a young age. These younger players are handicapped simply by having their birthday later in the selection year (Peterson, 2003; Verhulst, 1992).

Solutions to eliminate/reduce relative age effects

Junior sporting competitions are traditionally organized according to chronological age groupings. However, recent research has identified that this may not be best practice for optimising athletic potential in all athletes. Remarkably, as outlined in more detail in a previous section, the earliest studies examining talent identification (Crampton, 1908; Rotch, 1908) had suggested that a more realistic criterion than chronological age was needed for stratification of sports participation. This suggestion was made on the findings of the considerable variations in inter-individual growth and development in the adolescent and youth. Moreover, despite the majority of evidence suggesting the adoption of the same criterion, many talent identification and development programs are classified according to chronological age. A reliance on chronological age groupings has contributed significantly to the growth of the relative age effect in many junior team sports around the world. Relative age effects are considered to represent a social inequality that impedes the likelihood of immediate participation and long-term attainment in sport (Cobley, Schorer, et al., 2008).

Even before the emergence of the relative age effect in scientific literature (Barnsley et al., 1985; Grondin, 1982), studies were suggesting that between the ages of 12 – 16 a classification into age-maturity categories instead of one based on only chronological age categories would lead to fairer competition in youth sports (Beunen et al., 1981). Furthermore, this type of classification may also eliminate maturational-related problems such as significant differences in body mass, muscular strength, speed and power for young competitors (Beunen et al, 1981; Lefevre et al, 1990; Baxter-Jones et al, 1995). This suggestion appears to have been largely ignored, with the consequence being the development of relative age effects (Baxter-Jones & Helms, 1994; Dudink, 1994; Edwards, 1994).

To date there has been no research that has investigated methods to effectively eliminate relative age effects. However, several possible solutions have been proposed (Abbott et al., 2005; Barnsley et al., 1985; Baxter-Jones, 1995; Beunen et al., 1981; Boucher & Halliwell, 1991; Hurley, Lior, & Tracze, 2001; Hurley, 2009; Musch & Grondin, 2001). Some of these suggestions include rotating and changing cut-off dates for annual age groupings, introduction of age quotas, classification systems based on biological age, providing multiple squads based on different standards, and raising awareness about relative age effect with parents, coaches and those responsible for the organization and administration of youth sports. However, none of these possibilities have been considered to be either practical or viable long-term solutions (Abbott et al., 2005; Barnsley & Thompson, 1988; Cobley et al., 2009; Helsen et al., 2005; Musch & Grondin, 2001; Musch & Hay, 1999; Perez Jimenez & Pain, 2008).

Potential role of fundamental movement skills, decision-making and technical and tactical skill development

More recently, two other suggestions have been provided as a solution for the relative age effect. The first of these is to delay the processes of selection, identification and representation beyond stages of puberty and maturation (i.e. 15–19 years of age) (Baxter-Jones, 1995; Cobley et al., 2009; Helsen et al., 2005; Perez Jimenez & Pain, 2008). The second is that when selecting players, coaches and selectors pay more attention to assessment instruments based on technical and tactical skills and possibly tests based on real-world (game-based) situations (Fisher & Bailey, 2008; Gould, 2009; Helsen, Hodges, et al., 2000; Martindale et al., 2007; Musch & Grondin, 2001; Pienaar, Spamer, & Steyn, 1998; Vaeyens et al., 2008; Vaeyens et al., 2006). When these two suggestions are taken together, this approach might allow a shift to a long-term approach, focusing on the development of the full range of skills needed to develop sporting expertise. Additionally, Starkes and Ericsson (2003) has suggested that the best approach to developing sport expertise is to expose children to a large variety of motor skills and experiences early on (6 – 14 years) so that children will not miss windows of opportunity (i.e. sensitive development periods (Ford et al, 2011)) and leave specialization for later on (15 years and older) (Starkes & Ericsson, 2003).

In our quest to identify the small proportion of young athletes that are considered the ’teenage prodigies’ it seems that many of the current talent identification and development systems may be failing to fully develop the fundamental movement qualities and athletic potential of the greater majority of young athletes. This review has established that until recently, the process of talent identification and development was failing in its primary aim of recognizing participants with the greatest potential to excel in their particular sport. It is clear that since researchers began investigating the acquisition of expertise in sport, indicators of early physical maturity have been confused with talent in adolescent athletes.

More recently, this has given rise to the relative age effect. Prior to the 1980's relative age effects in team sports did not appear to exist. More recent research has also shown that an individual's place of birth may be more influential in determining whether they achieve elite success as an athlete. Current models of talent identification have become more dynamic and multidimensional as they attempt to nurture rather than (de)select talented individuals. This approach may form part of an effective solution to assist with the elimination of relative age effect in team sports.

Research also suggests that coaches and administrators should pay more attention to the long-term development of technical and tactical skills when selecting players (Helsen et al., 2005; Musch & Grondin, 2001). Such an approach might offset the effects of maturational changes and also minimize the likelihood of the relative age effect. This change would require a shift from a model of selection and elimination, to one of development and continual monitoring (Abbott & Collins, 2004). Indeed, a long-term approach reflective of the social, emotional, biological and cognitive needs of young athletes would allow them to experience optimal training and competition opportunities. Children and adolescents need to be given time to allow for their athletic potential to be realized and this may not occur until maturation is complete.

By providing equal time to the development of both cognitive and motor skills, young athletes will be better prepared to pursue sporting excellence, regardless of their maturational status. A previous case study analysing wage data of German Bundesliga soccer players, provided clear evidence of a month-of-birth related wage bias with players born late after the cut-off date (August 1st) were found to earn systematically more than their early-maturing counterparts (Ashworth & Heyndels, 2007). In the context of planning long-term talent development, the best performers in adulthood were not necessarily early maturing boys. For example, relatively younger Canadian players were selected in the earlier rounds of the annual National Hockey League draft (Baker & Logan, 2007). The authors suggested that these players likely displayed superior performance when compared to their earlier born peers. Furthermore, in professional male team sports, award winning athletes are more likely to be born later in the selection year (Ford & Williams, 2011). In addition, previous research into soccer has found that those who performed well for their maturity level during adolescence had a good chance of still performing at an above average level at the age of 30 (Lefevre et al., 1990; Philippaerts et al., 2006; Vaeyens et al., 2008; Wattie et al., 2008).

A wide variety of skills are needed for development in many sports (Helsen, Hodges, et al., 2000; Martindale et al., 2007; Strachan et al., 2008; Till et al., 2010). Included in an athlete's skill set would be more generic skills such as fundamental movements, decision-making, life and mental skills (Martindale et al., 2007). All of these skills need to be given time to develop appropriately and a variety of environments may be required to achieve this. The cumulative effects of training across all of these skills are essential for an athlete's long-term development and represent the summation of many years of training (Duthie, 2006). The most consistent variable distinguishing those who achieve the highest levels of success in sports and their less successful counterparts is hours of training (Baker, Horton, et al., 2003). Time spent mastering these fundamental skills provides the basis for more sport-specific development to take place in later years.

A realistic selection process free of bias that aims to maximise the number of elite performers nurtured with the best possible resources should surely be the objective of all sporting organizations. For example, the Crawford report into “The Future of Sport in Australia” has suggested that Australia can only maintain its place in the upper echelons of world sport by increasing the number of people playing sport. The report further suggests that the most effective way of achieving this is by increasing the talent pool from which to choose talented athletes to mould into future champions (Crawford, 2009). Therefore, whether motivated toward realizing the positive effects of sport on youth development (e.g. promoting fun, enjoyment and inclusive participation), or toward elite athlete development, the presence of relative age effects appears contradictory to both these outcomes. Certainly the current models of competition, selection and talent identification, appear to have contributed to the development of relative age effects. This effect should be a concern for many sport organizations, especially team sports. Therefore, there is a need to identify which of these fundamental qualities are most important to allow a young athlete to realize their athletic potential and then develop an effective model to enhance the development of these qualities.

Conclusion

The acquisition of expertise in sport is the result of complex interactions among biological, psychological, and sociological constraints (Baker, Horton, et al., 2003). Each year many young athletes participate in age-group competitions often with the goal of achieving success at the elite level. These early years in sport are fundamental in the process of acquiring and developing the skills they will need to become expert performers. Elite success is based on junior development pathways progressing to senior ranks and eventually international competition (Duthie, 2006). The current pathway for most young athletes begins in age-group competitions, progresses to ‘representative’ selection, often at an early age, and continues with selection to regional, state, national and international teams. As outlined in this review, this current pathway has many flaws. Current practices in talent identification may in fact be deselecting potentially talented young athletes and denying them access to coaching and the opportunity to fully develop their potential. A selection/identification process that incorporates fundamental sporting qualities across a number of performance domains therefore seems warranted.

There appears to be justification for research to firstly establish the existence and prevalence of relative age effects in elite junior team sports in Australia. Secondly, an investigation is warranted to determine the likely impact of using a multi-dimensional methodology to evaluate talented junior athletes. This would include an assessment of maturational status, plus selected kinanthropometric measures, physical performance, psychological and game-specific technical and tactical skills. This would, in all probability, provide a much deeper insight into the true sporting potential of young athletes involved in team sports. Using such an approach may ultimately provide an effective strategy to assist with reducing / eliminating relative age effects in elite junior team sports.

Chapter 3

Research Study

Study One: Determination of the presence of a relative age effect in an elite Australian junior team sport

Study Two: Determination of the effect of skill level and playing position on relative age effects

Study Three: Determination of the effect of increasing age on the strength of relative age effects.

Introduction

In Australia, as in most other countries, male junior sporting competitions are organised on chronological age categories. Previous research (Helsen et al., 1998; Musch & Grondin, 2001; Vaeyens et al., 2005) has shown that this organisational structure tends to provide an advantage to those boys born earlier in the competition year. This advantage, known as a relative age effect, is especially prevalent during adolescence, specifically between 12 and 16 years of age; particularly when selecting representative teams (Malina et al, 2000; Cobley et al, 2009; Mujika, 2009; Till et al, 2010). Despite a growing body of research, primarily from the sports of ice hockey and soccer (Cobley et al., 2009; Musch & Grondin, 2001), there has been surprisingly little research into the relative age effect in Australia.

Those few studies that do exist have been largely descriptive, with presentation of their findings limited to conference proceedings (Abernethy & Farrow, 2005; Hoare, 2000a; Pyne et al., 2006). To the author's knowledge, no research has investigated the presence of a relative age effect in elite Australian junior team sports.

Recent research has suggested that relative age effects may be moderated by such factors as age, playing position and skill level (Barnsley & Thompson, 1988; Malina, 1994; Mujika et al., 2009; Till et al., 2008). Accordingly, the investigation also attempted to determine whether the observed relative age effect from the U16 cohort would be affected by skill level and playing position. Finally, the affect of increasing age would be investigated by comparing similarities and / or differences between birth date distributions from the U16 National championships and the Australian U20 Junior World Cup teams (2008 – 2011). It was hypothesized that relative age effects would be moderated by skill level, playing position and increasing age.

The principal aim of this study was to therefore investigate whether a relative age effect is present in a cohort of elite junior Australian rugby union players. Even in these young players, the physical qualities of size, strength, power, speed and endurance are now considered to be essential to the demands of competition at an elite level (Austin, 2011; Duthie, 2006). Furthermore, given that Rugby is considered to be a contact sport (Duthie, 2006), and that previous studies from the sport of Rugby League (Till et al., 2010) have reported strong relative age effects in junior teams, it was hypothesized that a relative age effect would be found in a group of elite junior players competing at the annual National Under 16 schoolboy championships.

Methods

Subjects

For the first part of the study, player records were accessed for 1932 elite male U16 rugby players, from 12 representative regions competing at the Australian National Championships between 2004 and 2010. The subjects used in the study represented the best U16 rugby union players from each state and territory in Australia. Each player had been selected to attend the national U16 championships after competing in a selection carnival in their home state/territory. All players were under the age of 16 years at the time of the carnival. For the second part of the study, player records were accessed for the 110 players who represented the Australian U20 team between 2008 and 2011. To allow for direct comparison of birth date data, player records were also accessed for 1078 players who competed at the U16 National Championships between 2004 and 2007. A written consent form was obtained from a legal representative of the Australian Rugby Union (Appendix A) prior to the commencement of the study. The UTS Human Research Ethics Committee also granted ethical approval prior to the commencement of the current investigation.

Study Design

This investigation was conducted in two parts. The aim of part one was to determine the presence of a biased birth date distribution among players competing at the U16 National championships. In Australia the competition and selection year for junior rugby union is exactly the same, that being, January 1st to December 31st. Birth date data was accessed from available records of each participant who competed at the U16 National Championships (2004 – 2010). As in previous studies (Baxter-Kones, 1994; Cobley, 2009; Edwards, 1994), in order to test for relative age effects, players' birth dates were first tabulated into individual months and then recoded into quartiles (Q1 = January – March, Q2 = April –June, Q3 = July – September and Q4 = October – December). Expected birth-date distributions were calculated from available age-matched Australian population birth statistics for each year under investigation. Data was accessed from the Australian Bureau of Statistics for the years 1988 to 1994. This part of the study also included a determination of whether playing position and skill level act as moderators of relative age effects. For playing position, players were categorised as either a forward or a back, depending on their individual playing position (Table 3.1). For skill level, players were divided according to their ARU allocated division (Table 3.2). There were 8 teams in Division 1 and 4 in Division 2.

Table 3.1: Breakdown of playing positions showing individual and playing position.

Playing Position	
Forwards	**Backs**
Prop Forwards x 2	Halves x 2 (Includes Half-Back and Fly-Half)
Hooker x 1	Centres x 2
Locks/Second Row Forwards x 2	Wingers x 2
Flankers/Loose Forwards x 2	Fullback x 1
Number 8 x 1	
Total Forwards = 8	Total Backs = 7

Table 3.2: Breakdown of teams per playing division U16 National Championships (2004 – 1010).

Playing Division	
Division 1	***Division 2***
Queensland Red	South Australia
Queensland White	Northern Territory
NSW Schools	Tasmania
NSW Country	National Indigenous Team
Sydney Juniors	
ACT	
Victoria	
Western Australia	

Study two investigated the potential role of increasing age as a moderator of relative age effects. Birth date data was accessed from available records for the Australian U20 rugby union team (2008 – 2011) and also from the records of the same players for players who had competed at the National U16 championships (2004 – 2007). As for study one, players' birth dates were first tabulated into individual months and then recoded into quartiles (Q1 – Q4). Expected birth-date distributions were calculated from available age-matched Australian population birth statistics for each year under investigation. Data was accessed from the Australian Bureau of Statistics for the years 1988 to 1991. Once the birth date distributions had been calculated for each group, they were then compared to determine any similarities between the two groups.

Statistical Analyses

For study one, chi-square statistics were used to examine differences between observed and expected birth date distributions in all players, and general playing positions (forwards and backs). Comparison of birth date distributions between players in the 1st (top 8 teams) and 2nd division (bottom 4 teams) was also conducted. Odds ratios (ORs) and 95% confidence intervals (CIs) were also calculated for both quartile and half-year distributions (H1 and H2). For the OR analyses, the relatively youngest members, (i.e. Q4 and H2 respectively) of the annual age-groupings were assigned as referent groups. A higher odds ratio indicates an increased risk of a player appearing in a particular group as opposed to the referent group. These analyses were repeated in the second half of the study, when comparing the birth date distributions between the U20 and U16 players to determine if increasing age acted as a moderator of relative age effects. All analysis was conducted using PASW statistical software package (PASW, Version 17, Chicago, USA). Statistical significance was set at $p<0.05$.

Results

Table 3.3 shows the results by quarter for the U16 championships for the period 2004 – 2010. In addition, the quartile distributions for the general Australian population over the same time period are also presented. The results demonstrated that more rugby union players born in the first quarter were selected than those born in the fourth quarter. The quarterly birth-date distributions of all groups differed significantly from the general population. Players in the 2nd division were born later in the year than those in the first division.

Table 3.3: Quarterly birth rate data U16 National Championships 2004 – 2010, with

comparative data for the Australian population

		Quarter of Birth				
Division	**n**	**Q1**	**Q2**	**Q3**	**Q4**	X^2
One	1276	497	382	256	141	17.79***
(8 Teams)		(38.95%)	(29.94%)	(20.06%)	(11.05%)	
Two	619	215	175	121	108	7.97***
(4 Teams)		(34.73%)	(28.27%)	(19.55%)	(17.45%)	
Totals	1895	712	557	377	249	14.03***
		(37.57%)	(29.93%)	(19.89%)	(13.14%)	
Australian	1,797,609	444,495	449,333	460,188	443,593	
Population		(24.72%)	(25.00%)	(25.60%)	(24.68%)	

*** $p<0.001$

Table 3.4 shows the relative age effect results by playing position and demonstrates an uneven birth date distribution for backs and forwards. Indeed, more players from both groups were born in Q1 (backs and forwards) than from Q4. These birth-date distributions for both groups differed significantly from the expected result.

Table 3.4: Quarterly birth rate data by playing position U16 National Championships 2004 – 2010, with comparative data for the Australian population

	Quarter of Birth				
Playing Position	Q1	Q2	Q3	Q4	X^2
Forwards	37.24%	30.54%	19.09%	13.13%	14.54***
Backs	37.88%	27.77%	21.32%	13.03%	13.44***

*** p<0.001

Table 3.5 shows a comparison of quarterly birth date distributions for the Australian Under 20 Rugby Union team (2008 – 2011) and the U16 National Schoolboy Championships from the prior four-year time period (2004 – 2007). These players were born 1988 – 1991. Chi-squared analyses of each group found significant uneven birth-date distributions for the Under 20 teams and the equivalent Under 16 teams.

Table 3.5: Quarterly birth date data for Australian Under 20 Teams (2008 – 2011) and Under 16 National Championships (2004 – 2007).

		Quarter of Birth				
Team	N	Q1	Q2	Q3	Q4	X^2
Under 20s	110	32.73%	34.55%	21.82%	10.91%	15.48*
Under 16s	1078	37.29%	28.57%	21.06%	13.08%	148.44**
Australian Population	1,018,346	250,732 (24.62%)	255,419 (25.10%)	262,368 (25.76%)	254,853 (25.02%)	

*p<0.001

**p<0.0001

Table 3.6 shows the results of the subsequent odds ratios (95% CI analyses) for the observed and expected birth rate distributions from the Under 16 national Championships. This analysis demonstrated that there were significant differences between playing divisions across each quartile comparison as well as for the half-yearly comparisons. These results suggest that players with a higher skill level are more likely to play in a Division one team.

Table 3.6: Odds ratio comparisons Under 16 National Championships (2004 – 2010).

	Odds Ratio Comparisons (95% confidence interval)			
Division	Q1 vs. Q4	Q2 vs. Q4	Q3 vs. Q4	H1 vs. H2
One	3.52	2.67	1.75	2.24
(8 teams)	(2.92 – 4.24)	(2.20 – 3.24)	(1.42 – 2.15)	(1.99 – 2.52)
Two	1.98	1.62	1.08	1.72
	(1.58 – 2.50)	(1.27 – 2.05)	(0.86 – 1.44)	(1.46 – 2.03)
Overall	2.85	2.21	1.46	2.05
	(2.47 – 3.30)	(1.90 – 2.56)	(1.24 – 1.71)	(1.86 – 2.25)

Table 3.7 shows the subsequent odds ratio analysis by playing position. This analysis demonstrated there were no differences between forwards and backs and the strength of the relative age effect.

Table 3.7: Odds Ratio Comparisons, by playing position, U16 National Championships 2004 – 2010.

	Odds Ratio Comparisons (95% confidence interval)			
Playing Position	Q1 vs. Q4	Q2 vs. Q4	Q3 vs. Q4	H1 vs. H2
Forwards	2.83	2.30	1.40	2.13
(8 teams)	(2.34 – 3.43)	(1.90 – 2.80)	(1.13 – 1.74)	(1.87 – 2.42)
Backs	2.90	2.10	1.58	1.93
	(2.33 – 3.61)	(1.67 – 2.65)	(1.24 – 2.00)	(1.67 – 2.23)

Significant differences in odds ratios were also found for the Australian U20 teams and for the corresponding years from the U16 championships (Table 3.8). Similar to the distributions for the U20s, the Q1 to Q4 and the Q2 to Q4 ratios were similar, with both significantly higher than for Q3 vs. Q4 ratio. Half-yearly comparisons (H1 v H2) also revealed a significant OR. The odds ratios for the Q1 vs. Q4 comparison from the U16 championships (2004 – 2007) showed the greatest OR, but these were smaller for the Q3 vs. Q4 comparison (Table 3.8).

Table 3.8: Odds ratio comparisons, Australian Under 20 Team (2008 – 2011) and Under 16 National Championships (2004 – 2007).

	Odds Ratio Comparisons (95% confidence interval)			
Team	Q1 vs. Q4	Q2 vs. Q4	Q3 vs. Q4	H1 vs. H2
Under 20s	3.05	3.16	1.94	2.10
(2008 - 2011)	(1.59 – 5.86)	(1.63 – 6.05)	(0.97 – 3.88)	(1.41 – 3.13)
Under 16s	2.90	2.12	1.56	2.02
(2004 – 2007)	(1.58 – 2.50)	(1.27 – 2.05)	(0.86 – 1.44)	(1.46 – 2.03)

Figure 3.1 shows the differences in the quarterly birth distributions between the general Australian population and players from the National U16 schoolboy championships (Figure 3.1)

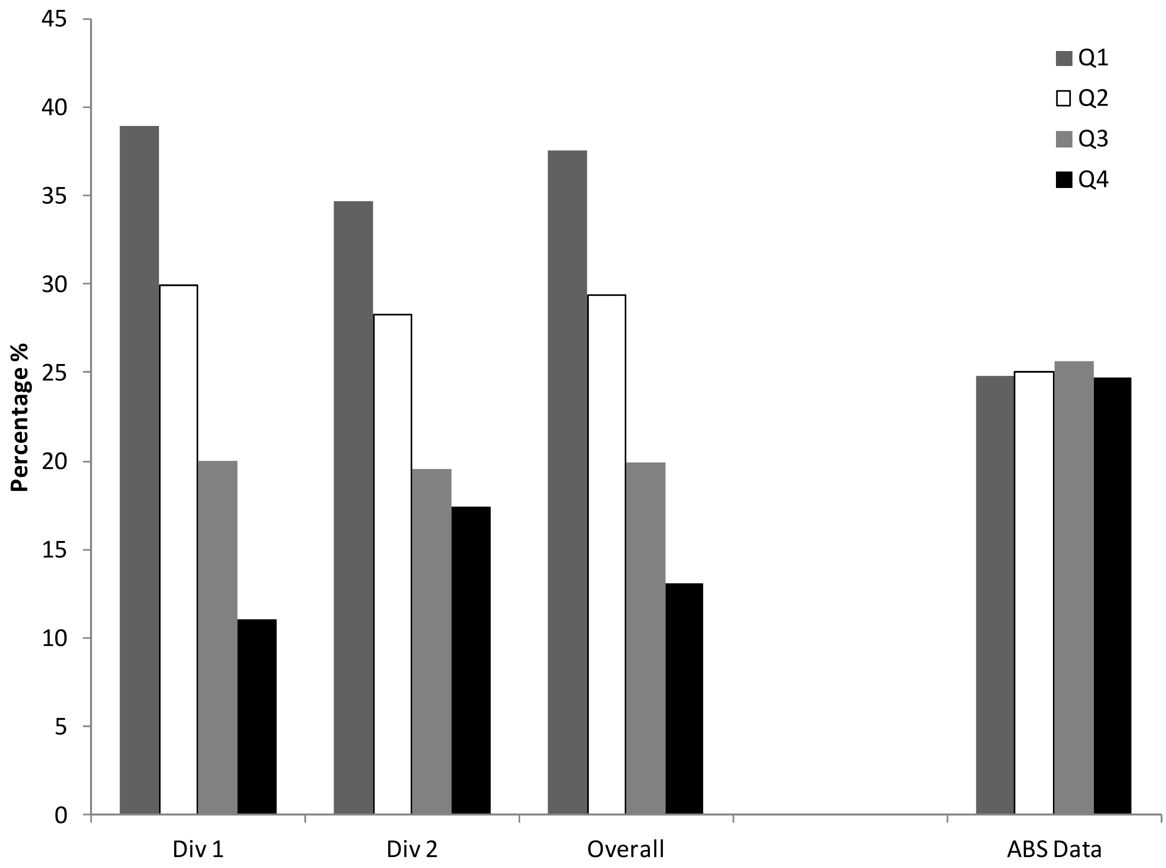

Figure 3.1: Quarterly birth data distributions from the players competing in the National U16 Championships (2004 – 2010). Q1 – Birth Quarter 1, Q2 – Birth Quarter 2, Q3 – Birth Quarter 3, Q4 – Birth Quarter 4.

Figure 3.2 shows the differences in the quarterly birth distributions between the general Australian population for the combined U20 and U16 data (Figure 3.2).

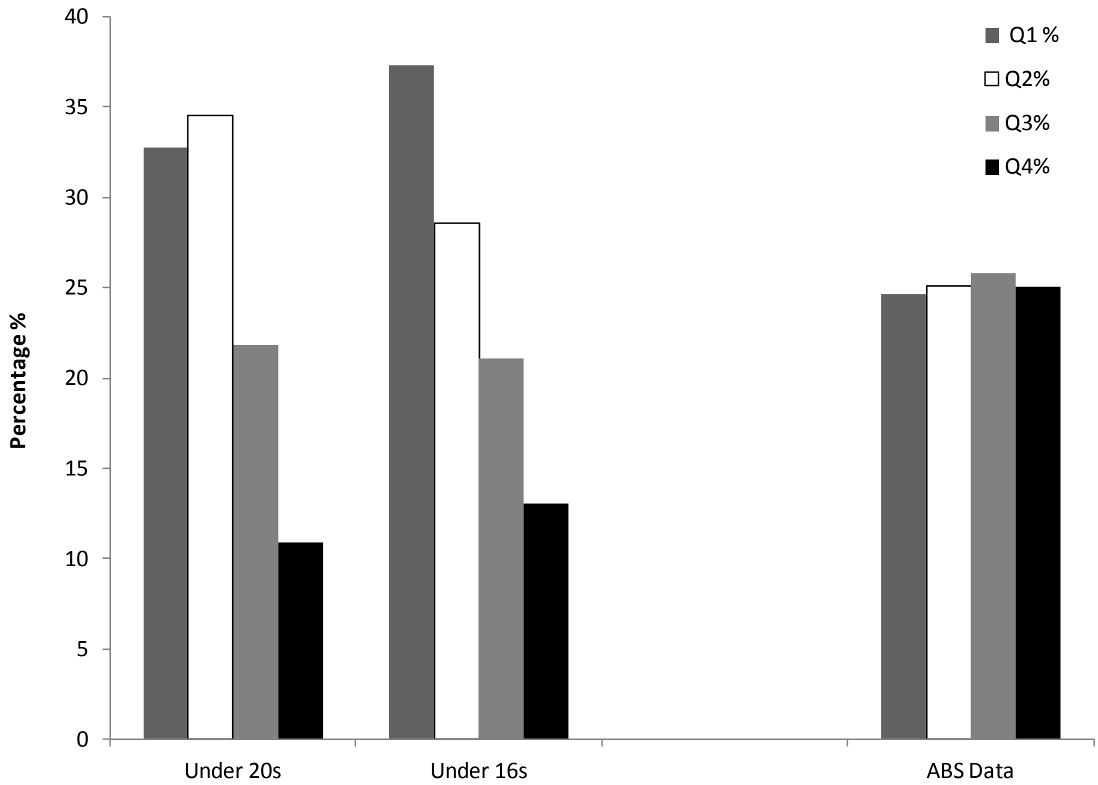

Figure 3.2: Quarterly birth data distributions, Australian U20 team (2008 – 2011) and players competing in the National U16 Championships (2004 – 2007). Q1 – Birth Quarter 1, Q2 – Birth Quarter 2, Q3 – Birth Quarter 3, Q4 – Birth Quarter 4.

Analysis of the pathway followed by players representing Australia at the U20 Junior World Championships showed a significant number had competed at the National U16 championships and then played for Australian schoolboy's teams. In contrast, relatively few players gained selection in an U20 team without first playing at the U16 championships (Figure 3.3).

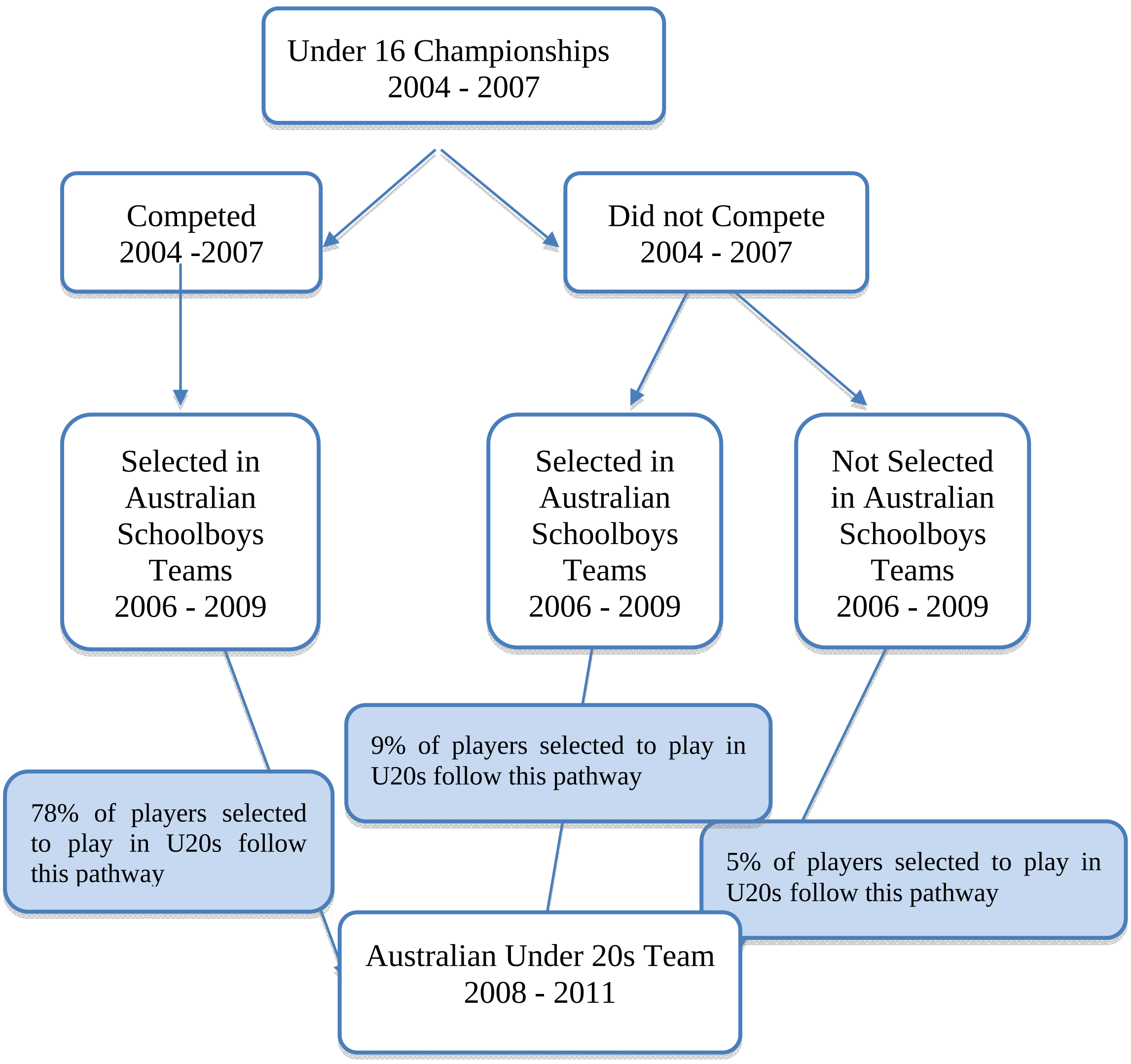

Figure 3.3: Under 16 to Australian Under 20 Development Pathways.

Discussion

The purpose of this study was to determine if a relative age effect was present within a cohort of elite junior rugby union players. Given that rugby union is a contact sport (Duthie, 2006), and that previous studies from rugby league (Till et al., 2010) have reported strong relative age effects in junior teams, it was hypothesized that a relative age effect would be found in a group of elite junior players competing at the annual National Under 16 schoolboy championships. The present findings supported the stated hypothesis and confirmed the existence of a relative age effect in elite U16 Australian rugby union players.

These results are consistent with findings from other junior male team sports (Barnsley & Thompson, 1988; Mujika et al., 2009; Till et al., 2008) such as rugby league, ice hockey and soccer that have shown that birth-rate distributions were significantly biased towards a higher number of births earlier in the selection year. This was in contrast to the even distribution of the general Australian population. The odds-ratio analysis showed that there was almost three times the likelihood of an elite player being born in the first quarter of the year and twice the likelihood of being born in the first six months of the year.

It has previously been reported that individuals that benefit from a relative age advantage also display maturational advantages, demonstrated in greater height, body mass, strength, speed and power attributes (Malina, 1994; Malina, Eisenman, et al., 2004). Possessing such qualities are likely to provide advantages in contact sports such as rugby union, especially for males during adolescence when there can be large variances in the rate of maturation between individuals (Baxter-Jones et al., 1994; Gasser et al., 2001; Malina, 1994). However, it was unfortunate that these characteristics were not able to be assessed in the present study. Given that these U16 championships are focused primarily on performance outcomes, players were likely to be selected on the basis of the short-term view of winning during the championships, as compared to the long-term view of player development. Such an objective has likely contributed to the strong relative age effect found in this cohort, especially for the Division 1 teams.

Previous research has shown the higher the level of competition, the stronger the relative age effect (Baker et al., 2010; Barnsley, 1988; Brewer et al., 1995; Cobley et al., 2009; Delorme, Boiche, & Raspaud, 2010; Helsen, Hodges, et al., 2000). The competition at the Under 16 championships was organised into two divisions, including eight teams in Division one, and four teams in Division two. There was a stronger relative age effect in the more competitive division one group, with approximately 69% of players born in the first half of the year compared to only 63% for the lower division. One of the most notable observations from these results is that when taken together as one cohort players from Q4 were significantly under represented when compared to Q1. This was especially evident in players from the Division one teams, with just over 10% of players born in the last three months of the year. This may in part be due to players already dropping out of the sport as suggested, in previous research (Barnsley & Thompson, 1988; Helsen et al., 1998). Previous research has suggested that relatively younger players who continually miss out on the opportunity to play at higher levels of competition tend to drop out of their chosen sport. This can start to happen as young as 11 years of age. In the case of junior rugby union in Australia, for example, the U16 age group provides players with their first opportunity to play in a national championship. The strength of the relative age effect evident from these findings indicates that a large proportion of young players are being deselected from the talent development pathway.

The influence of birth date distributions on playing position has also been previously investigated. Some studies observed that in junior male teams sports between 12 and 15 years of age, there was a clear influence of maturity on playing position (Grondin & Koren, 2000; Lariviere & Lafond, 1986; Malina, Eisenman, et al., 2004). For example, more recent research (Schorer et al., 2009; Till et al., 2010) has suggested that playing position may also act as a moderator on relative age effects in some contact sports. In general, these previous studies found that those positions in which physically larger athletes have an advantage show a bias towards athletes born in the first two quarters of the year. Consistent with this research, the present findings demonstrated that there was a bias towards birth dates in the first two quarters for both the forward and backline playing positions. However, in contrast to recent findings of rugby league players (Till et al., 2010), the present data did not reveal any differences between forwards and backs. This may be due to reasons specific to the nature of the positional demands of rugby union. For example, prop forwards in rugby union may have different game demands from prop forwards in rugby league. Accordingly, to determine the extent positional demands influence relative age effects it is suggested that future studies examine the relative age effect in specific playing groups, for example inside backs and loose forwards. Finally, the sample size of this cohort may have caused the current analysis to be underpowered.

Since 2008, the major global championship for elite youth rugby players is the Junior (U20) World Cup. Prior to this, the International Rugby Board held an U19 and U21 championship. With the introduction of the U20 international championships, there is now a major competition every two years for elite junior rugby players, from the age of 16. Indeed Figure 3.4 shows that the U16 National Championship competition is the first step in the developmental pathway for selection in the Australian junior national team.

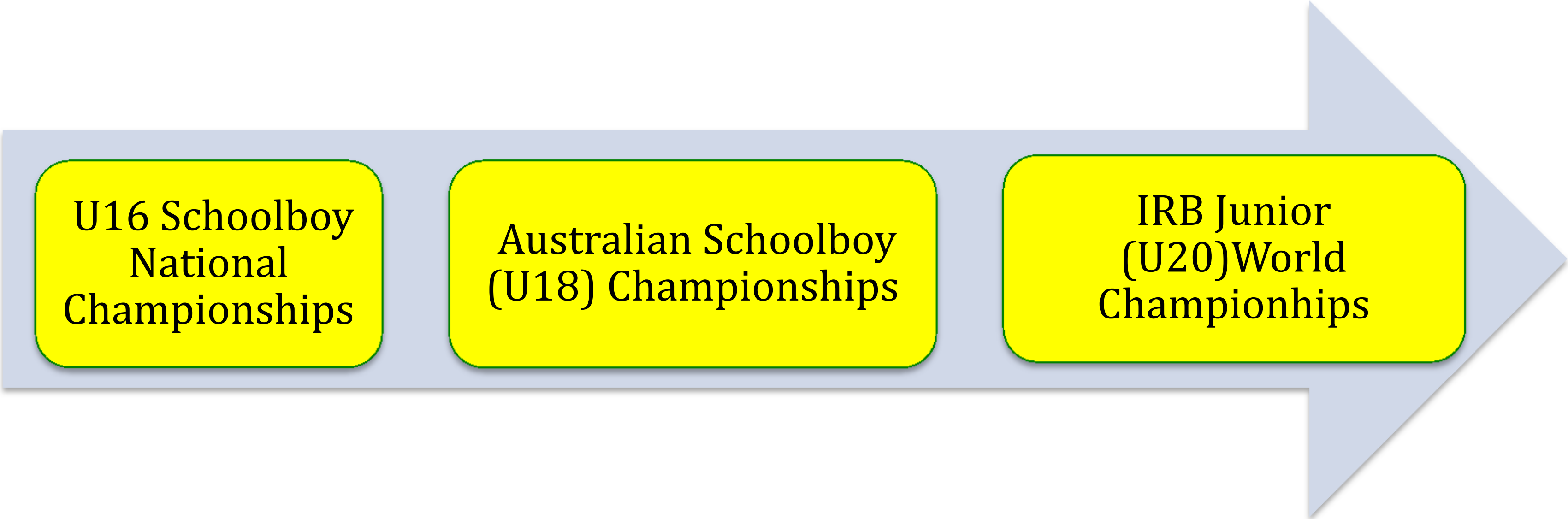

Figure 3.4: Developmental pathway to Australian Under 20 team selection

In 2008 the IRB introduced the Junior (U20) World Championships. This tournament is held on an annual basis and replaces the U19 and U21 world championships. For elite junior rugby players there is now a major competition every two years, commencing at 16 years. Australian Schoolboys teams are selected following the U18 championships. (The next major representative selection is the Australian national team).

Previous research has shown that relative age effects diminish with age (Brewer et al., 1995; Helsen, Starkes, et al., 2000; Mujika et al., 2009; Schorer et al., 2009; Vaeyens et al., 2005), even as players progress along the representative pathway to higher levels of competition. Based on these previous findings it was hypothesized in the current study that a diminished relative age effect would be found within the Australian Under 20 team. However, the present investigation showed there was a strong relative age effect for this group of players from 2008 – 2011. There was a clear bias towards birth dates in the first two quarters of the selection year, with the half-yearly data for the U20s being very similar to the U16s for the equivalent period. Indeed, the odds ratio analysis also showed there was approximately three times the risk of RAE inequalities for those players born in either of the first two quartiles or the first half of the selection year. For example, there was a significant underrepresentation of players from Q4 as compared to players born in either Q1 or Q2. When comparing both the quarterly birth date distributions and the subsequent OR analyses for the U20 teams and the equivalent U16 championships, there are remarkable similarities between both sets of data.

Collectively, the current results suggest there is strong player retention along the development pathway from the U16s to U20s. Indeed since there are three pathways to selection in the U20 team (see Figure 3.3, p.100) it is not surprising that many players were retained in the ARU development system. The main pathway shows that overall 78 percent of the players who were selected in the U20 team were first identified at the U16 championships and were subsequently selected for Australian schoolboys. The second pathway to the U20s via the Australian Schools without first playing in the U16 national championships produced only 9 percent of selected players. The final pathway, which is for those players who miss out on both of the first two steps, provides only a 5 percent chance of gaining selection in the U20 team. These results suggest that limited opportunities to gain selection to elite junior representative teams exist for young rugby players who are born in the second half of the year.

The findings of this present investigation suggest that in the U16 age group, there is a high probability that physical precocity may be misjudged for talent. Unfortunately the current structure of the under 16 championships facilitates coaches and selectors to choose those athletes that will afford each team a greater degree of success, rather than a focus on long term player development. Specifically, it appears the Division one teams may have bigger, stronger, faster and more skilful players that has afforded them a better opportunity of gaining selection to represent their state. Even though an estimate of maturation was not included as part of the current study, based on previous research (Baxter-Jones et al., 2005; Brewer et al., 1992; Figueiredo, Goncalves, et al., 2009b; Helsen, Hodges, et al., 2000; Lariviere & Lafond, 1986; Malina et al., 2000; Till et al., 2008), there is a high probability that the players who are born earlier in the selection year also possess a maturational advantage compared to their latter born peers.

It appears from the current data that selectors identify boys who are likely to benefit from a relative age advantage, which may also be deselecting boys born later in the year. Those players born in the latter quarters of the year may have just as much potential for success in rugby. However because these relatively younger players appear to be less physically gifted during adolescence they are overlooked for selection in these elite junior representative teams. Previous research has shown that once all of these players reach full maturation, at approximately 18 years of age, physical skills become less important, and cognitive, technical and tactical skills and abilities tend to differentiate between those that ultimately achieve success as an adult performer and those that do not (Ashworth & Heyndels, 2007; Baker, et al., 2010; Malina et al., 2004; Philippaerts et al., 2006). By deselecting players at younger ages (i.e. 16 y), coaches, selectors and administrators may be contributing to the loss of a large group of potentially talented rugby players. This phenomenon is a major concern for the continued growth and success of rugby union in Australia.

The present findings suggest young rugby players who benefit from a relative age advantage in the 16y age group are placed in an advantageous position to progress along the development pathway, with a much higher probability of eventually representing the Australian senior national team. Once selected to play at the national U16 championships, these players are exposed to better coaching, training facilities and competition, enjoy more time in front of selectors, and the chance to experience national and international competitions. The result of these opportunities is the increased likelihood of achieving success in playing at the highest levels possible within rugby. Conversely, those young players who likely have similar rugby playing potential are often overlooked and are of increased risk of withdrawing from rugby. If these trends were to continue, the talent pool from which the U20 and senior national teams are chosen will decrease as the result of increased player drop-out and the restricted size of the playing group from which these teams are selected. For example, there is only one player in the 2011 Australian Rugby World Cup squad who is born in the fourth quarter of the year. Rugby union in Australia is competing with three other codes of football for their talent pool, especially between 14–18y. It is possible that those young players who are continually overlooked for selection in representative teams may withdraw from the sport and look to pursue success in a competing football code, and/or be lost to sport altogether. Neither scenario will help to maximise the pool of potentially gifted junior rugby players in Australia.

Conclusion

The present study is the first to show the relative age effect in young elite Australian rugby union, with the observed birth-date distribution significantly different from the expected distribution of the peer group general population. Furthermore, the current findings also demonstrated a clear over-representation of players born in the first and second quarters of the selection year. Collectively, these findings suggest that the true playing potential of all players in this age group is not being realised. Given the importance of these championships in the talent pathway within Australian rugby union, further investigation is needed to examine if a more holistic approach to talent identification and development can minimise the RAE and enhance pathways for all younger players.

Chapter 4

Summary and Directions for Future Research

Summary and Directions for Future Research

The aim of this research was to determine if a relative age effect was present in a cohort of elite Under 16 rugby union players. The objectives of this research were to:

- Determine if a relative age effect would be present in a group of elite junior rugby union players competing at the annual Australian National Under 16 championships.
- Determine if various contextual factors act as moderators of relative age effects in elite junior rugby union players.
- Determine if the relative age effect was moderated through such factors as playing position, age and skill level.
- Assess the influence of relative age effects at different stages along the developmental pathway in junior rugby union.

Prior to the commencement of this investigation the hypotheses were:

- A relative age effect will be present in a cohort of elite junior rugby union players competing in a National U16 rugby union championship.
- A stronger relative age effect would be found in players of a higher ability/skill level competing in a National U16 rugby union championship.
- Playing position would act as a moderator of relative age effects, with a stronger effect to be found in a group of forwards as opposed to the backline positions.
- Age would act as a moderator of relative age effects, with a diminished effect found in a cohort of U20 Australian rugby union players competing at the Junior World Championships.

This thesis also aimed to add to the limited literature available on relative age effects in junior team sports in Australia. Even though birth date effects have been studied for over twenty-five years internationally, only a very small amount of this work has investigated Australian junior sport. Additionally, the present investigation sought to clarify the role of factors such as age, skill level, and playing position may have in moderating the magnitude of relative age effects. With the process of talent development strongly influenced by contextual factors such as relative age effects, the presence of such a bias in elite junior rugby union teams would cast some doubt over the efficacy of the criteria used to select players into elite representative teams.

The main finding of this thesis was the presence of a strong relative age effect within this cohort of elite junior rugby union players. The birth-date distribution was significantly biased towards a higher number of births earlier in the selection year. There was also a significant underrepresentation from players born in the fourth quarter of the year. Given the performance-based nature of the National U16 championships (i.e., the primary objective for each team is to win the national championship) it maybe that relatively younger players were perceived as lacking in the physical qualities required to help their team achieve greater success, which resulted in their de-selection. Another possible explanation for the small number of players born in the final three months of the selection year is that they have already dropped out of the sport, possibly after missing out on selection at a younger age and are thus underrepresented at the selection trials for this age group.

This present results also demonstrated that birth date distributions were influenced by age, skill level, but not playing position. A stronger age bias was observed for players from the division one teams competing at the U16 championships with a much larger disparity between players born in the first and last quarters of the selection year than in division two. This was also reflective of a greater number of players born in the second half of the year in division two.

The present findings did not demonstrate that playing position acts as a moderator of relative age effects. Even though there was a strong overrepresentation of players born in the first half of the year for both forward and backline playing positions, the percentage breakdown for each group was similar. While this suggests that enhanced physical attributes may offer selection advantages for both groups of players, further investigation, for example controlling for maturation, is required to establish if this is indeed the case. More detailed analysis, dividing each group down into smaller sub-groups such as front row, locks, back-row, halves, etc, may also offer a valuable insight into whether playing position in rugby union acts as a moderator on relative age effects. There was a strong retention of players along the developmental pathway from the U16 age group through to the Australian U20 Junior World Cup team. As a consequence, age did not appear to act as a moderator of relative age effects, with the bias in the birth date distribution almost identical in the U20 age group when compared with the initial results from the U16 National Championships.

Conclusion

This thesis has important theoretical and practical implications for all of those involved with the administration and coaching of junior rugby union in Australia. Practically, this study has established the presence of a strong relative age effect in a group of elite Australian U16 rugby players. The observed biased birth date distribution has also been shown to continue, undiminished, up to the Australian U20 team. Furthermore, there appears to be very strong player retention of players identified at U16 level, with just over seventy-five percent of the U20 National team progressing from the U16 national championships into the U20 National team. Skill level but not playing position was also found to have an influence on the overall magnitude of the relative age effect, with players in Division 1 of the U16 Championships more likely to be born in the first half of the competition year, than those playing in Division 2.

Theoretically, the findings of this thesis provide administrators, coaches and selectors with evidence that suggests that the current player detection and development models utilised in junior Australian rugby may not be fully optimized. There appears to be a significant pool of players who likely possess the potential to become successful elite senior rugby players but are being overlooked for selection simply because of when in the year they were born. Theoretically, this study adds knowledge to the area of relative age effects by establishing a clear and prolonged bias in the birth date distribution in elite Australian junior rugby union players.

The results of this present investigation lend support for the refinement of the current model used to identify and develop potentially talented players in Australian rugby union. At the junior level this would include an assessment of the maturational status relative to PHV of all players being considered for selection to each stage of the talent development pathway. This assessment would then be used to assist with the ongoing monitoring and refinement of the talent development process. For example, by controlling for differences in maturation, coaches and administrators will have a clearer picture of how each player is developing according to their potential. By refining the focus of development from a narrow, performance-driven model to a more holistic outlook that is focused on developing all of the skills an athlete requires to achieve success at the highest levels, will likely result in a deeper pool of talented junior and senior rugby union players in this country.

Recommendations

Recommendations from this study are:

- Coaches, selectors and administrators in rugby union need to be aware of the factors that lead to the development of relative age effects. A review of their current selection processes, especially for the U16y age group, is suggested as the first step in ensuring a more equitable distribution of players from each quarter of the selection year.
- The need to determine the maturational status of all young players entering the rugby talent development pathway. Combined with other physical measures, as well as maturation status specific physiological measures, this determination would allow coaches and performance coordinators to more accurately monitor and guide the individual progress of all players in the ARU's talent development pathway. This may then help to reduce the relative age effect.

Suggestions for Future Research

Future research suggestions are to:

- Include an assessment of the maturational status of participants in all future studies involving elite junior Australian athletes
- Further investigate the role of potential moderators of relative age effects, with particular attention to playing position and skill level

- Further examine the player development pathway to investigate the effect player retention at the elite representative level has on potentially moderating relative age effects.
- Determine the age at which relative age effects first appear in junior representative rugby union teams
- Examine the reasons for the low representation numbers for players born in the fourth quarter of the year.
- Develop a more holistic model for the identification, detection and development of young rugby union players who have the potential to achieve success at the elite senior level.

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Appendix A: Written Consent form

UNIVERSITY OF TECHNOLOGY, SYDNEY

INFORMED CONSENT FORM

I ________________________________ on behalf of __________________________________ agree to participate in the research project "**relative age effects in junior Australian team sports**" being conducted by Mr Peter Fernley, a post-graduate student, at the School of Leisure, Sport and Tourism, Faculty of Business, University of Technology, Sydney (phone 0418 662 853)

I understand that the purpose of this research is an important component of the researcher's Masters Thesis, which is seeking to examine whether relative age (birth-date) effects are present in junior team sports in Australia. I also understand a second purpose of this research is to determine if birth-place effects are also found in junior team sports in Australia.

I understand that the participation of ____ (National Sports Organisation) in this research will require providing Peter Fernley with data from individual player records/registration forms. This will include all junior players who have been selected to play in state and/or national representative teams in the sport controlled by our organisation for the previous 5 to 10 years (2000/2005 to 2010). I understand that the data to be provided includes month of birth, place of residence/post code, playing position, height and weight. Furthermore I understand that records will be accessed for players from the youngest age group at which state and/or national representation commences up to and including U18 years for the time period indicated above.

I am aware that I can contact Peter Fernley (phone: 0418 662 853) if I have any concerns about the research. I also understand that I am free to withdraw our participation from this research project at any time I wish and without giving a reason.

I agree that Peter Fernley has answered all my questions fully and clearly in relation to this project.

I agree that the research data gathered from this project may be published in a form that does not identify individual records in any way.

____ ____/____/____

Signed by Authorised representative

For _____________________________________

(National Sports Organisation)

NOTE:

This study has been approved by the University of Technology, Sydney Human Research Ethics Committee. If you have any complaints or reservations about any aspect of your participation in this research which you cannot resolve with the researcher, you may contact the Ethics Committee through the Research Ethics Officer, Ms Racheal Laugery, (Ph: 02 9514 9772, Racheal.Laugery@uts.edu.au). Any complaint you make will be treated in confidence and investigated fully and you will be informed of the outcome.

Appendix B

Overview of relative age effects studies (1984 – 2011); (See below).

Sport	Year	Study	Characteristics	Age Effects (H1 vs H2)	Country	Level of Comp-etition	Age	Gen-der	Major Findings
American Football	1987	Daniel & Janssen	Pro Football (NFL), USA	50/50	USA	Prof	23+	M	No RAE evident
	1992	Glamser & Marciani	College Football	66/34 (Very small sample, only 2 Universities)	USA	College	18-22	M	RAE evident at both schools, but stronger at the Southern college
	1995	Stanaway & Hines	Pro Football (NFL) Hall of Fame, USA	57/43 (Only a small sample, n=167)	USA	Prof	23+	M	RAE small, but trend evident
	2005	Cheung	Pro Football (NFL), USA	Results inconsistent, with RAE limited to two Offensive Positions and one Defensive position	USA	Prof	23+	M	RAE evident, but not in all playing positions, only present in three positions:- Running Back, Tight End & Defensive Linemen
	2009	MacDonald et al	Pro Football (NFL), USA	51.4/48.6	USA	Prof	23+	M	No RAE evident
Athletics	2007	Morris et al	Eng Schools Championships	75/25 - on average for M groups. U15&U17 Fs RAE Not Significant & 63/37 for Under 20 & Senior Fs	Eng	Junior	U15, U17, U20 & 20+	M & F	RAE evident in all M groups & in U20 & Senior F groups
	2007	Johnstone & Doyle	Elite Sports Academy, Eng	54.5/45.5 (M) & 68.4/31.5 (F), Grouped result = 63.3/36.6. Small group n=150	Eng	Elite Jnr	F mean age=15y M mean age=16.3 y	M & F	RAE evident for both genders
Australian Rules Football (ARF)	2005	Abernethy & Farrow	National Comp - AFL, Aust	58/42	Aust	Prof	18+	M	RAE small, but trend evident
	2006	Pyne et al	AFL draftees, 1999-2004	65/35	Aust	Elite Jnr	17-21	M	RAE clearly evident
	2010	Barnett	National Comp - AFL, Aust	58/42, players born in Q1 over-represented (32%), compared to those born in Q4 (20%)	Aust	Prof	Adult	M	RAE clearly evident
Baseball	1987	Daniel & Janssen	Pro Baseball (MLB), USA	55/45	USA	Prof	20+	M	RAE insignificant
	1991	Thompson et al	Pro Baseball (MLB), USA	56/44	USA	Prof	20+	M	RAE trend evident, but not as strong as for Ice-Hockey
	1992	Thompson et al	Little League, Ottawa, Canada	On average approx 50/50, with only 12 yr olds reaching stat significance	Canada	Junior	U6-U19	M	RAE limited to specific age groups, (U12) chosen for tournament play
	1995	Stanaway & Hines	Pro Baseball (MLB), USA	Moderate sample size, n=600	USA	Prof	20+	M	No RAE evident

Sport	Year	Study	Characteristics	Age Effects (H1 vs H2)	Country	Level of Comp-etition	Age	Gen-der	Major Findings
	2000	Grondin & Koren	Pro Baseball (MLB), USA & Prof Baseball in Japan	In MLB evidence of RAEs prior to 1900, RAE decreased between 1920 and 1950, but evident post 1960	USA & Japan	Prof	20+	M	RAE clearly evident in Japanese Baseball. RAE clearly evident in MLB,
	2006	Cote et al	Pro Baseball (MLB), USA	56/44, with players born in Q1 over-represented	USA	Adult Profesional	20+	M	RAE evident
	2006	Kura & Matsuzawa	Pro Baseball, Japan	Players born in Q1 over-represented, & those born in Q4 under-represented	Japan	Adult Profesional	Adult	M	RAE clearly evident
Basketball	1987	Daniel & Janssen	Pro Basketball (NBA), USA	49/51	USA	Prof	20+	M	No RAE evident
	2000	Hoare	National level Jnr & Prof players	For all 3 M groups, players born in Q1 were over-represented. For Fs only U16 group showed an over-representation in Q1	Aust	Elite Jnr & Adult Prof	U16 & U18 & Adult players	M & F	RAE evident for U16 M & F players, M U18 & NBL players. RAE not evident in U18 F nor in WNBL players
	2006	Cote et al	Pro Basketball (NBA), USA	50/50	USA	Adult Prof	22+	M	No RAE evident
	2006	Esteva & Drobnic	Youth and Adult Prof, Spain	82/18 - Youth(Spain) 60/40 - Adult(Spain)	Spain	Youth & Adult Prof	U20 & Adult	M	RAE clearly evident at all levels of Spanish B/ball. ** No RAE evident in NBA in US
	2009	Baker et al	Pro Basketball, Ger	51/49, Only a small sample, n=82	Ger	Prof	20+	M	No RAE evident
	2009	Delorme et al	French Junior Basketball players	RAE evident among all age groups & appears at age 7 years among girls & boys	France	Junior	U8-18+	M & F	RAE more pronounced in girls than in boys
	2009	Delorme et al	Prof basketball players (M & F), France	54/46 - M, 56/44 - F	France	Elite Prof	Adult	M & F	No RAE evident for either gender
Cricket	1994	Edwards	County Cricket	61/39 - fast bowlers	Eng	Prof	20+	M	RAE only found in fast bowlers
	2004	O'Donoghue et al	2003 World Cup	60/40 - North Hem.	Various	Elite Prof	20+	M	RAE only evident in northern hemisphere teams
	2005	Abernethy & Farrrow	First Class Players & Nat. Reps from 2003-2004 season	54/46 - First Class Players & 64/36 Austn Reps	Aust	Prof	20+	M	RAE more pronounced in Rep players
Dance	2006	Van Rossum	National Ballet Academy, Netherlands	Small overall sample - 544, Only 20% M	Nether-lands	Pre-Prof	U11-U18	M & F	No RAE evident; Due to high level of technical-motor skill required?
European Handball	2008	Schorer et al	Elite Jnr & Snr players	RAE strongest at first step of selection process for both M & F, with over 63% born in H1. "A" squad had an almost equal spread across each quarter	Ger	Elite Jnr Rep players & National team players	15-18yrs, 18-21 yrs, 19+ yrs	M & F	RAE was evident at each stage of the selection process, but strength of effect decreased with each step for both Ms and Fs

Sport	Year	Study	Characteristics	Age Effects (H1 vs H2)	Country	Level of Comp-etition	Age	Gen-der	Major Findings
European Handball (cont'd)	2008	Schorer et al	National League, Nationlaity & Career stage	RAE highest in Jnr years for German players & absent from 25+. For Intl players RAE remained strong beyond 30years	Ger	Elite Prof	19+	M	RAE evident in whole group, but higher(by 4%) in Intl than in German players
	2008	Schorer et al	National League, Ger	Playing position and laterality affect the strength of RAE's in handball	Ger	Elite Prof	19+	M	RAE highest for backourt players & lowest for GK's
	2009	Baker et al	Pro Handball Ger	52/48, Only a small sample, n=182	Ger	Prof	20+	M	No RAE evident
	2009	Delorme et al	Prof Handball players (M & F) , France	60/40 - M, 52/48 - F	France	Elite Prof	Adult	M & F	RAE in Ms small, but trend evident, No RAE in Fs
Field Hockey	1999	Wilson	Secondary School Rep Teams, Eng	25/8/8 (Competitive year split into thirds)	Eng	Junior	U14 -- U16	F	RAE clearly evident
Golf	2006	Cote et al	PGA players	51/49, with each quarter similar	USA	Adult Prof	23+	M	No RAE present
Gymnastics	1995	Baxter-Jones et al	Elite Jnr Gymnasts	Even distribution of birth dates over year	Eng	Elite Jnr	Aug-16	M & F	No RAE present
Ice Hockey	1982	Grondin	Junior Hockey	Q1 players over-represented & Q4 players under-represented	Canada	Junior & Elite Jnr	U10 - U19	M	RAE clearly evident across all age groups
	1984	Grondin et al	Junior Hockey	Q1 players over-represented & Q4 players under-represented	Canada	Elite Jnr	U10 - U19	M	RAE clearly evident across all age groups
	1985	Barnsley et al	2 Amateur (junior A) Hockey Leagues & NHL(Prof)	62/38 - NHL players, 71.5/28.5 - WHL, 72/28 - OHL	Canada	Elite Jnr & Adult Prof	U10 - U20 & 20+	M	RAE clearly evident across each of the 3 leagues
	1986	Lariviere & Lafond	Elite ProvincialJunior Hoxkey players	More players born in Q1 in each age category	Canada	Elite Jnr	15-18	M	RAE clearly evident in each age category
	1987	Daniel & Janssen	NHL & CFL(Pro), Canada & NFL, NBA & MLB (Pro) USA	64/36, NHL(1985-86) 49/51, CFL(1984-85) 50/50, NFL(1984-85) 49/51, NBA(1984-85) 55/45, MLB(1984-85)	Canada & USA	Adult Prof	20+	M	RAE very evident in NHL, but basically absent in each of the other sports
	1988	Barnsley & Thompson	Minor Hockey players	RAE first evident for 11-12 yrs, strongest for 13-14yrs.	Canada	Junior	U8 - U20	M	RAE clearly evident from U12-U18yrs, absent at younger ages & for 19-20yrs
	1988	Barnsley et al	Minor Hockey representative players	RAE again strongest in 13-14yrs	Canada	Elite Jnr	U8 - U20	M	RAE strongest in top (of 3) tier rep teams, & a reverse effect found in bottom tier teams
	1991	Grondin & Trudeau	NHL(Prof), North America	RAE strongest in Canadian & Intl players in NHL & weakest in US born players	North America	Prof	18+	M	RAE clearly evident
	1991	Boucher et al	Elite Jnr & NHL(Prof) players, Canada	63/37 Elite Junior, 64/36 NHL Players	Canada	Elite Jnr & Adult Prof	U9-U18 & Adult	M	RAE clearly evident at both junior & NHL level
	1994	Boucher et al	Elite Jnr & NHL(Prof) players, Canada	65/35 Elite Junior, 65/35 NHL Players	Canada	Elite Jnr & Adult Prof	U9-U18 & Adult	M	RAE clearly evident at both junior & NHL level

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	2000	Montelapare et al	Various Junior & Adult Leagues, Canada; NHL; Elite Junior players, Canada	69/31-CIAU(Elite Jnr), 65/35-OHL(Elite Jnr), 65/35-(World Jnrs), 60/40-CMHA(Elite Jnr), 53/47-CMHA(Rec League), 63/37-NHL	Canada	Jnr and Adult Rec leagues, NHL & World Jnr	U12-U18, Adult Prof	M	RAE exists in elite/rep levels of each league, but not in recreational leagues.
	2003	Peterson	Junior Ice-Hockey, Sweden	74/26	Sweden	Elite Jnr	U15	M	RAE strongly evident
	2006	Cote et al	NHL(Prof), North America	66/34, with Q1 over-represented & Q4 under-represented	North America	Adult Prof	20+	M	RAE clearly evident
	2007	Wattie et al	Elite Ice Hockey, Canada, M & F	RAE first evident in NHL in late 1970's, no evidence of any RAE prior to this	Canada	Elite Prof	Adult	M & F	RAE evident in M group, but not for Fs.
	2007	Wattie et al	Junior Hockey, Canada	Relatively older hockey players are more likely to present with hockey-related injuries, especially in younger age groups	Canada	Junior	10-15yrs	M	RAE prevalent in each age group, but risk of injury not associated with RAE, but prevalence of injury higher for relatively older players
	2007	Baker & Logan	NHL draftees for 2000-2005 seasons,	Relatively younger Canadian , but not US players, more likely to be chosen in earlier rounds of the draft	North America	Elite Jnr	20+	M	RAE clearly evident for players drafted to play in the NHL
	2007	Sherar et al	Youth elite regional ice-hockey players, Canada	77.5% of boys chosen at final selection camp had birthdates in first 6 months of selection year	Canada	Junior	14-15 yrs	M	RAE clearly evident, with effect becoming stronger at each selection process
	2007	Sherar et al	Junior Ice-hockey, Canada	79/21, Fast-Track Bantam(U15) & 68.4/31.6 Fast-Track Jnr(U18)	Canada	Elite Jnr	U15-U18	M	RAE strongly evident at younger age, tended to diminish at U18 level.
	2009	Hurley	Elite Junior Ice-Hockey, Canada	For each age group players born in Q1 are over-represented and those born in Q4 under-represented	Canada	Elite Jnr	U8 - U17	M	RAE clearly evident across all age groups for 'AAA' elite Jnr players
	2009	Stenling et al	M Youth players, Sweden	No relationship between birth date & perf.measures	Sweden	Youth	U16-U20	M	RAE clearly evident
	2009	Stenling et al	Elite F players, Sweden	No relationship between birth date & perf.measures	Sweden	Elite Jnr	20+	F	RAE clearly evident
	2009	Romann et al	Elite youth Ice-Hockey, Switzerland	70/30	Switz-erland	Elite Jnr	U15-U16	M	RAE clearly evident
	2009	Delorme et al	Elite senior ice hockey players, France	56/44, with players born in Q1 over-represented	France	Junior	U9-U18	M	RAE clearly evident
Netball	1999	Wilson	Secondary School Rep Teams, Eng	17/6/5 (Competitive year split into thirds)	Eng	Junior	U14 - U16	F	RAE clearly evident
	2004	O'Donoghue et al	1999 World Championships	55/45 -North Hem., 45/55 - South Hem.	Various	Elite Adult	20+	F	Signioficant RAE only for Northern Hemisphere squads.
					Eng	Elite Adult	20+	F	

Sport	Year	Study	Characteristics	Age Effects (H1 vs H2)	Country	Level of Comp-etition	Age	Gen-der	Major Findings
	2008	Cobley et al	Secondary School Rep Teams, Eng	62/38	Eng	Junior	U14 - U16	F	RAE small, but trend evident
Olympic Athletes	2009	Baker et al	Olympic athletes from 4 countries, Canada, USA, UK and Ger	Athletes came from a number of different disciplines, primarily individual sports.	Canada, USA, UK, Ger	Elite Adult	20+	M & F	No **Date of Birth effects** evident for Olympic Athletes in any of the countries studied
Rugby League	2005	Abernethy & Farrow	National Comp(NRL) & Rep Players, Aust	66/34 NRL Players, 65/35 Rep Players	Aust	Prof	20+	M	RAE clearly evident in both groups
	2008	Till et al	Junior Rugby League, Eng,	Props' in particular more likely to be born in the first half of the year (82.9%)	UK	Elite Jnr	14-15	M	RAE clearly evident, especially for 'Props' and 'Backrowers'
	2009	Till et al	Junior M & F players, Junior representative players, adult M & F players, Eng	Increased risk of RAE's when selection steps & perf levels increased	UK	Junio, Elite Junior, Adult Prof	Jnr M - U7-U18, Jnr F, U12, U14, U16, EliteJnr,- U13, 14&15, Snr M & F	M & F	RAE prevalent across M RL starting @ U7 level, RAE clearly evident in Jnr Rep Players, RAE not evident in F players
Rugby Union	1999	Wilson	Secondary School Rep Teams, Eng	27/18/12 (Competitive year split into thirds)	Eng	Junior	U14-U16	M	RAE clearly evident
	2003	Spamer & Winsley	Elite Jnr Eng & Sth African players	64/36(English),	Eng	Elite Jnr	U18	M	RAE strongly evident in both cohorts
				71/29(South African)	South Africa	Elite Jnr	U18	M	
	2005	Abernethy & Farrow	2004 Super 12 & Austn Reps	60/40 Super 12 & 59/41 Nat Reps	Aust	Prof	18+	M	RAE small, but trend evident
	2008	Cobley et al	Secondary School Rep Teams, Eng	60/40	Eng	Junior	U14 - U16	M	RAE clearly evident
	2009	Delorme et al	M Prof Rugby Players, France	57/43	France	Elite Prof	Adult	M	RAE small, but trend evident
Shooting	2009	Delorme et al	Youth & Adult members of Federation of Shooting Sports, France	In age groups where RAE was evident, birth dates in Q1 were over-represented and under-represented in Q3 & Q4	France	Jnr-Snr	U11-U20	M	Fs-RAE only evident in 15-17yr group, Ms-RAE evident in all but 13-14 & 18-20yr group

Sport	Year	Study	Characteristics	Age Effects (H1 vs H2)	Country	Level of Comp-etition	Age	Gen-der	Major Findings
Soccer	1992	Verhulst	1st & 2nd div soccer players from France, Belgium & Netherlandds	Lower birth rates in Q4 with much higher rates in Q1	France Belgium Nether-lands	Adult Prof	20+	M	RAE clearly evident
	1992	Barnsley et al	1990 FIFA World Cup, 1989 FIFA U17 & U20 World Cups	54/46 World Cup players, 79/21 U20 World Cup, 79/21 U17 World Cup	Various	Elite Jnr & Adult Prof	U17, U20 & Adult	M	Weak RAE in Snr World Cup, but clearly evident in both U17 & U20
	1992	Brewer et al	Swedish U17 Squad	78/22 Only small sample, n=59	Sweden	Elite Jnr	U17	M	RAE clearly evident
	1994	Edwards	Professionla soccer, Eng	RAE present in GK's, defenders, midfielders and forwards	Eng	Adult Prof	18+	M	RAE clearly evident
	1994	Baxter-Jones & Helms	Junior soccer players, Eng	Most junior players born in first half of selection year	Eng	Junior	U16	M	RAE clearly evident
	1994	Dudink	Elite Prof soccer players, Eng & Netherlands	60/40 (approx) in both Netherlands & Eng	Eng & Nether-lands	Elite Adult Prof	18+	M	RAE clearly evident
	1995	Brewer et al	Swedish U17 Squad, Swedish Nat. team, English Elite Jnr players & Premier League players (Eng)	78/22 Swedish U17, 69/31 Swedish Snr, 53/31/16 FA School of Excellence, 46/31/23 FA Snr Players	Sweden & Eng	Elite Jnr & Adult Prof	U15-U19 & Adult	M	RAE clearly evident for both elite junior and adult Prof
	1998	Helsen et al	1st Division Adult Prof, Elite youth(2 groups) & youth league players, Belgium	33.3/18.6(Q1 v. Q4) - Adult Prof. 46.3/10(Q1 v.!4) - National Youth 35.7/13.6 (Q1 v. Q4) -Youth Transfers	Belgium	Regular & Elite youth league, National Youth players, Adult Prof	U7-U17, Mainly U11-U17 youth & Adult	M	RAE clearly evident for regular & elite youth players and adult Prof, first noted @ 6-8 yrs.
	1999	Wilson	Secondary School Rep Teams	25/15/15 (Competitive year split into thirds)	Eng	Junior	U14-U16	M	RAE small, but trend evident
	1999	Musch & Hay	Elite Prof players, Ger, Japan, Brazil & Aust	In all four coutries, players from Q1 over-represented & players from Q4 under-represented	Ger, Brazil. Japan, Aust	Prof	20+	M	A strong RAE was found in all four countries
	1999	Richardson & Stratton	English World Cup Players 1982-98	50/28/22 (Competitive year split into thirds)	Eng	Prof	20+	M	RAE strongly evident, & was greater for goalkeepeers, forwards & defenders

Sport	Year	Study	Characteristics	Age Effects (H1 vs H2)	Country	Level of Comp-etition	Age	Gen-der	Major Findings
	2000	Helsen et al	National youth league, Belgium	For all age groups, except 16-18yrs, players born in Q1 are over-represented & those born in Q4 under-represented	Belgium	Elite Junior	4 age grps, 10-12, 12-14, 14-16 & 16-18yrs.	M	RAE clearly evident in 10-12, 12-14 & 14-16yrs. No RAE evident for 16-18yrs
	2001	Simmons & Paull	Elite youth soccer players, Eng	For each of 4 youth squads investigated, more players (approx, 70%) were born in the first four months of the selection year, than the last four months (approx 15%)	Eng	Elite Junior		M	RAE clearly evident
	2003	Peterson	Junior Soccer Players, Sweden	62/38	Sweden	Junior	U13-U18	M & F	RAE evident across all age groups and in both genders
	2004	Glamser & Vincent	Elite youth soccer players, USA	70/30 with players born in Q1 over-represented (37%) compared to Q4 (12%)	USA	Elite youthh, Olympic Devel Program	U18	M	RAE clearly evident
	2004	Edgar & O'Donoghue	Elite professional 2002 FIFA World Cup	RAE slightly lower in European countries qualifying for 2nd round of World Cup	All 32 teams @ World Cup	Adult Prof	23+	M	RAE clearly evident
	2005	Helsen et al	Various European National Youth squads in UEFA & FIFA comps & elite club teams	On average an overrepresentation of players born in Q1 of the selection year.	Europe	Elite Jnr	U12-U18	M & F	RAE clearly evident for all age groups U15-U18. RAE less evident in U18&U21 & Women's U18
	2005	Vaeyens et al	Senior soccer players, Div 2, 3 & 4 from Belgium	approx 30/20 - Q1 vs. Q4 comparison	Belgium	Adult Prof	20+	M	RAE clearly evident
	2005	Abernethy & Farrow	U17, U23 & Aust. National teams	75/25 - U17 team, 65/35 - U23 team, 47/53 - Socceroos	Aust	Elite Jnr, & Prof	U17, U23 & Adult	M	RAE strong early, but diminishes with age
	2006	Kura & Matsuzawa	Prof soccer players (J-League), Japan	Players born in Q1 over-represented, & those born in Q4 under-represented	Japan	Adult Prof	Adult	M	RAE clearly evident
	2006	Folgado et al	Junior and youth soccer players, Portugal	RAE most evident in U11, U13 & U15 & among Defenders & Midfielders	Portugal	Junior & youth	U8, 11, 13, 15, 18 and Snr Reserve	M	RAE clearly evident
	2006	Vincent & Glamser	Elite youth soccer players, USA	52/48 - F, 62/38 - M	USA	Elite Junior	U17 & U19	M & F	RAE clearly evident in M teams, is weaker for 16 and 17 years Fs

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	2007	Gil et al	Elite junior soccer players, Spain	79/21	Spain	Elite Junior	U14 - U17	M	RAE clearly evident
	2008	Jiminez & Pain	Adult Prof and elite youth players, Spain	National youth team members, U17 & U21 show an even more pronounced RAE	Spain	Elite Jnr & Adult Prof	U12 - U17, U17 - U21 National Team & Adult Prof	M	RAE clearly evident across all age categories, including adult
	2008	Cobley et al	Adult Prof (Bundesliga), Ger	RAE grew from 1950 to 1990, with players born in Q1 generally over-represented	Ger	Adult Prof	Adult	M	RAE clearly evident across the history of the Bundesliga
	2008	Cobley et al	Secondary School Rep Teams, Eng	60/40	Eng	Junior	U14 - U16	M	RAE clearly evident
	2008	Jullien et al	Elite youth soccer players, France	77/23	France	Elite youth	18+	M	RAE clearly evident
	2009	Carling et al	Elite youth soccer players, France	72/28, with Q1 over-represented & Q4 under-represented	France	Elite Jnr	U14, U15, U16	M	RAE clearly evident
	2009	Delorme et al	F Soccer Players (France) Youth & Adult, U8-U17 & Adult	For all youth categories, results reflect a classical RAE with more players born in 1st half of year.	France	Jnr & Adult	U8 - U17 & Adult	F	RAE clearly evident across all age categories, including adult
	2009	Delorme et al	Prof soccer players (M & F), France	57/43 - M, 55/45 - F	France	Prof	Adult	M & F	No RAE evident in either gender
	2009	Romann et al	Elite youth Soccer, Switzerland	71/29	Switz-erland	Elite Jnr	U15-U20	M	RAE clearly evident
	2009	Baker et al	Bundesliga, Ger	55/45	Ger	Prof	20+	M	RAE small, but trend evident
	2009	Hirose	Elite youth soccer players, Japan	U10-U15 37.9-58.8% born in Q1 & only 3.2-13.5% born in Q4	Japan	Elite Junior	U10-U15	M	RAE clearly evident across all age groups
	2009	Williams	FIFA U17 World Cup competition	For entire cohort 40% of players born in Q1 , with only 16% born in Q4	Various	Elite Junior	U17	M & F	Strong RAE found in all FIFIA zones except Africa, where a reverse RAE was found.
	2009	Mujika, Vaeyens et al	Youth, Elite youth and adult Prof players, Spain	RAE incidence progressively increased with a higher level of involvement in youth football	Spain	School, local, regional and elite youth & adult Prof	U10 - U18 & Adult	M	RAE clearly evident across all age categories, including adult

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Swimming	1995	Baxter-Jones	Elite junior (UK)	50% of athletes born in Q1	UK	Elite Jnr	U8-U16	M	RAE clearly evident
	2005	Dunman et al	2005 British Age&youth swimming champs	68/32 for both genders in youngest age groups.	UK	Elite Jnr	U11 - U18	M & F	RAE clearly evident only in younger age groups in both genders
	2007	Morris et al	Eng Schools Championships	RAE Not significant in U15-U18 make group & U14-u17 & Senior F groups	Eng	Junior	M=U11-U18 & 18+, F=U11-U17 & 17+	M & F	RAE evident in 2 of 3 M groups, but only in youngest F group
Tennis	1994	Dudink	Netherlands	50% of players born in Q1	Nether-lands	Jnr	U12-U16	M	RAE clearly evident
	1995	Baxter-Jones	Elite Junior (UK)	50% of players born in Q1	UK	Elite Jnr	U8-U16	M	RAE clearly evident
	1999	Giacomini	Junior players, USA	67/33 - U14 M, 65/35 - U16 M, 59/41 - U18 M, 60/40 - U14 F, 58/42 - U16 F, 51/49 - U18 F	USA	Junior	U14 - U18	M & F	For Ms, RAE significant in U14 & U16 age groups, but not so in U18. For Fs RAE less evident in U14 & U16 and none for U18
Volleyball	1982	Grondin	Junior players, Canada	While no overall RAE, Q1 players over-represented & Q4 under-represented	Canada	Junior	U10-U19	M & F	No RAE evident
	1984	Grondin et al	Junior players, Canada	While no overall RAE, Q1 players over-represented & Q4 under-represented	Canada	Junior	U12 - U20	M & F	No RAE evident
	2009	Baker et al	Pro Volleyball, Ger	51/49, Only a small sample, n=111	Ger	Prof	20+	M	No RAE evident
	2009	Delorme et al	Pro Volleyball, France	53/47	France	Elite Adult	Adult	M	No RAE evident