Relative age effects among student-athletes in a university high-performance programme: Prevalence, annual variation and between-group comparisons

By

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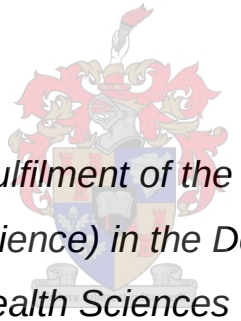

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SUMMARY

Among the factors facilitating or impeding an athlete's pathway to success are primary or direct influences such as psychological characteristics, genetic factors and training. Indirect or secondary factors, for instance an individual's birthdate may influence the type, amount and quality of coaching they receive. Independently, the birthdate is insignificant, but through the simultaneous interaction with age-grouping policies, it may influence selection and long-term athletic development. The term relative age represents the difference in age among participants grouped together based on a pre-established cut-off date (i.e., 1 January to 31 December in South Africa). These differences are associated with short-term and/or long-term effects and has been labelled relative age effects (RAEs). Research is consistent in reporting the short-term and long-term selection and participation advantages enjoyed by relatively older participants in comparison to relatively younger participants. Coach influence, age level, sport type, sex and level of competition are potential moderating factors. Research is plentiful among youth sport and elite athletes, however, few investigations have explored the prevalence of RAEs among university athletes. Moreover, the researchers' understanding of the RAE within the South African context is limited. Hence, the aim of this retrospective study was to determine the prevalence and magnitude of the RAE among student-athletes from a high-performance (HP) programme at a South African university, in comparison to non-HP-student-athletes according to the competition year, sex and sport code. Relative age distributions of HP student-athletes (N = 950, women = 306, men = 644) and non-HP-student-athletes (student cohort) (N = 46 377, women = 26 376, men = 19 988, undisclosed = 13), aged 18 to 25 years from 2016 to 2021 were analysed. Only South African students were included in both samples to ensure all participants were subject to the same age-grouping policy and cut-offs. The RAE denoted a significant difference between the observed and expected distribution of the participants. Student-athlete (observed) vs non-student-athlete (expected) differences were determined using Chi-squared and Fisher's exact test. Odds Ratios (OR) and 95% Confidence Intervals (CI) assessed relative age quartile differences. The steps were applied across competition years, sex and sport codes. Overall, student-athletes born in the first quartile of the competition year were significantly overrepresented compared to the non-student-athletes in both sexes. However, the RAE was not prevalent across all individual years. Further

investigations into the 11 HP sport codes revealed a RAE prevalence in swimming, cricket and rugby only. RAEs were also larger in men than in women. This study provides a starting point for future research. Potential moderators for RAE are multifactorial and complex. Further exploration of the underlying mechanisms responsible for the prevalence or lack of RAEs, such as individual (e.g., sport psychological profiles), environmental (e.g., sport's popularity and coach influence) and task (e.g., level of physicality) constraints is suggested. Subsequent studies should consider expanding this line of enquiry to other sporting codes and participation levels within South Africa.

Key words: Relatively older, selection bias, talent development, college, university sport

OPSOMMING

Faktore wat ’n atleet se pad na sukses vergemaklik of belemmer sluit direkte of primêre invloede soos genetiese faktore, sielkundige kenmerke en inoefening in. Indirekte of sekondêre faktore soos ’n individu se geboortedatum mag die tipe, intensiteit en kwaliteit van afrigting wat hul ontvang beïnvloed. Onafhanklik is die geboortedatum onbeduidend, maar deur die gelyktydige interaksie met ouderdom groeperingsbeleide, kan dit seleksie en langtermyn atletiese ontwikkeling beïnvloed. Die term relatiewe ouderdom beskryf die variasie (verskille) in ouderdom van persone wat saam gegroepeer is op grond van ’n voorafbepaalde afsnydatum (d.i. 1 Januarie tot 31 Desember in Suid-Afrika). Hierdie verskille in ouderdom word met korttermyn- en/of langtermyn effekte geassosieer en staan as die relatiewe ouderdomseffekte (ROE) bekend. Verskeie navorsingstudies oor die jare is eens dat relatief ouer deelnemers ’n voordeel het bo relatief jonger deelnemers, in terme van kort- en langtermyn seleksie van spanne. Invloed van die afrigter, ouderdom, tipe sport, geslag en vlak van kompetisie bly bepalende faktore. Onder jeugsport en elite atlete is navorsing voldoende, maar slegs ’n paar ondersoeke is reeds gedoen ROE by universiteitsatlete te ondersoek. Die begrip van ROE in die Suid-Afrikaanse konteks is beperk en daarom is die doel van hierdie retrospektiewe studie om die voorkoms en omvang van die ROE onder atlete van ’n Suid-Afrikaanse Universiteit te ondersoek. Dit sal ook voorts met studente wat nie aan sport deelneem nie vergelyk word, asook volgens die kompetisiejaar, sportkode en geslag. Relatiewe ouderdomsverspreidings van studente-atlete in ’n hoë-prestasie (HP) program (N = 950, dames = 306, mans = 644 en nie-HP-atlete (studente kohort) verbonde aan ’n Suid-Afrikaanse Universiteit (N = 46 377, dames = 26 376, mans = 19 988, onbekend = 13) tussen die ouderdom van 18 en 25 jaar vanaf 2016 tot 2021 is ontleed. Slegs Suid-Afrikaanse studente is by beide steekproewe ingesluit om te verseker dat alle deelnemers aan dieselfde ouderdom groeperingsbeleid en afsnypunte blootgestel was. Die ROE het ’n beduidende verskil tussen die waargenome en verwagte verspreiding van die deelnemers aangedui. Kansverhoudings (KV) en 95% vertrouensintervalle (VI) het relatiewe ouderdom kwartielverskille ondersoek. Die stappe is oor kompetisiejare, geslag en sportkodes toegepas. Studente-atlete (waargeneem) teenoor studente (verwagte) verskille is bepaal met behulp van Chi-kwadraat en Fisher se presiese toets. Die stappe is oor kompetisiejare, geslag en sportkodes toegepas. Oor die

algemeen was studente-atlete wat in die eerste kwartiel van die kompetisiejaar gebore is betekenisvol oorverteenwoordig in vergelyking met die nie-studente-atlete van beide geslagte. Nie alle individuele jare is egter geraak nie. Verdere ondersoeke na die 11 hoë prestasie sportkodes het ’n ROE in slegs swem, krieket en rugby aan die lig gebring. Die ROE was ook groter onder mans as dames. Die huidige studie bied ’n basis vir toekomstige navorsing. ROE is kompleks aangesien dit deur verskeie faktore beïnvloed word. Verdere ondersoek van die faktore wat verantwoordelik is vir die voorkoms of gebrek daaraan soos individuele (bv. sport sielkundige profiele), omgewings- (bv. sport gewildheid en afrigter invloed) en taak (bv. vlak van fisiekheid) beperkings word voorgestel. Toekomstige studies moet dit oorweeg om hierdie lyn van ondersoek na ander sportkodes en deelnamevlakke binne Suid-Afrika uit te brei.

Sleutelwoorde: Relatief ouer, keuringsvooroordeel, talentontwikkeling, kollege, universiteit sport

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ABBREVIATIONS

CI	:	Confidence Intervals
FIFA	:	The Federation Internationale de Football Association
HP	:	High Performance
NCAA	:	National Collegiate Athletic Association
NF	:	National Federations
NHL	:	National Hockey League
NSRP	:	National Sport and Recreation Plan
OR	:	Odds Ratio
PPP	:	Peak Performance Profile
Q	:	Birth Quarter
RA	:	Relative Age
RAE	:	Relative Age Effect
RSA	:	Republic of South Africa
SASCOC	:	South African Sport Confederation and Olympic Committee
SRSA	:	Sport and Recreation South Africa
TDE	:	Talent Development Environments
TID	:	Talent Identification
USSA	:	University Sport South Africa
Vs	:	Versus

Chapter One

INTRODUCTION AND PROBLEM STATEMENT

1.1 ORGANISATION OF SPORT IN SOUTH AFRICA

Sport is a cross-cultural language that has the potential to unite people, eliminate differences and it has the capability to empower and craft transformation (Burnett, 2010; Jacobs *et al*., 2019). Despite sport being a beautiful medium through which much can occur and much can evolve it has its flaws. Sport functions in a massively open system that is influenced by a nation's economic, cultural and social environment. Similar to society, it functions within an entity where privilege and power are prevalent and it maintains a significant aura (Burnett, 2011; Bolsmann & Burnett, 2015). As in several other African countries, the Republic of South Africa (RSA) faces challenges such as mass poverty, ethnic and cultural segregation, as well as socio-economic inequality. Notwithstanding these contextual dynamics, sport participation is regarded as essential to the South African society (Jacobs *et al*., 2019).

Suitably, the first formal legislation on sport after the end of the apartheid era, the White Paper on Sport and Recreation (1996) was designed by the new ministry for the purpose of guiding the development of mass sport participation programmes and elite sport systems (SRSA, 2012). In addition to presenting more broadly the 'strategy' concerning mass and elite sport in the country it has also been used as the foundation in establishing the National Sport and Recreation Plan (NSRP) (NSRP, 2012; SRSA, 2012). In its efforts to promote just behaviour, fairness and equal opportunities together with an unbiased resource distribution to encourage affirmation and empowerment, the NSRP functions as an implementation scheme on mass and elite sport participation (NSRP, 2012; SRSA, 2012; Jacobs *et al*., 2019). Furthermore, situated at the top of the sporting system is the national government who primarily functions to develop, monitor, coordinate and implement the developed sport policies.

Identified by Sport and Recreation South Africa (SRSA) as the only non-governmental macro body operating as a multi-sport organisation, the South African Sport Confederation and Olympic Committee (SASCOC) provides services to the elite sporting system (SRSA, 2012). Functioning closely together with SASCOC is the

National Federations (NF's), the main upholders for the development of the relevant sport codes. Included in the mass sport initiative is the goal of increasing recreational activities and sport participation with the precise aim of building an 'active nation' (SRSA, 2012). Many schemes have been recognised within school sport policies, among others, to facilitate the admission of many scholars to accomplish the objectives specified in the mass sport portfolio (NSRP, 2012; SRSA, 2012). To promote mutual understanding amongst people with diverse histories and cultures, university sport is considered an ideal vehicle. Scholars learn to respect each other through the corporate international language of sport.

Because of the distinctive landscape of student sport, SRSA and SASCOC agreed that University Sport South Africa (USSA) should be governed autonomously. Established on 16 April 1994 and founded within the tertiary education sector USSA is the official unified nationwide sport structure responsible to protect and represent the sporting interests of all students at member institutions. Principally, USSA is responsible for the coordination, organisation and regulation of student sport activities at national, provincial and regional levels in the tertiary education sector of South Africa. This is inclusive of all coaches, student-athletes and other stakeholders of the system. Furthermore, South Africa's sport system is uniquely organized; school and university sport are often part of the pathway to elite sport compared to elsewhere in the world where club systems dominate (USSA, 2016).

1.2 THE STUDENT-ATHLETE

Sportspersons in various sport codes are faced with relatively short careers as players, and in most cases many of them enter their final stage of elite sport participation during their tertiary education years (Burnett, 2011). Throughout these years at higher educational institutions, career choices materialise for those who enter either a sport-related career or another occupation after exiting from high performance sport and/or high school sport. For those who succeed in pursuing a professional career as an athlete and a student, such a duality has earned them the identity of student-athletes (Burnett, 2011; Bolsmann & Burnett, 2015). The popular usage of the term student-athletes (i.e., athletes participating in secondary, tertiary and/or post-secondary school sport) has been extensively studied by researchers who perceive it as a propaganda

mechanism in the United States of America (i.e., National Collegiate Athletic Association (NCAA)) (Eckard, 2010).

Although student-athletes per definition are seldom regarded as professionals, in a highly marketed sporting environment (i.e., Varsity Cup) numerous student-athletes participating in a revenue-generating sport (e.g., Rugby) have fundamentally been commercially exploited (Burnett, 2010, 2011; Eckard, 2010). Many student-athletes enter university unprepared for such a dual role and eventually become overwhelmed by the exorbitant demands (Weiss & Robinson, 2013). Literature suggests that most student-athletes receive preferential treatment (e.g., lower academic entry-level requirements) and disproportionate obligations to keep their sport benefits (e.g., sport bursaries and sport housing). This infers that they could actually primarily be considered as athletes and secondary as students purely because they have been formally registered (bona fide) for a tertiary qualification (Eckard, 2010; Weiss & Robinson, 2013).

This could unfavourably impact the retention of scholars and lead to a relatively poor academic preparation of athletes (Gayles, 2009). It is also typical that many student-athletes drop out of university (i.e., after encountering career ending injuries or once they are no longer selected for teams) (Burnett, 2011; Weiss & Robinson, 2013). Consequently, an acceptable academic progress rate must be upheld for institutions to be spared from NCAA forfeits. Comparable processes have been employed in South African university sport where student-athletes who are eligible for competing in the respective Varsity Sport competitions, receive housing and/or a sport bursary, have to accomplish academic success in passing at least 60 (out of a typical 120) credits in a given academic year (Burnett, 2010). Therefore, after entering the university environment a concentrated effort by a team of individuals (e.g., coaches, high performance support staff, faculty and other students/tutors), working together in this multi-faceted process is required to keep student-athletes academically eligible to participate and enjoy the added benefits (Burnett, 2011; Weiss & Robinson, 2013).

1.3 STELLENBOSCH UNIVERSITY: MATIES SPORT

Previous exploratory research demonstrate a differential pattern of sport participation for women and men student-athletes at South African universities (Burnett, 2011). According to Burnett (2011), about eight to 20 per cent of students are actively involved in sport. Stellenbosch University has an extensive and honoured sporting tradition, which has been a strong platform from which Maties Sport (Maties is the nickname of Stellenbosch University students), have generated operational units to streamline its activities.

Principally, Maties Sport aims to: 1) develop world-class sports men and women; 2) achieve a dominant position in focus sport codes; 3) deliver an excellent experience of university sport; and 4) promote recreational sport participation. With 30 sporting clubs accessible, Maties Sport makes it easy for students to find a sport that suits their needs and skills. They also offer sports such as swimming, cycling, athletics and wheelchair rugby for people with disabilities. Each of the five operational units and their objectives will be discussed next.

1.3.1 Recreation and Active Lifestyles Unit: Mass sport participation

This unit aims to:

- develop new opportunities in recreation and community interaction;
- provide active recreational programmes that are relevant and appealing; and
- promote the benefits of participation in physical activity.

The sport codes in this unit includes:

- volleyball;
- underwater sport;
- equestrian club;
- ultimate (frisbee); and
- cheerleading.

Recreational participation for many students takes the form of competitions during “fun days” or ad hoc and informal participation. All residential universities offer hostel and/or in-house leagues with up to 700 players competing annually across a wide

range of sporting codes. Typically, willing students take on the added responsibility of assisting in the administration of these leagues under the guidance of existing sport club structures. For some students, this level of mass participation is deemed fun and recreational, whereas for others the competitive element (e.g., against other residences or hostels), and the resulting "sporting image" is vital. Perhaps, according to pyramid analogy, the value-add of such a broad spectrum, provides a base for talent identification and can function as a facilitator for students to advance to higher levels of sport participation (e.g., intervarsity competitions).

1.3.2 High Performance Sports Unit: Elite sport

This unit aims to:

- identify, recruit and develop champions in both individual and team sports; and
- facilitate the academic success of student-athletes through athlete support programmes.

The sport codes in this unit includes:

- field hockey;
- rugby;
- netball;
- athletics;
- football (soccer);
- swimming;
- cricket;
- tennis;
- basketball;
- cycling; and
- water polo.

Considering the competitive nature of sport and a result driven culture within many team sports, the pursuit for instantaneous performances may prevail over trying to identify more talented athletes who can provide better results in the future (Helsen *et al*., 2005; Hill & Sotiriadou, 2016). Additionally, the image of competitive university sport is largely captured by the regional and/or international performances of elite

athletes. Hence, this unit prioritizes sport medicine services, as well as performance empowerment and enhancement. Only an elite few student-athletes are selected into this high-performance (HP) unit each year for the various 11 sport codes. Selection into this unit offers hp student-athletes access to benefits like the holistic student-athlete support programme (PACER) and performance enhancement programs (i.e., strength and conditioning, performance psychology, technology). Also, these priority sport codes have sport teams that travel across South Africa annually to compete against other university in the annual USSA tournaments. The top 8 teams then qualify for Varsity Sport competitions. For instance, Varsity Cup started in 2008 with the inclusion of only eight university rugby teams. Rugby is a premier team sport within South African university sport, with a national contest (i.e., the Varsity Cup) that attracts national TV audiences. Students and alumni gather on Monday evenings to watch the games at the beginning of the academic year. Noteworthy, Maties is the most successful university at this competition, having reached 10 semi-finals and clinching five championships during the first 12 years.

The Varsity Sport concept started in 2012, with some codes dropped and new ones added since then. In 2012 beach volleyball and rugby sevens were played. Field hockey, football, athletics, and netball were added in 2013, and cycling were included in 2016. At Stellenbosch University (SU), the High Performance (HP) programme concept originated in 2012, but only received strategic support from SU from 2015 after the appointment of chief director of sport in 2014. According to Maties Sport staff, the database from 2016 onwards is up to date and reliable. This is when Maties Sport started the induction, monitoring and tracking of student-athletes through the HP unit. In this thesis all student-athletes included into this unit can be considered as hp-student-athletes whereas every other student despite mass sport participation is considered as non-hp-student-athletes.

1.3.3 The Centre for Sports Leadership

This unit aims to:

- be a custodian of Maties Sport's social impact and internationalisation strategies;
- develop leaders within a sporting context; and
- provide thought leadership through impactful research

The Centre takes an interdisciplinary approach to its research activities and looks to collaborate with other academic units or individual researchers. Current research focus areas for the Centre include the historical intersection between sport and politics as well as the application of data science within sport.

1.4 STATING THE PROBLEM: THE RELATIVE AGE EFFECT

Inequality is multidimensional and has unique indications at all stages of human existence. It symbolizes an intricate and dynamic process whereby vulnerable individuals are exposed through interlocking influences that deny them relative access to accessible resources. Although the precise details are unknown, literature indicates the interaction and influence of innumerable factors on athletic development and success (Baker & Horton, 2004). One secondary factor that has been extensively investigated in sport science literature is the relative age effect (RAE) (Musch & Grondin, 2001).

1.4.1 Annual Age Banding using Cut-off Dates

For more than a century scientists have been entranced by the association between various developmental outcomes and an individual athlete's birth-date (Musch & Grondin, 2001). Research has exposed that an individual's birthdate, under certain settings, may have a major influence on his/her accomplishment in sport (Ashworth & Heyndels, 2007). As children grow, they continue to mature, develop and learn (Malina *et al*., 2004). Owing to this assumption, many associations providing educational and competitive activities have sought to group individuals by yearly age groups. These tend to use specific cut-off dates coinciding with the typical start of the school years (e.g., 1 January to 31 December in the Southern hemisphere, while 1 September to 31 August is often used in the Northern hemisphere) (Musch & Grondin, 2001; Roberts & Stott, 2015). In combat sport such as boxing and judo, weight category systems are commonly utilized (Edginton *et al*., 2014; Albuquerque *et al*., 2016).

Irrespective of the type of grouping system used, the cut-off periods are universally used to initiate standardized competitions and moderate maturational differences (Musch & Grondin, 2001; Chittle *et al*., 2018; Rađa *et al*., 2018). Whilst with the honourable intent of providing a fair and uniform chance of success, as well as

developmentally appropriate instructions and tasks, policies of grouping learners often afford advantages to some (relatively older individuals), while disadvantaging others (relatively younger individuals) (Wattie *et al*., 2015). This situation can easily result in an age variance of almost 12 months (or 24 months in the case of a two year band within age-group sport), between those born at the end of a competitive year and those born at the beginning of the same year (Musch & Grondin, 2001).

This disparity in chronological age among participants within the same age grouping has been named the Relative Age (RA) (Cobley *et al*., 2009). For example, take two athletes born within the same competitive year (1 January to 31 December). The athlete with a January birthdate may have almost a one-year developmental advantage relative to his/her peer born in December. Furthermore, these disparities are associated with instant or long-term effects universally known as the “relative age effects” (RAEs) (Musch & Grondin, 2001). Reviews of RAEs (e.g., Musch & Grondin, 2001; Smith *et al*., 2018) express that this effect is widespread and highlight inequalities that are problematic to manage.

RAE is a well-documented phenomenon in many youth team sporting codes, such as soccer (Helsen *et al*., 2005), baseball (Thompson *et al*., 1991), ice hockey (Barnsley & Thompson, 1988), cricket (Jones *et al*., 2018), rugby union (Grobler *et al*., 2016) and basketball (Steingröver *et al*., 2016). Furthermore, it has been observed in various strength, power, endurance and technique based events during the Youth Winter Olympic Games (O’Neill *et al*., 2016). A meta-analysis examining junior (11- to 14-year-old), adolescent (15- to 18-year-old) and senior (19 years and older) recreational and elite athletes across multiple sports, exposed robust support for biases towards relatively older athletes. More precisely, Cobley and colleagues provided evidence that athletic accomplishment may be positively influenced by an early birthdate across 14 sports in 16 different countries (Cobley *et al*., 2009).

This data has insinuations for the efficacy of the selection process and provision of a fair and uniform chance of success. As with earlier work in this domain, many investigations have focused on professional and youth sport with very few investigations at university level (Dixon *et al*., 2013; Chittle *et al*., 2018). With specific reference to research on the RAE conducted in university sport context, the bulk has

focused on American and European student-athletes (Dixon *et al*., 2013; Chittle *et al*., 2016, 2018). Hence, the examination of the RAE in university sport seems to be a fruitful avenue for investigators desiring to understand the existence and prevalence of the RAE, since most of students are 18 years or older when they start their courses (Burnett, 2011; Roberts & Stott, 2015). This is typically the phase in which most athletes make the transition into elite sport and many often use University sport as a pathway to elite sport.

Hereafter, having traced a RAE and potentially a reversal of advantages at a senior level, the primary investigator of the current study is intrigued to see if this phenomenon is in fact noticeable across men and women student-athletes selected to be part of a high performance unit within the South African context. Given the paucity of research devoted to both sexes participating in sport at university level, the focus of this enquiry will go beyond the scope of examining the prevalence of the RAE among student-athletes, by also including the general student population. While fully recognizing that transferring such data to other domains and contexts may be problematic it seems essential to impose a comparison cluster of aged-matched non-student-athletes in order to be able to evaluate whether the RAE is generally prevalent across all sporting codes and both sexes or to specific ones only.

1.5 RESEARCH QUESTIONS

1. Is the RAE prevalent in South African high performance student-athletes aged 18 to 25 years for the years 2016 to 2021 in comparison to the age-matched SU students that are not in the high performance unit?
2. How does the distribution differ across each academic year?
3. How does the distribution differ across each sex?
4. How does the birthdate distribution differ across various sporting codes?

1.6 AIMS

1. The primary aim is to determine and compare the prevalence of RAE among hp-student-athletes and the non-hp-student-athletes.
2. The secondary aim is to compare the prevalence and persistence of the RAE from 2016 to 2021 and how these effects vary over time

3. The tertiary aim is to describe and compare the birthdate distributions of various Maties HP student-athletes with reference to their sex
4. The quaternary aim is to describe and compare the birthdate distributions of various Maties HP student-athletes with reference to sport code.

1.7 OBJECTIVES

The objectives of the current study were to compare the birthdate distribution of the:

- HP-student-athletes with an age-matched student cohort;
- HP-student-athletes across different academic years;
- HP-student-athletes across the different sexes; and
- HP-student-athletes across different years for various sporting codes.

1.8 MOTIVATION

This study will potentially contribute to the existing literature on the RAE in the following ways:

- it is one of the few studies to examine the RAE in university student-athletes;
- it adds to the scarcity of information on RAE among women athletes;
- it is one of the few studies that will utilize an academic comparison group to help assess whether the prevalence of RAE is sport specific or general; and
- it is one of the few studies to consider inter- and intra-sport differences.

1.9 OUTLINE OF THE THESIS CHAPTERS

The aim of Chapter 1 was to provide the South African university context and outline the aims, objectives and motivation for the thesis, Chapter 2 reviews the literature and presents an analytical summary of the past work relevant to the RAE. Chapter 3 reflects on the primary researcher's research journey and includes a short summary of the major events that lead to the current study. Part of this reflection was to give the reader an understanding of how the COVID-19 pandemic affected the initial inquiry. Chapter 4 presents the article that will be submitted for publication in which the methodology, results and discussion of the results will be presented. Chapter 5 rounds up everything and presents the summary, conclusion and recommendations from the study.

Chapter Two

LITERATURE REVIEW

2.1 IDENTIFICATION AND DEVELOPMENT OF TALENT IN SPORT

Arguably the ambition of most sporting organizations is to drive and nurture proficient performance (Ericsson & Starkes, 2003; Coutinho *et al*., 2016). Proficient performance can be rationalized as reliable incomparable athletic performance over an extended period, whereas a talented athlete can be considered as an athlete whose performance is superior or increases at a quicker rate than his or her peers at a competition and training level (Elferink-Gemser *et al*., 2004; Sarmento *et al*., 2018).

In many top-level sport clubs and organisations, science-based support systems (e.g., physical and mental conditioning, computer-based match analysis and player tracking) are now central to the development, training and performance of elite sportspersons (Vaeyens *et al*., 2008). Talent identification (TID) refers to the practice of spotting participants with the capacity to progress towards proficiency, whereas talent development environments (TDE) exposes these detected and identified athletes to useful resources and an appropriate learning environment with the intention of increasing the prospect of realizing their potential (Williams & Reilly, 2000; Gulbin *et al*., 2010).

2.1.1 Primary Factors: Exploring the controversial dualism of nature vs nurture

The dynamic nature of talent and its development is complex and multifaceted (Gulbin *et al*., 2013). The sheer volume of literature on sport expertise is overwhelming. However, in reviewing relevant evidence in this research area, success in sport is essentially a result of various primary factors, for instance, genetics, anthropometric and physiological characteristics and/or practice (Ericsson & Charness, 1994; Davids & Baker, 2007; Tucker & Collins, 2012). Predominantly, a question of increasing interest is how genetic and environmental components network and interact to shape performance variations (Davids & Baker, 2007; Tucker & Collins, 2012). The historic debate, nurture vs. nature, is one of the most convoluted and persistent controversies in medicine and science research (Davids & Baker, 2007; Tucker & Collins, 2012).

For example, in medicine and physiology it is recognised as how the ecosystem and heredity account for disparities in health and human performance. In growth-related science, it is the 'learning versus maturation debate', while in psychology it is recognised as the 'nativism-empiricism issue' (Spelke, 1998; Davids & Baker, 2007; Tucker & Collins, 2012). Patently, this dualistic debate has led to reductionist deductions fuelled by their respective extreme views (Davids & Baker, 2007).

Indeed, the development and identification of talented individuals plays a significant role in other creative performance professions (e.g., music, art) and education, but no domain has embraced the concept as tenaciously as sport (MacNamara *et al*., 2010; McCarthy & Collins, 2014; Collins *et al*., 2016). For instance, research has proposed that the association between the effects of genes and practise on elite performance cultivates key implications for talent identification, allocation of resources and athlete management by sporting federations (Ziegler & Shi, 2010; Tucker & Collins, 2012). This together with other factors has led to more intricate and convoluted questions, for example:

- Why and when do some athletes benefit more from competitions, practise and training than others do?
- Which factors are the most important?
- When during an athlete's lifetime does nature/nurture play a more critical role?
- Who is most advantaged or disadvantaged by either one of these factors?
- How much variation of either of these factors can be accounted for by the other? and
- Where do either one of the factors thrive and/or are more prominent?

2.1.1.1 Nature

Biological determinism (i.e., nature) is undoubtedly driven to a considerable extent by the publications of *Darwin's Origin of Species in 1859* (Darwin, 2008), which subsequently advised one of the longest longitudinal studies in history, namely Terman's *Genetic Studies of Genius* (Terman & Oden, 1947; Holahan & Sears, 1995). Mainly, this perspective reasons that biology is the paramount constraint to proficiency and realization. Definitely, some athletes are built like a tank and have physiques with the essential flexibility, speed, agility and strength to support that they must have been

instinctively born to be elite sportspersons (Tucker & Collins, 2012). Some would even claim that certain athletes hold a universal athletic capability that allows them to outperform and excel in nearly any sporting code (Ericsson *et al*., 1993; Davids & Baker, 2007).

2.1.1.2 Nurture

Nonetheless, contrary to popular belief that athletic proficiency suggests innate capacities and abilities, more recent research in many fields of expertise have attempted to show that elite performance and proficient is largely facilitated by learning complex and intricate skills (Ericsson & Charness, 1994; Gagné, 2004; Tucker & Collins, 2012). This opposing social deterministic perspective is laconically demonstrated everywhere. It is inevitable that sport fanatics become absorbed by the series of reviews and social media videos on the virtuosity of top performers. Be it the class and strength of Sonny Bill Williams, the revolutionary Serena Williams, the athleticism of Cristiano Ronaldo, the greatness of Lionel Messi, and not to mention the speed of Usain Bolt and Shelly-Ann Fraser-Pryce, all sport paramours have perhaps found themselves in the 'Social Media void.' Seeing such proficiency can be a sensible and prudent cue that mastery and proficiency is not something that anyone is born with (Ericsson & Starkes, 2003; Van Yperen, 2009). Be it in team or individual sport, a musical instrument or profession, if a person wants to achieve true success, the right management and regular training to move towards this goal is essential.

This concept was also presented in the introductory chapter of bestselling novel *Outliers: The Story of Success* (Gladwell, 2008). Malcolm Gladwell is a journalist and writer that makes a person query their worldview. One of his strengths is extracting fascinating stories out of monotonous research to present remarkable facts. His understanding of academic material has allowed him to write about classical music, hockey players, sociological studies, psychological experiments, and law articles, which he transforms into style accessible to the general public (Gladwell, 2008). In his book, Gladwell reveals chronicles of extraordinary individuals from various walks of life. He later reveals that what often separates these extraordinary individuals from the norm is a matter of circumstance and how individuals interact with the environment rather than the intelligence or innate ability they embrace (Gladwell, 2008). Through

his book, he shares lessons that top performers and business tycoons can learn to help them thrive (or make sense of their lack of success). Beguilingly in many cases, success really is a matter of circumstance or luck, because the playing field is not level. To support his thesis Gladwell capitalized on how a musical band like the Beatles developed into one of the most popular musical performances in history, how Microsoft co-founder Bill Gates achieved his extreme wealth and how cultural differences play a large part in rational decision-making and perceived intelligence among other examples.

Aptly, one of Gladwell's examples included some of the work by psychologist K. Anders Ericsson and two collaborators at Berlin's Elite Music Academy regarding the role of "deliberate practise" in the success of violin students. The study found that by the time the students turn 20, the most accomplished students had put in 10,000 hours of work (Ericsson *et al*., 1993). In contrast, the average or good students had accumulated only approximately 4,600 hours and 7,800 hours, respectively. As Gladwell articulates, it takes 10,000 hours of exhaustive practise to realize mastery, like becoming as good as Bill Gates at computer programming before founding Microsoft or playing a violin (Gladwell, 2008). Gladwell also approximates the 10,000 hours of practise that the Beatles put in while playing in Hamburg in the early 1960s. Essentially, "once a musician has enough ability to get into a top music school, how hard he or she works is the thing that distinguishes the top performers from the ordinary, that's it" (Gladwell, 2008:39). The 10,000-hour rule was born, the complete correspondence between the average accumulation of practise time and skill level. Put in your 10,000 hours and become an expert, easy right?

Well, it is not so simple. Yet, looking at it this way is reductionism. Yes, for sure, nobody is great without work; there is no evidence of high-level performance without practise or experience. While the time spent practising is important, it is far from being the only factor. There appears to be some innate abilities necessary to become a master, besides the number 10,000 is very arbitrary and not all practise is the same or equal. For instance, the model for deliberate practise is often guided by skilled coaches, experts, or mentors who offer feedback on specific ways to improve and without such feedback it is tough to top the ranks (Ericsson *et al*., 1993; Ericsson & Starkes, 2003). This model emphasises the important distinction of quality over quantity because the

type and quality of feedback and concentration matters not just the hours. Numerous great athletes are legendary for the inhuman discipline of their practise habits. A real-world example is Michael Jordan who intensely beyond the already arduous team practise spent many hours practicing further. Another textbook example is Tiger Woods whose father introduced him and encouraged him to practise golf extensively at a very young age (18 months). Woods had accumulated at least 15 years of practise by the time he won the Masters at the age of 18 years – he was the youngest winner ever and he was still an amateur at the time. A person's position in this debate depends very much on his/her opinion and own experience. When a person looks at the highest level, hard work and access to training becomes the tiny difference between defeat and victory. The dire reality is that individuals are not captives to some naturally contracted level of aptitude or talent. Many assume they would coast to riches and fame if they discovered their talent or natural ability. However, this view is dreadfully constraining. Often countless individuals when struggling to cope with the inevitable trials and tribulations are likely to conclude that they just are not gifted and consequently give up (Collins & MacNamara, 2012; Collins *et al*., 2016).

2.1.2 Complexity of individual variability

The literature reveals that while experts in Sport Science have a broad understanding about the behaviour that produces great performance, little is understood about where this behaviour emanates from. The field of Sport Science may claim that sport proficiency is the result of a cluster of psychological, environmental and physiological traits that are currently too complex to analyse, however, experts have not worked out exactly what determines proficient performance. Also, though it is generally accepted that there are extreme theoretical perspectives on the processes required to achieve expert performance, little has been presented regarding the performance environments and the authentic transitions and pathways that athletes take toward sporting excellence (Davids & Baker, 2007; Gulbin *et al*., 2013). Nevertheless, the extent to which elite athletes are made (nurture) and/or born (nature) is very much a question that lingers (Baker & Horton, 2004; Davids & Baker, 2007; Gulbin *et al*., 2013). Notwithstanding the continuous advancement of technology and investigation techniques, it is improbable that this debate will be resolved soon (Davids & Baker, 2007; Tucker & Collins, 2012).

Undoubtedly, prioritizing one perspective and discounting another, i.e., the mentioned 10,000-hours of deliberate practise to describe all proficient athletic development (Ericsson *et al*., 1993; Ericsson & Charness, 1994), versus the universal sporty capacity (biological determinism) is naive and overlooks other overriding noteworthy traits of individual variability. Henceforth, in addition to these primary factors, it is equally important to recognize how a broader environment modulates the development of youth athletes (Baker & Horton, 2004; Bullock *et al*., 2009).

2.1.3 Secondary Factors: Socio-cultural variables

The function of these primary factors (i.e., training and genetics) is often influenced by several secondary factors (Baker & Horton, 2004). Examples of secondary factors include, but are not limited to, socio-cultural variables, such as money, chance, socialization, resources, biases and policies (Baker & Horton, 2004; Rees et al., 2016a). These factors are significant and their influences on the development of expertise is often overlooked (Baker & Horton, 2004; Hopwood *et al*., 2015). Gagne (2004) conveyed three forms of catalytic agents that can impede or facilitate this developmental process: 1) fate or chance (e.g., hereditary characteristics, athlete-coach relationships and the possibility of or access to certain opportunities); 2) environmental catalysts (e.g., psychological influences and socio-demographic factors; and 3) interpersonal catalysts (e.g., self-management processes and personal traits). In these ways, such a perspective add to our understanding of the complex and often misinterpreted talents and their development into proficiency (Gagné, 2004; Tucker & Collins, 2012; Unnithan *et al*., 2012).

Indeed, development pathways from grassroots to elite levels is a contested and debated topic in contemporary Sport Science research (e.g., Baker & Horton, 2004; Tucker & Collins, 2012; Coutinho *et al*., 2016). Regardless of the plethora of research on athletic proficiency including the performer and their environment (Sarmento *et al*., 2018), practise (Ericsson *et al*., 1993) and coaching (Coutinho *et al*., 2016), the pathway to athletic proficiency starts with the preliminary introduction to physical activity and sport (Baker & Horton, 2004; Blazo & Smith, 2018). Undeniably, early sport experiences play an important role in athletic development and these experiences can impact the long-term outcome of personal development, the continuation of sport

participation, as well as the prospect of a successful transitioning from a talent development system (Baker & Horton, 2004; Ziegler & Shi, 2010; Gulbin *et al*., 2013). Accordingly, the rest of this literature review aims to discuss in detail one secondary factor (i.e., the relative age effect [RAE]) that has been investigated in Sport Science literature. Specifically, the focus will be on what it entails, how it is measured and when and why the RAE is prevalent.

2.2 WHAT IS THE RELATIVE AGE EFFECT?

Early scholars indicated that people of eminence tend to be born within the spring calendar months with trivial disparities based on the particular population being surveyed (Kassel, 1929). While the basis was to comprehend the human species gestational patterns, it laid the foundation for more contemporary inquiry associating performance to birth date in various developmental milieus like education and sport (Barnsley *et al*., 1985; Billari & Pellizzari, 2012; Eckstein *et al*., 2010).

While the season-of-birth literature studies the birthdates of individuals (i.e., placement in the calendar year), relative age (RA) phenomena are aimed at ascertaining relative (dis)advantages between individuals within a pre-defined age group (Cobley *et al*., 2009). This (dis)advantageous effect is likely, for instance to exist "…when, for management and logistical purposes, individuals are grouped by age for school attendance or other activities where performance is strongly associated with development" (Thompson *et al*., 1999, p. 82). Age-based classification policies often unintentional offer relatively older individuals an advantage while disadvantaging the relatively younger individuals within the same cohort (i.e., RAE). Much has been published about the RAE in sport and education over the past century (Musch & Grondin, 2001; Helsen *et al*., 2012). To date, much of this research has been cross-sectional in nature, with only a few longitudinal studies.

Age related cut-off points for categorisation are implemented in most educational systems (Roberts & Stott, 2015). Similar to school grades, learners participating in sport are also commonly organized into age-groups (Navarro *et al*., 2015). The assumption is that a particular schooling system uses a distinct selection year to group its learners (e.g., 1 January to 31 December). In South Africa for instance, admission

to formal education (grade R) is required once a child turns the age of six. The admission date for first year of primary school for most schools is 1 January. The enormity of the relative age differences and the possible variances in maturity status at the beginning of formal schooling has serious negative effects for those born later in the cut-off year. The relatively youngest child can be as much as 20% younger than their relatively older peers (Malina *et al*., 2004; Dixon *et al*., 2011; Hill *et al*., 2020).

Furthermore, it is essential to understand that it is not the absolute time of year or the specific birth month that is important, but rather it is the 'relative age difference', which relates to the proximity of a birth date to the pertinent cut-off date used to group participants:

- If a participant's birth date falls after a cut-off date, they are included in the group; and
- If a participant's birth date falls before the cut-off date, they are excluded from a group.

Principally, in this taxonomy, the RA difference between an individual born at 23:59 on 31 December and an individual born at 00:00 on 1 January is not one minute, it is one year – and that is where the complications begin.

2.2.1 How is the RAE determined?

To investigate RAE, birth date is typically distributed over four quarters. In South Africa the distribution is considered as follows:

Quartile 1 (Q1): January to March

Quartile 2 (Q2): April to June

Quartile 3 (Q3): July to September

Quartile 4 (Q4): October to December.

Researchers bring up the RAE when a biased distribution of athletes' birth dates is observed. Typically there is an under-representation of relatively younger individuals (e.g., October to December in the Southern hemisphere) and an over-representation of relatively older individuals (e.g., January to March) within youth sport age-grouped

cohorts (Musch & Grondin, 2001; Wattie *et al*., 2015). This is normally investigated by looking for discrepancies between the 1) observed and expected (i.e., parent population from which the sample was drawn) count of participants born per quarter or month (i.e., four relative age quarters in a year), or 2) observed against expected frequency that assumes an unbiased and random distribution throughout the year (Musch & Grondin, 2001; Delorme & Champely, 2015).

Generally, those born early (January to March) have an unintended advantage over their relatively younger peers (October to December), whereas relatively younger individuals experience both long and short-term disadvantages compared to the older individuals (Cobley *et al*., 2009). Whereas the prevalence of a RAE might be the consequence and the setting of a single distinctive cut-off date for eligibility might be the cause, the links between the two are both questioned and multifaceted (Musch & Hay, 1999; Roberts & Stott, 2015). Literature has consistently highlighted that RAEs are seen from a very early participation age and seem to continue into adulthood (Cobley *et al*., 2009; Tribolet *et al*., 2019).

2.3 RELATIVE AGE EFFECT IN EDUCATIONAL SETTINGS

RAEs were first validated in the education system where relatively younger students had the tendency to perform poorly compared to their relatively older counterparts (Jinks, 1964; Armstrong, 1966). A number of subsequent findings within the education system have documented how the relatively older students outperform the relatively younger students in a range of academic and cognitive outcomes (Rosenthal & Jacobson, 1968; Billari & Pellizzari, 2012; Fumarco & Baert, 2019). Research has consistently demonstrated higher achievement scores for relatively older scholars who are consequently also more likely to be classified as “gifted” in learning streams and selected for leadership positions (e.g., student representatives) (Dixon *et al*., 2011; Billari & Pellizzari, 2012). In some cases, children born just before the cut-off date may be among the oldest in their class (i.e., December for 1 January cut-off), if their parents hold them back because of their awareness of the RAE or relative immaturity of a later born child (see Graue & DiPerna, 2000). Maddux *et al*. (1981) found that in a group of scholars who were classified as “gifted”, nearly 60% had a relative age advantaged gained by a late entry into the first grade.

To quote from a research paper abstract on this topic, "... school admission cut-offs encourage systematic within grade differences in learner maturity, which in turn creates differences in leadership occupation. We discover that the relatively oldest learners are four to eleven percent more likely to lead a varsity sports club or team before graduating high school than the relatively youngest" (Dhuey & Lipscomb, 2008:175). Similarly, scholars who developed leadership skills during high school are more likely to take up supervisory positions a decade later (Dixon *et al*., 2011; Billari & Pellizzari, 2012). Relatively younger students tend to suffer from grade retention and are more likely to be assigned to remedial classes (Fumarco & Baert, 2019).

Motivated by a series of studies that explored the psychological effects, RAEs may offer other returns to relatively older athletes compared to relatively younger athletes (Thompson *et al*., 2004; Helsen *et al*., 2005). Psychological skills are assumed to be essential attributes of proficiency and for this reason high measures of psychological skills are considered essential to endure effort and determination in pursuit of proficient performance (Van Yperen, 2009; Grobbelaar, 2018; Sarmento *et al*., 2018). In addition, some research on behavioural development propose that the RAEs may initiate heightened self-efficacy, motivation, perception of competence along with other ego boosting characteristics in relatively older athletes that sequentially have an influence on performance and the quality of learning (Thompson *et al*., 2004; Helsen *et al*., 2005; Ashworth & Heyndels, 2007; Cobley *et al*., 2009). This together with the reinforcements and fulfilment of participation lead to a greater likelihood of increasing intrinsic and extrinsic motivation to retain their participation (Musch & Grondin, 2001; Cumming *et al*., 2018).

A few studies attempted to scrutinize whether children's low self-esteem is to some extent explained by being relatively younger within an age-grouping system (Thompson *et al*., 2004; Larsson & Regborn, 2019). It is through a person's relationships to significant others (i.e., teachers, coaches, family, etc.) that he/she formulates the standards by which they evaluate themselves. As such, self-esteem functions as an internal monitor that keeps track of one's social value in a given environment (Thompson *et al*., 2004). Low self-esteem is associated with multiple negative effects on behavioural and socio-emotional development, for instance, antisocial personality disorder, mental health problems and suicidal ideation (Jooste

et al., 2013; Larsson & Regborn, 2019). Along a similar vein, high self-esteem is related to low risk taking, high sense of mastery, as well as better health (Larsson & Regborn, 2019).

As frontal cortex neurological maturity and development become more efficient with age (Roberts & Stott, 2015), numerous speculations have been made regarding the developmental delay in cognitive accomplishment among relatively younger adolescents (Bisanz *et al*., 1995; Morrison *et al*., 1995). Hence, relatively younger adolescents are more likely to experience social limitations resulting in a reduction in task involvement and low self-esteem (Thompson *et al*., 2004; Roberts & Stott, 2015). More alarmingly, evidence from United Kingdom (UK) students insinuates that relatively younger adolescents generally display greater health problems and are at a larger risk of psychiatric support service referrals (Goodman *et al*., 2003; Roberts & Stott, 2015). Perhaps the most unsettling consequence relates to the high incidences of suicide in relatively younger children within school entry cohorts (Thompson *et al*., 1999). Nevertheless, these variations in academic performance appear to be more noticeable at the primary school level and are more likely to reduce upon the onset of puberty (Billari & Pellizzari, 2012; Navarro *et al*., 2015). Hence, if truly these disparities reduce over time, then a person can reason that the effects for learners in tertiary education settings may be marginal.

2.4 RELATIVE AGE EFFECT IN SPORT

This section will assess the chronology of RAE in sport and provide some reasonable research-informed explanations of the RAE to help future inquiry.

2.4.1 The 1980s

It appears Grondin *et al*. (1984) and Barnsley *et al*. (1985) were the first scholars to discuss a probable association between sport participation and a RAE that mirror similar associations between academic success and relative age. Their sample included two of the three major amateur “junior A” developmental leagues (16 to 21 years) of the National Hockey League (NHL), the Ontario Hockey League (OHL) and Western Hockey Leagues (WHL). These birthdates were compared to the actual distribution of male live births by month in Canada. The magnitude of this phenomenon

can be best comprehended when it is gathered that four times more participants in the OHL and WHL were born within the first quarter (January, February and March) compared to participants born in the fourth quarter (October, November and December), with this disparity following through to the NHL (Barnsley *et al*., 1985). Simply put, the birth breakdown of ice hockey players in Canada was as follows: 10% of the players were born between October and December (Q4); 20% between July and September (Q3); 30% between April and June (Q2); and 40% of the players between January and March (Q1) (Barnsley *et al*., 1985).

Daniel and Janssen (1987) also made an imperative contribution to the discovery of the RAE in ice hockey. They noted a fundamental change in the organisation for minor hockey (u/7) in the early 1970s, namely during the international series with the Soviet Union (Hurley *et al*., 2001). Greater emphases were placed on transitioning to a systematic approach of developing talent in European youth sport by streaming players via different levels of proficiency at an early age (Daniel & Janssen, 1987). The authors found comparable data in then present-day hockey (i.e., overrepresentation of early-born players), but stress that it did not appear to occur until after the transition. The following year Barnsley *et al*. (1988) also recognized similar disparities among Canadian minor representative leagues (11 years and younger), elite developmental leagues, as well as National Hockey League (NHL) players.

2.4.2 The 1990s to 2000s

Barnsley and his team branched out into other sports throughout the 1990s and again the RAE was being mentioned as an influence for success in Major League Baseball (Thompson *et al*., 1991) and soccer (Barnsley *et al*., 1992). Barnsley *et al*. (1992) analysed the existence of the RAE during the FIFA Soccer World Cup in 1990. Data from this study regarding the u/17 and u/20 players bear a striking resemblance to the ice hockey observations. While ice hockey in Canada tends to advantage players born in January, February and March, soccer players in Europe, because of a “cut-off” date of 1 August, are typically benefit if they are born in August, September and October (for a review, see Boucher & Mutimer, 1994). RAE investigations in soccer has been popular and has been detected in professional competitions of various countries from numerous continents, such as France and the Netherlands (Verhulst, 1992), as well

as Brazil, Germany, Japan and Australia (Musch & Hay, 1999). Furthermore, Musch and Hay (1999) investigated what emerged within the Australian soccer league following a scheme by the World Soccer Association in 1988 to alter the cut-off date from 1 January to 1 August. Despite of this alteration an analogous shift in RA distribution of professional players was observed 10 years later. The newly relatively older athletes were overrepresented, while the formerly relatively older were no longer overrepresented (Musch & Hay, 1999).

Helsen *et al*. (1998) investigated the association between RAE and sport dropout. They observed a regular birth date distribution among the six- to 10-year-old group, but a RAE in the 12- to 16-year-old group. “From the age of twelve years on, there were a higher number of dropouts from participants born towards the end of the selection year” (Helsen *et al*., 1998: 794). Because of the possible psychological, economical and health-related effects of RAE, the most stimulating statement was made at the end of the paper… “what remedies for the problem can be suggested?” (Musch & Hay, 1999: 61). Boucher and Halliwell (1991) proposed the Novem System. By cutting the selection window to nine months the authors believed recycling the cut-off date through the calendar year into three-by-three-month intervals may solve the problem (Boucher & Mutimer, 1994). However, this rotating cut-off date and smaller age band proved difficult to manage due to logistical issues (e.g., there may be fewer players available in each age group) (Webdale *et al*., 2020).

The RAE was also found in junior tennis players with at least 85% of elite British tennis players born within the first half of the year (Baxter-Jones *et al*., 1995). Because RA is highly correlated with physical development, RAEs have been attributed to the physical advantages enjoyed by relatively older players (Barnsley & Thompson, 1988; Musch & Grondin, 2001). Consequently, Baxter-Jones *et al*. (1995) proposed the consideration of maturity status and possible grouping of players using biological age bands. However, many sport organisations apparently ignored this phenomenon, therefore, some authors even called for some sort of federal government intervention (Hurley *et al*., 2001). Fittingly, Hurley *et al*. (2001) proposed the Relative Age Fair (RAF) Cycle System, which created contagious birth quarters to mitigate RAE biases. The RAF operates on a calendar year, for example, by using a 1 January cut-off, a relatively younger participant born in December 1996 would be categorised as P4 (i.e.,

fourth quarter) in a u/12 team for the 2019 season. In the subsequent season (i.e., 2020 season), P4 moves from the relative youngest to the oldest (Hurley *et al*., 2001). These approaches, however, have not been received well by youth coaches because of their complexity and potential shift in the cultural and social dynamics of youth participation (Baker *et al*., 2010).

2.4.3 The 2000s to 2010s

Data provided by Vaeyens *et al*. (2005) among Belgian athletes, provided evidence that certainly a major, perhaps causal, factor underlying the RAE is the cut-off date. This study was significant for various reasons, primarily because the Royal Belgian Football Association aligned with other European nations and moved their cut-off date to 1 January from 1 August in 1997. Accordingly, it is one of the few studies that clearly pursued the investigation of the RAE prevalence or lack thereof in participants before and after a modification in a cut-off date (Vaeyens *et al*., 2005). Furthermore, the study investigated the RAE in relation to two game-related variables (i.e., minutes played and number of matches selected). The results again confirmed the RAE prevalence with an overrepresentation of relatively older players in both game involvement and squad composition variables (Vaeyens *et al*., 2005). Surprisingly, this study revealed that recycling the cut-off dates, as suggested in the Novem System, is not a sustainable scheme for eradicating or lessening RAEs. The authors suggested that the problem is just transferred, therefore, further studies should consider educational or social solutions (i.e., raising awareness at academies, sports clubs, federations, etc., about this phenomenon) (Vaeyens *et al*., 2005; Hill & Sotiriadou, 2016).

This confirmed earlier findings in ice hockey that because the participants are grouped based on the cut-off dates, it creates a relative age difference between the participants and generates a long-term effect of providing the developmental leagues and successively the NHL with relatively older, rather than relatively younger players (Barnsley *et al*., 1985; Barnsley & Thompson, 1988). An inquiry by Nolan and Howell (2010) in a replication of studies and as a follow-up to the reports of Barnsley *et al*. (1985, 1988), came about a few years later. Nolan and Howell (2010) aimed to determine whether some of the developments over the past 25 plus years, including assorted rule modifications to speed up the game and the globalization of the sport,

had changed the pattern of the data. From the data it appeared that the relationship had not changed much since the initial investigation, and that the RAE is still a phenomenon in professional ice hockey (Nolan & Howell, 2010a).

Helsen *et al*. (2005) investigated the birthdate distribution of u/15, u/16, u/17 and u/18 national youth soccer players for the 1999/2000 season across 10 European countries (e.g., Belgium, Denmark, England, France, Germany, Italy, Portugal, Sweden, Spain and The Netherlands). Among the investigated sample a clear RAE was found for all national youth selections, whereby approximately 43.41% were born within the first quarter and only 9.32% represented those born in the last quarter (Helsen *et al*., 2005). In their discussion, the argument given was that youth team coaches should shift their focus by putting less emphasis on physical attributes and focus more on the tactical and technical qualities of young players.

Senior elite tennis players who competed in the single events of the Grand Slam tennis tournaments in 2002 and 2003 were also studied (Edgar & O'Donoghue, 2005). Again, a biased distribution was observed with nearly double as many participants born in Q1 compared to Q4 among both men and women from different regions. Additionally, Cobley *et al*. (2009) used a meta-analysis to examine junior (11 to 14 years), adolescent (15 to 18 years) and senior (19 years and older) recreational athletes and elite athletes across multiple sports and found robust support for biases towards relatively older athletes. Cobley and colleagues incorporated studies published from 1984 to 2008 and provided evidence that athletic accomplishment may be influenced by birthdate across 14 sports in 16 countries. This together with other birthdate effects relating to season cut-off periods provide convincing evidence that in several sports and worldwide participants have an advantage if they are relatively the oldest in the relevant sports' year. Ever since, multiple studies have confirmed the RAE in several youth and elite soccer competitions at both national and international levels (Helsen *et al*., 2005; Ashworth & Heyndels, 2007; Cobley *et al*., 2009; Müller *et al*., 2018).

Between 2000 and 2010, research still mainly focused on obtaining RA distributions rather than trying to understand how RAE function. Nevertheless, several interacting assumptions have been proposed in an attempt to explain these RAEs (Musch & Grondin, 2001; Baker & Horton, 2004; Cobley *et al*., 2009; Baker *et al*., 2014).

Moreover, the magnitude of the RAE seems to be influenced by age categories, sport context, sex and skill level (Cobley *et al*., 2009). Multiple social agents including, but not limited to coaches, parents and the sporting environment may also exert a significant influence (Hancock *et al*., 2013). In an exhaustive presentation of factors, mechanisms and moderators of the RAE, Musch and Grondin (2001) discussed factors, such as competition level, psychological factors, physical development and experience. Certainly, there has been ongoing discussions of significance concerning the theoretical underpinnings and implications of RA differences. To quote Musch and Grondin (2001, p. 159) in their review, “the increasing number of theoretical considerations and empirical findings suggest that a combination of social, emotional, cognitive, physical and motivational causes work together to produce the effect”.

Aside from the above-mentioned mechanisms and factors, Baker *et al*. (2010) also suggested that a range of factors moderate RAEs, including socio-economic status and playing position. Yet, beyond these mere facts including cognitive and physical disparities, this age disparity denotes to nearly 10% of absolute life experience. Imaginably more significantly this disparity signifies an extra year of experience in a certain sport itself, which means substantially more. “This training consequence is likely to heighten chances of participating more actively in competitions during the season” (Musch & Grondin, 2001, p. 159). Despite the analysis suffering from the familiar limitation of aggregate statistics (i.e., the high chance of identifying false negatives and positives), Cobley *et al*. (2008) extracted birth date data across a 20-year period and reported historical evidence for the RAE prevalence. More fascinatingly, inequalities related to cut-off dates appear to extend beyond a playing career because a RAE was also observed among head coaches of Bundesliga teams. With many coaches being former players, Cobley et al. (2008) concluded that RAEs also appears to influence the likelihood of transitioning to a professional coaching career after concluding a professional playing career. Of particular significance is the influence of an amplified sport popularity, which subsequently increases competition levels and intensifies selection.

2.4.4 The 2010s to 2020s

Studies on talent identification and development have noted the clear bias towards advanced physical capabilities (Larkin & O'Connor, 2017). Consequently, a biased selection for teams appears to be favouring participants who have better physical and cognitive abilities (McCarthy & Collins, 2014). Arguably, successful athletes in certain sports are typically characterized by size, strength, power, speed and technical skills (Elferink-Gemser *et al*., 2004; Davids & Baker, 2007; Vaeyens *et al*., 2008). While not established empirically, it has been suggested that at certain ages athletes may appear as more talented and are selected because of maturity associated advantages in body size, strength, endurance, and speed (Sherar *et al*., 2007; Carling *et al*., 2009), consequently positively impacting the opportunities, coaching, game-time and access to resources (Cobley *et al*., 2009; McCarthy & Collins, 2014).

Earlier studies concerning the RA and maturity status of elite adolescent athletes have essentially been observational with little indication on why biological and chronological age biases exist (Sherar *et al*., 2007; Carling *et al*., 2009). However, due to problems associated with colleting the data, biological age was rarely accounted for in the past (Malina *et al*., 2004; Baker & Logan, 2007; Vaeyens *et al*., 2008). Nonetheless, new insights have suggested non-invasive practical techniques to assess biological maturity status of youth athletes (Malina *et al*., 2015). Athletes go through puberty at distinctive periods and subsequently have their growth spurts over a wide range of chronological ages (Helsen *et al*., 2005; Beunen & Malina, 2008; Cumming *et al*., 2018). Such variations go together with variations in height, weight, strength and speed potentially affecting performance that tend to influence the coaches' decision-making during selection (Musch & Grondin, 2001; Cobley *et al*., 2009; O'Neill *et al*., 2016). Sherar *et al*. (2007) confirmed through an estimation of maturity status that a combination of early maturation with its concomitant physical size advantage (i.e., height and weight) and being born relatively earlier in the selection year increases the likelihood of selection.

In addition to the competitive advantage obtainable through early recruitment, reliable talent identification programmes would help guarantee efficiency and effective investigations, by providing limited available resources to a smaller number of

developing athletes (Hugo, 2004). Unfortunately, traditional attempts during the talent identification process are associated with low foretelling value and their effectiveness and validity have been widely questioned (Cripps *et al*., 2015; Rees *et al*., 2016a). Such conventional attempts typically involve the use of cross-sectional identification models to predict success in senior competitions by measuring the present-day performance of young athletes (i.e., a combination of physical, physiological, technical or anthropometric variables), within age-specific groups (Unnithan *et al*., 2012; de la Rubia *et al*., 2020; Leyhr *et al*., 2021). Notably, the RAE seems to be a deep-rooted phenomenon throughout the competitive early adolescent phase (11 through 16 years) and in some cases appears noticeable within elite sport (Musch & Grondin, 2001; Romann *et al*., 2018; Tribolet *et al*., 2019). It is during this period that most identification processes occur along with selections by organizations to channel certain athletes towards elite groups (Cripps *et al*., 2015). It is also during the adolescent phase where extreme differences in physical and cognitive ability between athletes born within the same cut-off date can be observed (Cumming *et al*., 2017).

Therefore, talent identification structures at youth team sport levels are more likely to have selection biases that confuse maturation for talent (Musch & Grondin, 2001; Sherar *et al*., 2007; Cobley *et al*., 2009). In its place, coaches misguidedly grant less opportunities (e.g., coaching, contact with elite teams or resources) to relatively younger athletes and/or late developers than should be justified by their latent capacity or talent (Sherar *et al*., 2007; Cobley *et al*., 2009; Baker *et al*., 2014).

Nevertheless, this has proven problematic for various reasons (Vaeyens *et al*., 2008; Carling *et al*., 2009). Primarily, cross-sectional identification models are based on the notion that the essential attributes of success in senior elite sport can be extrapolated by extending the use of a conclusion to an unknown situation or context to identify talented young athletes (Sherar *et al*., 2007; Unnithan *et al*., 2012). Similarly, it has been implied that many of these qualities may not be evident until late adolescence, consequently confounding the early detection and selection of athletes (Beunen & Malina, 2008; MacNamara *et al*., 2010; Sarmento *et al*., 2018). Moreover, youngsters who hold the required elite aptitudes may not necessarily preserve their qualities throughout maturation. Likewise, pre-adolescent qualities do not automatically transform into proficiency in senior sport (Malina *et al*., 2004; Vaeyens *et al*., 2008).

A famous quote by Brown (2001) explain on this problem:

> *"Talented athletes who excel in their sports or perhaps even dominate their peers exist at every age level. They may be bigger, stronger, faster, or simply better than other children. Such children are great age-group athletes, nothing more and nothing less. They are good at what they do right now. There is no guarantee that because an athlete is good at 10, he or she will be good at 14, 16, or 18" (p. 6).*

The strength of the argument for the maturation-selection bias as the principal basis for RAE has gained impetus. Conflating this consolidation of a relatively older age and an advanced biological maturation still appears to lead to a selection advantage and consequently to the RAE (Torres-Unda *et al*., 2016; Müller *et al*., 2017; Cumming *et al*., 2018). These findings have been noted in basketball (Torres-Unda *et al*., 2016) and national top level alpine ski racers (Müller *et al*., 2017), where together with relative age, maturation status may be pertinent for sporting success. Moreover, Baker *et al.* (2014) advocated for this proclivity towards older athletes and the presumed dominant maturational advantage. Baker and colleagues also reasoned that while relatively younger athletes frequently had a greater probability of being selected if they matured early, relatively older soccer players had an augmented prospect for selection regardless of their maturity status (Baker *et al*., 2014; Teixeira *et al*., 2019).

Contrary to these findings, the RAE phenomenon could also be rationalized by the idea that relatively younger and "weaker" athletes develop low self-expectations. They consequently drop out or change to another sport after failing in a sport that require a developed physical profile for success in pursuit of social acceptance, autonomy and competence (Calvo *et al*., 2010; Delorme *et al*., 2010; Cumming *et al*., 2018; Jones *et al*., 2018). Nevertheless, it could be argued that relatively older players are selected from a young age, whilst relatively younger players are not selected, therefore, it is not so much a case of the relatively younger players later dropping out, but that from the onset they were not selected. The initial selection bias merely perpetuated over time (Baker *et al*., 2014; Steingröver *et al*., 2016; Müller *et al*., 2018). This type of exploration requires precise collection of dropout or sport dropout data.

2.5. THE DEVELOPMENT OF THEORETICAL FRAMEWORKS

2.5.1 The Social Agent Model

In the two decades that followed the discovery of RAE in sport, arguments to speculate and develop the understanding of RAEs in sport were offered through diverse models (Hancock *et al*., 2013; Pierson *et al*., 2014; Wattie *et al*., 2015). Scientific techniques and research not only help accumulate knowledge, but also examine, verify and/or contradict pre-existing theories and phenomena. Nevertheless, surplus descriptive studies in different sports and contexts without a theoretical base do not necessarily solve these disputes. Without doubt, inadequate theory has connected social agents with RAEs and there has been a preoccupation with observational investigations. In isolation, factors such as an advanced biological age do not directly influence RAEs. Instead, these skills and attributes are influenced by social agents which help illuminate the dawn, preservation and strengthening of RAEs in sport (Hancock *et al*., 2013; Reed *et al*., 2017).

Despite compelling arguments for the social agents' role, both negative and positive, the first theory proposed by Hancock and his colleagues lays the groundwork in understanding how social agents influence RAEs. They proposed that the social agents (i.e., coaches and scouts) ultimately interpret characteristics such as skill, maturity and size (Hancock, *et al*., 2013). Such theories work from the premise that athletes (via self-regulation and self-evaluation), coaches (via team selection, feedback and praise), and parents (via initial enrolment and support), correspondingly impact the extent of the RAE advantages, which tend to lead to supplementary benefits that may turn out to be a self-fulfilling prophecy for all parties involved (Hancock *et al*., 2013).

2.5.1.1 The Matthew effects: Residual bias

Useful to several fields such as politics, economics and technology, the Matthew effect was devised by Merton (1968) to illustrate a tendency in the scientific reward system. Matthew effects demonstrate settings where people begin with benefits that several of their colleagues do not obtain and those benefits endure over time. Williams and Reilly (2000, p. 659) proposed this as a "residual bias", which describes a snowballing of advantages, whereby athletes known to selectors earlier on are likely to be considered

in the future (Vincent & Glamser, 2006). Additionally, the phenomena can be comprehended using a Bible passage in the book of Matthew:

> *"Whoever has will receive more, and they will have an abundance. Whoever does not have, even what they have will be taken from them." (13:12)*

This could be rephrased as the poor getting poorer and the rich getting richer, which can be explained in absolute or relative terms (Rigney, 2010). Confirmation of this hypothesis could account for the findings of Barnsley and colleagues (Barnsley *et al*., 1985; Barnsley & Thompson, 1988), with respect to their studies on 8- to 19-year-old ice hockey players. Specifically, relatively older participants appeared to be intuitively better coordinated, stronger, faster, bigger and performed better in comparison to relatively younger participants (Barnsley & Thompson, 1988; Musch & Grondin, 2001; Müller *et al*., 2017; Cumming *et al*., 2018). By doing better, they received greater rewards for their accomplishments leading to greater psychosocial investment and a greater prospect of retaining their participation status (Helsen *et al*., 2005; Schorer *et al*., 2013). Relatively younger participants, on the other hand, experience discrimination and often terminate their sport participation in pursuit of other recreational activities that offer a greater chance for success (Barnsley & Thompson, 1988; Delorme *et al*., 2010). This contributes to the fact that RAE is still prevalent at the elite sporting levels.

2.5.1.2 Self-fulfilling prophecies

The RAE has also been discussed in the context of other existing models and theories. Two forms of self-fulfilling prophecies exist, i.e., the “Pygmalion effect” (Rosenthal & Jacobson, 1968) and “Galatea effect” (Merton, 1958). These neologism, self-fulfilling prophecies sprung from Thomas and Thomas’s (1928, p. 572), where the investigators acknowledged, “If men demarcate situations as real, they are real in their consequences”. In other words, self-fulfilling prophecies arises when there is a deceitful belief complemented by a different behaviour grounded on that belief, which ultimately makes the previously deceitful conception real (Hancock *et al*., 2013).

2.5.1.3 Pygmalion effects

Primarily, the “Pygmalion effect” denotes to the insight that the higher the expectation placed on an individual the superior the outcome that said individual will realize (Hancock *et al*., 2013). Illustrations of self-fulfilling prophecies are plentiful, for instance, Rosenthal and Jacobson (1968), in a classroom setting inaccurately informed teachers that specific learners were talented, and others were not. The talented/ not talented learners were in fact selected at random. Consequently, the unconscious preferential treatment (e.g., a series of verbal and nonverbal interactions), from teachers inadvertently controlled the learner's subsequent achievement behaviour leading the “gifted” students to outperform and outclass other learners (Rosenthal & Jacobson, 1968; Musch & Hay, 1999; Dixon *et al*., 2011).

Such effects typically flow from power relationships; i.e., parent-child relationships teacher-pupil, or coach-athlete and might explain parental support, coach selection biases, and subsequent behaviours and interactions. It is apparent that the Pygmalion effect in sport are facilitated by coaches (Musch & Grondin, 2001; Peña-González *et al*., 2018). Firstly, even prior coach selection, coaches could be framing certain expectations of participants, which persevere throughout try-outs and as the season progress (Ashworth & Heyndels, 2007). Secondly, even after coach selection, whether in individual or team sport, orchestrated practises in groups and interactions during competition (i.e., praise, feedback, or instructions) may be offered to high-expectancy athletes. The corollary is that low-expectancy athletes may receive more general instructions and the resultant outcomes are more likely to be inferior (Peña-González *et al*., 2018). Hence, individuals benefitting the most from an initial RA advantage are likely to be erroneously perceived as the most gifted in their cohort (Dixon *et al*., 2011; Peña-González *et al*., 2018). Accordingly, the Pygmalion effect may stabilize and strengthen this RA advantage if the behaviours of coaches, peers and parents align with the initial perception about the individual’s abilities (Rosenthal & Jacobson, 1968; Hancock *et al*., 2013).

2.5.1.4 Galatea effect

Another illustration of the self-fulfilling prophecy is whereby once an expectation is placed on an individual, that particular individual stereotypically acts harmoniously with

that expectation (Hancock *et al*., 2013; Aune *et al*., 2018). This is in accordance with Harter's (1978) competence motivation theory, which insinuates that individuals who perceive themselves as talented or gifted and capable of performing at an elite level are more likely to invest more effort and time into sport, school and supplementary areas in life to continue perfecting their talents. Though the link between Galatea and Pygmalion effects is patent, they differ in that Galatea effects are applicable to the person upon whom deceitful beliefs or expectations are placed versus the individual who places such expectations (Merton, 1958; Hancock *et al*., 2013). From the coaching illustration above, Pygmalion effects denote to the coaches' expectations of the participant (Peña-González *et al*., 2018), while Galatea effects denote to the participants' expectations of themselves (Hancock *et al*., 2013). Although Galatea effects have been considered in education (Thompson *et al*., 2004; Larsson & Regborn, 2019), no research could be found that specifically investigated Galatea effects in sport. Nevertheless, these effects might help rationalise the role of the coach and participant in creating, amplifying, or extending RAEs in sport.

2.5.1.5 Making sense of the Integrated Social Agent Model: The example of Owen and Ben

To help illustrate, take two 11-year-olds, Owen and Ben. On 1 January 2021 they are both 11 years old, and therefore, compete in the u/12 age group of their sport (rugby, for instance). However, not all 11-year-olds are comparable (Beunen & Malina, 2008). Owen is 11 years and 11 months old (born in February), while Ben is 11 years and two months old (born in November), and therefore he is a full nine months younger than other children he competes with, like Owen. According to Malina *et al*. (2004), even though an age disparity of less than 12 months may have an insufficient bearing for adults, it may be substantial during adolescence. This suggests that the nine-months advantage that Owen has over Ben by virtue of being born relatively earlier may translate into better performances on the playing field (Brustio *et al*., 2019; de la Rubia *et al*., 2020).

Subsequent, the coach enters the picture with a large group of enthusiastic young participants, he/she selects his/her team and assigns his/her attention and time to those whom he/she believes have the most potential (Sæther, 2014; Peña-González

et al., 2018). However, the coach is unable to distinguish between maturity and capacity of performance (Romann *et al*., 2017). Hence, Owen the relatively older child appears to be stronger, more coordinated, bigger, and therefore, gets pats on the back. Accurate or not, Owen merits the "gifted" sticker – realizing the maturation-selection hypothesis. Owen plays more games in higher quality competitions and receive superior coaching (Lemoyne *et al*., 2021) – realizing the Pygmalion effect. Contrariwise, Ben the relatively younger player is typically less physical and is yet to develop such attributes. Playing with participants much bigger than he is and not being recognised by the coach, he is likely to experience less fun and satisfaction. He gets relegated to lesser-skilled competition and grows exasperated at the ever-growing gap between himself and the other participants who are being more deeply invested in and possibly hastily hangs up his boots (Delorme et al., 2010a).

The above-mentioned illustration is a generalisation, however, exceptions can be found (Müller *et al*., 2015; Ulbricht *et al*., 2015). It is equally important that relative age and maturation are not confused and used as synonyms, because they exist and function as independent constructs governed by different factors (cut-off and birth dates vs. nature). It is entirely possible to be relatively the oldest and least biologically mature, as well as to be the relatively youngest and the most biologically mature athlete within an age cohort (Mueller *et al*., 2015; Ulbricht *et al*., 2015; Cumming *et al*., 2018). Whilst maturity selection biases do not emerge until the onset of puberty (i.e., 10 to 14 years), RAEs can be observed from seven years of age and maintained through to adult sport (Malina *et al*., 2004; Cobley *et al*., 2009). Additionally, recent observational studies have contended that maturity status alone does not influence the RAE (Lemez *et al*., 2016; Teixeira *et al*., 2019).

To continue, Owen is later recruited to an elite rugby team in his province. He believes his selection is because of his greater skills and talents - a deceitful belief as his recruitment was actually because of his advanced physical maturity. To echo and reiterate, the primary researcher, state that in this specific illustration, it is a deceitful belief and the Matthew effect is born. The deceitful belief is complemented by new behaviours (e.g., more frequent and diligent training) that match Owen's higher self-expectation of his skills. Because of these new behaviours, the original deceitful notion then turns out to be real - Owen develops and enhances his skills and compared to

his peers becomes more skilled - realizing the Galatea effect (Hancock *et al*., 2013). Owen is a better athlete now thanks to the opportunities he has received and the initial relative advantage. What is imagined here is a self-fulling prophecy where Owen is selected, because he is better and successively turned out to be superior, because he was selected, deceptively justifying the coach's early judgement and expectations (Peña-González *et al*., 2018). The key question here is, was his preliminary selection the consequence of his relative age, or was he authentically the superior sportsman?

While these social interactions support the Pygmalion and Galatea effects in sport, it is unclear whether these effects relate to the perceived skill variances and RA differences – a prosperous future inquiry. Likewise, this framework has some limitations, not the least of which they are still ambivalent (not empirically tested), they are also not domain-specific in their application to sport and RAEs are too multifaceted to be appropriately rationalized by these theories alone (Wattie *et al*., 2015; Roberts *et al*., 2021).

2.5.2 The Behavioural Dynamic Model

The second model noted in the literature presents a solution to mitigate RAE in youth ice hockey (Pierson *et al*., 2014). At the core of the Behavioural Dynamic Model is an ageing chain that stimulates the movement of ice hockey players through youth participation into professional teams. The authors consider the RAE as a positive feedback loop that amplifies small differences between participants, and therefore, induce a higher portion of age-disadvantaged participants to relinquish participation. While this model postulates a great deal of information concerning alleviating RAEs, as the authors acknowledge, the model is ice hockey specific and at this time, to the best of the researchers' knowledge, it has not been examined in any other sporting code. Thus, a deeper elucidation of this model is beyond the scope of this review. For more information about this model please refer to Pierson *et al*. (2014).

2.5.3 A Developmental System Model

To help overcome some of these limitations, Wattie *et al*. (2015) recognized the significant influence of environmental constraints (e.g., grouping policy, family structure, popularity of sport), individual (e.g., birthdate, handedness, maturation, sex),

and task-related (e.g., participation level, physicality of sport, playing position), organized in a triangular interactional structure on the RAE within sport. More importantly, Wattie and colleagues reasoned that existing research on RAEs in sport support the use of a constraints-based theoretical model (Newell, 1986), making each of the three influences equally necessary for understanding the (non)existence of RAEs (Wattie *et al*., 2015).

2.5.3.1 Individual constraints

Formally known as the organismic constraint in Nowell's (1986) framework, Wattie *et al*. (2015) refers to it as individual constraints, because of unique descriptions of individual human qualities. Primarily, since it is relatively time-independent an individual's birth date can be categorised as a structural individual constraint. Alternatively, RA itself cannot be categorised as an individual constraint, because of its dependency on a cut-off date for age categorisation (i.e., an environmental constraint Wattie *et al*., 2015). Reasonably, RA can only surface from the concurrent interaction of an age grouping policy and an individual's birth date (Musch & Grondin, 2001). Independent of the environment, RA cannot be an individual constraint per se.

Regarding the role of physical maturation on the likelihood of selection (see *Making sense of the Integrated Social Agent Model: The example of Owen and Ben* section 2.5.1.5) another important individual constraint on RAEs is the variance between biological and chronological age (Romann *et al*., 2017; Cumming *et al*., 2018). Considering the mentioned inter-individual variations in the tempo (i.e., speed) and timing (i.e., onset) of growth (Malina *et al*., 2004), the study by Sherar *et al*. (2007) noted that 90% of the selected players in team sport were above the 90th percentile for both age-based weight and height. They also demonstrated that with every one-month increase in age at peak height velocity, adolescent athletes became 17% less likely to be considered for selection in highly competitive team sport (Sherar *et al*., 2007). Additionally, Hill *et al*. (2021) reported the positive association between an advanced biological maturation and a more positive coach evaluation during match and practise performances. This means that the more mature players were considered to perform better, consequently favouring selection. Also, Teixeira *et al*. (2019)

provided evidence that the combination of being relatively younger and also having matured later provides significant disadvantages for selection in elite youth soccer.

Sex represents another individual constraint. While there might be various explanations for the sex differences found in the RAE, primarily the physical maturation advantage in men participants, RAEs have been weaker for elite women athletes in various sports (Vincent & Glamser, 2006; Smith *et al*., 2018). Research on women athletes has been inconclusive and pertinent factors explaining the reversal of the RAE may be different (e.g., body image, increased body mass to height ratio) (Schorer *et al*., 2013). Some studies on women athletes have shown significant RAEs (Delorme & Raspaud, 2009; Navarro *et al*., 2015; Smith *et al*., 2018), while others have found no such effect (e.g., Vincent & Glamser, 2006; Till *et al*., 2010; Costa *et al.*, 2013; Baker *et al*., 2014). Furthermore, the women birth date distribution pattern has been found to be non-linear with a some studies exhibiting a peak in the second quartile among developmental girls' hockey in Ontario Canada (Smith & Weir, 2013).

Sex differences in RAEs could be rationalized by the dynamic and complex interactions of socialization (environmental constraint), maturation and biological issues (Vincent & Glamser, 2006; Smith *et al*., 2018). This may be a judicious assumption when one considers the extent of sport disparities between the two sexes, for example, the level of physicality, cultural acknowledgement and support, media attention and sport-specific funding (Cobley *et al*., 2009; Smith *et al*., 2018). Without doubt, in South Africa the muscularity extensively upheld by the media has vested in elite sporting practices where higher numbers of sporting opportunities are presented for men (Eckard, 2010; Burnett, 2011). Even considering the intentionally dedicated programmes and safe spaces, society has a history of ostracizing and discriminating women from sport (seen in depth of participation). Additionally, before puberty variations in gross motor skills between sexes are trivial, however, post-pubescent women (12 - 15 years) generally experience a plateau in gross motor skill performance (Malina *et al*., 2015).

Physical changes such as wider hips and shorter legs around the time of puberty and in some cases women who mature early generally get heavier and taller, disadvantaging these athletes particularly in motor skills such as agility, running and

jumping (Malina *et al*., 2004; Sherar *et al*., 2007; Beunen & Malina, 2008). Therefore, contact sports such as soccer, ice hockey, or rugby may be considered “gender inappropriate” for early maturing females. Social pressures and socially constructed gender roles and perceptions to conform may subsequently socialize them away from sport involvement in pursuit of other activities (Da Costa *et al*., 2010). Nevertheless, the meta-analysis of Cobley *et al*. (2009) indicated little evidence of overall sex disparities. However, only 2% (or 3 321 out of 124 524 participants) of the total number of participants included in their study were woman. Therefore, the question whether RAEs are prevalent within and across women sports remains a mystery. Equally, as suggested by Musch and Grondin (2001), imminent investigations should look more meticulously at RAEs in woman’s sport compared to men’s sport.

2.5.3.2 Task constraints

Indeed the individual constraints discussed above form a central part to any RAE theory however, recognising other task constraints, for example, the skills required, the level of competition and sport type, is essential to understanding the RAE prevalence (Till *et al*., 2010; Schorer *et al*., 2015). As demonstrated earlier, RAEs are frequently observed in sport where increased physical size, strength and speed positively correlate with selection, like basketball (Lupo *et al*., 2019), ice hockey (Barnsley & Thompson, 1988), soccer (Helsen *et al*., 2005), baseball (Thompson *et al*., 1991) and rugby union (Grobler et al., 2016). Likewise, various strength, power, and endurance events included in the Youth Winter Olympic Games (O’Neill *et al*., 2016) may be more likely to promote the prevalence of the RAE.

It is also essential to note that RAEs are not universal across all sport and levels. Musch and Grondin’s (2001) review acknowledged the contribution of competition levels. Specifically, for RAE to become prevalent in youth sport there must be competition between athletes to make the team, typically with many players vying for the limited number of positions and resources. Other researchers have also observed that RAEs were of small magnitude, reversed, or absent at recreational tiers, while notable RAEs existed at competitive tiers indicating a positive linear relationship (Barnsley & Thompson, 1988; Musch & Grondin, 2001; Kelly *et al*., 2021). Specifically, the task constraints of competitive contact sport (i.e., soccer, rugby union and ice

hockey), such as the presence of body contact and physicality of play are different from those of recreational sport. Till *et al*. (2010) also observed considerably larger RAE magnitudes at more competitive levels of rugby union compared to recreational levels. Whilst the RAE often persists at younger levels, the effect is reduced among adults and in some cases may even vanish at the elite levels (Cobley *et al*., 2009). As suggested by Baker *et al*. (2014) the effects within individual sport are less consistent. The RAEs seem to diminish particularly in sport where technical attributes are favourable and where physical attributes are unproductive or even disadvantageous (Delorme & Raspaud, 2009; Langham-Walsh *et al*., 2021).

In some sport, both the physical and technical characteristics are important and vary according to positional roles within the sport. Hence, some studies have reported the influence of playing position on the RAE prevalence (Ashworth & Heyndels, 2007; Kearney, 2017a). In team sport like futsal, rugby union and soccer the prevalence of RAE may be influenced by playing position. In rugby union RAEs appear to be more prevalent in back line players in particular with no indication of a bias in other specialists positions such as props (typically the heaviest players) and locks (typically the tallest players) (Till *et al*., 2010; Kearney, 2017a).

Likewise, research in soccer exposed the RAE prevalence in positions, such as goalkeepers and defenders (high physical demand), but not among forwards (high technical demand) (Ashworth & Heyndels, 2007; Lago-Fuentes *et al*., 2020). Another example is in tennis where the task creates the prospect of a tactical advantage depending on laterality (i.e., whether the player is left-handed or right-handed). This characteristic has been suggested to interact with RA and ultimately modify the prevalence of RAEs. Loffing *et al*. (2010) noted a meaningful RAE among right-handed players, but not among left-handed players. What does emerge is that left-handed relatively younger players, perhaps because of their rarely seen game style and low frequency, are more likely than expected to reach the top echelons of tennis and are able to overcome hypothetical disadvantages (Loffing *et al*., 2010; Connor *et al*., 2019). Artistic sports such as figure skating, dance and gymnastics where smaller physiques may have a biomechanical advantage (mobility, higher strength to weight ratio and flexibility), have been found to generate a RAE reversal (Delorme & Raspaud, 2009; Baker *et al*., 2014; Bjerke *et al*., 2017). Comparably, in swimming this

effect seems to depend on age, race distance, sex and swimming technique (Costa *et al*., 2013; Cobley *et al*., 2018).

Other approaches have narrated how RAE may reduce when transitioning into senior elite sport (McCarthy *et al*., 2016). Across all sports it can be argued that at senior level, technical, tactical and psychological traits become more valued than body size (Jones *et al*., 2018). Moreover, despite the tendency of RAEs to affect both junior and even elite level sport in terms of the over-representation of those born early in the sporting year, there is evidence that points to the opposite, flipping the widely held beliefs regarding RAEs on its head (Gibbs *et al*., 2012; Fumarco *et al*., 2017; Kelly *et al*., 2019). New evidence underlining a RAE reversal at senior level suggests that relatively younger athletes are more likely to experience success (McCarthy *et al*., 2016; Jones *et al*., 2018) and enjoy longer careers (Gibbs *et al*., 2012). McCarthy *et al*. (2016) examined the RAE across key developmental landmarks within cricket and rugby union. They observed a RAE with an overrepresentation of those born in the first half of the year at the initial phase of selection into academies. However, a reversal was observed as the conversion ratio from junior to senior athletes was superior for those born in the last half of the year (Lemez *et al*., 2016; McCarthy *et al*., 2016). Likewise in water polo, rugby union, basketball and volleyball the RAE was only prevalent in early phase groups, but not in late phase group (Lupo *et al*., 2019). The fading effect has also been found in handball (Schorer *et al*., 2013) and other elite sports (Cobley *et al*., 2009).

Additionally, an investigation by O'Neill *et al*. (2016) on the RAE amongst Olympic athletes, found no RAE among Spanish and Australian Olympians when comparing finalists, medallists and non-finalists by birth quarter. However, among team sport Olympians, the RAE was prevalent. The authors established that these results may suggest that even though RAEs are likely to be sport specific and regardless of relative age each individual had an equal opportunity to contest at the highest level (O'Neill *et al*., 2016). This RAE reversal has been termed the "underdog hypothesis" (Gibbs *et al*., 2012:648; Cumming *et al*., 2018:148). Regarding ice hockey, surely being on an NHL roster is an accomplishment, but which is the best league? Interestingly, whilst relatively younger ice hockey players are less likely to make it to the NHL, of the individuals who did, scored more points, played more games, and earned higher

salaries than relatively older athletes (Deaner *et al*., 2013; Bryson *et al*., 2017; Jones *et al*., 2018). Gibbs *et al*. (2012) found a 40% reduction in the distribution of relatively older players from junior to elite ice hockey players. Their findings support the idea that indeed relatively younger athletes enjoy longer careers (Gibbs *et al*., 2012; Fumarco *et al*., 2017).

In support, Jones *et al*. (2018) proposed the so-called evolution of the fittest concept within super-elite performers (Olympic medallists). They suggest that while relatively younger players (9 to 18 years) may be disadvantaged they "must then remerge as viable acquisitions via alternative means" (p. 697). For example, by developing superior mental resilience, as well as technical and/or tactical skills to be successful at senior levels (19 years and older) (McCarthy *et al*., 2016; Fumarco *et al*., 2017; Jones *et al*., 2018). Successively, the RAE reversal has been accredited to relatively younger athletes developing stronger psychological profiles developed through developmental experiences in comparison to their relatively older counterparts (Kearney, 2017b). From an applied perspective the "underdog effect" or reversal of advantages explains the "work harder" attitude that relatively younger athletes, as well as late developers develop throughout the initial developmental phases to overcome adversity that facilitates "resilience" and "mental toughness" (McCarthy *et al*., 2016:1461; Jones *et al*., 2018:710; Kelly *et al*., 2019:115).

Although these qualities are defined and understood in different ways they generally refer to the constructs of motivation and autonomy (Gillet *et al*., 2009, 2012; Ryan & Deci, 2017), an athlete's ability to rebound from failure (MacNamara *et al*., 2010), to cope with pressure and persist in the face of adversity (Collins *et al*., 2016) and/or to command a wide range of mental skills (e.g., imagery, self-talk, goal-setting) (Rees et al., 2016a; Weinberg & Gould, 2018). Once the physical disadvantage is no longer prevalent they seemingly have an advantage (McCarthy *et al*., 2016; Fumarco *et al*., 2017; Jones *et al*., 2018). Therefore, if relatively younger players survive the RA discrimination they will be better than average and thus rewarded at senior level. Put simply, it is critical to define success in sport. When success is defined as playing in a sport academy the effect is strong (Fumarco *et al*., 2017; Jackson & Comber, 2019; Kelly *et al*., 2019). But the effect seems to diminish when success is defined as making it to elite sport (Jones *et al*., 2018), like playing in the NHL (Fumarco *et al*., 2017) and

competing in the Olympics (O'Neill *et al*., 2016). When sport success is defined as the most elite levels of play the RAE reverses.

2.5.3.3 Environmental constraints

Environmental constraints include developmental systems of the sport (Baker & Logan, 2007; Schorer *et al*., 2015) and the different policies (Cobley *et al*., 2009). Other sports (i.e., American football, Boxing, Judo) because of the significant physical size, could be expected to produce RAEs but paradoxically do not. American football participants are classified into weight categories until late adolescence when maturation variances level out (MacDonald *et al*., 2009). Combat sports such as Judo, Taekwondo and boxing also separate their athletes into weight categories (Albuquerque *et al*., 2013; 2016). Literature suggests that this grouping might alleviate the probability of a RAE prevalence. Relatedly, Albuquerque *et al*. (2012) reported no RAE during the Olympic Games for Taekwondo athletes attributing it to the grouping of athletes into weight categories. Studies by Delorme and Raspaud (2009) and Albuquerque *et al*. (2013) found no RAE in amateur and professional boxers and Olympic Taekwondo athletes. However, in Judo only heavyweight categories seem to produce an RAE compared to the lightweight categories. The explanation for these results is based on the variation in physical demands, also with no upper body mass limit for the heavy weight category, bigger, stronger and more matured athletes may be at an advantage (Albuquerque *et al*., 2014).

Other factors include the cultural popularity of the sport in a particular region or country, as well as the maturity of the sport. Additionally, Musch and Grondin (2001) reviewed the likelihood that RAEs might be rationalized by reasons other than an age-position effect. These included sociocultural, environmental, climatic and/or biological factors. At large, the environment fundamentally affects the strategic implementation and planning of high-performance programmes, which consequently influence the developmental pathway (Bullock *et al*., 2009). Specifically, cultural values and sport subculture formations play an imperative role in the athletic development experience. These social constructs can impact the long-term outcome of personal development, the continuation of sport participation, as well as the probability of successfully transitioning from talent development programmes into elite senior levels (Baker &

Horton, 2004). The level of importance that a specific culture or society places on a particular sport also affect these experiences. Typically, if an individual is constrained by a lack of support, resources or money it can negatively influence the quantity and quality of training (Blazo *et al*., 2014; Sarmento *et al*., 2018). Evidence from various competition levels assert to the significant influence of societal endorsements and support networks including family, coaches and peers (Hopwood et al., 2015; Rees et al., 2016a).

For example, individual cultures value different sports and may offer societal resources to endorse the development of their valued sport (Baker & Horton, 2004). Competitiveness is induced by the number of participants available to participate in the sport, which is reliant on the sports' popularity in each country. German soccer, which has a long history of formalization and popularity reveals evidence of RAE as far back as the 1960s (Cobley *et al*., 2008). Canada is a well-known nation for producing stars and has a long history in ice hockey. Despite the conducive climate to ice hockey, Canada's hockey heroes are also idolized and the competitions receive lavish attention on national media (Baker & Horton, 2004). As a result the amalgamation of societal ascendancy and ecological advantages has certainly contributed to the quality and quantity of high-profile ice hockey players Canada has produced (Wattie *et al*., 2015). This example illustrates the influence of the socialization process, i.e., social interactions, interpersonal relationships and the dynamic social space where athletes experience and interpret sport participation within a context with heightened subjective social constructs (Burnett, 2010).

Disparities between historical time points may demonstrate this constraint effectively. In Canadian men's ice hockey, RAEs only became prevalent towards the end of the 20th century (Hurley *et al*., 2001; Addona & Yates, 2010), following the formalization of youth sport. Additionally, initial investigations among Canadian women during the 2004 and 2006 National Championships did not find any prevalence of RAE. However, as woman's sport have gained considerable growth in participation and an increase in popularity and international competitions, RAEs have since been observed (Smith & Weir, 2013; Smith *et al*., 2018). Similar findings were reported in New Zealand and Australian developmental rugby union among women participants, where increased popularity and participant trends may eventually lead to a mirroring of what is seen in

men's sport (Lemez *et al*., 2016). Basketball also presents interesting findings (see review Riaza *et al*., 2020). America, arguably provides the greatest and most competitive pool of Basketball participants worldwide, yet no RAE was found in North America (Côté *et al*., 2006) and American Olympic athletes (Werneck *et al*., 2016). Instead, countries such as France, Australia and Spain have demonstrated RAEs among Olympic Basketball players. Additionally, the delayed selection of players into elite teams, namely the eligibility for the NBA draft (19 years and older) applied in America seems to minimize the maturation-selection bias influence (Côté *et al*., 2006; Werneck *et al*., 2016).

As suggested by Wattie *et al*. (2015), though some research has convincingly identified RAE differences among professional sport, the influence of environmental constraints linked to educational systems (e.g., varsity sport, intercollegiate, college sport) may be useful to consider. Indeed, research is plentiful among youth and elite professional sport, however, few studies have investigated the RAE prevalence at university level (Glamser & Marciani, 1992; Dixon *et al*., 2013; Chittle *et al*., 2018). There continues to be contradictory findings regarding RAEs within this environment.

Grondin *et al*. (1984) were the first to explore RAEs among ice Hockey players in Canadian universities but found no RAE. The authors observed a trivial underrepresentation of relatively younger players which did not reach the level of statistical significance. Dixon *et al*. (2013) demonstrated an RAE among Division I female Softball players in the National Collegiate Athletic Association (NCAA). The results of Montelpare *et al*. (2000) differed from that of Grondin *et al*. (1984). They reported a significant RAE among ice Hockey players in the Canadian Interuniversity Athletic Union with 69% of the players born within the first half of the calendar year. However, other studies yielded no RAEs in samples of NCAA Division I Basketball players (Chittle, 2016), Canadian university ice Hockey players, and two NCAA Division I American Football teams (Chittle *et al*., 2018).

Notably, of the existing research dedicated to varsity sport most of the research emanates from one research group who investigated American athletes. It appears that delaying entry into university through red-shirting (i.e., those born close to the end of the cut-off date postponing their entry into the system to allow extra time for social,

intellectual or physical growth), and other methods may moderate the RAE in university sport and potentially beyond this environment (Graue & DiPerna, 2000; Chittle, 2016). While there are numerous explanations for student-athletes to delay their participation eligibilities it is challenging to determine the precise reasons without detailed reports and accounts of their lives and/or educational histories. Notwithstanding, within the current inquiry among university student-athletes in South Africa, information relating to such moderators is limited (i.e., only the intensity of competition and sex are known) and, hence, supplementary information noting the influence of such agents is beyond the scope of this thesis. More information about the influence of academic timing (i.e., delaying entry into university) on the RAE can be found elsewhere (e.g., Dixon *et al*., 2013; Chittle, 2016; Chittle *et al*., 2016, 2018).

2.6 CONCLUDING THOUGHTS

Approaching 40 years of research and debate, the search for RAE solutions is proving to be vague. Without a doubt, the focus remains on outlining these phenomena in various contexts with little devotion to forecasting and comprehending the effects through theory (Roberts *et al*., 2021). Despite the problematic sharing of theoretical concepts and the challenge of integration of ideas in Sport Science, the hope lies in closing the gap between practice and science. Undeniably, there appears to be a paucity of practical and empirical research application of strategies designed to moderate RAEs (see Webdale *et al*. (2020) for a review of solutions).

Noteworthy, almost all the suggested strategies engaged some sort of modification to the current constraint imposed by grouping policies. These include different ways of rotating the cut-off date (Boucher & Mutimer, 1994; Baker *et al*., 2010; Haycraft *et al*., 2018), grouping youths by biological bands (Cumming *et al*., 2017), implementing relative age quotas (Wattie *et al*., 2015), age-ordered shirt numbering or even delaying and disregarding early specialization in elite teams until the age of 15 or 16 (Cobley *et al*., 2009). However, these have proven difficult to manage as the RAEs are often merely shifted after a change in selection date. Most strategies are difficult to integrate into sport systems and may not be well received by coaches, parents and athletes. To some degree these methods are also subject to the qualification and training of the assessor (Webdale *et al*., 2020). Additionally, while raising awareness about the social

agents that influence the RAE certainly seems to be valuable and logically essential for tackling RAEs, it is likely far from ample in and of itself (Hill & Sotiriadou, 2016).

The next chapter aims to give an overview of the primary researcher's research journey. Essentially, it provides a brief account of the processes, rationale, challenges and steps taken to develop and conduct the current study. There were two time points in which the study deviated from the original plan because of the Covid-19 pandemic and uncertainty about the resumption of sport, as well as recommendations by the Departmental Committee for Postgraduate Research to narrow the scope of the study. Initially the target population was youth soccer players aged 10 to 18 years where the RAE, biological maturity status and various physical and psychological skills would have been assessed. The study then shifted to university student-athletes (the sample included in the final study); however, the initial proposal was to capture and analyse sport psychological skills data in relation to RAE. The primary researcher finally reverted to "mining" existing datasets to unearth RAE prevalence and analysing annual variations and with-in sport RAE.

Chapter Three

RESEARCH JOURNEY

3.1 AIM OF CHAPTER THREE

Usually in this chapter, the Methodology of the study is explained. However, this is not a typical methodology chapter. Please note that the methodology will be discussed in detail in Chapter Four where the article is presented. This chapter rather presents a timeline and story about the primary researcher's unique journey amidst the pandemic and its restrictions.

3.2 BACKGROUND

Undertaking postgraduate studies can be overwhelming and the experience may not always be precisely what was imagined or expected. The initial journey to develop the research proposal felt like a haze, one that clouded the primary researchers' mind and made it laborious to concentrate on even the menial tasks. Expressly, the primary researcher registered for his first year of the Master's degree in January 2020. Soon thereafter, life (and almost everything) changed drastically. Who would have believed that the relentless spread of the SARS-CoV-2 virus would reach the Southern tip of Africa and cause so much turmoil and desolation? Virtually everyone had to be resilient during the past two years and will have to endure more challenges. Across the world, people are angry, scared and uncertain. Wherever we look and go there are constant reminders of this deadly virus. Every news channel, social media platform, internet search bar and email thread from organisations provides detail on how the virus is unfolding every day and affecting people's livelihood.

Unfortunately, the COVID-19 info emic (i.e., the spread of both inaccurate and accurate information about the pandemic) has become a part of people's lives. This is something the primary researcher has since reflected on from the perspective of being: 1) a Christian; 2) part of a family and loved family members that are being affected by the pandemic; 3) a member of an affected community (town of Stellenbosch); 4) a postgraduate student pursuing a master's degree (M.Sc. in Sport Science); and 5) a Sport Science consultant practitioner at a professional football club (Stellenbosch Football Club). The primary researcher has always turned to fellowship with family and friends to find comfort and support through difficult times. However, during the

lockdown, places of worship has been closed and travelling has been banned, making it difficult for to come to terms with the realities of this virus. The primary researcher had to show a fair amount of resilience, discipline and determination to continue develop as an individual. Despite the challenges and setbacks, this experience has allowed the researcher to look at things differently and be more appreciative. The essentials – good health food, and clean water, for example, are much more essential than buying the newest iPhone or having a haircut. Being with other is key to happiness and no culture or background seems to matter in this moment in time more than humanity. Furthermore, the lockdown offered the researcher opportunities to upskill and explore other areas of expertise like data science (programming, data modelling and visualization), which is something he now very much enjoys doing.

3.3 FIRST PROPOSAL

Having been privileged and honoured to be in a community and part-time employed by a professional soccer club with a newly launched youth soccer academy (January 2019), which utilize two-year age bands for grouping the players (u/12, u/14, u/16 & u/18), pursuing my MSc. within this environment seemed fruitful. In this environment, an opportunity presented itself to optimize future recommendations in RAE research. This would have ensured: 1) collaboration between practitioners and researchers; 2) collection of a comprehensive database of the players' profiles (which would have formed part of the primary researcher's standard practice as a sport science consultant); and 3) investigating sport psychological skills and the influence of various social agents. In the build-up to the inaugural season, more than 600 youths took part in trials, with only 20 players making the cut for each age band, which is approximately 15% of the total try-outs.

Currently it is difficult to support the idea that proficiency in sport can be foretold, because of any measure of talent (Vaeyens *et al*., 2008). Yet, it is unusual to encounter a coach who thinks he/she is not capable to ''realize'' or "see" talent. An imperative question in this regard is what coaches use as measures to identify talented young athletes and if there is somewhat authentication to propose that their ''vision'' could be biased by temporary discrepancies in growth and biological maturation (Romann *et al*., 2017). Thus, the aim of the initial proposal of the current study was to investigate

variance in relative age, biological age and a battery of sport psychological and physical tests among the selected academy players related to the coaches' evaluation.

It is ironic that this initial proposal involved exploring social barriers to sport participation, because the COVID-19 pandemic uncovered numerous social and systemic barriers that have disturbed individuals on an intimate level, irrespective of profession. The national lockdown forced many people to pause and deeply reflect, criticise and reconsider their priorities. Perhaps this was a call to start thinking and acting differently. With the achievement-oriented, fast-paced lives people live, they tend to neglect that their performance builds as much on theoretical knowledge, dynamic collaboration, coping strategies and mental stability as it does on practical skills and ability. Fortunately, for everybody's wellbeing, Stellenbosch University followed the strict guidelines set out by the Centre of Disease Control and Prevention from the onset. This also meant that most university-affiliated research came to an abrupt halt, particularly research involving physical contact with research participants and, naturally, the initial study in youth football had to be suspended. Organised sport was also cancelled and the primary researcher had to explore alternative options. Furthermore, studies that could be executed on online platforms required amendments to existing ethical applications and resulted in a delay of receiving ethical clearance for projects (like the current study) that were still under review.

3.4 ADJUSTED PROPOSAL: RAE AMONG UNIVERSITY STUDENT-ATHLETES

The primary researcher came to comprehend that the current study was only the next step in his expedition as a scientist and researcher. Conducting research is not a quick process. Having experienced elation and some frustrations after interruptions along the way, because to unforeseen circumstances taught him to be patient. There was not much time to linger on the setbacks and disappointment, thus, the primary researcher adapted the study to focus on Maties Sport student-athletes. Fortunately, he established a good relationship with Maties Sport during his B.Sc. Honours degree in High Performance Sport Science in 2019 where he formed part of a research group that explored the psychosocial responses of injured Maties student-athletes during the return-to-competition phase. After reviewing current literature on RAEs, the primary researcher recognised the presentation of limitations, such as the lack of consideration

of women athletes, intra sport variations, inconsistent definition of expertise levels, as well as the dearth of research among varsity student-athletes and in South Africa specifically (Dixon *et al*., 2013; Jones *et al*., 2018; Smith *et al*., 2018).

Although the literature has extensively reviewed the physiological and physical impact and its association with RAE, much less attention has been placed on the association thereof with various psychological skills and constructs (Musch & Grondin, 2001; Cobley *et al*., 2009; McCarthy *et al*., 2016). Indisputably, psychological theories and constructs have been applied to sport, but not directly to RAEs (Musch & Grondin, 2001; Hancock *et al*., 2013). Investigating the RAE phenomenon is rare within the context of exploring various sport psychological skills, however, the presentation of various theories will equip researchers to develop the knowledge and link between RAEs and these skills.

Given the paucity of RAE research devoted to both sexes participating in sport at university level, the intended focus of the current study was to go beyond the scope of examining the prevalence of RAE among student-athletes by also including the general student population. An additional feature of the current study was to include the use of one measure of sport motivation, namely the Sport Motivation Scale-II (Pelletier *et al*., 2013) and the Bull's Mental Skills Questionnaire (Bull *et al*., 1996), which reflects multiple psychological skills associated with performance, namely mental preparation (goal setting), imagery ability, anxiety and worry management, self-confidence, motivation and relaxation ability. The current study would also have employed the Peak Performance Profile (PPP) scale to assess three psychological dimensions proposed to affect optimal performance, namely confidence, stress control and concentration (Potgieter & Kidd, 2011). This was not only going to provide the opportunity to compare sport psychological skill levels between relatively older and younger student-athletes, but also provide valuable information on how these scores varies across multiple sporting codes and sexes. These results would have helped evaluate and recognize the strengths and weakness regarding mental skills of the student-athletes, as well as provide guidance for future development of performance and wellbeing enhancing interventions.

3.5 FINAL PROPOSAL

All seemed in order, Maties Sport had bought into the research concept and were willing to collaborate. Undoubtedly, a Master's degree is academically challenging. For example, the process of reviewing relevant literature and formulating the most pertinent inquiry, which benefits both the advancement of literature and have positive practical implication is difficult. Yet, it is also an opportunity to achieve more than ever before. This was certainly the case for the primary researcher. After presenting this newly moulded proposal to the Departmental Committee for Postgraduate Research during November 2020, their response was largely influenced by the broad scope of the initial proposal, alongside the implementation of the augmented remote teaching, learning and assessment of all undergraduate programmes, resulting in a lack of varsity sport. Most Stellenbosch University undergraduate students returned home in March and remained there for the remainder of 2020, reverting to online platforms for classes and assessments and there was uncertainty about the 2021 academic year and the resumption of organised sport.

3.6 CONCLUDING REMARKS

This feedback and unfolding circumstances and uncertainties about the resumption of university sport resulted in a study that will "merely" analyse the prevalence of the RAE. The primary researcher knew that he was at a fundamental juncture on the journey to becoming a researcher. Accepting when things are not going the way you wished-for or planned is something that develops confidence. As he progressed with the thesis under these uncertain circumstances, he learnt from these experiences and began to better appreciate his own strengths and weaknesses and realised that these unplanned events are all part of the learning process. What matters is how a person develop as a researcher, how he/she seeks appropriate support when it is needed and how to utilise the university's amenities more effectively. A person can either work with those impediments, work around them or do nothing to succumb to the impediments. The primary researcher's new challenge and goal was to explore the RAE-specific issues further along with the unanswered inquiries emanating from the exploration of the available literature.

Chapter Four

RESEARCH ARTICLE

This article will be submitted for publication in the *South African Journal of Sports Medicine.* The article is herewith included according to the guidelines for authors of this esteemed journal see (Appendix E). However, to provide a neat and well-rounded final product for this thesis it has been edited to represent a published article, as it would appear in this journal. This does not imply that the article has been accepted or will be accepted for publication. Subsequently, the referencing style, font, figures and tables used in this chapter may differ from that used in the rest of the chapters of this thesis.

Prevalence of the relative age effect among student-athletes in a university high-performance programme versus an age-matched student cohort

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ABSTRACT

Objectives: To determine the prevalence and magnitude of the Relative Age Effect (RAE) among student-athletes in a high-performance (HP) programme at a South African university, according to year, sport code and sex, and in comparison to non-HP-student-athletes (general student cohort). *Design:* Cross-sectional descriptive analysis of HP-student-athletes and an age-matched student cohort from 2016 to 2021. *Methods:* Birthdate data was extracted for the HP student-athletes (N = 950: men = 644, women = 306) and student comparison group (N = 46 377, women = 26 376, men = 19 988, not disclosed = 13). Differences were determined using Chi-squared and Fisher's exact test. Odds Ratios (OR) and 95% Confidence Intervals (CI) examined relative age quartile differences. The steps were applied across academic years, sport code and sex. *Results:* The RAE was more pronounced among the student-athletes and seems to become more apparent with each passing year. When analysing the different sport codes, RAEs were observed for swimming, rugby union and cricket only. Within-sport sex differences were observed in athletics, soccer and field hockey. *Conclusions:* Selection bias favoured the relatively older student-athletes. The mechanisms for RAE are multifactorial and complex. A combination of factors, such as competition depth, the popularity and physicality of a sport and socialization may be involved.

1. Introduction

Individuals born within the same calendar year can have up to 12 months age differences and up to 24 months in the case of two-year age-group bands. These differences are typically associated with short- and/or long-term effects universally known as the relative age effect (RAE).[1] The RAE is expressed by the difference between expected and observed birthdate distributions of participants.[2] Research is consistent in reporting the immediate and long-term selection, attainment and participation advantages enjoyed by relatively older participants (i.e., those born earlier in the selection year).[3] These outcomes extend across developmental periods, but appear to be deep-rooted and most pronounced in competitive adolescent team sports.[1]

Importantly, RAEs are not reinforced by a single factor. Supported by a range of descriptive data over the last three decades, a combination of physical, psychological, motivational and socialization factors work together to produce the effect.[4] The maturation-selection hypothesis assumes the association between relative age and maturation (both physical and cognitive).[1]

Among adolescent athletes where differences in maturation are more prominent, inaccuracies resulting from the difficulty or impracticality of observing ability independent of maturity, leads to a selection bias favouring early maturing and relatively older participants in physically demanding team sports like soccer,[5,6] cricket [7] and rugby union.[8]

Once participants are selected, they will have access to better coaches, training facilities, game-time etc. This becomes a key aspect of their future sporting career, resulting in the continued prevalence of the RAE at senior sporting levels.[3]

Being relatively younger is not an automatic disadvantage. Contradicting results have been noted among the world's best cricketers and rugby union players,[9] and in women's sport.[10] Recent evidence point to a RAE reversal at senior elite levels, suggesting that relatively younger athletes may be more likely to experience success and enjoy longer careers compared to relatively older players[9,11] One possible explanation for this reversal is that at senior sport levels and in certain individual sports, technical, tactical and psychological traits become more valued than body size.[9] Once the physical advantage is no longer prevalent, superior skills gained by relatively younger players, who persist in an unfavourable system, places them at an advantage.[1]

Whilst most RAE studies have focused on youth and professional sport, few inquiries have investigated its prevalence among university student-athletes. South Africa's sport system is uniquely organized in that competitive school and university sport often forms part of the pathway to elite sport, compared to elsewhere in the world where club sport tend to dominate.

Stellenbosch University (SU) has a high-performance programme that selects a limited number of student-athletes into its talent development programme each year. This stream offers differentiated experiences including better coaches, sport science services and opportunities for televised competitions (e.g., Varsity Sport/ Varsity Cup). Selection into the HP programme is prestigious and represents a facet of cultural identity, which probably proliferates competition and selection pressure. These factors make it a suitable environment for the RAE to be prevalent, as many participants vie for the limited number of positions and resources.[12]

The aim of this study was to determine if the RAE is prevalent among HP-student-athletes across academic years, sport codes and sex, and in comparison to an age-matched student cohort. This is a pertinent inquiry as sportspersons in diverse sport codes have relatively short playing careers, and in many cases may enter the final stage of elite sport participation during their tertiary education years.[13] Therefore, the examination of the RAE in university sport seems a fruitful avenue. The researchers hypothesise the likelihood of the RAE prevalence and a bias towards relatively older athletes.

2. Methods

Ethical approval was received from the SU Research Ethics Committee for Social, Behavioural and Educational Research (REC: SBE project number: 21919), and institutional permission was granted by the Division for Information Governance (IG-2166). Since the data did not contain identifiable information, informed consent was not required. The study was conducted according to the Declaration of Helsinki.

Birthdate data of South African men and women SU students aged 18 to 25 years from 2016 to 2021 were included. Since the HP programme focus on Varsity Sport/ Varsity Cup sporting codes, 25 years was set as the maximum age, coinciding with the competition age limit. Non-South-Africans were excluded to ensure that all participants were subject to the same cut-off date (1 January) used for age-group categorisation.

All 128 230 data records were imported and analysed in RStudio. For the overall analysis, duplicates were removed so that

each participant was only represented once (N = 47 327). The data was divided into two subsamples: 1) SU students (N = 46 377; men = 19 988; women = 26 376; not disclosed = 13), and 2) HP-student-athletes (N = 950; men = 644; women = 306). The student-athletes consisted of 11 HP sport codes: Athletics = 90; Basketball = 67; Cricket = 77; Cycling = 33; Field hockey = 133; Netball = 67; Rugby union = 260; Soccer = 95; Swimming = 72; Tennis = 40; Water Polo = 16). It was essential to impose a comparison cluster of aged-matched students to assess whether the RAE is prevalent in the general student population or whether the phenomenon is sport-specific. Sport codes with low participant counts were considered as one homogenous group, encompassing of both men and women.

Starting with the month of January all participants were grouped into quartiles (Q1: January to March, Q2: April to June, Q3: July to September, Q4: October to December) and half years (H1: January to June, H2: July to December).

The chi-square goodness-of-fit test was used along with a day-corrected quartile distribution as the expected distribution for the student cohort (Q1 = 24.71%, Q2 = 24.91%, Q3 = 25.19%, Q4 = 25.19%).[2] Compared to a uniform distribution (25% per quartile), the day-corrected distribution accounts for the varying number of days per month. A series of chi-squared test of independence ($\chi 2$) and Fisher's exact analysis were applied across academic year, sex and sport code to determine the differences between the birth quartile frequencies of HP-student-athletes and the student cohort.

Furthermore, Cramer's V identified the magnitude of effect size and Odds Ratios (OR) with 95% confidence intervals (95% CI) provided a common risk indicator of effect size for Q1, Q2 and Q3 vs Q4, as well as H1 vs H2. For all analyses a p-value of <0.05 was the criteria for a significant difference in distributions. Following a significant $\chi 2$, a post hoc test to calculate the standardized residuals (SR) was used to determine which birth quartiles differed significantly from the expected distribution. Since all the quartile distribution comparisons had $df = 3$, Cramer's V were interpreted as follows: $0.06 < V \leq 0.16$ = small effect; $0.17 \leq V < 0.29$ = medium effect; and $V > 0.29$ = large effect. Standardized residuals > 1.96 = over-representation, while < -1.96 = under-representation of births. OR were calculated between quartiles with Q4 acting as the reference group (e.g., Q1 vs Q4), and were interpreted as follows: $OR < 1.22$ = negligible; $1.22 < OR < 1.86$ = small; $1.86 \leq OR < 3.00$ = medium; and $OR \geq 3.00$ = large effects.[14]

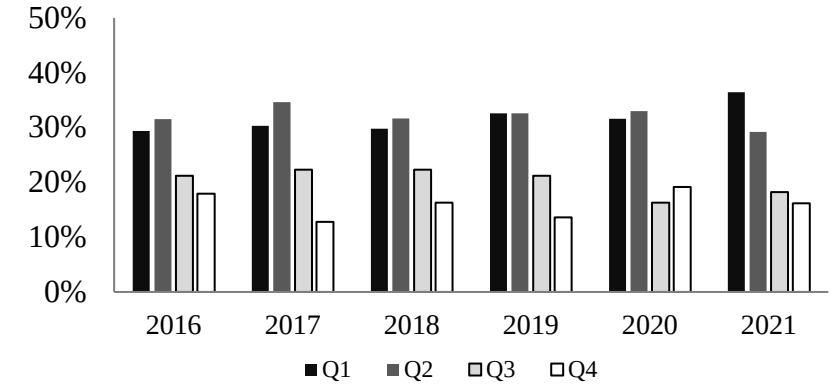
3. Results

For the student cohort (Q1 = 27.01%, Q2 = 25.26%, Q3 = 24.82%, Q4 = 22.91%), a RAE was evident ($\chi 2 = 203.84$, $p < 0.01$, Cramer's V = 0.03) when compared to the day corrected distribution. Further analysis confirmed a significant association between sex and birth quarter among the student cohort ($\chi 2 = 18.43$, $p < 0.01$, Cramer's V = 0.02) with a quartile distribution [SR] for men (Q1 = 27.84% [2.30], Q2 = 25.47% [0.61], Q3 = 24.31% [-1.48], Q4 = 22.38% [-1.59]) and women (Q1 = 26.36% [-2.02], Q2 = 25.10% [-0.54], Q3= 25.21% [1.3], Q4 = 23.32% [1.4]).

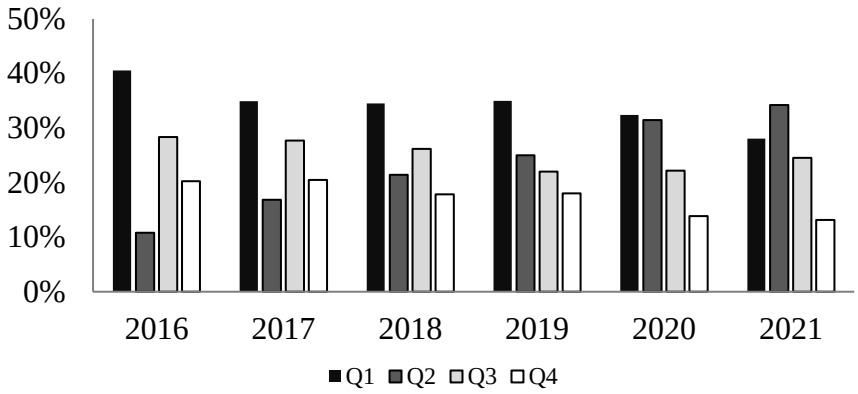
Figure 1 is a graphical representation of the HP-student-athletes' birthdate quartile distribution. Significantly more athletes were born in Q1 and Q2, with very few in Q3 and Q4, compared to the student cohort. The RAE were prevalent in both the men and women HP-student-athletes.

Table 1 contains the day-corrected expected and observed birth distribution of the student cohort, as well as that of the HP-student-athletes by academic year and sex. Table 2 summarises the OR analysis for both men and women HP-student-athletes for each year and sport code.

(a) Men HP-student-athletes for each year.



(b) Women HP-student-athletes for each year.



(c) HP-student-athletes for each sport code.

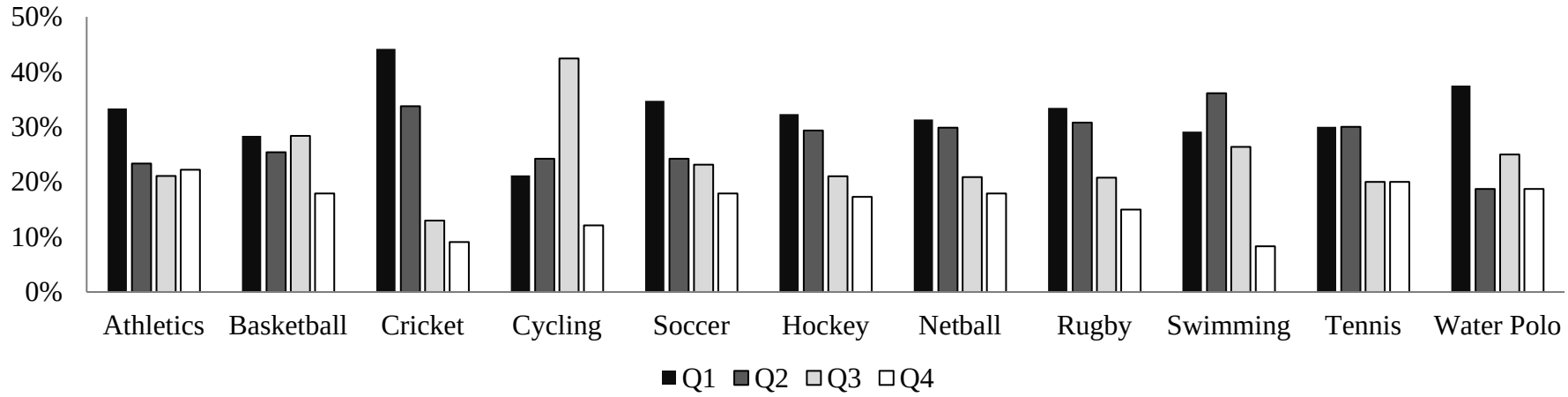


Fig. 1. (a, b & c) A graphical summary of quartile distribution for selected Men (a) & Women (b) HP-student-athletes for each year. Summaries (c) according to sport code for all unique HP-student-athletes for 2016 - 2021 (inclusive)

Table 1
Distribution, p-value, Chi-square and Cramer's V analysis of HP-student-athletes and age-matched student cohort

Group	Total *N*	Q1 (%)	Q2 (%)	Q3 (%)	Q4 (%)	P	$\chi 2$ (df = 3)	Cramers' V
Day-corrected expected distribution		24.71%	24.91%	25.19%	25.19%			
Student-cohort observed distribution	46 377	27.01%	25.26%	24.82%	22.91%	< 0.01	203.84	0.03
All HP-student-athletes	950	32.95%	28.95%	22.21%	15.89%	< 0.01	41.36	0.03
2016	258	32.56%	25.58%	23.26%	18.60%	0.200	4.55	0.01
2017	294	31.63%	29.59%	23.81%	14.97%	< 0.01	12.88	0.02
2018	299	31.10%	28.76%	23.41%	16.72%	0.04	8.19	0.02
2019	284	33.45%	29.93%	21.48%	15.14%	< 0.01	14.37	0.03
2020	317	31.86%	32.49%	18.30%	17.35%	< 0.01	18.48	0.03
2021	306	33.33%	31.05%	20.59%	15.03%	< 0.01	18.35	0.03
HP-student-athletes (Men)	644	33.23%	30.28%	20.81%	15.68%	< 0.01	29.62	0.04
2016	184	29.35%	31.52%	21.20%	17.93%	0.12	5.84	0.03
2017	211	30.33%	34.60%	22.27%	12.80%	<0.01	18.40	0.04
2018	215	29.77%	31.63%	22.33%	16.28%	0.04	7.52	0.03
2019	184	32.61%	32.61%	21.20%	13.59%	0.01	11.14	0.03
2020	209	31.58%	33.01%	16.27%	19.14%	<0.01	11.42	0.04
2021	192	36.46%	29.17%	18.23%	16.15%	<0.01	12.40	0.04
HP-student-athletes (Women)	306	32.35%	26.14%	25.16%	16.34%	0.01	10.81	0.02
2016	74	40.54%	10.81%	28.38%	20.27%	<0.01	11.42	0.03
2017	83	34.94%	16.87%	27.71%	20.48%	0.21	4.55	0.02
2018	84	34.52%	21.43%	26.19%	17.86%	0.37	3.12	0.02
2019	100	35.00%	25.00%	22.00%	18.00%	0.29	3.90	0.02
2020	108	32.41%	31.48%	22.22%	13.89%	0.04	7.66	0.02
2021	114	28.07%	34.21%	24.56%	13.16%	0.03	8.15	0.03

Table 2
Results from Fisher's exact test comparing the HP-student-athletes across years and sport codes

	OR Q1 vs Q4	(95% CI)	OR Q2 vs Q4	(95% CI)	OR Q3 vs Q4	(95% CI)	OR H1 vs H2	(95% CI)
Overall	1.77 *	(1.46 – 2.18)	1.66 *	(1.36 – 2.05)	1.29 *	(1.04 – 1.61)	1.49	(1.31 – 1.21)
2016	1.45 *	(1.00– 2.12)	1.27	(0.86 –1.88)	1.16	(0.678– 1.74)	1.26	(0.98 – 1.63)
2017	1.76 *	(1.21 – 2.59)	1.85 *	(1.27 – 2.73)	1.49 *	(0.00 – 2.23)	1.44 *	(1.13 – 1.84)
2018	1.54 *	(1.08 – 2.23)	1.57 *	(1.09 – 2.27)	1.28	(0.87 – 1.88)	1.36 *	(1.07 – 1.73)
2019	1.84 *	(1.27 – 2.70)	1.77 *	(1.21 – 2.62)	1.31	(0.87 – 1.98)	1.55 *	(1.21 – 2.00)
2020	1.56 *	(1.11 – 2.21)	1.69 *	(1.20 – 2.39)	0.97	(0.66 – 1.44)	1.64 *	(1.30 – 2.09)
2021	1.89 *	(1.32 – 2.76)	1.81 *	(1.25 – 2.64)	1.25	(0.74 – 2.11)	1.64 *	(1.29 – 2.09)
Athletics	1.29	(0.71 – 2.39)	0.96	(0.50 – 1.87)	0.88	(0.44 – 1.74)	1.20	(0.78 – 1.88)
Basketball	1.35	(0.63 – 3.07)	1.30	(0.58 – 2.98)	1.47	(0.68 – 3.32)	1.07	(0.64 – 1.79)
Cricket	3.96 *	(1.73 – 10.61)	3.31 *	(1.40 – 9.05)	1.32	(0.45 – 4.09)	3.13	(1.80 – 5.73)
Cycling	1.50	(0.38 – 6.99)	1.83	(0.49 – 8.31)	3.24 *	(1.02 – 13.53)	0.77	(0.36 – 1.61)
Hockey	1.60	(0.94 – 2.79)	1.55	(0.90 – 2.72)	1.13	(0.63 – 2.05)	1.48 *	(1.03 – 2.14)
Netball	1.56	(0.73 – 3.47)	1.55	(0.72 – 3.49)	1.08	(0.46 – 2.56)	1.49	(0.89 – 2.54)
Rugby union	1.82 *	(1.23 – 2.74)	1.81 *	(1.21 – 2.73)	1.28	(0.83 – 1.99)	1.58 *	(1.22 – 2.07)
Soccer	1.66	(0.90 – 3.19)	1.24	(0.63 – 2.47)	1.20	(0.61 – 2.41)	1.32	(0.86 – 2.04)
Swimming	3.00 *	(1.17 – 9.09)	3.97 *	(1.60 – 11.79)	2.93 *	(1.13 – 8.98)	1.73 *	(1.04 – 2.93)
Tennis	1.29	(0.48 – 3.63)	1.37	(0.52 – 3.87)	0.93	(0.30 – 2.83)	1.38	(0.70 – 2.78)
Water Polo	1.71	(0.37 – 10.60)	0.92	(0.12 – 6.84)	1.24	(0.21 – 8.44)	1.18	(0.39 – 3.71)

* Significance $p < .05$, OR = Odds Ratio and 95 % Confidence Intervals = (95% CI)

Subsequent analysis confirmed that the observed birthdate quartile distributions of the HP-student-athletes were independent of sex across all years, with one exception. No RAE was observed in 2016. The effect became more prevalent in both men and women with each passing year. No association existed between sport code and birth quarter, but the RAE for swimming, rugby union and cricket differed significantly from the student cohort. No differences existed between team and individual sports. Within-sport sex differences were noted for athletics, soccer and field hockey.

4. Discussion

The birthdate distribution of the HP-student-athletes differed from that observed among the student cohort. Results from Cramer's V effect size suggested trivial effect sizes for all group differences. This might have been influenced by the RAE observed in the student cohort. Regardless of sex, RAEs were apparent for men and women HP-student-athletes. This confirms the selection and participation advantage enjoyed by relatively older men and women athletes. To the best of the researchers' knowledge, this is the first study to investigate the RAE among South African university students. This research provide groundwork evidence that could direct future research inquiry.

The odds of Q1 and Q2 vs Q4 respectively, seem to be increasing in magnitude with each academic year. There was no RAE in 2016 (the year with the lowest number of participants). The discrepancy (medium effects) between the two sexes were noted in the first two years only (2016 and 2017). A spike was noted in Q2 during 2017, before dropping again in 2018. From 2019 onwards, the relative distribution in H1 born athletes increased for both sexes. Among the women, a large increase was evident in Q2 born HP-student-athletes over the 6-year period.

The assumption is that this prevalence may be due to the actions of different social agents and contextual factors (e.g., developmental pathway, the level of competitiveness and sport popularity).[1,12,15] The RAE prevalence at university sports level, may point toward underlying mechanisms and problems with talent identification and youth sport development programmes. The initial selection bias may have merely perpetuated over time.[4] By doing better, relatively older swimmers, rugby union and cricket players probably received more rewards for their accomplishments, leading to greater psychosocial investment and a better prospect of retaining their participation status, resulting in the RAEs still being prevalent at university and senior levels.[4]

Like other sport codes, swimmers are grouped according to chronological age and RAEs are possible. The current findings agree with earlier findings that showed RAEs among youth (u/18) swimmers.[16]

Structural changes to the South African first class cricket competition, i.e., cutting the 11 professional teams to six franchises, has reduced the viable development pathways. A shift to early identification and selection was noted. The inflexibility of the developmental system creates issues for those de-selected from the traditional pathway. Essentially, because of the low quality of competition, late developing adolescent cricketers may find themselves in a development and learning environment that lacks progression and are eventually likely to drop out altogether. Subsequently, fewer professional players are coming through the tertiary education pathway.[17]

While the OR results indicate a medium to large effect size, the number of swimmers (n = 72) and cricketers (n = 77) in the current study was relatively small, therefore, the observed effect may have been amplified. These findings should be interpreted cautiously.

Among team sports, rugby union is a strong candidate for RAE prevalence based on high physicality (task constraint), cultural relevance and popularity (environmental constraints).[15] A residual

bias may accumulate from being selected early in the process. The current observations resonate with previous rugby union research,[8] adding information about the pathway to professional rugby.

It is difficult to explain the absence of the RAE in soccer and basketball, considering the consistent prevalence reported in these sports in other contexts.[1,6] If students only take up sport later, i.e., post-puberty, there could be fewer development variations (e.g., weight, height) at university sport level. This may decrease the likelihood that RAEs will prevail, because of reduced physical selection biases. In addition, the different school systems operating in South Africa and the demographic backgrounds of participants associated with these sport codes play a role in shaping and providing differential developmental pathways.

Sport like basketball and soccer may adopt a more flexible approach, where university coaches tend to accept almost any student who wants to be part of the programme, which encourages more students to join these programmes regardless of their initial skill and/or experience, thereby possibly moderating the RAE. In comparison to rugby union and cricket, very few soccer and basketball players use university sport as a springboard to elite sport. Additionally, and with reference to tennis and cycling, the limited exposure to elite competitions, and the 'pick-up' or 'street' nature of basketball and soccer, whereby individuals participate in these codes in an unorganised manner, there is not necessarily much competition for spots in these programmes. The lack of competition and a more flexible approach may serve as a moderator for the RAE.

The sex differences observed in athletics (track and field), soccer and field hockey could be explained by socialization or a self-restriction process hindering certain participants from continuing their participation in the sport or by precluding them from taking up the sport in the first place. The data showed that only 2% of the SU students were part of the HP-student-athlete programme. Many of the students in the student cohort are competing in sport, but at a lower competitive level. Women were underrepresented among the student-athlete cohort (32% women vs 68% men, respectively). This is alarming considering there were more women than men students (approximately 57% vs 43%, respectively), and raise questions about the underrepresentation of women in university sport. Perhaps the RAE only came into effect when the women's HP programme became more competitive and professional. The "gender inappropriate" stigma attached to female sport may have weakened, allowing relatively older woman student-athletes to continue their participation.

There appears to be a systematic biased distribution across different developmental stages in favour of relatively older participants, particularly in rugby union and cricket. It may not so much be a case of the relatively younger players later dropping out, but that from the onset they were not selected.[4]

A growing body of evidence suggest that the social environment influence the athletes' progression and transitions along the developmental continuum.[3,15] For instance, the support provided to athletes during key developmental periods and the developmental experiences created during practice sessions and matches influence their transition and progression. Psychological perspectives embrace the notion of the self-fulfilling prophecy, i.e., the greater the expectation (self-expectations, coach or parent expectations) placed on the player, the greater the achievement result.[4] Studies revealed that coaches held greater expectations of participants born in the first quarter (Q1) of the year than those born in the fourth quarter (Q4).[18] Hence, to limit the possible negative consequences of RAE, South African sport federations should offer diverse solutions to benefit all participants during different participation and development phases.

Practitioners should endeavour to find solutions to support participants as they transition from high school to university teams. In fact, this support is needed both before and once they arrive at university. Considering that relatively younger players can still reach top-level senior sport, practitioners should consider the delayed development trajectories of some young participants. Although a number of solutions have been proposed for youth sport,[19] few have been implemented successfully or tested empirically.

Whilst raising awareness is important to address the RAE, it is likely to be insufficient. Moreover, it would be naive to enforce any of the earlier practical recommendations as solutions to reduce this phenomenon. Mainly because of the absence of direct evidence that their application will reduce the effect, as well as considering that the current findings was limited to information on birthdate, sport codes and sex. It may be too late to impel such interventions at this participation level. Focusing on developing a broader understanding of the processes influencing early and late developing student-athletes may be more appropriate.

5. Conclusion

Both women and men HP-student-athletes were affected by the RAE. Evidence suggest that the RAEs may be sport-specific.

The observed RAE exemplifies a social inequality that inhibits the prospect of immediate and long-term participation in university HP sport. Even though student-athletes are per definition seldom professionals, it is desirable that equal opportunities are afforded to everyone to become a HP student-athlete, regardless of birthdate. Even if this bias is unintended, it should be prudently assessed, given the rewarding nature of some sport codes (e.g., access to high quality resources, television coverage, recognition, financial and academic support).

A limitation to this study is the small sample size (especially when split into sport codes). Whilst the present study is representative of student-athletes from Stellenbosch University, South Africa and provides information on the general prevalence of the RAE at this competitive level it is not comprehensive. The study was also delimited to the last six years for which complete datasets exist. Findings from this study is, therefore, context-specific and should not be generalized to other universities or countries.

Future studies should examine the mechanisms responsible for the prevalence of RAE or the lack thereof at various participation levels (e.g., primary and high school, and sports academies). Though not examined in this study, it is reasonable to assume a degree of interaction among various constraints. Future research should consider and measure various individual (physical abilities and psychological skills), task (playing position, participation level and physicality of the sport), and environmental constraints (popularity of sport, coach and family influence, sport-code rules and polices), explicitly to gain a better understanding of their association to the RAE prevalence. Our understanding about these interactions remains limited.

Future studies may benefit from triangulating findings from qualitative and quantitative sources and should utilise a sound theoretical framework, such as Henriksen et al.'s Athletic Talent Development Environment model. [20]

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Chapter Five

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This Chapter provides a summary and take-home message for each chapter. Additionally, a summary of the main findings and recommendations for future researcher are provided.

5.1 SUMMARY OF CHAPTER ONE

Chapter One provided a brief overview of the organisation of sport in South Africa. School sport policies facilitate the admission of many scholars to accomplish the objectives specified in the mass sport portfolio. South Africa's sport system is unique in the sense that University sport often forms part of the pathway to elite sport, compared to elsewhere in the world where club sport dominates. The unique sport structure within Stellenbosch University, i.e., Maties Sport, was discussed. Of particular interest is the High-Performance (HP) Sport unit, which prioritizes performance enhancement and empowerment. One of the principal initiatives of the HP unit involves the development of recognition and support systems that rewards talented athletes through talent identification and development programmes.

Chapter One also outlined the research problem, i.e., the relative age effect, which denotes to a statistically significant difference between observed and expected birthdate distributions of sport participants. Additionally, the aims and objectives of the study were presented in Chapter One and will be discussed in section 5.4.

5.2 SUMMARY OF CHAPTER TWO

In Chapter Two, a chronology of three decades of RAE research in sport was presented. Explanations for who reaches the top echelons of sport developmental systems (Maties HP unit in this case), is a lot more convoluted than it may appear. Typically, in competitive athletic talent development environments there is a selection, participation and attainment bias towards relatively older participants (i.e., those born in January, February and March), and an under-representation of relatively younger participants born further away from the cut-off date (last six months of the year). The birthdate itself does not independently become significant. Rather it can only influence athletic success through the simultaneous interaction with age grouping policies (i.e.,

1 January to 31 December in South Africa). This result in relative age differences that are associated with short- or long-term effects, i.e., relative age effects (RAEs). Hence, only after the participant is embedded in the environment of school and/or school sport and the environmental influence therein (i.e., annual age grouping), can he/she undertake the fixed characteristic of a specific relative age.

Processes of RA, maturity status and behavioural development are interrelated and have an influence on the collective and individual short-term athletic performance. Hence, at certain age's athletes who appear as more 'talented' are selected merely because of maturity-associated advantages in strength, endurance, speed and body size. This positively affects their opportunities, coaching, game-time and access to resources. Independently, influences like variations in maturity and skill do not directly influence RAEs, rather these characteristics (e.g., size, skill, maturity) are interpreted by social agents (e.g., parent, coaches, athletes), who help influence the emergence, preservation and strengthening of RAEs. RAEs seem to be deep-rooted in male competitive adolescent team sport and continue to be prevalent despite more than three decades of empirical Sport Science research. While in female sport findings have been inconclusive. Additionally, although literature has extensively reviewed the physiological impact and its association to the RAE, the association with various psychological skills and constructs has received much less attention. Notwithstanding the need for intervention studies, few of the recommended solutions have been empirically applied or tested. Solutions often address one factor in isolation, while overlooking the multidimensional nature of RAEs and athlete development.

In conclusion, people do not rise from nothing. Elite athletes may appear as if they did it all by themselves. They may moreover stereotypically be the beneficiaries of cultural legacies with unseen opportunities and advantages that permitted them to acquire skills, work hard and comprehend the world in means others cannot (Gladwell, 2008). Although research has convincingly identified RAE differences among youth sport and elite sport athletes in other countries, the understanding of the RAE prevalence in South Africa is limited. Even more so in the unique landscape of school and university sport, hence, the examination of the RAE in South African university sport seemed a fruitful avenue.

5.3 SUMMARY OF CHAPTER THREE

Chapter Three presented a reflection on the primary researcher's research journey and included a short summary of the major events that lead to the current study. The initial proposal was aimed at exploring the RAE, physical characteristics (e.g., maturity status, anthropometric measures), and player psychosocial profiles (i.e., sport motivation and sport psychological skills) among 10 to 21-year-old soccer academy players in South Africa. However, because of the Covid-19 pandemic, national lockdown and cancelation of all sport, this was not possible. Accordingly, the next proposal shifted to explore the association between the RAE and various psychological skills and constructs among Stellenbosch University student-athletes.

This was not only going to provide the opportunity to compare sport psychological profiles between relatively older and younger student-athletes but would also provide valuable information on how it varies across multiple sporting codes and sexes. The psychological skill results could have also been used to evaluate and recognize the strengths and weakness of psychological skills and strategies of these student-athletes and provide guidance for future development of performance and well-being enhancing interventions. Once again, unfolding circumstances and uncertainties about the resumption of university sport resulted in the current study that "merely" analysed the prevalence of the RAE. It seemed essential to impose a comparison cluster of aged-matched non-student-athletes as the expected distribution to assess whether the RAE is prevalent across all sporting codes or specific ones and whether it is prevalent generally.

5.4 MAIN FINDINGS FROM THE STUDY

5.4.1 Description of the data

The researchers received two separate datasets from the Stellenbosch University Centre for Institutional Information and Maties Sport, respectively. The Centre for Institutional Information Data contained the first six digits of a South African ID number, which relates to the individual birthdate (i.e., 010109 = the 9th day of January 2001) and the sex (man or woman). The Maties dataset had an additional column with the student-athletes' sport code. Both datasets contained two additional columns, which the respective gatekeepers created. Namely: 1) year (which was later used to

determine the annual variations and participants age at that time); and 2) a participant counter (i.e., Name00001 for the first individual's birth date, etc.). Because the data contained participants from 2016 to 2021, the numbering system was key to ensure that each participant was included in the overall analysis only once. The full sample of South African students included: N = 47 327; men = 20 632; women = 26 682, non-binary = 13. The sample group was divided into hp-student-athletes: N = 950; men = 644; women = 306 and non-hp-student-athletes: N = 46377; men = 19 988; women = 26 376; non-binary = 13. The hp-student-athletes were further categorised into 11 HP sport codes. Rugby represented 27% (n = 260) of the total student-athlete sample, whilst water polo was the smallest with 2% (n = 16).

5.4.1.1 Under-representation of women in high performance sport

From this data, we noted that only 2% of the 2016 to 2021 cohort of South African students were part of the Maties HP unit. Out of the selected participants, women participants were underrepresented (32% vs. 68%, respectively). This is alarming, considering that there are more women students at Stellenbosch University than men (Approximately 57% vs. 43%, respectively) and raises questions about underrepresentation of women in sport. Despite the gradual increase over the last three years, women are still underrepresented. Figure 5.1. presents the distribution of both samples by sex from 2016 to 2021.

5.4.2 RAE prevalence in the cohort of Stellenbosch University students

Firstly, the distribution of the South African cohort was compared to a day-adjusted expected distribution (Q1 = 24.71%, Q2 = 24.91%, Q3 = 25.19%, Q4 = 25.19%). We observed a statistically significant difference ($\chi 2 = 42.13$, $p < 0.01$, Cramer's V = 0.03), with a distribution of (Q1 = 27.01%, Q2 = 25.26%, Q3 = 24.82%, Q4 = 22.91%). for (47 327) among the full student cohort. These results suggest a RAE among the cohort of Stellenbosch University students.

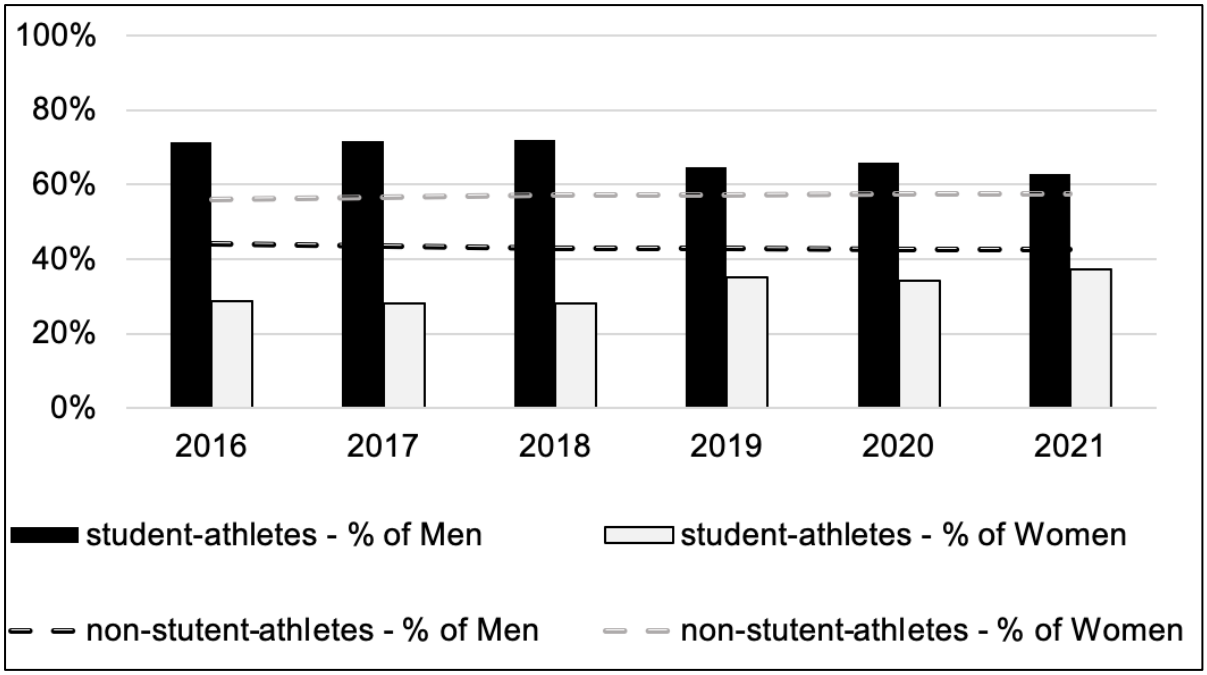

Figure 5.1. Percentage distribution by sex

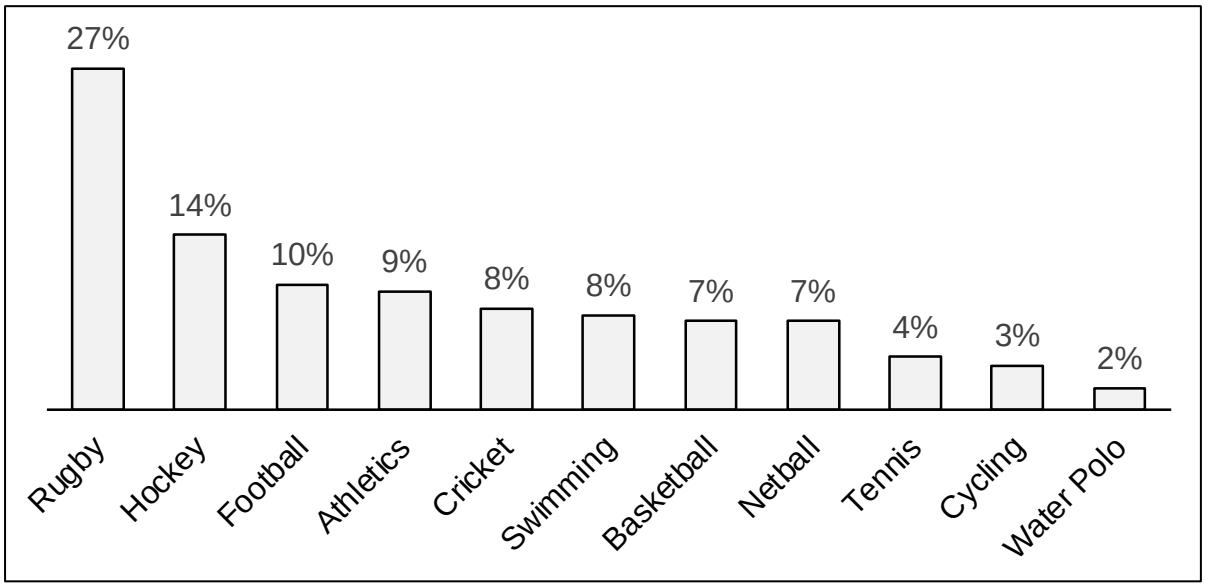

Figure 5.2. Distribution of student-athletes by sport code

5.4.3 Relationship between sex and birth quarter among the Stellenbosch University student cohort

A Chi-square test of independence was used to check whether the two variables (sex and birth quarter) are likely to be related or not. Table 5.1 represents a description of the birth quartile distribution of both Stellenbosch University student-athletes and non-student-athletes aged 18 to 25 from 2016 to 2021.

Table 5.1 Birth quartile distribution for Stellenbosch University students

	Q1%	*Q2%*	*Q3%*	*Q4%*
Men student cohort	**27.84%**	**25.47%**	**24.31%**	**22.38%**
2016				
non-HP-student-athletes	28.42%	24.74%	24.14%	22.69%
HP-student-athletes	29.35%	31.52%	21.20%	17.93%
2017				
non-HP-student-athletes	28.64%	24.39%	24.15%	22.82%
HP-student-athletes	30.33%	34.60%	22.27%	12.80%
2018				
non-HP-student-athletes	27.87%	25.27%	24.51%	22.36%
HP-student-athletes	29.77%	31.63%	22.33%	16.28%
2019				
non-HP-student-athletes	27.84%	25.96%	24.07%	22.13%
HP-student-athletes	32.61%	32.61%	21.20%	13.59%
2020				
non-HP-student-athletes	27.59%	25.89%	24.19%	22.33%
HP-student-athletes	31.58%	33.01%	16.27%	19.14%
2021				
non-HP-student-athletes	27.43%	25.95%	24.56%	22.07%
HP-student-athletes	36.46%	29.17%	18.23%	16.15%
Women student cohort	**26.37%**	**25.10%**	**25.22%**	**23.32%**
2016				
non-HP-student-athletes	26.99%	24.89%	25.09%	23.03%
HP-student-athletes	40.54%	10.81%	28.38%	20.27%
2017				
non-HP-student-athletes	26.96%	24.79%	25.02%	23.23%
HP-student-athletes	34.94%	16.87%	27.71%	20.48%
2018				
non-HP-student-athletes	26.99%	24.73%	25.25%	23.03%
HP-student-athletes	34.52%	21.43%	26.19%	17.86%
2019				
non-HP-student-athletes	26.92%	24.91%	25.05%	23.12%
HP-student-athletes	35.00%	25.00%	22.00%	18.00%
2020				
non-HP-student-athletes	26.45%	25.04%	25.23%	23.28%
HP-student-athletes	32.41%	31.48%	22.22%	13.89%
2021				
non-HP-student-athletes	25.94%	25.80%	25.17%	23.09%
HP-student-athletes	28.07%	34.21%	24.56%	13.16%

When considering the role of sex among the cohort, a statistically significant difference was noted ($\chi 2 = 18.43$, $p < 0.01$, Cramer's V = 0.02). The distribution of the men was (Q1 = 27.84%, Q2 = 25.47%, Q3 = 24.31%, Q4 = 22.38%) and for the women (Q1 = 26.37%, Q2 = 25.10%, Q3 = 25.22%, Q4 = 23.32%). Considering the relationship between the two variables, a repulsion between men and Q3 and Q4 and the positive association to Q1 was noted, while the women were slightly positively associated with Q3 and Q4 and negatively with Q1 compared to the expected overall cohort.

5.4.4 Differences between student-athletes and non-student-athlete groups comparison by sex and sport code

Overall, the birthdate distribution of the student-athletes differed significantly from that of the non-student-athlete cohort ($\chi 2 = 41.36$, $p < 0.01$, Cramer's V = 0.03). The student-athletes' distribution was (Q1 = 32.95%, Q2 = 28.95%, Q3 = 22.21%, Q4 = 15.89%). In this case, a simple well intended policy that defined cut-off dates (i.e., 1 January to 31 December) has an influence on the probability of reaching the highest tier within sport at Stellenbosch University. When considering the different sexes, both the men (Q1 = 33.23% Q2 = 30.28% Q3 = 20.81% Q4 = 15.68%) and the women (Q1 = 32.35%, Q2 = 26.14%, Q3= 25.16%, Q4 =16.34%) demonstrated statistically significant differences compared to their respective comparison groups.

While sex differences were noted among the Stellenbosch University student cohort, there were no sex differences between the student-athletes, because both sexes had more participants born within the first two quarters. Because of low participant counts in some sport codes, all sport codes were considered as one homogenous group encompassing of both men and women. When each sport code was compared to the non-student-athletes, RAEs were only prevalent in swimming, rugby and cricket.

Furthermore, rugby is a premier sport within South African university sport, with a national contest (i.e., the Varsity Cup) that attracts national TV audiences. Noteworthy, Maties is the most successful university at this competition, having reached 10 semi-finals and clinching five championships during the first 12 years. Specifically, the task constraints of competitive contact sport (i.e., cricket, rugby) such as the presence of body contact and physicality of play might influence the effect. The RAEs seem to

diminish particularly in sport where technical attributes are favourable and where physical attributes are unproductive or even disadvantageous.

Sex differences among the sex were only noted in athletics, football, and hockey. Results from the standard residuals gave more information about the specific nature of difference.

Athletics: The difference we see between the sex is largely contributed by the under-representation we see in Q2 (-1.89) born women and an over representation of Q2 (1.72) born men Basketball: Q1 (1.08) born women are positively associated whereas men are associated with more Q4 (1.09) born and low Q1 (-0.97) born men.

Football: The differences are significantly seen in the over representation of Q3 (3.15) and an under representation of Q4 (-1.87) born women. Men are underrepresented in Q3 (-164) and are more in Q4 (0.97) than expected.

Hockey differences are seen Q2 were a negative association between Q2 (-1.9) born women and a positive association between Q2 (1.86) born men. In addition, differences in Q1 can be noted with a negative association between Q1 (-1.13) born men and a positive association between Q1 (1.14) born women.

Swimming: Among swimming the contribution to the overall $\chi 2$ appears to be differences found in Q1 and Q4.

5.4.5 Comparison of the prevalence and persistence of the RAE from 2016 to 2021 and how the effects varied over time

Among the overall Stellenbosch University student cohort, 2016 was the only year not affected by the RAE, because there was a statistically significant difference between student-athletes and non-student-athletes' birth distribution for all the other years. Among the men, 2016 was likewise non-significant, whereas for the women 2017, 2018 and 2019 presented non-significant findings. Perhaps, the RAE prevalence or lack thereof at varsity sports level is symptomatic of underlying mechanisms and problems with talent identification and youth developmental sport programmes.

Combining all the results it is evident that the effect among hp-student-athletes men increases as the academic years increase. Only 2016 and 2018 did not present an effect that differed from the non-student-athlete men. Q1 and Q2 birth quarters are both consistently above 29%. Most of the drop we see comes from Q4 born men. Among the women, the effect is only observed in 2016 and 2021. However, from the trends we can see that the increase we observe in Q2 born students is from 2016 to 2021 is very high from 11% to 34%.

5.4.6 Contribution by the current study

While this study only determined the prevailing characteristics of Stellenbosch University students from 2016 to 2021 it provides a useful springboard to further research that might explore the underlying mechanisms. The current enquiry went beyond the scope of merely determining the prevalence of the RAE among student-athletes by also including the general student population as the comparison distribution. This study adds to the limited RAE among women and men student-athletes in South Africa. This study is ground breaking in its own right because it has exposed the RAE at the RSA university level. Now that we know there is a problem, we need to better understand it and try and solve it. Also, it provided

5.5 IMPLICATIONS FOR PRACTICE AND RESEARCH

Broadly speaking, from the initial ‘beginner’ sport participation there are competitions for diverse age categories and in each age category the participants who are assessed, evaluated and classified as being the most “gifted” are separated and coached to reach the next level (Cobley *et al*., 2009). In team sport (e.g., rugby, football, cricket) the selection process is traditionally based on viewing participants in a game or training session environment, whereby the participants aim to impress coaches (Sæther, 2014). Essentially, the very nature of talent selection is centred on the measurement and subsequent judgement of characteristics that contribute to sport-specific performance (Kelly *et al*., 2021; Pino-Ortega *et al*., 2021). Consequently, the physique and skills of a young participant hold imperative social stimulus value, which influence the evaluations and perceptions of peers, coaches and key stakeholders involved in sport (Wattie *et al*., 2015; Romann *et al*., 2017).

In many cases, the effectiveness of development programmes depends on the efficient allocation of limited available resources. Accordingly, understanding the developmental process and pathways towards elite sport is key to accomplish constructive outcomes in any sport. Hence, the requirement to discover new methods by which talent can be recognized and nurtured (which, is controversial as well as its definition), is vital for coaches and practitioners working with student-athletes. Notably, there is little consensus in the literature about the description of talent (Tucker & Collins, 2012). There is agreement that the concept is interpreted and understood differently within different sport codes. It has also been a challenge to identify talent development and transition studies from a South African cultural perspective. Our knowledge tends to hinge upon European and North American scientific traditions (Coutinho *et al*., 2016; Rees *et al*., 2016; Sarmento *et al*., 2018). There is consequently a need to expand the spectrum. More specifically, there is a need to identify pertinent information for South African stakeholders and coaches that will permit them to aid participants optimally as they develop from the junior to the elite senior level. Conceptual theories of athletic talent development (and talent development environments) highlight a variety of psychological, biological and physical attributes that need to be examined during the developmental process.

Coaches working with student-athletes must recognise that associations between birth date and performance during assessment can be significant for participants (de la Rubia *et al.,* 2020). It is crucial that they recognise the existence of the RAE when they categorise and support student-athletes. In a more pragmatic vein, the RAE may function as an artificial consequence of the grouping polices implemented in competitive learning environments, resulting in a loss of possibly capable participants, which in the long-term may contribute to a decline in performance standards of professional and national teams (Delorme *et al*., 2010). Arguably, the recruitment process and selection system implemented may be singled out as being accountable for the biased distribution. The RAE does not occur in a vacuum; coaches, parents and athletes all influence the RAE prevalence. The importance of coach education in all areas of RAE is emphasized, including numerous managerial and practical recommendations on coach organization along with the decision-making procedures throughout the talent selection and development process (Hill & Sotiriadou, 2016; Romann *et al*., 2018).

To be successful, players must adapt to the complex and often rapidly changing environment by executing the right action at the right moment under high-pressure situations. Therefore, it is not surprising that characteristics, such as anxiety control, mental preparation, technical ability and motivation often distinguish elite players from their near-elite counterparts. (Leyhr et al., 2021). Beyond the typical biases towards physical performance that may occur, the subjective biased nature of selection towards other characteristics may extend to varsity levels. The current study suggests that coaches integrate an in-depth assessment of participants in relation to competition and training performance (i.e., psychological skills, physical fitness, technical and tactical skills, etc.). They should not only consider primary characteristics (age, sex, laterality, etc.), but also focus on secondary factors (e.g., coaches, friends, family and sport types). This would enable a holistic evaluation of sport talent and its development in relation to RAEs. In any case, quality education about RAEs should involve discussions and training on the general sport environment (i.e., talent development and selection). Having mentioned that, this approach assumes that there is a robust evidence-based comprehension of talent and proficiency in sport (see Baker *et al*., 2019 for a roadmap for beginning this enquiry). Additionally, a call for multidimensional approaches incorporating both subjective and objective assessments of talent is required. In combination with monitoring physical activity workload, consideration of how the RAE can affect these outcomes is encouraged (Webdale *et al*., 2020).

Developmental structures may have to consider diverse solutions for various contexts using multiple solutions (Webdale *et al*., 2020; Leyhr *et al*., 2021). Most significantly, at this stage is that researchers should attempt to assess and extend potential solutions, while considering the broader characteristics of the developmental environment. Development structures may be missing prospects to nurture world-class athletes by releasing or not selecting them into their systems during fundamental learning periods. Hence, further research aimed at bridging the gap between research and practice in the future are fundamental (Roberts *et al*., 2021).

5.5.1 Consideration of a theoretical framework

The reality is that student-athletes are imbedded in diverse developmental contexts with distinctive levels of task, environmental and individual constraints (Wattie *et al*.,

2015). The univariate method utilized in the current study has essentially de-contextualized the influence of RA regarding the broader characteristics of student-athlete's developmental ecology. Recent literature by Roberts *et al.* (2021) suggests a shift from this conventionally narrow view of RAE inquiry, urging transdisciplinary research. Therefore, future research should consider implementing a macro approach, based on a comprehensive theoretical model (e.g., Henriksen's Athletic Talent Development Environment model (Henriksen *et al*., 2010)) to systematically explore multiple constraints. The aim of this will be to account for the extensive range of constraints that influence the non-existence or existence of RAEs. Such an endeavour will require a multidisciplinary approach (triangulation of result finding from numerous sources and methods like qualitative and quantitative designs) and multivariate multilevel modelling techniques may need to become more common practice (Pino-Ortega *et al*., 2021).

Possible individual constraints could include structural factors, such as anthropometric characteristics and functional factors (e.g., personality traits and psychological qualities of motivation and resilience). Task constraints can include rules/goals of the sport, as well as the demands, physicality and qualities required for success (e.g., agility, strength, technical ability). Finally, the environmental constrains, which denote to the broader social constructs that influence development like the different sport policies and selection criteria, social-cultural and physical environment, as well as the influence of important social agents, such as coaches, friends and family should be considered (Wattie et al., 2015).

5.5.2 Expand research to other developmental contexts

As research aim to move forward in efforts to gain a comprehensive understanding of the educational developmental system and ascertaining its relevant influences, micro-level approaches to research may add value (Wattie *et al*., 2015). Contextual factors associated with the location and timing of initial introduction to sport may have an enduring effect on both participation and the athlete's chance of reaching the highest playing standard (McCarthy & Collins, 2014). Henceforth, given that there is paucity of RAE research in South African sport, subsequent studies should consider

expanding the current study to other sporting contexts and participation levels (i.e., primary and high school sports and other South African universities).

It has been proposed that researchers, for instance Ph.D. students working in applied development environments, should engage in more longitudinal transdisciplinary research (Roberts *et al*., 2021). For example, since the processes of physical growth, behavioural development and biological maturation are interrelated and collectively impact short-term physical performance, researchers should consider longitudinal tracking of players from their introduction into sport.

5.5.3 Influence on psychosocial processes

Micro-level approaches should study the change in particular constraints or factors over time (i.e., physical maturity, training time and other psychosocial and physical measures relevant to athlete performance). This is even more exciting since Stellenbosch University has a working partnership with the recently established Stellenbosch Football Club that presents opportunities for collaborative and longitudinal research. Additionally, at the Football Club sport scientists are provided a good platform to explore and expand this research in a professional football setting. Particularly, as the primary researcher has observed a biased birth quartile distribution of (Q1 = 40.21%, Q2 = 30.93%, Q3 = 16.49%, Q4 = 12.37) among the 98 selected academy players between 2020 and 2021. In other words, 71.14% of the players selected are born within the first six months of the year. Furthermore, the use of two-year age-bands (i.e., u12, u14, u16, u18) makes it even more stimulating. For instance, one could consider evaluating psychosocial processes and how they change over time. Pygmalion effects occur when expectations and subsequent preferential treatment from coaches (e.g., praise, detailed instructions and investing more time), facilitate the success of relatively older athletes (see Peña-González *et al*., 2018), while Galatea effects present themselves when an athlete's self-efficacy and self-expectations of their abilities results in new behaviours (e.g., more diligent and frequent training), leading to positive attainments.

It may be significant that sport scientists explore in what way coaches place distinctive expectations on relatively younger and/or older athletes (e.g., associating body size

with talent instead of forming performance-based expectations), and in what way Pygmalion effects present themselves in competition and practice. Particularly, because coaches' expectations beforehand and after selection may amplify and/or perpetuate RAEs initiated during earlier ages (Peña-González *et al*., 2018). This inquiry might be helpful to recognize social agents that influence RAEs more efficiently. Perhaps if biased can be identified and lessened, RAEs could also lessen, thereby helping to create a non-discriminatory environment (Leyhr et al., 2021). An additional essential inquiry is one on the effects of being selected or not being selected into better teams and its influence on self-expectations. Moreover, if Galatea effects exist it will be interesting to fathom how they become discernible (e.g., increase training frequency and intensity, motivation or confidence). The primary researcher does not endorse or advocate manipulating legitimate self-expectations of relatively older athletes to lessen RAEs; the purpose is rather to comprehend how Galatea effects influence RAEs.

5.5.4 Time points at which RAEs originate

The point at which the RAE originates within the South African talent pathway should be recognised to allow more targeted selection interventions that address the RAE. In this way, it would be able to make suggestions and recommendations, whether it entails amending sport talent identification processes or developmental pathways in more team sport and various competitive levels. Provided this time point can be identified another option is to assess the effectiveness of the various suggestions that have been put forward to mitigate the RAEs (i.e., grouping participants based on biological age or weight and various techniques of rotating the selection date) (Webdale *et al*., 2020).

Also, future inquiry that involves manipulation of constraints should consider how these adjustments affect the rest of the development system. Just as RAEs are an unpremeditated consequence of a certain grouping policy, so too may any modifications thereto produce unintended consequences (Wattie *et al*., 2015).

5.5.5 Person-oriented analysis to micro-level research

Lastly, to improve the classification of diverse developmental experiences accurately, longitudinal cohort studies utilising person-oriented analysis may be more favourable. Applying solutions based on aggregate statistics (e.g., count, mean and sum) may be problematic (Wattie *et al*., 2015). Instead of the common variable-oriented analysis, person-oriented analysis places the individual as the prime unit of comparison. This can be achieved by focusing on the common and distinguishing characteristics that individual participants have (e.g., scores on a particular psychometric measure). It is challenging to recognise the ways that participants in different birth quartiles are similar or different with respect to certain constraints. Instead of grouping participants by birth quartiles and generating aggregate statistics for a given constraint, individual measures and important variables should be used to create sub-groups within a larger sample (Wattie *et al*., 2015). This approach does not a priori assume that participants within the same birth quartile are homogeneous and thereby attempts to directly address and give an account of diversity among individuals. This information could become pertinent when interventions are being considered, applied and assessed (Webdale *et al*., 2020).

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APPENDICES

Appendix A - Letter of permission: Maties Sport

February 2019

Application for Approval of Research

All research conducted either with Maties Sport Club members or on Maties Sport activities must be submitted for approval to the Chief Director, Maties Sport. **It is not always possible to accommodate all requests.** A response to each application will be made in consultation with the Head of the High-Performance Sport Unit and relevant sport managers and coaches when appropriate.

This Application must be submitted electronically to: surmon@sun.ac.za

General Information				
Institutional Research Proposal Number (REC): *To be submitted to DESC and REC in 2021*		Date of Submission to Maties Sport: 2020-11-03		
1. Title of Research	Relative age effects of South African student-athletes: Prevalence, annual variation and between-group comparisons.			
2. Aim of the Project	The primary aim is to determine and compare the prevalence of RAE among Maties student-athletes and the general aged-matched Stellenbosch University student population. The secondary aim is to describe and compare the birthdate distributions of various Maties student athletes considering the sport code and sex. The tertiary aim is to compare the prevalence and persistence of the RAE annually since the inaugural season of varsity sports (from 2008 – 2021) and see if there were consistencies of percentages in each Q1-Q4.			
3. Name(s) of Investigator	Sindiso Rangarirai Dube		Student or staff no. 20075073	
4. Contact Information	email	rento3x@gmail.com	phone	0634263837
5. Academic Department	Sport Science			

6. Please mark all the following boxes that apply to this application:

a) The primary investigator is an SU academic staff member

■ b) This research is part of an M or a PhD programme
If yes, please provide the name of your supervisor/promoter here:
A/Prof Heinrich Grobbelaar

c) This research is part of an Honours or other Post-graduate programme
If yes, please provide the name of your supervisor/promoter here:

d) This research is part of an undergraduate programme
If yes, please provide the name of your supervisor/promoter here:

e) The primary investigator is NOT from Stellenbosch University
Please provide the name and details of the primary investigator here:

f) Does this study require access to data managed within the Maties Sport Smartabase Athlete Management System?
If yes, it is required that a separate application is submitted to ISEM for approval.

Sport-specific Information

Please provide details in response to the following questions as they apply to this research:

7. Which Maties Sport team or target group do you hope to involve in this research?

Student-Athletes selected to participate in any of the 8 varsity sport teams aged 18 – 25 years of age from 2008 – 2021 on an annual basis.

8. In which months do you intend to be involved with this group?

April-June 2021

Specific Information regarding the Impact on Maties Sport

9. How many student-athletes do you hope will volunteer for your research?

No student-athletes will be required to actively volunteer, just access to their information (birthdate, sex and sport code)

10. How much time in total will you require from each of the volunteers?

No time required

11. Does this research involve any intervention of any kind? If yes, please describe the intervention and attach any relevant documentation to assist your application.

No intervention for this study, but may provide baseline information for future studies that may include interventions.

12. When would you ideally schedule an information session for the sport club manager(s) and coach(es) whose student-athletes are involved?

April 2021

13. When would you ideally schedule an information session for the student-athletes?

No information session will be required for the student-athletes

14. Please indicate the impact/relevance of the research project with regards to Maties Sport (student-athletes in general) and the broader society (max 200 words).

The reality of competitive sport is that decisions must be made about the distribution of limited resources. Notions of talent identification, competition and athlete selection, which seem to create RAEs across developmental stages, should be addressed. The central question of this research is "how can we make

these processes better?" and the decisions more evidence based accompanied with certain performance indicators. Where prevalent RAEs can act as a sport dropout factor. Attenuating RAEs may be helpful in maintaining player involvement and promote the efficient use of resources. In any case, coaches' awareness of this phenomenon should be increased, and team sports coaches should consider the later development trajectories of youth athletes.

Agreement to Submit a Report to Maties Sport

By signing this application, the primary investigator agrees to submit to the Head: High Performance, Maties Sport, an abstract of this research that describes the results/outcomes of the project **within one week of submitting the final thesis or project report.**

Signature: _____ Date: 2020-11-02

Approved on 8 April 20201

Sean Surmon

Maties Sport, Deputy Director High Performance

these processes better?" and the decisions more evidence based accompanied with certain performance indicators. Where prevalent RAEs can act as a sport dropout factor. Attenuating RAEs may be helpful in maintaining player involvement and promote the efficient use of resources. In any case, coaches' awareness of this phenomenon should be increased, and team sports coaches should consider the later development trajectories of youth athletes. ¶

¶

Agreement to Submit a Report to Maties Sport

By signing this application, the primary investigator agrees to submit to the Head: High Performance, Maties Sport, an abstract of this research that describes the results/outcomes of the project **within one week of submitting the final thesis or project report.**¶

¶

¶

Signature: _____ Date: 2020-11-02¶

¶

¶

Approved on 8 April 2020¶

Sean Surmon¶

Maties Sport, Deputy Director High Performance¶

Appendix B: Letter of ethical clearance: REC

UNIVERSITEIT
STELLENBOSCH
UNIVERSITY

NOTICE OF APPROVAL

REC: Social, Behavioural and Education Research (SBER) - Initial Application Form

5 May 2021

Project number: 21919

Project Title: Relative age effect of South African student-athletes: Prevalence, annual variation and between-group comparisons.

Dear Mr SR Dube

Co-investigators:

Your REC: Social, Behavioural and Education Research (SBER) - Initial Application Form submitted on 28/04/2021 15:43 was reviewed and approved by the REC: Social, Behavioural and Education Research (REC: SBE).

Please note below expiration date of this approved submission:

Ethics approval period:

Protocol approval date (Humanities)	Protocol expiration date (Humanities)
5 May 2021	4 May 2024

GENERAL REC COMMENTS PERTAINING TO THIS PROJECT:

INVESTIGATOR RESPONSIBILITIES

Please take note of the General Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

If the researcher deviates in any way from the proposal approved by the REC: SBE, the researcher must notify the REC of these changes.

Please use your SU project number (21919) on any documents or correspondence with the REC concerning your project.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

CONTINUATION OF PROJECTS AFTER REC APPROVAL PERIOD

You are required to submit a progress report to the REC: SBE before the approval period has expired if a continuation of ethics approval is required. The Committee will then consider the continuation of the project for a further year (if necessary).

Once you have completed your research, you are required to submit a final report to the REC: SBE for review.

Included Documents:

Document Type	File Name	Date	Version
Default	CV HGrobbelaar-2021	29/03/2021	1
Proof of permission	Maties Sport Application for Research Approval_SRDube_ Approved 8.4.2021	27/04/2021	2
Request for permission	Proof of request for letter (Permissions)	27/04/2021	1
Request for permission	Institutional_permission_SR_Dube_20075073_MSc Sport Science_April_2021	27/04/2021	1
Budget	Budget_For_Masters_Study_for_Ethics Application_2021	27/04/2021	2
Research Protocol/Proposal	Updated_Research_Proposal_SR_Dube_20075073_MSc Sport Science_26_April_2021	27/04/2021	3
Default	TEMPLATE FOR RESPONSE LETTER	27/04/2021	1

If you have any questions or need further help, please contact the REC office at cgraham@sun.ac.za.

Sincerely,

Clarissa Graham

REC Coordinator: Research Ethics Committee: Social, Behavioral and Education Research

National Health Research Ethics Committee (NHREC) registration number: REC-050411-032.
The Research Ethics Committee: Social, Behavioural and Education Research complies with the SA National Health Act No.61 2003 as it pertains to health research. In addition, this committee abides by the ethical norms and principles for research established by the Declaration of Helsinki (2013) and the Department of Health Guidelines for Ethical Research: Principles Structures and Processes (2nd Ed.) 2015. Annually a number of projects may be selected randomly for an external audit.

Appendix C: Letter of institutional permission: Information Governance

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jou kennisvennoot • your knowledge partner

INSTITUTIONAL PERMISSION:

AGREEMENT ON USE OF PERSONAL INFORMATION IN RESEARCH

Name of Researcher:	Sindiso Dube
Name of Research Project:	Relative age effects of South African student-athletes: Prevalence, annual variation and between-group comparisons.
Service Desk ID:	IG-2166
Date of Issue:	21 May 2021

The researcher has received institutional permission to proceed with this project as stipulated in the institutional permission application and within the conditions set out in this agreement.

Appendix D: Declaration of Language Editing

UNIVERSITEIT·STELLENBOSCH·UNIVERSITY
jou kennisvennoot·your knowledge partner

29 November 2021

TO WHOM IT MAY CONCERN

I, Prof Karel J. van Deventer, hereby declare that I conducted the language and technical editing of the MSc thesis titled, *Relative age effects of South African student-athletes: Prevalence, annual variation and between-group comparisons*, authored by Mr SR Dube.

Yours sincerely

KJ van Deventer
(Emeritus Associate Professor [Retired])

Sportwetenskap
Sport Science
STELLENBOSCH

Departement Sportwetenskap ◆ Department of Sport Science
Privaat Sak/Private Bag X1 ◆ Matieland 7602 ◆ Suid-Afrika/South Africa
[redacted]

Appendix E: South African Journal of Sport Medicine Guidelines

Submission Preparation Checklist

As part of the submission process, authors are required to check off their submission's compliance with all of the following items, and submissions may be returned to authors that do not adhere to these guidelines.

- ✔ I agree to abide by the terms of the copyright statement.

Author Guidelines

Accepted manuscripts that are not in the correct format specified in these guidelines will be returned to the author(s) for correction, and will delay publication.

AUTHORSHIP

Named authors must consent to publication. The given name(s) and family name(s) of each author must be inserted, and check that all names are spelled correctly. Authorship should be based on substantial contribution to: (i) conception, design, analysis and interpretation of data; (ii) drafting or critical revision for important intellectual content; and (iii) approval of the version to be published. These conditions must all be met (uniform requirements for manuscripts submitted to biomedical journals; refer to www.icmje.org).

Qualification, affiliation and contact details of ALL authors must be provided in the manuscript and in the online submission process. The highest qualification of each author should be provided. Authors are allowed a maximum of two qualifications providing each qualification represents a different field or speciality. Each author's ORCID ID must be provided during the online submission process. Affiliations need to be provided in ascending order on the manuscript and must include, Unit (where applicable), Department/School, University or Organisation, City and Country

e.g. John Smith, School of Medicine, Faculty of Health Sciences,University of Pretoria, South Africa

Corresponding author. Clearly indicate which author will be handling the correspondence at all stages of reviewing, editing, and publication, also post-publication. Provide a correct email address for the corresponding author. The contact details for all authors are to be kept up to date by the corresponding author. Where changes occur, the corresponding author should notify the Editor-in-Chief.

The corresponding author must provide not more than **five** keywords. These keywords should not appear in the title of the manuscript. The keywords should be inserted immediately after the Abstract.

CONFLICT OF INTEREST

Authors must declare all sources of support for the research and any association with a product or subject that may constitute conflict of interest. If no funding was received for the research, kindly state that no funding was received from any funding agencies in the public, commercial or non-profit sectors.

RESEARCH ETHICS COMMITTEE APPROVAL

Provide evidence of Research Ethics Committee approval of the research where relevant.

PROTECTION OF PATIENT'S RIGHTS TO PRIVACY

Identifying information should not be published in written descriptions, photographs, and pedigrees unless the information is essential for scientific purposes and the patient (or parent or guardian) gives informed written consent for publication. The patient should be shown the manuscript to be published. Refer to **www.icmje.org**.

ETHNIC CLASSIFICATION

References to ethnic classification must indicate the rationale for this. For details, see: Ncayiyana, D. (2007). Racial profiling in medical research: What are we measuring? *South African Medical Journal*, *97*(12), 1225.

MANUSCRIPTS

Shorter items are more likely to be accepted for publication, owing to space constraints and reader preferences.

All submissions should have a short Abstract, followed by the keywords as indicated above. At the end of each article the contribution of each author and collaborator needs to be stated.

Original articles not exceeding 3000 words (excluding references), with up to 6 tables or illustrations, are usually observations or research of relevance to sports medicine and exercise science. References should be limited to 20. Please provide a **structured abstract** not exceeding 250 words, with the following recommended headings: *Background, Objectives, Materials and methods, Results, Discussion* and *Conclusion(s).*

Short reports, ***Commentaries*** or ***Case Studies***, should be 1500 words or less, with one table or illustration and no more than six references. Please provide an accompanying **abstract** not exceeding 150 words.

Qualitative articles not exceeding 5000 words (excluding references), with an **unstructured abstract** not exceeding 250 words. References should be limited to 20. Please ensure single quotation marks, except where 'a quotation is "within" a quotation'. Long quotations should be indented without quotation marks. Recommended headings: *Background, Objectives, Materials and methods, Results, Discussion* and *Conclusion(s)* .Additional guidelines for qualitative reporting can be found here.

Editorials, ***Opinions***, etc. should be about 1000 words and are welcome, but unless invited, will be subjected to the SAJSM peer review process.

Review articles are rarely accepted unless invited.

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Refer to articles in recent issues for the presentation of headings and subheadings. If in doubt, refer to 'uniform requirements' - **www.icmje.org**. Manuscripts must be provided in **UK English**.

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Journal references: Price NC, Jacobs NN, Roberts DA, et al. Importance of asking about glaucoma. Stat Med 1998;289(1):350-355. [http://dx.doi.org/10.1000/hgjr.182] [PMID: 2764753]

Book references: Jeffcoate N. Principles of Gynaecology. 4th ed. London: Butterworth, 1975:96-101. *Chapter/section in a book:* Weinstein L, Swartz MN. Pathogenic Properties of Invading Microorganisms. In: Sodeman WA jun, Sodeman WA, eds. Pathologic Physiology: Mechanisms of Disease. Philadelphia: WB Saunders, 1974:457-472.

Internet references: World Health Organization. The World Health Report 2002 - Reducing Risks, Promoting Healthy Life. Geneva: World Health Organization, 2002. http://www.who.int/whr/2002 (accessed 16 January 2010).

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