TALENT IDENTIFICATION AND DEVELOPMENT IN RUGBY UNION: A MULTIDISCIPLINARY INVESTIGATION INTO AN ENGLISH PREMIERSHIP CLUB

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Contents

Abstract

Different methodological approaches have been used to explore the processes of talent identification (TID) and talent development (TD) in rugby union (RU). However, there is currently no investigation that has analysed an academy at an English Premiership RU club using a mixed-method, multidisciplinary approach. The aim of this project was to optimise the TID and TD processes at Worcester Warriors Rugby Football Club following these steps: (a) systematically review the existing literature surrounding the TID and TD systems, (b) explore the factors that differentiated selected and non-selected U15 players, by position, during the initial entry into a professional academy (i.e., U15), (c) analyse a range of multidimensional characteristics that distinguished age-grade players and playing position among a professional academy (U16-21), (d) identify differences among the academy's 'top-ten' and 'bottom-ten' players based on the coaches perception of their potential to achieve senior professional status, (e) explore professional players' and coaches' perceptions of the TID and TD processes in professional RU, and (f) offer practical implications to coaches and practitioners working in youth RU for identifying and developing players.

Using the ecological dynamics framework as a guiding model, results showed that despite significant differences among playing positions, task, performer, and environmental constraints were the most investigated areas in TID and TD systems in RU literature. Sprint time appeared the most important physical factor that distinguished both selected and non-selected players, as well as the top-ten and bottom-ten potential professional players. In general, players need to develop anthropometric and physical qualities in line with their age and position. It also appeared that relatively older players were significantly overrepresented across all age groups when compared to relatively younger players. Environmental and performer constraints differentiated playing positions, whereas task and environmental constraints discriminated player ranks. Players' and coaches reported that task, performer, and environmental constraints have a different influence on players' progression towards the senior professional status. Overall, RU academy policy makers

should interpret this work as an attempt to provide an initial framework for coaches and practitioners. Future investigations should consider a mixed-method (i.e., both quantitative and qualitative analysis), longitudinal (e.g., several-year investigation), and multidimensional approach (e.g., using an holistic analysis such as anthropometric, physical, psychological, technical-tactical, socioeconomic, sport background, and relative age) when investigating the talent identification and development processes in RU.

Chapters published

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Dimundo, F., Cole, M., Blagrove, R. C., McAuley, A. B., Till, K., & Kelly, A. L. (2021). Talent identification in an English Premiership rugby union academy: Multidisciplinary characteristics of selected and non-selected male under-15 players. *Frontiers in Sports and Active Living*, *3*, 162. https://10.3389/fspor.2021.688143

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1. CHAPTER ONE

General Introduction

Talent Identification and Development in Sport

Research in the fields of talent identification (TID) and talent development (TD) in sport has grown considerably over the last two decades due to the ever-growing interest in achieving expertise in sport (Cobley et al., 2020). Between 1990 and 2019, more than the 75% of the studies surrounding the topic of athlete selection and development were published in the last 10-years. Coinciding with the academic interest is the commercialisation of TID and TD, which have accelerated the awareness across several athlete development pathways (Cobley et al., 2020). Such growing interest for topics on talent is the consequence of vast financial investments that organisations (e.g., national governing bodies, private companies, professional clubs) have subsidised in order to cope with the increasing professionalisation of sports coupled with the development of TID an TD pathways (Reilly et al., 2000; Vaeyens et al., 2008).

Generally, across both the academic (e.g., universities) and applied (e.g., academies) environments, there are different definitions, descriptions, and applications of the word 'talent'. In fact, the popular press associate this concept exclusively with the 'innate pre-disposition' and the 'unchangeable' status of athletes that remain static over time (Schorer et al., 2017). More specifically, *talent* has been defined as the "functional relationship developed between a performer and a specific performance environment" (Davids et al., 2017, p. 193). There is growing evidence that *talent* can be viewed and developed in an ecological dynamics framework, whereby the temporary status of the talented athlete derives from a moulded combination of factors affected by macro areas of constraints, which are changeable across each individual path (Sarmento et al., 2018). Therefore, an ecological dynamic framework seems a suitable model to apply to TID and TD in sport to capture the holistic and malleable nature of these processes. Indeed, this approach negates the possible weaknesses of using a one-dimensional approach that is used in several sport contexts (Henriksen et al., 2010).

It has been theorised that the general development of a young player depends on several factors. The *Ecological Systems Theory* (Bronfenbrenner, 1974) has provided a platform for the ecological dynamic framework that is used in this thesis to explain how general youth development is affected by five levels of the surrounding environment (i.e., microsystem, mesosystem, exosystem, macrosystem, and chronosystem), such as immediate settings of family and school to broad cultural values, laws, and customs. From a sport specific perspective, a player's progression is multifactorial and cannot be the result of a single independent factor (Davids et al., 2012). Therefore, talent in sport is instead the result of a combination of *task* (i.e., participation history), *performer* (i.e., psychological, technical-tactical, anthropometric, physiological), and *environmental* (i.e., relative age, sociocultural) constraints (Sarmento et al., 2018; see Chapter 2 for an overview of the ecological dynamics framework). As such, TID and TD should consider the combination of these aspects to gain a more accurate understanding of players management.

Investigations focussed on TID and TD have furthered our knowledge in sports such as football (Sarmento et al., 2018), basketball (Gál-Pottyondy et al., 2021), cricket (Kelly et al., 2022), volleyball (Albaladejo-Saura et al., 2022), as well as general sport activities (Thompson et al., 2022). Rugby union (RU) increased in popularity from 1995 due to professionalisation of the game (Collins, 1998; Duthie et al., 2003). With more than 8.5 million registered players practicing worldwide (World Rugby, 2022), the increase in participation has led RU clubs to invest significant sums towards optimising youth academy environments (Hogan & Norton, 2000). Despite initial examinations in the path of rugby league, a paucity of explorations have been carried out in RU (Jones et al., 2018). Due to the diverse laws of the two codes of rugby, a specific investigation into the constraints that affect the RU talent path is required (see Chapter 2). Studies have suggested that future investigations in RU should consider task, performer, and environmental constraints in unison when studying professional academy environments to better understand the holistic demands of the TID and TD process (Baker et al., 2017; Cobley et al., 2020), thus it seems logical to utilise the ecological dynamics framework as a theoretical framework for this project.

The Rugby Football Union

In England, the country with the larger number of RU members per population, the Rugby Football Union (RFU) is responsible for the fourteen regional academies that are aligned with Premiership clubs. The purpose of these academies is to provide a developmental pathway to prepare talented young RU players for the demands of professional competition. Each regional academy is thought to: (a) have a specific zone of influence in order to avoid ‘poaching players’ across geographical areas, (b) encourage the ‘home-grown players’ process, and (c) support education and relationships among communities (Till, Barrell, et al., 2020).

Despite the RFU providing direct support to improve the talent path across Premiership clubs, it is the regional academies’ responsibility to deliver their system and programme using the national philosophy. The fourteen regional academies are reviewed for a *minimum standard of operation* and assessed annually upon assurance, funding, and performance based on a total of 106 criteria related to seven factors: (a) leadership and strategic planning, (b) staffing, (c) coaching, (d) player development pathways and programs, (e) individual athlete support, (f) lifestyle and education, and (g) financial management. Thus, the minimum standard of operation constitutes the framework in which an optimal talent path is thought to be structured. Importantly, though, despite the national guidelines, each professional club in the country preserves its own *modus operandi* with academy age groups (e.g., under [U]15, U16, U18, and U21 players) using different professional implementations such as coaching strategies, strength and conditioning support, and a long-term athlete development (LTAD) approach. As such, it is important to evaluate existing approaches within respective academy environments in order to inform evidence-based practice and create more appropriate settings.

The Worcester Warriors Talent Pathway

Worcester Warriors Rugby Football Club (WWRFC) operates in the English Premiership and has a distinguished academy, which is comprised of two macro-phases of development as reported in Figure 1.1: (a) *phase of exploring the boundaries for player development*, and (b) *phase* *of adaptation to win*. The first phase is compounded by four sub-stages that aims to optimise the TID initial process: (a) selection through club festivals, (b) selection through U13 Warriors Developing Players Program (DPP) group, (c) selection for the U14 and 15 Warriors DPP group, and (d) selection for the Warriors Players Development Group (PDG) squad. The final stage consists in the identification of Senior Academy (i.e., U21s) players who are able to perform at Premiership standard of RU.

Figure 1.1. The Worcester Warriors Rugby Football Club talent identification and development ladder.

Although WWRFC provides guidelines to develop players from the U13 age group, a significant effort on TID and TD is placed on players when they are selected to train at Warriors Training Centre at the U15 Warriors DPP stage. This is due to the fact that RU is considered a late specialisation sport (Phibbs et al., 2018), and therefore a ‘narrowed’ selection is typically performed by professional clubs around this age (e.g., when Premiership teams organise scouting in partner schools and local clubs). Once potential young players are identified, WWRFC invite selected U15 players to train at regional representational level concurrently with players’ original club and school rugby training. Moreover, when players are selected to be part of the U15 squad and are allowed to start training at Warriors Training Centre, the TD programme, the position-specific rugby training, the strength and conditioning provision, and training regimes become more specialised to ensure players become prepared for the demands of the professional game as they move towards adulthood (see Chapter 3). Therefore, it is understandable that two moments are considered critical in the path of a WWRFC academy player: (a) the initial identification into the WWRFC U15 academy squad, which represents the very first initial step into a *more structured* and *more intense* style of RU training, and (b) player selection at U21, during which managers decide whether to sign a senior professional contract with a player or release them from the club's training program.

At WWRFC, which is perhaps relevant to all English Premiership clubs, the outcome of an academy player follows a binary path that is affected by three area of constraints (i.e., task, performer, and environmental). These variables could impact on a player's path in two possible ways: (a) selecting (i.e., until the phase of signing a professional contract with the club), or (b) deselecting (i.e., drop out or released from the talent pathway) the athlete. Thus, since the pyramidal structure of talent systems reduces the number of players at each stage of selection (and often promising players are erroneously deselected during early phases of the selection path), there are still questions surrounding the most appropriate processes that facilitate players' development towards RU senior professional status and, therefore, the ideal strategy to use to optimise talented youths' development in this sport remains unclear (Till, Weakley, et al., 2020).

Epistemological Approach and Study Design

Several studies (see Chapter 2) outline that RU has been rarely explored TID and TD using an ecological dynamic approach (e.g., Lewis et al., 2015; Scott et al., 2003). Indeed, the majority of the investigations published in this field have been performed using one-dimensional approach (e.g., Darrall-Jones et al., 2015; Fontana et al., 2015; Holway & Garavaglia, 2009; Sherwood et al., 2018), which represents a gap in the current knowledge. Therefore, this thesis differentiates from previous investigations since, for the *first time-ever*, an ecological dynamic approach has been used across a whole Premiership RU academy. This work seeks to explore the effects that a combination of constraints can have on the TID and TD processes through a multidisciplinary approach.

To date, quantitative research on TID and TD in RU represents the larger proportion of academic work compared to qualitative studies (e.g. McAuliffe et al., 2021). As such, this thesis supports the idea that a mixed method investigation is required to investigate talent processes due to the plethora of useful information that can be discovered using combined analysis. Mixed method research has been defined as a research approach whereby researchers collect and analyse both quantitative and qualitative data within the same study (Bowers et al., 2013). Moreover, it has been established that this approach can be used to gain a better understanding of connections or contradictions between qualitative and quantitative data and, thus, could facilitate a deeper understanding surrounding multifactorial topics (Fetters & Molina-Azorin, 2020).

For the scope of the present thesis, the objective was to collect quantitative data to carry a deductive analysis to *establish* causality on the TID and TD processes in an academy of an English Premiership RU club (i.e., "Can we identify specific characteristics that influence player selection and development outcomes at WWRFC?"). Through collecting qualitative data, the objective was to perform an inductive analysis with the aim to *explain* causality of the TID and TD phenomenon within the same club (i.e., "What is the perspectives of coaches and players on the TID and TD pathway at WWRFC?"). Therefore, using a quantitative or *etic* epistemology trail (e.g., collecting anthropometric, physiological, psychological, socioeconomic status, birth quartiles, training activities, and perceptual-cognitive data), the goal was to provide an 'outsider' perspective of factors affecting the selection and development of young RU players. Whereas, using a qualitative or *emic* approach (e.g., using focus groups with coaches and players), the goal was to provide an 'insider' perception on the players' pathway towards professional status within the same club.

Aims of the Thesis and Chapter Overview

The scope of this investigation was to analyse the TID and TD processes of a male English Premiership RU academy from players' entry stage in a *more competitive level* of RU (i.e. from U15) to the professional player' status (i.e., U21) using a mix-method and ecological dynamic approach.

In particular, the aims of this thesis were to:

(a) Systematically review the existing literature on TID and TD in male RU. This was in order to outline where the existing research lies, identify the most researched topics, provide updated guidance for coaches and practitioners, and outline avenues for potential data collection methods and future research (Chapter 2).

(b) Explore the anthropometric, physiological, perceptual-cognitive, and relative age characteristics that differentiated selected and non-selected U15 WWRFC academy players. These factors were also observed based on position (i.e., forwards vs backs) (Chapter 3).

(c) Evaluate the anthropometric, physical, and relative age characteristics of WWRFC academy players based on age group (i.e., U16 vs. U18 vs. U21) and playing position (i.e., forward vs backs) (Chapter 4).

(d) Examine a range of task (i.e., participation history and sport activities), environmental (i.e., socioeconomic), and performer (i.e., anthropometrical, physical, psychological, perceptual-cognitive expertise, and social identity) constraints of WWRFC academy players (i.e., U16 to U21) based on coach rankings and playing position (Chapter 5).

(e) Evaluate the perspectives of both academy coaches and U21 players regarding the TID and TD processes at WWRFC academy (Chapter 6).

Lastly, Chapter 7 offers a general summary of the thesis, provides limitations and future directions for researchers working on TID and TD in RU, and presents practical applications for coaches and practitioners working in youth RU.

2. CHAPTER TWO

Talent identification and development in male rugby union: A systematic review

Dimundo, F., Cole, M., Blagrove, R., Till, K., McAuley, A., Hall, M., Gale, C., & Kelly, A. (2021). Talent identification and development in male rugby union: a systematic review. *Journal of Expertise*, *4*(1), 33-55.

Dimundo, F., Cole, M., Blagrove, R. C., Gale, C. J., & Kelly, A. L. (2019, May). Talent identification and development in male rugby union: A systematic review. Paper presented at the 8th annual Conference of the Expertise and Skill Acquisition Network (ESAN), Twickenham, London, England. ***Winner of the Best Poster Award at the conference***.

Abstract

The pathway towards expertise in sport has been studied within different contexts. Various methodological approaches have been used in research to explore the processes of talent identification (TID) and talent development (TD) in rugby union (RU). The aim of this study was to critically review the existing literature on TID and TD in RU in order to outline where the existing research lies, identify the most researched topics, and provide updated guidance for coaches, practitioners, and future research. Searches were conducted in the electronic databases PubMed, Web of Science, Scopus, SPORTDiscus, and Google Scholar. The following Boolean combination key words were applied: rugby union, AND, talent identification, talent development, early selection, youth selection, talent transfer, and youth development. This process was carried out in accordance with PRISMA guidelines. Databases provided 382 studies, with a total of 253 articles fully assessed (IRR = 98.6%, k = 0.94), of which a further 234 were excluded (IRR = 97.7%, k = 0.85). Following this screening, 15 articles were added from studies and review citations, resulting in a total of 34 articles included in the review. The ecological dynamics framework was applied to collate factors from the one- and multi-dimensional findings (Sarmento et al., 2018). The most investigated topics were: (1) *task constraints*: (a) participation history; (2) *performer constraints*: (a) psychological factors; (b) technical and tactical skills; (c) anthropometric factors; (d) physiological factors; (3) *environmental constraints*: (a) relative age effects; (b) socio-cultural factors. Practitioners need to consider the players' anthropometric, physiological, psychological, technical, and tactical profile, when selecting and developing young rugby union players. Further longitudinal mixed-method research is required to provide indications of the success of talent identification and development processes, to gain a better understanding on how these factors can affect selection and long-term progress.

Keywords: rugby football; selection; athlete development; youth selection; development process

Introduction

Although often used interchangeably, the concepts of talent identification (TID) and talent development (TD) are separately defined. TID can be considered as the process of recognising current participants with the potential to excel in a particular sport, whereas TD is the process of providing the most appropriate learning environment to realise this potential (Williams & Reilly, 2000). In practical terms, the two diverse concepts are related, since the effectiveness of one could directly affect the outcomes of the other. This interconnection can be explained by the fact that the progression of a player to top-level sports is multi-contextual and multi-factorial. Thus, practitioners continue to search for the unique and dynamic factors responsible for optimum developmental outcomes. In light of this, it is reasonable to suggest that the processes of TID and TD can be described using an ecological dynamics theoretical approach. This theory states that talent should be considered as a dynamically varying relationship moulded by the constraints imposed by physical and social environments, the tasks experienced, and the personal resources of a player; thus, it cannot be the result of a single independent factor (Sarmento et al., 2018).

Current sport science literature has investigated the TID and TD process of various sports and across the different codes of rugby (i.e., rugby union [RU], rugby league [RL], and rugby sevens). In particular, a number of papers have attempted to provide recommendations for how to advance the talent pathway in RL (e.g., Cupples et al., 2018; Dobbin et al., 2017; Gabbett, 2002, 2006, 2008; Ireton et al., 2017; McMahon et al., 2017; Spamer & Hare, 2001; Till et al., 2010, 2011, 2013, 2015, 2016a, 2016b, 2016c, 2016d, 2017a, 2017b; Waldron, 2013) and rugby sevens (e.g., Higham et al., 2013; Ross et al., 2014). Contrary to RL, a paucity of investigations endeavoured to address this topic in RU. However, since England RFU's and World Rugby's aim to ensure that rugby is enjoyed at all age grade (England Rugby, 2017; World Rugby, 2018) and considering that rugby is a sport in continuous evolution, there is the constant necessity to optimize the talent path in RU.

Studies report that there are no significant differences between forwards and backs for several important performance parameters, such as the distance covered in a game and the average sprint duration (Gabbett et al., 2008; McLellan et al., 2011). However, some key dissimilarities justify the importance and need for a specific investigation into the process of TID and TD specifically in RU. In fact, it is well acknowledged that RU has a clear diversification in the requirements for forwards and backs (Cahill et al., 2013; Deutsch et al., 2007; Smart et al., 2013; Valentza, 2017; Vaz et al., 2016; World Rugby, 2018). Moreover, the activity ratio (work:rest) for RL ranges from 1:5 to 1:6 (Gabbett et al, 2008), whereas it is 1:7 to 1:20 for RU (Deutsch et al., 2007; World Rugby, 2018). In addition, it is plausible to suggest that RU teams have to meticulously select their players in order to maintain both high intensity activity during the game and technical facets of play (e.g. scrum, lineout, maul) according to the different laws of the two games. Therefore, these differences reflect the need for a diverse approach when selecting and developing players for RL and RU. These differences justify the importance and need for a specific investigation into the process of TID and TD in specifically in RU.

Rugby union is played at varying levels of age and competition (Jones et al., 2018a), with figures reporting an increasing popularity across the globe (Freitag, Kirkwood, & Pollock, 2015). National governing bodies and professional clubs invested a large portion of their financial budget on the identification and development of talented youth athletes (Jones et al., 2018a; Reilly et al., 2000). However, the complex nature of predicting youth trajectories towards expertise remains a challenge for investors and coaches selecting athletes into talent development pathways (e.g., Abbott & Collins, 2002; Baker & Horton, 2004; Williams & Reilly, 2000). Differences in the physical qualities have been suggested as key discriminative functions between playing standards and age categories in RU (Jones et al., 2018b). Despite this, for a young player to become professional and be considered an expert in RU, they are required to possess a wide range of additional skills, such as effective psychological and technical characteristics (Davids et al., 2013a).

The topic of TID and TD has been studied extensively in other sports; particularly soccer. In fact, during a recent systematic review on TID and TD in soccer by Sarmento and colleagues (2018), three different macro-areas were identified as important aspects for TID and TD: *task constraints*, *performer constraints*, and *environmental constraints*. Each area was subcategorised (7 major factors in total) and results were presented in a one-dimensional or multi-dimensional analysis. To the authors knowledge, there are currently no articles examined the literature surrounding RU using any type of macro-areas analysis. Thus, the aim of this study was to systematically review the existing literature on TID and TD in RU in order to outline where the existing research lies, identify the most researched topics, provide updated guidance for coaches and practitioners, and outline avenues for future research.

Materials and Methods

Search Strategy: Databases and Inclusion Criteria

The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses guidelines. Searches were conducted using the key words of "rugby union", combined with the Boolean search of "AND", alongside combinations of the following keywords: "talent identification", "talent development", "early selection", "youth selection", "talent transfer", and "youth development". These searches were conducted on the electronic databases PubMed, Web of Science, Scopus, SPORTDiscus, and Google Scholar (February, 2019). Other studies were added following a process of citation checking in eligible papers and similar reviews.

The following inclusion criteria were applied to studies: (a) written in the English language, (b) used male participants, (c) has original and peer-reviewed data, and (d) solely examined RU data, and (e) specifically researched TID and/or TD. There were no restrictions regarding study design or publication year. Studies were not excluded on the basis of participants' age or skill level. The process was performed by two independent reviewers (first and last author). Agreement on study quality between reviewers was expressed as the inter-rater reliability (IRR) percentage (%)

and Cohen's kappa statistic (*k*) as reported in Figure 2.1. If an agreement was not reached by the two reviewers a third reviewer (second author) assisted in making the decision.

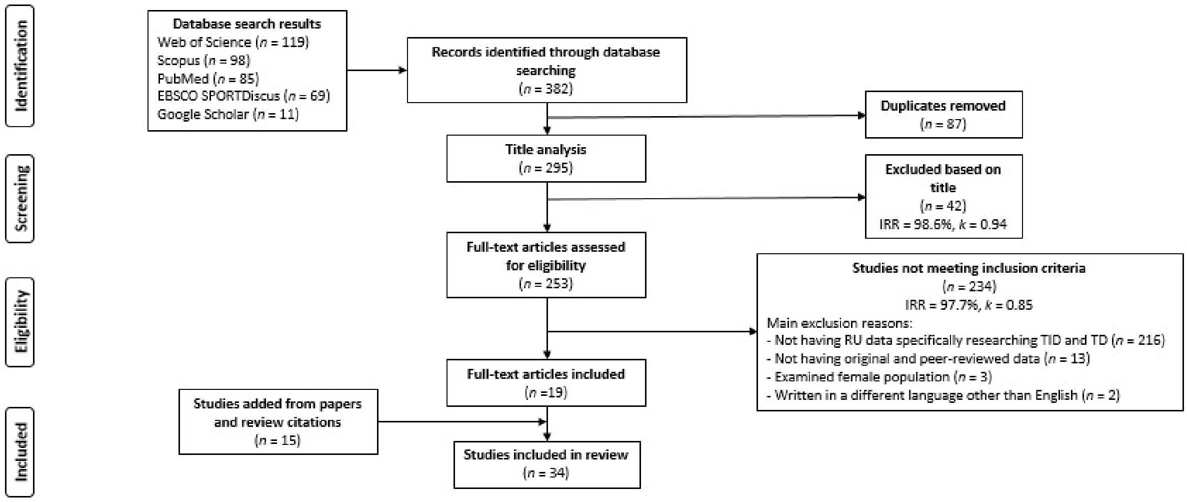

Figure 2.1. Schema of PRISMA guidelines followed, comprised of the processes for identification, screening, eligibility, and inclusion of papers.

Quality of the Studies and Extraction of Data

Studies were assessed for their overall methodological quality following the recommendations of Faber and colleagues (2015). As such, Critical Review Forms were used to score quantitative papers using Law and colleagues (1998) assessment guidelines (counting 16 items) and Letts and colleagues (2007) for scoring qualitative studies (counting 21 items). If a paper presented both quantitative and qualitative analysis, both scoring systems were applied.

Each quantitative article was assessed objectively to determine if it contained the following components: objective (item 1), relevance of background literature (item 2), appropriateness of the study design (item 3), sample included (items 4 and 5), informed consent procedure (item 6), outcome measures (item 7), validity of measures (item 8), details of the intervention procedure (item 9), significance of results (item 10), analysis (item 11), clinical importance (item 12), description of drop-outs (item 13), conclusion (item 14), practical implications (item 15), and limitations (item 16).

Qualitative studies were assessed to identify whether they included: objective (item 1), literature reviewed (item 2), study design (items 3, 4, and 5), sampling (items 6, 7, 8, and 9), data collection (descriptive clarity: items 10, 11, and 12; procedural rigor: item 13), data analyses (analytical rigor: items 14 and 15; auditability: items 16 and 17; theoretical connections: item 18), overall rigor (item 19), and conclusion/implications (items 20 and 21). The score per each item were: 1 (meets criteria), 0 (does not meet the criteria), or N/A (not applicable).

The overall score was expressed as a percentage by summing the points in a given article and dividing by the total number of scored items for that specific research design (i.e., 16 or 21 items). If certain items were scored as "N/A", then the total number was adjusted to reflect that. The classification adopted the guidelines provided by Faber and colleagues (2015) and Te Wierike and colleagues (2013), therefore the articles were graded as: (a) excellent methodological quality—with a score >75%, (b) good methodological quality—with a score between 51 and 75%, and (c) low methodological quality—with a score ≤50%. To assess risk of bias, a Cochrane Consumers and Communication Review Group's data extraction template was adopted for this study. One author extracted the data (first author) and another verified the decision (last author), with disagreements resolved by discussion between the two authors.

Articles included in this study were classified according to the research topics that emerged from the included articles and adopted a similar ecological dynamics theoretical approach implemented by Sarmento and colleagues (2018). The ecological dynamics theoretical framework states that talent development, skill acquisition, and superior performance should be considered as a relationship that varies dynamically and is shaped by constraints affected by task (i.e., engagement in activities), performer (i.e., psychological, technical, tactical, anthropometric, and physiological characteristics), and environmental (i.e., relative age effects and socio-cultural factors) constraints of each individual (Davids et al., 2013b, 2017).

Results

Search, Selection, and Inclusion of Publication

The "Identification phase" returned 382 papers including 87 duplicates that were removed either automatically or manually. During the "Screening phase", 295 papers were examined based on their title, with 42 subsequently excluded (IRR = 98.6%, $k = 0.94$). A total of 253 articles were fully assessed at the "Eligibility phase", of which a high proportion ($n = 216$) were excluded (IRR = 97.7%, $k = 0.85$) because they had no RU data specifically researching TID and TD. Others papers were also excluded because they did not have original and peer-reviewed data ($n = 13$), they examined a female population ($n = 3$), or were written in a language other than English ($n = 2$). After this screening, 15 articles were added from studies and review citations as reported in Figure 2.1. At the end of the "Selection phase", a total of 34 articles were included in the review.

Quality of the Studies

Regarding the quality of studies, a separate mean score for quantitative, qualitative, and mixed-methods articles was calculated. Only one qualitative-only paper was found and its score was 100%. The overall means for the studies were classified as excellent: quantitative-only scoring 85.6% ($n = 31$) and mixed-methods scoring 85.7% ($n = 2$). Specifically, of the 34 articles; five scored between 51 and 75%; one scored 100%; and the remaining 28 achieved an overall rating of >75% as reported in Table 2.1.

General Description of the Studies

The authors categorised the studies in this review into one-dimensional (OD) (i.e., only analysed one factor) and multi-dimensional (MD) (i.e., analysed two or more factors) articles. This included analysing each study according to the seven major research topics that came to light from the investigation. This allowed the authors to adopt the ecological dynamics theoretical framework, as previously presented by Sarmento and colleagues (2018). The main findings of the 34 articles are presented in Table 2.1.

Articles used in this review focused on: (1) *task constraints* (OD = 1, MD = 1): (a) participation history (OD = 1, MD = 1); (2) *performer constraints* (OD = 7, MD = 47): (a) psychological factors (OD = 1, MD = 0), (b) technical and tactical skills (OD = 2, MD = 7), (c) anthropometric factors (OD = 4, MD = 20), and (d) physiological factors (OD = 0, MD = 20); and, (3) *environmental constraints* (OD = 2, MD = 7): (a) relative age effects (OD = 2, MD = 3) and, (b) socio-cultural factors (OD = 0, MD = 4). The studies included in the systematic review accumulated a total of 50,716 players and 27 coaches. In total, ten out of 34 articles were OD in nature, with the remaining 24 comprising of MD methodologies. Although more articles were MD, 13 only combined two factors, whilst none of these included all of the seven major factors. It appears that anthropometric (*n* = 24), physiological (*n* = 20), and technical and tactical (*n* = 9) performer constraints were the most researched factors. See Figure 2.2.

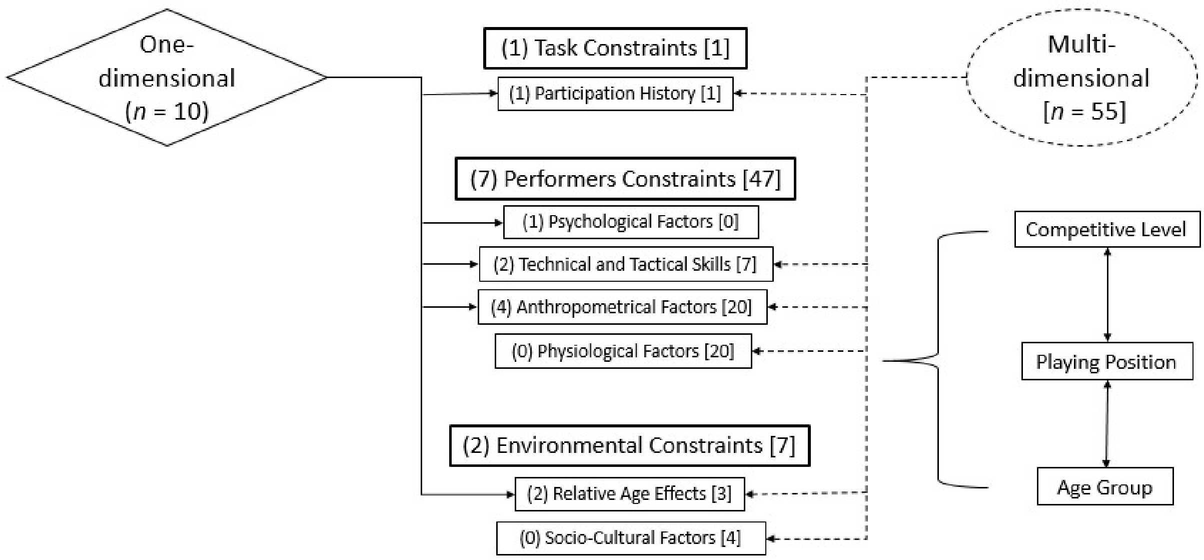

Figure 2.2. One-dimensional and multi-dimensional classification of papers in accordance with the ecological dynamic theoretical framework.

Table 2.1. Summary of the 34 articles included in this systematic review.

Authors	Aim	Participants	Constraints Examined	Results	Quality Score
Darrall-Jones et al. (2015)	To evaluate the anthropometric and physical characteristics of English regional academy players by age category.	Professional regional academy U16 (n = 29) U18 (n = 23) U21 (n = 15)	Anthropometric and physiological factors	Anthropometric and physical characteristics were more developed across older groups. Physiological characteristics also improved with age. Sprint times, aerobic profile, and ASR appear to remain stable across age categories.	87.5%
Darrall-Jones et al. (2016)	To evaluate the anthropometric, sprint, and high-intensity running profiles of English regional academy players by playing positions.	Professional regional academy U16 (n = 29) U18 (n = 24) U21 (n = 15)	Anthropometric and physiological factors	Forwards displayed significantly different anthropometric and sprint momentum compared to backs. Body mass and sprint momentum have the largest differences at consecutive age categories for positions.	81.3%
Delahunt et al. (2013)	To describe and contrast the body composition and anthropometric profiles of adolescent Irish rugby union players using total-body dual-energy x-ray absorptiometry.	Schoolboy U16 (n = 136)	Anthropometric factors	There were significant differences in fat mass characteristics between forwards and backs. The players with a higher body mass were twice as likely to be classified as forwards.	87.5%
Durandt et al. (2011)	To establish how many players in the 2005 U13 group participated in subsequent U16 and U18 tournaments.	Regional and national U13, U16, and U18 (n = 349)	Participation history	Talented young players (U13) were not necessarily selected to participate at later stages (U16 and/or U18). Specifically, only the 31.5% of the initial talented group reached the U16 squad and the 24.1% reached the U18 team.	73.3%
Farrow et al. (2010)	To compare expert, intermediate, and novice participants on their ability to recall and anticipate structured rugby union line-out patterns.	Senior international (n = 20) Provincial (n = 15) Novice (n = 14)	Technical and tactical skills	Expert rugby players were able to recall and anticipate structured patterns of play with significantly greater accuracy than the lesser skilled participants. Overall, technical videos predicted players' levels.	87.5%
Fontana et al. (2015)	To explore the anthropometric reference database of senior rugby union players competing at different levels in the southern European region.	Professional (n = 362)	Anthropometric factors	Forwards had greater anthropometric characteristics than backs. The lower the competitive level, the higher the within-role variability observed. Fat free mass was the variable that predicted the likelihood of being classified as an international or national player.	87.5%
Fontana et al. (2016)	To examine if and to what extent specific anthropometric and functional characteristics can accurately predict subsequent career progression in rugby union.	U16 to senior national and international (n = 531)	Anthropometric and physiological factors	Players' success was predicted using a linear combination of anthropometric and physical characteristics, among which a lower percent body fat and higher speed over a 15 m sprint provided the most important predictors of the highest career success.	93.3%
Grobler et al. (2017)	To determine the prevalence of RAEs in schoolboy rugby union players in South Africa. Also, to determine if RAEs were related to physical fitness parameters.	Schoolboy U14 to U16 (n = 281)	RAEs and anthropometric and physiological factors	Stronger and more physical players were most likely to be selected. RAEs were also prevalent in all groups, with the first two quartiles of the year overrepresented. U15s demonstrated a significant relationship between stature, hand-grip strength, and upper-body muscle endurance and RAEs.	93.8%
Hansen et al. (2011)	To investigate the discriminative ability of rebound jump squat force–time and power–time measures in differentiating speed performance and competition level in professional and academy rugby union players.	Professional (n = 25) Academy (n = 15)	Anthropometric and physiological factors	Force and power differentiated playing levels. Lean mass parameters also helped the transition from academy to professional status.	87.5%
Hill et al. (2015)	To identify both positive and negative issues that influenced talent development using a retrospective qualitative investigation, which was conducted with academy coaches and directors within nine different English rugby union academies.	Professional regional academy (n = 15)	Psychological factors	A range of positive (e.g., self-regulated learning strategies, ownership and independence, and motivation), negative (e.g., lack of commitment, lack of development awareness, and mental health issues) and dual-effect (e.g., perfectionism, obsessive passion, and over-commitment) characteristics were identified.	100% (Qual)

Holway and Garavaglia (2009)	To explore anthropometric characteristics to establish whether front row forwards have larger muscular–skeletal parameters than the other groups of players.	Professional and semi-professional (n = 133)	Anthropometric factors	Front row forwards had larger proportional muscle and skeletal structure both than other forwards and backs, as well as similar muscle-to-bone ratio.	92.9%
Howard et al. (2016)	To evaluate the mediating effect of biological maturation on anthropometric measurements, performance indicators, and subsequent selection in a group of academy rugby union players.	Professional regional academy U14 to U17 (n = 51)	Anthropometric and physiological factors	There was a selection bias towards early-maturing players. This prevalence appears to result from the superior anthropometric attributes exhibited, which likely contributed towards improved components of speed, anaerobic power, and momentum.	93.8%
Jones et al. (2018a)	To compare the physical qualities between academy and schoolboy rugby union players.	Professional regional academy U18 (n = 55) Schoolboy U18 (n = 129)	Anthropometric and physiological factors	Academy players had superior height, body mass, strength, 20 and 40 m sprint, 10 m momentum, and aerobic fitness compared to schoolboy players.	81.3%
Jones et al. (2018b)	To compare anthropometric and physical factors between current professional and amateur rugby union players. Also, to determine which anthropometric and physical characteristics were predictive of playing standards.	Professional and amateur (n = 60)	Anthropometric and physiological factors	Professional players were anthropometrically and physically superior to amateur players. The sum of the eight skinfolds, power, and CMJ peak velocity were predictive of playing standard.	75%
Kearney (2017)	To examine RAEs in forwards and backs in international players from four different countries.	International (n = 6,663)	RAEs	RAEs were not greater in backs than in forwards. RAEs may have influenced talent development in South African rugby union to a greater extent than in other major playing nations.	92.9%
Lewis et al. (2015)	To examine the presence and prevalence of RAEs in Welsh age-grade rugby union. Also, to consider how coaches' selection processes have the potential to contribute to the manifestation of RAEs.	Regional to national U7 to U19 (n = 34,788) RDO (n = 26)	RAEs and socio-cultural factors	Those born in BQ1 were overrepresented compared to those born in BQ4. Differences increased with level of performance. Players' physical characteristics, 'open mindedness', 'work ethic', and 'overall coachability' were also noted as being important criteria when selecting players.	87.5% (Quant) 90.5% (Qual)
McCarthy and Collins (2014)	To investigate the initial academy identification process and the impact of RAEs during this phase in England. Also, the same cohort of players were assessed as they progressed (or not) into senior professional level.	Professional regional academy U16 to senior (n = 118)	RAEs	The initial selection was significantly skewed towards BQ1 and BQ2 players. However, there was evidence of a RAE reversal effect, whereby the conversion rate was skewed towards BQ3 and BQ4 players.	92.9%
Parsonage et al. (2014)	To examine conditioning-specific movement tasks and physical fitness characteristics of U16 players. Also, to perform an exploratory analysis that classified players into groups by their conditioning specific movement tasks ratings, then compare scores between the groups.	Regional and national U16 (n = 156)	Anthropometric and physiological factors	Training conditioning specific movement tasks (overhead squat, Romanian deadlift, double leg to single leg landing, single leg squatting, sprinting, and jumping) improved sprinting over 40 m and endurance running. Successful training intervention after movement screening can facilitate players' long-term development.	81.3%
Pienaar and Spamer (1998)	To determine why certain 10-years-old rugby union players who were initially identified as having talent were selected in a high-performance primary school programme.	Schoolboy U10 (n = 31)	Technical and tactical skills and anthropometric and physiological factors	The successful group was significantly better in rugby skills and motor abilities, including passing for distance, passing for accuracy, throwing over the crossbar, rolling and picking up of the ball running speed, agility run, sit and reach, and vertical jump.	87.5%
Pienaar et al. (1998)	To identify the physical, rugby specific skills, and anthropometric variables that enable coaches to identify 10-year-old schoolboys who could become successful rugby union players.	Schoolboy U10 (n = 218)	Technical and tactical skills and anthropometric and physiological factors	Anthropometric parameters (body height), physical characteristics (sprint and strength), and some rugby-specific skills (passing for accuracy) were qualities that predicted selected and deselected young players.	93.8%

Plotz and Spamer (2006)	To compare anthropometric, game-specific, and physical variables in talented South African and English 18-year-old players.	International U18 (n = 64)	Technical and tactical skills and anthropometric and physiological factors	Both South African and English groups reported no significant anthropometrical differences. English players demonstrated significantly worse results in the physical and motor abilities, while the South African players performed the best in game-specific skills.	75%
Quarrie et al. (1996)	To describe the anthropometric and physical performance characteristics of a sample of professional rugby union players to highlight differences between the positional categories of the players.	Professional (n = 94)	Anthropometric and physiological factors	Anthropometric characteristics of forwards differed significantly between positional categories. As an example, Locks and loose forwards were taller than the front row forwards, whereas outside backs were taller, heavier, and had greater than the inside backs.	87.5%
Read et al. (2017)	To compare the physical characteristics of academy and schoolboy U18 rugby union players by position (forwards and backs).	Regional academy and schoolboy U18 (n = 66)	Anthropometric and physiological factors	Academy players covered greater total distance and greater jogging distances than school players. Academy backs accumulated greater player load and the academy forwards greater sprinting distance than school players in their respective positions.	87.5%
Roberts and Fairclough (2012)	To examine whether RAEs existed in representative youth rugby union squads. Also, to what extent is an RDO, who responsible talent identification and development, was aware of RAEs.	Regional representatives U13 (n = 43) U14 (n = 47) U15 (n = 47) U16 (n = 30) RDO (n = 1)	RAEs and socio-cultural factors	RAEs were found to exist in all the age groups, with the largest effect size found in the U16. The RDO revealed a lack of knowledge, understanding, and awareness of RAEs.	87.5% (Quant) 81% (Qual)
Scott et al. (2003)	To evaluate the differences in aerobic fitness between forwards and backs from a professional rugby union team.	Professional (n = 28)	Anthropometric and physiological factors	Backs had a higher peak oxygen uptake per kilogram than forwards. The greater stature, body mass, and body fat percentage of forwards is likely to be the reason for their lower peak oxygen uptake.	87.5%
Sedeaud et al. (2013)	To investigate the changes over time in anthropometric parameters of junior and senior rugby union players in France.	Regional and national Senior (n = 2,051) Junior (n = 145) U15 (n = 448)	Anthropometric factors	Senior backs have become heavier by 12 kg and taller by 5.4 cm, whilst forwards have become heavier by12.3 kg and taller by 2.9 cm. Junior backs have become taller by 6 cm and heavier by 9.9 kg, whilst forwards have become taller by 4.4 cm and heavier by 11.1 kg. U15 backs have gained 5.1 cm and 6.5 kg, whilst forwards have gained 4.7 cm and 4.7 kg.	92.9%
Sedeaud et al. (2017)	To quantify the impact of selections and shared selections on the match results in French international rugby union.	Senior international (n = 1,054)	Technical and tactical skills and socio-cultural factors	Squads with superior collective effectiveness where more successful than those with less. Overall, the coach's culture affects selection.	86.7%
Sherwood et al. (2018)	*Study 1:* To understand whether accuracy when recalling rugby union patterns is a valid measure of on-field decision making performance. *Study 2:* To explore differences between novice and expert players on a pattern recall task that included structured, semi-structured, and unstructured rugby union patterns.	*Study 1:* Senior professional (n = 57) *Study 2:* Professional development squad U18 (n = 47) University recreational level (n = 41)	Technical and tactical skills	*Study 1:* Total number of years playing rugby union was correlated with recall accuracy. *Study2:* Experts were significantly more accurate than novices when recalling structured and semi-structured patterns. However, there were no differences when recalling unstructured patterns.	87.5%
Smart et al. (2013)	To examine the between-player differences and within-player changes in physical performance in rugby union players.	Senior professional and provincial (n = 1,161)	Anthropometric and physiological factors	Small-to-moderate differences between players selected and not selected for provincial teams and small-to-large differences between provincial and professional players.	81.3%

Spamer and De La Port (2006)	To identify the characteristics of U16 and U18 schoolboy rugby players in South Africa with reference to anthropometric variables, physical and motor abilities, and game-specific skills.	Schoolboy U16 (n = 71) U18 (n = 75)	Technical and tactical skills and anthropometric and physiological factors	U18s were taller, heavier, and leaner than U16s. U18s were also stronger, more agile, and had a better aerobic endurance than U16s. Conversely, U16s were faster than U18s. Game-specific handling skills of both U16 and U18 decreased across the study.	81.3%
Spamer et al. (2009)	To conduct a comparative study between elite U16 rugby union players of New Zealand and South Africa, by examining game specific skills and anthropometric and physical profiles.	Provincial U16 (n = 88)	Technical and tactical skills and anthropometric and physiological factors	New Zealand players outperformed the South African players in game-specific tests, physical abilities, and anthropometric measurements.	62.5%
van Gent and Spamer (2005)	To compare playing groups in terms of anthropometric, rugby-specific skills, physical, and motor components among U13, U16, U18, and U19 provincial players.	Provincial U13 (n = 21) U16 (n = 22) U18 (n = 18) U19 (n = 19)	Technical and tactical skills and anthropometric and physiological factors	There were significant differences between playing groups for anthropometric, rugby-specific, skills, physical, and motor components. Forwards developed later in terms of anthropometric components. The older the players, the fewer the differences in rugby-specific skills, physical, and motor components.	81.3%
Winn et al. (2016)	To examine whether higher levels of deprivation was associated with lower engagement in organised activities such as rugby practice and competition.	Provincial U15 (n = 590)	Participation history and socio-cultural factors	The more deprived players accumulated less rugby-specific practice hours and engaged in fewer sport than their less deprived peers.	87.5%
Wood et al. (2018)	To provide normative data relating to the physical fitness of elite adolescent Irish rugby union players and determine the differences in the physical capacities between players in the forward and back units.	International U18 (n = 89)	Anthropometric and physiological factors	Forwards had greater anthropometrics than backs. Forwards had a significantly lower CMJ height, triple hop for distance score, and 150 m shuttle test score on their right leg compared to backs. Forwards had a significantly higher 10 m sprint time than backs.	87.5%

U = under; n = number; RDO = Rugby Development Officer; RAEs = relative age effects; BQ = birth quarter; maxV = maximal velocity; Yo-Yo IRT-1 = Yo-Yo intermittent test level 1; 30-15IFT = 30-15 intermittent fitness test; ASR = anaerobic speed reserve; PCDEQ = Psychological Characteristics of Developing Excellence Questionnaire.

Discussion

The aim of this study was to review the existing literature investigating TID and TD in male RU players. Based on an ecological dynamic theoretical framework, the following sections discuss the main findings of the 34 papers included in this systematic review.

Task Constraints

Participation History

Previous research in sport has identified three pathways towards senior expertise: (a) early sampling, (b) early engagement, and (c) early specialisation (see Ford & Williams, 2017). Within the context of RU, there is limited research on the most appropriate pathway towards senior professional status, with only two articles identified in this systematic review (Durandt et al., 2011; Winn et al., 2016). Although there appears to be no existing literature that explores the practice history profiles of professional RU players, Winn and colleagues (2016) examined the effect of deprivation on participation in Welsh RU developmental activities. They found that those players from more deprived groups accumulated less hours of structured RU practice and participated in fewer sports when compared to those from less deprived groups. This may be due to the unviable cost, parental support, and limited access to coaching, resources, and facilities; which are crucial for improved athlete development outcomes (Côté et al., 2014). Since participation in structured practice and multi-sport activities is vital for achieving expertise in sport (see the Development Model of Sport Participation; Côté et al., 2007), this may have significant developmental implications based on individual circumstances. Thus, deprivation is an important consideration whilst examining who is at risk of lower access to structured practice and multi-sport activities in RU. As such, RU coaches and practitioners, as well as clubs and organisations, are encouraged to offer more equitable access to athlete development pathways, which may also provide a larger cohort of prospective talent in the future (Till & Baker, 2020).

Second, Durandt and colleagues (2011) investigated the effectiveness of TID procedures in U13 South African players and their consequent progression towards U16 and U18 squads. Considering that 31.5% and 24.1% of the U13 players were reselected to play in the U16 and U18 squads, respectively, it is suggested that early selection processes may be flawed due to the high levels of deselection. However, it is important to note that since reaching higher competition levels is inevitably going to become increasingly difficult with age (i.e., into adulthood), deselection at some stage during the talent pathway is going to be somewhat unavoidable (Faber, Damsma, & Pion 2021). Moreover, since selection at U13 is during a stage of considerable maturational differences (Kelly & Williams, 2020), as well as the timing aligned to the introduction of more structured rules (i.e., 15-a-side) and competition (i.e., league formats) (Till et al., 2020), individual variances should be considered.

Overall, according to these two studies (Durandt et al., 2011; Winn et al., 2016), key stakeholders (e.g., coaches, practitioners, administrators) in charge of planning, adopting, and evaluating long-term player development programmes in RU should be cautious of individual deprivation circumstances and early TID. Moving forward, future research is encouraged to substantiate these claims. Furthermore, since there appears to be no research exploring the developmental trajectories of players specifically in RU, further research identifying the most suitable pathway is warranted.

Performer Constraints

Psychological Factors

Psychological skills have been broadly investigated as a factor of achieving success in high-performance sport environments. However, due to search strategy, there only appears to be one study that has examined the psychological factors that may influence TID and TD in RU (Hill et al., 2015). Using a retrospective research design, Hill and colleagues (2015) attempted to identify the range of psychological characteristics that impact the TD process within English RU academies. They interviewed 15 professional RU coaches, who revealed that they perceived commitment, self-regulation, resilience, realistic performance evaluation, growth mind-set, and being proactive, as key psychological characteristics that discriminate successful players in a professional RU environment. It is suggested this skillset is vital because it provides players with the essential competencies to face developmental opportunities and challenges (Hill et al., 2015).

Similar findings have been reported in previous sport literature. For instance, self-regulation has been illustrated as one of the most important characteristics for TD; as individuals without this skill tend to rely on others, attributing failures to maladaptive causes, and are not in charge of their own development (Karoly, 1993; Petlichkoff, 2004). It may therefore be useful for key stakeholders employed in RU to assess the psychological profiles of players in order to outline individual strengths and weaknesses that are important to development (e.g., Hill et al., 2018). Unfortunately, at the time of writing, there was no research investigating: (a) the perceptions or psychological profile of youth RU players according to their perceived experiences or responses, and (b) how psychological skills can be effectively trained specifically in youth RU players. Thus, future research is encouraged to explore the perceptions and psychological profile of young RU players, as well as considering effective methods to practically facilitate optimal psychological development.

Technical and Tactical Skills

The ability to recognise patterns of play is an essential skill for RU players (Hendricks, 2012) as it is a key component of decision-making and anticipation (Farrow et al., 2010). In this review, two studies investigated whether the ability to recall patterns could differentiate players based on competitive playing levels (Farrow et al., 2010; Sherwood et al., 2018). Sherwood and colleagues (2018) found that expert RU players were significantly more accurate than novices in recalling structured and semi-structured tactical patterns. However, there were no statistically significant differences when recalling unstructured tactical patterns. These findings are consistent with those that previously emerged in a study on soccer players (van Maarseveen, et al., 2018), which concluded that pattern recall seems to be an inconsistent method to discriminate players' performance level, and therefore it should not be used as the only way to select athletes. In contrast, a study of Farrow and colleagues (2010) revealed that pattern recall could discriminate expert, intermediate, and novice RU players. Despite these findings, the major limitation of Farrow and colleagues' (2010) investigation is that they examined a tactical component that exclusively involved forward players. Therefore, ecological validity is lacking for back players due to the diverse positional requirements that exist in RU. Together, these findings suggest that pattern recall could be a useful tool for TID and TD; albeit as part of a holistic battery of assessments. Further research exploring tactical situations (e.g., structured vs. unstructured), position-specific considerations (i.e., forwards vs. backs), and playing levels (e.g., selected vs. deselected) in youth RU is warranted.

Seven multi-dimensional studies analysed TID and TD in RU from a technical and tactical perspective. These coincided with coach culture (Sedeaud et al., 2017), as well as anthropometrical and physiological characteristics (Plotz & Spamer, 2006; Pienaar, et al., 1998; Pienaar & Spamer, 1998; Spamer & de la Port, 2006; Spamer et al., 2009; van Gent & Spamer, 2005). Broadly, these studies attempted to identify the key factors that influenced player selection. Interestingly, a novel approach was used by Sedeaud and colleagues (2017), whereby they analysed how much collective effectiveness (i.e. the ability to play well together) impacted tactical outcomes during French senior international selection. They revealed how collective effectiveness relied on a balance between stability and workforce renewal during the selection process for competition. Indeed, discipline and cohesion between teammates have been considered crucial factors in team sports during the execution of specific strategies and tactics (Hendricks et al., 2013; Sewry et al., 2015). As an example, during set pieces in RU games (e.g., scrum, line-out) when turnovers become more decisive, cohesion and teamwork among teammates is vital to gain an advantage over the opposition. From a position-specific perspective, van Gent and Spamer (2005) proposed forwards may require stronger cohesion and coordination in reading offensive, defensive, and breakdown situations; whereas backs may require good handling skills, off-loads, and outflanking capabilities. As such, it is suggested that teammate capabilities and position-specific requirements are important considerations during the TID and TD processes.

Two studies compared the selection process of U10 South African players (Pienaar et al., 1998; Pienaar & Spamer, 1998). As part of their longitudinal study, Pienaar and Spamer (1998) found that during the initial TID at U10, greater physical-specific skills (i.e., linear speed, agility, sit and reach, and vertical jump characteristics) were important for selection. The subsequent selection two years later at U12 compared those who were successful against those who were unsuccessful. Findings revealed that a higher level of technique-specific skills (i.e., passing for distance, passing for accuracy over 7 m, throwing over the crossbar, and rolling and picking up of the ball) discriminated selection decisions in the U10 age group. This demonstrates how selection was initially based on physical qualities, but then subsequently oriented towards technical attributes. Similar findings were revealed by Pienaar and colleagues (1998). They found how technique-specific skills, as well as some physical-specific skills, were important for U10 selection in South African youth RU. However, questions remain over the validity of these findings and the effectiveness of such TID practices due to the maturation biases of early selection, as well as considering the lack of long-term outcomes associated with these studies.

Plotz and Spamer (2006) and Spamer and colleagues (2009) adopted a cross-cultural comparison as part of their methodology when exploring youth international RU players across three nations (England, New Zealand, and South Africa). Spamer and colleagues (2009) illustrated differences between New Zealand and South African youth U16 players on several technical, physiological, and anthropometrical factors. Specifically, New Zealand players were taller, heavier, faster, as well as possessing significantly greater ground and kicking skills. Conversely, Plotz and Spamer (2006) revealed how South African youth U18 players outperformed their English and New Zealand counterparts on a number of technique-specific tests. These findings suggest differences in age and national sport culture are important considerations whilst exploring TID and TD processes in RU. However, it is also important to note the limited sample size (n = 88 and n = 64) in both these studies. Future research should consider the opportunities that are presented to young players in different national contexts (with larger samples), to better understand the organisational structures that support long-term development outcomes in RU.

As previously mentioned, inter-positional differences among players is an important consideration during the TID process in RU (van Gent & Spamer, 2005). van Gent and Spamer (2005) compared inter-positional characteristics among South African academy players (i.e., U13, U16, U18, and U19). They reported that forwards mature later compared to backs, whilst backs have superior technical and physical skills compared to forwards. This is likely due to backs being largely responsible for decision-making actions and ball-possession tactics, whereas forwards are more responsible for greater invasive actions (i.e., first contact, scrumming, turnovers). Interestingly, the older age groups (i.e., U18 and U19) had considerably fewer differences compared to the younger age groups (i.e., U13 and U16). These findings suggest that both playing position and age group are important contextual factors when exploring the TID and TD processes.

Overall, findings illustrate the importance of technical and tactical skills in RU. More specifically, situational factors, position-specific requirements, playing level, national sport culture, and age group may all play an important role in the development of technical capabilities in RU. Thus, future research is encouraged to consider these circumstantial factors as part of their methodologies, to gain a broader insight into the technical and tactical requirements in RU.

Anthropometric and Physiological Factors

It is common for anthropometric and physiological factors to be combined within research methodologies, therefore these domains have been synthesised and discussed together in this section. Four studies focused solely on the analysis of anthropometric factors in Argentinian, French, Irish, and Italian RU populations (Delahunt et al., 2013; Fontana et al., 2015; Holway & Garavaglia, 2009; Sedeaud et al., 2013). In a 20-year French longitudinal investigation, Sedeaud and colleagues (2013) found that both youth and senior players selected to play in national RU academies and professional clubs became progressively heavier and taller compared to those selected during the previous years of their investigation (e.g., selected players have increased by 12.3 kg in body mass and 6 cm in height from 1988 to 2008). Similarly, a comparison between those playing in the top level of Argentinian RU and the general population showed that front row forwards (props and hookers) had largest skeletal structure and greater muscle mass (Holway & Garavaglia, 2009). This suggests that anthropometric factors are becoming increasingly important during the TID process in RU.

Inter-position differences are crucial for RU players since different roles require diverse anthropometric profiles. In fact, even at a young age, U15 and U21 French (Sedeaud et al., 2013) and U16 Irish (Delahunt et al., 2013) forwards were found to be heavier, taller, and older compared to backs, with body mass being the significant predictor of role position classification. Moreover, fat percentage also discriminated levels among players with some inter-position differences (Fontana et al., 2015). For instance, in a cross-sectional study on Italian players, the lower the level of the player, the closer the percentage of fat free mass was compared to the normal population (Fontana et al., 2015). This is in agreement with previous findings on South African youth players that reported national youth representatives had a lower body fat percentage compared to their provincial counterparts (Spamer & de la Port, 2006).

Importantly, backs possess lower fat percentage compared to forwards (Holway & Garavaglia, 2009), which is likely because they are involved in short duration high-intensity actions (Wood et al., 2018; Quarrie et al., 1996). Together, these findings suggest that the only predictive value to discriminate players' status is to measure fat percentage, with professionals being leaner than amateurs as previously reported in literature (Jones et al., 2018b). An investigation on players' selection showed that forward positions require players to be older (relative to their age group peer) if athletes want to be successful to play in this role (Sedeaud et al., 2013). In fact, some authors (Holway & Garavaglia, 2009) agreed that forwards develop anthropometric components important for their role later compared to other positions (e.g., backs), suggesting that these factors become more predictive of selection for at older ages for forwards compared to other positions and thus, a more longitudinal screening on their maturity status is preferred. Cumulatively, these findings confirm that anthropometric characteristics are used by coaches as one of the main criteria for TID.

Anthropometric and physiological factors are often analysed together as body size and speed are correlated to force production and momentum, which are vital during an invasion game such RU (e.g., while ball-carrying; Barr et al., 2014). However, other performance aspects can also interact with body sizes and physical parameters during the TID and TD processes (e.g., technical and tactical skills: Pienaar et al., 1998; Pienaar & Spamer, 1998;

Plotz & Spamer, 2006; Spamer et al., 2009; Spamer & de la Port, 2006; van Gent & Spamer, 2005; relative age effects: Grobler et al., 2017). Therefore, for the purpose of the current section, a total of twenty multi-dimensional studies were selected since they included anthropometric and physiological factors (Darrall-Jones et al., 2015, 2015; Fontana et al., 2016; Hansen et al., 2011; Howard et al., 2016; Jones et al., 2018a, 2018b; Parsonage et al., 2014; Quarrie et al., 1996; Read et al., 2017; Scott et al., 2003; Smart et al., 2013; Wood et al., 2018).

Overall, results show that high-performing RU players when compared to lower-performing RU players had superior: (a) maximal speed (Jones et al., 2018a; Parsonage et al., 2014); (b) acceleration (Pienaar & Spamer, 1998; Smart et al., 2013; Wood et al., 2018); (c) momentum (Darral-Jones et al., 2015a, 2015b; Fontana et al., 2016; Jones et al., 2018b; Quarrie et al., 1996); (d) maximal strength (Grobler et al., 2017; Hansen et al., 2011; Pienaar et al., 1998; Spamer & de la Port, 2006; van Gent & Spamer, 2005); (e) peak power (Howard et al., 2016); (f) agility and change of direction performance (Spamer et al., 2009); and, (g) speed endurance and aerobic qualities (Read et al., 2017; Scott et al., 2003).

Some authors (Howard et al., 2016) correlated the optimal size and physical attributes of selected players with the peak of their individual biological maturation, which include changes in skeletal, dental, reproductive, and neuroendocrine systems (Cumming et al., 2012; Malina et al., 2004). The connection among these factors affects the selection of young talent in RU since early-maturing players possess greater anthropometric and power characteristics compared to their age-equivalent but later-maturing counterparts (Howard et al., 2016). In fact, the complex phenomenon of relative age effects (see the following section) are linked to the phenomena of biological maturation, as reported also in the study of Grobler and colleagues (2017). They attempted to analyse the prevalence of relative age effects in young South African RU players and determine if they were related to anthropometrical and physiological parameters. Results showed a significant overrepresentation of those born during the early months of the selection year (i.e., relative age effects), as well as those who were relatively older being more mature and possessing greater handgrip and upper body strength (although findings varied depending on age group).

Pienaar and colleagues (1998) used a battery of eight assessments, including anthropometric, physiological, and technical tests, which were subsequently able to predict 88% of future talents from a pool of already selected U10 RU players. Among all, the technical test of "passing for accuracy over 7 m" had the highest practical significance among all other tests of the battery, indicating that passing skill is fundamental for every player to possess. However, it has been reported that although there were many more anthropometric, physiological, and technical differences among backs compared to forwards (in all age groups), these were attenuated in older squads as also reported in a previous investigation (van Gent & Spamer, 2005). Therefore, evidence suggests that "handling skills" should be monitored throughout the development of a player, alongside anthropometric and physiological qualities, if coaches aim to select and develop talented players.

In summary, the findings indicate that although anthropometric and physiological characteristics are two key factors during TID and TD in RU, a combination of other features, such as technical and tactical skills, should be encouraged to be taken into account when attempting to select talented forwards and backs of different ages. Future research is encouraged to expand on age group and position-specific characteristics of those selected into academies to better understand the mechanisms of the selection processes.

Environmental Constraints

Relative Age Effects

Skewed birthdate distributions among youth players favouring those born near the start of the cut-off date for an age group have been well-documented (Webdale et al., 2020) in sport—commonly known as relative age effects (RAEs; Barnsley et al., 1985). From an athlete development viewpoint, those born in birth quarter one (BQ1) of an annual-age group in England (i.e., September, October, November) are more likely to be endowed with superior anthropometric and physiological characteristics, cognitive skills, and an older training age compared to their later born BQ4 peers (i.e., June, July, August; Hancock et al., 2013).

From a recreational perspective, Lewis and colleagues (2016) found consistent RAEs across all Welsh age-grade and district cohorts from U7 to U19 (e.g., BQ1=29% vs. BQ4=22%). They also revealed an increasingly pronounced effect at U16 representative levels where regional and national selection occurs (e.g., BQ1=44% vs. BQ4=12%). Likewise, Roberts and Fairclough (2012) examined the North West of England representative squads from U13 to U16, revealing a significant overrepresentation of those born in BQ1 (46%) compared to those born in BQ4 (14%). Moreover, McCarthy and Collins (2014) identified a significant overrepresentation of BQ1s (48%) compared to BQ4s (8%) in a single English Premiership RU academy. Collectively, these results suggest that RAEs are prevalent throughout youth RU, with an increasingly skewed BQ distribution at higher playing levels.

Whilst exploring whether RAEs existed at senior international level, Kearney (2017) adopted a cross-cultural comparison as part of his methodology. In contrast to the youth studies, they illustrated only South Africa had a pronounced RAE across all playing positions at the senior level (although other countries had varying RAEs dependant on position), suggesting differences in national sport culture may be an important consideration in RAEs. This also implies that RAEs are considerably less prominent at senior levels compared to youth levels in RU.

When exploring RAEs during the transition from academy to professional level at an English Rugby Premiership club, McCarthy and Collins (2014) identified a *reversal effect* of relative age. More specifically, they revealed that despite RAEs at the academy level favouring relatively older players, there was a greater proportion of relatively younger players who successfully converted to professional level (e.g., BQ1=20% vs. BQ4=50%). This illustrates the importance of combining both youth and senior representatives together to better understand who is at risk of RAEs, as well as identifying the potential mechanisms of the youth to senior level transitions.

Socio-cultural Factors

Socio-cultural factors play an important part in the access to, and subsequent development in, TD pathways in sport (Hambrick et al., 2018). However, despite this notion, they appear to be one of the least studied across the discipline; which is echoed by just four groups of researchers in this review. As part of a socio-cultural interaction and subsequent selection at different RU levels were considered topics surrounding: (a) sport deprivation (Winn et al., 2016), (b) coaching culture (Lewis et al., 2015; Roberts & Fairclough 2012; Sedeaud et al., 2017), and (c) national sport culture (Sedeaud et al., 2017). Since these articles have already been discussed in the preceding sections of this discussion due to their multi-dimensional nature, this particular section will only briefly summarise the importance of such socio-cultural factors in RU.

First, the access to coaching and resources are an important part of the TD process (Côté et al., 2006). Indeed, birthplace effects have been highlighted as important factors with regards to developmental opportunities in sports (Côté et al., 2006). However, little is known about the impact of birthplace effects, access to RU organisational structures, and subsequent development outcomes, thus further research is warranted. Second, the knowledge and understanding of the coach that athletes have access to is also an important consideration (Rynne et al., 2017). For instance, admittance to a highly qualified coach who has an expert understanding of the TID and TD processes will likely provide greater opportunities for subsequent selection and development outcomes when compared to limited/no access.

Finally, national sport culture can also impact upon selection and development opportunities in RU. As an example, those who originate from RU hotspots (e.g., England, New Zealand, South Africa) are more likely to gain access to TID and TD opportunities compared to those who grow up in places that do not have a strong RU culture (Kearney, 2017). Thus, emerging RU nations are encouraged to be forward-thinking in their structural design to ensure they are not replicating the flaws of the current popular RU nations (i.e., avoiding early selection strategies and focus on holistic, long-term development; Bennett et al., 2019). Overall, future research is encouraged to examine the socio-cultural factors associated with TID and TD in RU, to better understand the access to and subsequent development in talent pathways.

Limitations and Future Directions

This review is not without limitations. Firstly, only papers written in English were included, therefore, studies published in other languages would have been overlooked. Furthermore, some papers could have been excluded due to an unclear definition of the type of rugby (e.g., rugby league, rugby sevens, touch rugby, rugby football) used in the investigation. It is also worth mentioning that the quality score of these studies could have been affected by the different metric sections. Therefore, the inclusion of a panel of experts who suggest more articles in line with the searching criteria, may be needed following electronic database searching. Moreover, it was the authors' initial intention to also include female participants, however due to the lack of research within this context and the considerable differences between sexes and success in RU (Suarez-Arrones et al., 2014), only males were included. Thus, future research needs to consider the multi-dimensional factors within the female TID and TD processes in RU.

Conclusion

In the last two decades, there has been a plethora of investigations into TID and TD in RU. The existing one-dimensional and multi-dimensional factors that were reviewed permitted the recognition of the most frequently addressed topics in this area based on: (a) *task constraints*; (b) *performer constraints*; and, (c) *environmental constraints*. Overall, although inter-positional differences were found, selected RU players appear to be taller, heavier, and have higher lean mass compared to those deselected. Moreover, talented RU were faster, more powerful, and possessed greater technical and tactical skills (e.g., passing for accuracy over 7 m); but these differences seemed more attenuated in older high-performing players, where collective effectiveness and tactical cohesion played an important role. In general, the results revealed that coaches tended to select early-maturing players; at least during the first stages of TID process, as well as also according to their subjective vision of the game. Although this procedure brings short-term benefits to the team, it could lead to the exclusion of a considerable number of promising players that require a longer time to reach maturation and showcase their talent. In fact, in this review, it emerged that RAEs can influence progression in RU, with some interesting inter-role differences in adult players.

Athletes' psychological characteristics constitute another important factor for TID and TD. Therefore, it is recommended that key stakeholders (e.g., coaches, scouts, managers) consider the interactions among constraints during their TID and TD processes. In addition, RU deprivation represents both an important task and environmental constraint that could affect participation and engagement in the initial stages of TID and TD. Together, these results confirm that the TID and TD processes follow an ecological dynamic theoretical framework; where talent is developed on the base of a combination of anthropometric, physical, technical, tactical, psychological, environmental, circumstantial, and players' individual experience factors. Therefore, it is recommended that key stakeholders (e.g., coaches, scouts, managers) consider the interactions among constraints during their TID and TD processes. There is a clear need for further research in this area. Future studies should focus on explore factors outside the physical sphere and emphasise longitudinal research utilising both a quantitative and qualitative approach on the aforementioned constraints, since several of the aspects mentioned in this review have yet to be analysed utilising both a multi-dimensional and mixed-methods approach.

3. CHAPTER THREE

Talent identification in an English Premiership rugby union academy: Multidisciplinary characteristics of selected and non-selected male under-15 players

Dimundo, F., Cole, M., Blagrove, R. C., McAuley, A. B., Till, K., & Kelly, A. L. (2021). Talent identification in an English Premiership rugby union academy: Multidisciplinary characteristics of selected and non-selected male under-15 players. Frontiers in Sports and Active Living, 3, 162. https://10.3389/fspor.2021.688143

Dimundo, F., Cole, M., Blagrove, C. R., McAuley, A. B. T., Till, K., & Kelly, A. L. (2021, May). Characteristics that differentiated selected and non-selected male under-15 players at an English Premiership rugby union academy. Poster presented at the 9th online annual Conference of the Expertise and Skill Acquisition Network (ESAN), Twickenham, London, England.

Abstract

Entry into an academy can be a defining moment for a promising young player. The aim of this study was to explore the multidimensional characteristics that differentiated selected and non-selected male under-15 rugby union players at an English Premiership academy. Seventy-four players (mean age 14.6±0.3 years: selected *n*=29; non-selected *n*=45) were measured across nine characteristics from four overarching factors: (a) anthropometric (*n*=2), (b) physiological (*n*=5), (c) cognitive (*n*=1), and (d) birth quartile. An ANOVA compared differences between groups (selected vs. non-selected), whilst a Welch's *t*-test and Cohen's *d* were used for further comparisons. A multivariate logistic regression was also used to predict selection. Results showed significant differences between selected and non-selected players for anthropometric (*P*=0.021) and physiological factors (*P*<0.001). Moreover, relatively older players were overrepresented with 65% born in the first half of the year, whereas no significant differences were apparent for the cognitive test. More specifically, selected players possessed greater body mass (*P*=0.022, *d*=0.5) and handgrip strength (P=0.020, d=0.5) compared to non-selected players, whilst multivariate analysis showed the 20 m sprint explained 25.4% of the variance (P=0.001). Overall, it appears selection into an English Premiership rugby union academy may be due to enhanced physical attributes rather than cognitive abilities.

Keywords: talent development, athlete development, rugby football union, expertise, physical characteristics

Introduction

Achieving professional status in sport is the quest of many young athletes across the globe (Till & Baker 2020). Indeed, one of the increasing pressures for sport organisations is to identify promising young athletes and provide them with an optimal learning environment to facilitate long-term performance (Baker et al., 2013). The male rugby union (RU) talent pathway in England is comprised of an academy programme, delivered via fourteen Regional Academies (currently aligned with twelve Premiership clubs, one Championship club, and one unaffiliated; Kelly, Till et al., 2021). Individuals are typically identified from age-grade or school rugby union, whereby they are selected at the end of the Under (U) 15 age group into Regional Academies (Till et al., 2020). Once selected into a Regional Academy at U15, the pathway consists of U18 and senior academy (e.g., U21) rosters to facilitate development towards the first team. Thus, it is plausible to suggest that initial selection into a RU academy at U15 can be a crucial moment for an aspiring young player.

Talent identification (TID) can be defined as recognising young athletes with the potential to achieve expertise in a particular sport (Williams & Reilly, 2000). The TID process in RU is often influenced by a number characteristics, such as: (a) *anthropometric* (e.g., greater body size and mass; Fontana et al., 2015), (b) *physiological* (e.g., superior speed, strength, and power; Owen et al., 2020), (c) *cognitive* (e.g., advanced tactical skills; Sherwood et al., 2018), and (d) *birth quartile* (e.g., relatively older players overrepresented; Kelly, Barrell et al., 2021). From an anthropometric perspective, body mass and body fat percentage has been found to predict competition levels in youth RU players (Dimundo et al., 2021; Till et al., 2020). In a cross-sectional study on Italian players, Fontana et al. (2015) found that the lower the level of the player, the higher the percentage of fat mass was. Moreover, physiological attributes, such as sprint speed, strength, and power are regarded as important factors that differentiate between players based on age group, competition level, and position (Dimundo et al., 2021; Owen et al., 2020). For instance, Darrall-Jones et al. (2015) found that countermovement jump (CMJ) height, peak power, sprint momentum, acceleration speed, and isometric strength improved with age (i.e., U16–U21) in an English Premiership Regional Academy.

Cognitive characteristics, such as anticipation and decision-making skills (i.e., perceptual-cognitive expertise; see Mann et al., 2007 for a review), are also crucial for differentiating players based on ability levels, which has been explored in different rugby contexts including Australia, Italy, New Zealand, South Africa, and Zimbabwe (Kelly et al., in press). As an example, Farrow et al. (2010) used video simulations to examine anticipatory skills, revealing that pattern recall could differentiate expert, intermediate, and novice Australian RU players. In addition, birth quartile appears to play an important role during initial selection into RU talent development pathways (Kelly, Barrell et al., 2021). Specifically, Kelly, Till et al. (2021) demonstrated that 42.5% of players selected into English Regional Academies at U15 across the last three seasons (2016–2019) were born in the first three months of the annual selection year (i.e., September, October, and November) compared to just 9.6% born in the last three months (i.e., June, July, and August). These phenomenon are commonly termed as relative age effects (RAEs; Cobley et al., 2009). Overall, since there are various factors that can influence selection into RU talent development pathways, it is important to consider a multidisciplinary research methodology whilst examining the TID process.

The initial selection into a RU academy at U15 is a critical time for all English Premiership clubs, since these players will form the core of the subsequent age groups for the proceeding years towards their respective first team. As part of forming the U16 age group, it is common practice for Regional Academies to hold an annual trial (or performance camp) for promising U15 players from their regional junior centres and developing player programme (Till et al., 2020). However, the multidisciplinary factors (i.e., anthropometric, physiological, cognitive, and birth quartile) that differentiate those who are selected, compared to those who are non-selected, are yet to be empirically evaluated. As such, the aim of this study was to explore the anthropometric, physiological, cognitive, and birth quartile characteristics of selected and non-selected U15 English Premiership RU academy players. Moreover, a secondary aim of this study was to distinguish differences between selected and non-selected players based on position (i.e., forwards vs. backs).

Materials and Methods

Participants

Seventy-four participants (mean age 14.6±0.3 years: selected *n*=29; non-selected *n*=45) from an English Premiership RU Regional Academy participated in this study. Participants were also divided by their preferred playing position (selected forwards *n*=14; non-selected forwards *n*=18; selected backs *n*=15; non-selected backs *n*=27) for further analysis. Ethical approval was granted by Birmingham City University via the Health, Education, and Life Sciences Research Ethics Committee.

Procedures

The participants were invited to a four-day performance camp (i.e., annual trial) in an attempt to be selected for the U15 squad at an English Premiership RU Regional Academy. Alongside specific RU training, participants were tested to record key performance parameters. All measures were collected during day-1 of the performance camp, which comprised of nine characteristics from the four overarching factors: (a) *anthropometric* (i.e., body height and mass), (b) *physiological* (i.e., 10 and 20 m sprint time, CMJ, isometric hip extension [IHE], and dominant handgrip strength), (c) *cognitive* (i.e., perceptual-cognitive video simulation test), and (d) *birth quartile* (i.e., date of birth). This approach allowed comparison between those who were subsequently selected and non-selected.

Participants' body height and mass were measured to the nearest 0.1 cm and 0.1 kg using a Seca Alpha stadiometer and calibrated Seca Alpha (model 220) scales wearing only shorts (e.g., Darrall-Jones et al., 2015). Sprint time over 10 and 20 m was recorded using timing gates (Brower Timing Systems, IR Emit. Draper, UT, USA). Each sprint started 30 cm behind the initial timing gate, with participants instructed to commence at a freely-chosen time and run maximally through the final 20 m timing gate (e.g., Darrall-Jones et al., 2015). A CMJ was performed with the participants hands placed on the hips while stood between two portable infrared recorders (Microgate, OptoGate, Italy) that recorded jump height to the nearest 0.1 cm. Participants were instructed to complete the CMJ starting from a standing position, moving to a self-selected depth (without overpassing the knees joint with their hip), and to jump as high as possible (e.g., Román et al., 2018). A portable back and leg dynamometer (Takei Scientific Instruments Co., Ltd, Niigata-City, Japan) was used to measure IHE. Participants stood on a portable platform and pulled a handle connected with the platform via a chain. They were required to maintain a standard straight knees, back, and flexed hip. Following familiarisation, participants were instructed to pull as hard and fast as possible after a 3-second countdown for 5-seconds (Coldwells et al., 1994). Handgrip strength was measured using a handgrip dynamometer (Takei 5401, Takei Scientific Instruments, Japan). Once an optimal position was determined by sitting and holding the tested hand's elbow 90° flexed, participants' were instructed to "squeeze" as hard as possible for a 5-second duration (Massy-Westropp et al., 2011) only using the preferred (strongest) hand. Strong verbal encouragement was provided during the maximal strength tests. Each test was completed three times with the best attempt recorded for analysis.

A perceptual-cognitive video simulation test was used to examine the participants' decision-making skill based on a combination of tactical situations, which have been shown to be valid and reliable measures for PCE research in several sport environments (e.g., Kelly, Wilson, Jackson et al., 2020). Fifteen video clips were carefully chosen from live rugby match footage, filmed from different elevated angles to provide a wide-range view of the pitch. Following a few seconds of general build-up play, the screen unexpectedly frozen for eight seconds prior to a critical decision-making moment. At this point, a question with four possible options appeared on the frozen action and participants had to select an answer on their response sheet before the next clip automatically began. As per examination conditions, participants were seated separately for approximately 45-minutes and were unable to engage with each other. Participants overall score was ranked using percentiles (i.e., 90^{th}; 75^{th}; 50^{th}; 25^{th}; 10^{th}) and then classified (i.e., 1=excellent; 2=good; 3=average; 4=low; 5=poor) for analysis. The total accuracy of the participants' responses was recorded for analysis. Finally, each participant was assigned a birth quartile, which was calculated using their date of birth. The annual selection year was divided into four birth quartiles according to the English cut-off dates (birth quartile one [BQ1]=September, October, and November; BQ2=December, January, and February; BQ3=March, April, and May; BQ4=June, July, and August; McCarthy & Collins, 2014).

Statistical analysis

Data were checked for normal distribution using a Shapiro–Wilk test. Scores were then normalised using *z*-scores ($z=(x- \mu)/\delta$), where x is the raw score, μ is the population mean, and δ is the population standard deviation. A multivariate analysis of variance (MANOVA) was used to calculate difference among the combined anthropometric and physiological factors both between selected and non-selected participants and positions, whereas a one-way analysis of variance (ANOVA) was used to explore the differences for the cognitive test. A Cohen's *d* was also used to calculate the effect size of these factors. Cohen's *d* effect size was calculated as reported in previous literature (Cohen, 1988) with threshold values of 0.20 (small), 0.50 (medium), 0.80 (large), with corresponding 95% confidence intervals (CIs). A Welch's *t*-test was then conducted for the eight variables from the anthropometric, physiological, and cognitive factors to compare selected and non-selected participants, as well as position-specific comparisons (i.e., forwards vs. backs).

For birth quartiles, a chi-square (χ^2) goodness-of-fit was used to compare quartile distributions for selected participants against national norms (McHugh, 2013; ONS, 2015). Since the χ^2 does not reveal the magnitude of difference between quartile distributions, a Cramer's V was also used to report the effect size (0.00 and under 0.10, negligible; 0.10 and under 0.20, weak; 0.20 and under 0.40, moderate; 0.40 and under 0.60, relatively strong; 0.60 and under

0.80, strong; 0.80 and under 1.00, very strong; Ferguson, 2009). Finally, a binary logistic regression was performed to model selected and non-selected participants, which comprised of multivariate analysis performance test only for statistically significant variables evidenced in the Welch's *t*-test or χ^2. The pseudo R-squared values, odds ratios (ORs), and 95% CIs were reported for each model. Significance was set for an α level of 0.05 with the statistical analysis conducted using IBM SPSS Statistics Version 24.

Results

Results from the MANOVA and ANOVA showed that there was a significant difference between selected and non-selected players for both anthropometric (P=0.021) and physiological (P<0.001) characteristics. Further results from the Welch's *t*-tests revealed moderate to large differences between participants for body mass (selected = 69.9±11.5 kg vs. non-selected = 63.5±12.1 kg; P=0.022, d=0.53), handgrip strength (selected = 38.1±7.2 kg vs. non-selected = 33.9±8.0 kg; P=0.020, d=0.52), IHE (selected = 137.4±22.6 kg vs. non-selected = 117.0±23.8 kg; P<0.001, d=0.87), and 20 m sprint (selected = 3.33±0.14 s vs. non-selected = 3.44±0.21 s; P<0.001, d=0.75). When analysing groups based on position, selected forwards had greater IHE (144.3±23.7 kg vs. 130.2±12.6 kg; P=0.054, d=0.77) and 20 m sprint (3.40±0.11 s vs. 3.53±0.21 s; P=0.041, d=0.71) compared to non-selected forwards with large effect size differences. In comparison, selected backs had greater IHE (130.9±20.2 kg vs. 108.3±25.6 kg; P<0.001, d=0.95) and 20 m sprint (3.26±0.13 s vs. 3.38±0.18 s; P=0.011, d=0.78) compared to non-selected backs with large effect size differences. In addition, there was no significant differences between groups and positions for the perceptual-cognitive video simulation test. The descriptive statistics are reported in Table 3.1. The MANOVA for anthropometric and physiological factors and the ANOVA for cognitive factor are reported in Table 3.2. The Welch's *t*-test analysis is reported in Table 3.3.

Table 3.1. Descriptive statistics for selected and non-selected U15 players.

Characteristic	**Selected**			**Non-selected**		
	Forwards (n = 14) mean±SD	Backs (n = 15) mean±SD	All players (n = 29) mean±SD	Forwards (n = 18) mean±SD	Backs (n = 27) mean±SD	All players (n = 45) mean±SD
Anthropometric						
Body mass (kg)	77.2±10.9	63.1±7.2	69.9±11.5	71.3±9.6	58.3±10.9	63.5±12.1
Height (cm)	173.2±3.6	170.5±7.3	171.8±5.9	175.1±7.0	166.9±10.1	170.2±9.8
Physiological						
Handgrip (kg)	40.6±7.3	35.8±6.6	38.1±7.2	36.8±6.3	31.9±8.5	33.9±8.0
IHE (kg)	144.3±23.7	130.9±20.2	137.4±22.6	130.2±12.6	108.3±25.6	117.0±23.8
10 m sprint (s)	1.41±0.05	1.34±0.06	1.37±0.06	1.45±0.10	1.38±0.09	1.41±0.10
20 m sprint (s)	3.40±0.11	3.26±0.13	3.33±0.14	3.53±0.21	3.38±0.18	3.44±0.21
CMJ (cm)	28.8±4.7	33.2±5.8	31.1±5.7	27.3±5.3	31.5±5.8	29.8±5.9
Cognitive						
perceptual-cognitive video simulation test (au)	2.9±1.3	3.5±1.1	3.2±1.2	3.2±1.5	3.3±1.3	3.2±1.3
Birth Quartile						
BQ	2±1	3±1	2±1	2±1	2±1	2±1

Note. Shows difference between selected and non-selected players and reports comparison among positions. SD = standard deviation; IHE = isometric hip extension; CMJ = countermovement jump; au = arbitrary unit; BQ = birth quartile.

Table 3.2. MANOVA for the anthropometric and physiological factors and ANOVA for the cognitive factor.

Factor	**Selected vs. non-selected forwards (*P*)**	**Selected vs. non-selected backs (*P*)**	**All selected vs. all non-selected (*P*)**	**Selected forwards vs. selected backs (*P*)**
Anthropometric	0.031*	0.331	0.021*	0.165
Physiological	0.246	0.020*	0.001**	0.617
Cognitive	0.502	0.568	0.989	0.453

Note: Significance set for P = 0.05; *denotes a statistical significance of ≤. 05; **denotes a statistical significance of ≤. 001.

Table 3.3. *Z*-scores and Welch's *t*-tests for selected and non-selected players.

Characteristic	Selected *z*-score (mean±SD)	Non-selected *z*-score (mean±SD)	Welch's *t*-test (*P*)	Cohen's *d*
Body mass				
Forwards	0.32±1.04	-0.25±0.92	0.124	0.58 (-0.14. 1.28)
Backs	0.31 ±0.73	-0.17±1.10	0.099	0.49 (-0.15. 1.13)
Selected vs. non-selected	0.31 ±0.88	-0.20±1.02	0.022*	0.53 (0.06. 1.01)
Selected forwards vs. backs			0.982	0.00 (-0.72. 0.73)
Height				
Forwards	-0.19±0.62	0.15±1.21	0.320	-0.33 (-1.03. 0.37)
Backs	0.25±0.79	-0.14±1.09	0.199	0.39 (-0.25. 1.03)
Selected vs. non-selected	0.04±0.74	-0.02±1.14	0.761	0.06 (-0.40. 0.53)
Selected forwards vs. backs			0.100	-0.61 (-1.35. 0.14)
Handgrip				
Forwards	0.31±1.05	-0.23±0.92	0.133	0.56 (-0.16. 1.27)
Backs	0.31±0.82	-0.17±1.06	0.111	0.49 (-0.16. 1.12)
Selected vs. non-selected	0.31±0.92	-0.19±1.00	0.020*	0.52 (0.05. 1.00)
Selected forwards vs. backs			0.999	0.00 (-0.73. 0.73)
IHE				
Forwards	0.41±1.23	-0.31±0.65	0.054	0.77 (0.04. 1.49)
Backs	0.56±0.78	-0.31±0.99	0.001**	0.95 (0.28. 1.60)
Selected vs. non-selected	0.49±1.00	-0.31±0.86	0.001**	0.87 (0.38. 1.36)
Selected forwards vs. backs			0.707	-0.14 (-0.87. 0.59)
10 m sprint				
Forwards	-0.13±0.32	0.10±1.31	0.477	-0.23 (-0.93. 0.47)
Backs	-0.06±0.44	0.03±1.21	0.711	-0.09 (-0.73. 0.54)
Selected vs. non-selected	-0.09±0.38	0.06±1.24	0.432	-0.16 (-0.62. 0.31)
Selected forwards vs. backs			0.633	-0.18 (-0.91. 0.55)
20 m sprint				
Forwards	-0.38±0.61	0.29±1.15	0.041*	-0.71 (-1.42. 0.02)
Backs	-0.47±0.73	0.26±1.05	0.011*	-0.78 (-1.43. -0.12)
Selected vs. non-selected	-0.43±0.66	0.27±1.08	0.001**	-0.75 (-1.23. -0.27)
Selected forwards vs. backs			0.709	0.14 (-0.59. 0.87)
CMJ				
Forwards	0.17±0.94	-0.12±1.05	0.411	0.29 (-0.41. 0.99)
Backs	0.18±0.99	-0.10±1.01	0.381	0.28 (-0.35. 0.92)
Selected vs. non-selected	0.17±0.95	-0.11±1.01	0.222	0.29 (-0.18. 0.76)
Selected forwards vs. backs			0.965	-0.02 (-0.75. 0.71)
Perceptual-cognitive video simulation test				
Forwards	-0.14±0.93	0.10±1.07	0.499	-0.24 (-0.94. 0.46)
Backs	0.12±0.90	-0.06±1.06	0.546	0.19 (-0.45. 0.82)
Selected vs. non-selected	0.00±0.91	0.00±1.05	0.981	0.00 (-0.47. 0.46)
Selected forwards vs. backs			0.455	-0.28 (-1.01. 0.45)

Note. Shows difference between selected and non-selected players and reports comparison among positions. In the column headings indicate overall effects (significance set for P = 0.05). Post-hoc and Cohen's *d* effect size (90% confidence interval). IHE = isometric hip extension; CMJ = countermovement jump; *denotes a statistical significance of ≤. 05; **denotes a statistical significance of ≤. 001.

Birth quartiles showed an higher proportion of those born in the first half of the year for selected participants (BQ1=28%, BQ2=38%, BQ3=10%, and BQ4=24%), although it was not statistically significant and had weak effect size (χ^2 (3)=4.62, V=0.28, *P*=0.206). Moreover, birth quartiles were significantly skewed for non-selected participants with a moderate effect size (χ^2 (3)=9.34, V=0.32, *P*=0.025), whereby a higher proportion were born in the first half of the year (BQ1=38%, BQ2=29%, BQ3=27%, and BQ4=6%). With regards to position, both selected forwards (BQ1=36%, BQ2=36%, BQ3=14%, and BQ4=14%; χ^2 (3)=2.59, V=0.30, *P*=0.458) and selected backs (BQ1=20%, BQ2=40%, BQ3=7%, and BQ4=33%; χ^2 (3)=3.99, V=0.36, *P*=0.262) birth quartile's were skewed towards the first half of the year with moderate effect sizes, although it was not statistically significant. Likewise, both non-selected forwards (BQ1=33%, BQ2=33%, BQ3=28%, and BQ4=6%; χ^2 (3)=3.99, V=0.32, *P*=0.274) and non-selected backs (BQ1=41%, BQ2=26%, BQ3=26%, and BQ4=7%; χ^2 (3)=5.96, V=0.33, *P*=0.113) birth quartile's were skewed towards the first half of the year with moderate differences, although it was not statistically significant. The birth quartile results are reported in Table 3.4.

Table 3.4. Birth quartile distributions by position vs. national norms.

Cohort	BQ1 (*n*) %	BQ2 (*n*) %	BQ3 (*n*) %	BQ4 (*n*) %	Total (*n*) %	X^2 (df = 3)	Cramer's V	*P*	Q1 vs. Q4 (OR, 95% CI)	Q2 vs Q4 (OR, 95% CI)	Q3 vs Q4 (OR, 95% CI)
Selected forwards	5 35.7%	5 35.7%	2 14.3%	2 14.3%	14 100%	2.59	0.30	0.453	2.49 (0.27-22.55)	2.59 (0.28-23.70)	1.03 (0.08-12.02)
Selected backs	3 20%	6 40%	1 6.7%	5 33.3%	15 100%	3.99	0.36	0.267	0.59 (0.07-4.49)	1.24 (0.19-0.01)	0.20 (0.01-2.72)
Selected forwards and backs	8 27.6%	11 37.9%	3 10.4%	7 24.1%	29 100%	4.62	0.28	0.206	1.14 (0.27-4.81)	1.63 (0.40-6.62)	0.44 (0.08-2.41)
Non-selected forward	6 33.3%	6 33.3%	5 27.8%	1 5.6%	18 100%	3.88	0.32	0.274	5.99 (0.50-71.66)	6.23 (0.51-75.07)	5.15 (0.41-63.63)
Non-selected backs	11 40.7%	7 25.9%	7 25.9%	2 7.5%	27 100%	5.96	0.33	0.113	5.49 (0.87-34.60)	3.63 (0.54-24.31)	3.60 (0.54-24.10)
Non-selected forwards and backs	17 37.8%	13 28.9%	12 26.7%	3 6.6%	45 100%	9.34	0.32	0.025*	5.65 (1.29-24.74)	4.50 (1.00 - 20.24)	4.12 (0.91-18.68)

Note: BQ1 = September, October, and November; BQ2 = December, January, and February; BQ3=March, April, and May; BQ4 = June, July, and August. Birth quartile (BQ1–BQ4) distribution by positions, total number of players, and comparisons against national norm with odd ratio (OR) set at 95% of confidence interval (CI), significance set for P = 0.05; *denotes a statistical significance of ≤. 05.

The multivariate logistic regression model explained between 21% (Cox and Snell R square) and 29% (Nagelkerke R square) of the variance in selection (*P*=0.001). Only the 20 m sprint made a statistically significant contribution to the model that predicted selection. In general, 20 m sprint time explained 25.4% of the variance (r^2=0.254, *P*=0.039). The multivariate logistic regression is reported in Table 3.5.

Table 3.5. Main variables for multivariate logistic regression for selection and positions.

Cohort	Predictor	Coefficient β	SE	Wald's χ2	Odds Ratio (95% CI)	Log likelihood	Cox & Snell R^2	Nagelkerke R^2
Forwards: selected vs. non-selected						-18.87	0.198	0.265
	IHE	-0.714	0.445	χ2(1) = 2578, P = 0.108	0.490 (-1.585; 0.158)			
	20m sprint	0.741	0.503	χ2(1) = 2174, P = 0.140	2.099 (-0.244; 1.727)			
	Constant	0.319	0.405	χ2(1) = 0.620, P = 0.431	1.376 (-0.475; 1.113)			
Backs: selected vs. non-selected						-25.44	0.209	0.287
	IHE	-0.884	0.499	χ2(1) = 3.131, P = 0.077	0.413 (-1.863; 0.095)			
	20m sprint	0.557	0.495	χ2(1) = 1264, P = 0.261	1.745 (-0.414; 1.528)			
	Constant	0.820	0.400	χ2(1) = 4.200 , P = 0.040	2.270 (0.036; 1.604)			
All: selected vs. non-selected						-40.74	0.212	0.287
	Body mass	0.378	0.370	χ2(1) = 1.042, P = 0.307	1.459 (0.706; 3.014)			
	Handgrip	-0.282	0.391	χ2(1) = 0.522, P = 0.470	0.754 (0.351; 1.622)			
	IHE	0.661	0.399	χ2(1) = 2.741, P = 0.098	1.936 (0.886; 4.232)			
	20m sprint	-0.805 *	0.391	χ2(1) = 4.244, P = 0.039 *	0.447 (0.208; 0.962)			
	Constant	-0.621	0.288	χ2(1) = 4.651, P = 0.031	1.861 (0.057; 1.186)			

Note: SE = standard error; IHE = isometric hip extension; 20m sprint = sprinting time; *denotes a statistical significance of ≤. 05.

Discussion

Key findings suggest that those who were selected into the Regional Academy were significantly heavier, stronger, and faster over 20 m compared to their non-selected peers with effect sizes for anthropometric, physiological, and cognitive factors ranging from small to large. Further multivariate logistic regression also revealed that only the 20 m sprint was a significant predictor for selection; irrespective of playing position. With regards to birth quartile and the cognitive factor, there was no statistically significant differences reported for selected players, despite being overrepresented in the first two birth quartiles (i.e., BQ1=28% and BQ2=38%) compared to the second two birth quartiles (i.e., BQ3=10% and BQ4=24%).

When comparing anthropometric characteristics findings (i.e., body height and mass) with other selected RU players, some similarities and variations occur based on other studies across other nationality. As an example, Nutton et al. (2012) reported similar body mass in Scottish U15 RU players (175.0±7.0 cm; 68.0±11.4 kg), although they appeared to be considerably taller. The population of the present study was also shorter (171.8±5.9 cm), as well as lighter (69.9±11.5 kg), than South African U15 RU players (175.0±6.0 cm, 75.9±13.2 kg; Grobler et al., 2017). Whereas, they were taller and heavier when compared to their Brazilian U15 RU equivalents (169.7±12.1 cm, 63.8±10.9 kg; Kobal et al., 2016). In a recent systematic review by Owen et al. (2020), it was reported that body height and mass in U15 RU players ranged from 169.7 to 175.0 cm and 63.8 to 75.9 kg, respectively; which is in line with the present findings. Thus, it is important to consider national youth sport culture during the TID process, since variations in anthropometric characteristics can be considerable.

When analysing anthropometric data by position, both selected forwards (173.2±3.6 cm, 77.2±10.9 kg) and selected backs (170.5±7.3 cm, 63.1±7.2 kg) presented similar characteristics to those reported in a French U15 academy (forwards=175.9±7.0 cm, 72.5±9.8kg; backs=169.5±6.5cm and 60.8±8.2 kg; Sedeaud et al., 2013). Indeed, body mass was pivotal when distinguishing selected RU players in both a South African academy (Pienaar et al., 1998) and in New Zealand at senior international level (Quarrie et al., 1996). Moreover, similar to the present study's findings, Barr et al. (2014) showed that body mass, but not height, differentiated U20 and international RU players. The variation in anthropometric measures among playing positions, although not statistically significant, align with the idea that forwards and backs need a dissimilar body characteristic to perform key roles and cope with position-specific demands of the game. Together, these results demonstrate that anthropometric characteristics, and in particular body mass, appear to be an important factor to consider during TID in U15 RU players. As such, these findings offer an important benchmark for coaches and practitioners when selecting U15 RU players, as well as highlighting the differences between positions.

Strength parameters have been shown to differentiate by age, competition levels, and position of young RU players across various environments (e.g., Dimundo et al., 2021; Grobler et al., 2017; Hansen et al., 2011; van Gent & Spamer, 2005; Owen et al., 2020; Pienaar et al., 1998; Spamer & De la Port, 2006). In this current study, selected players reported superior handgrip strength when compared to non-selected players. Indeed, similar conclusions have been reported in Portuguese (Vaz et al., 2019) and Scottish (Nutton et al., 2012) RU academy players, whereby it was suggested that handgrip strength should be one of the measures included in a battery of tests during the TID process since it was deemed a practical, safe, reliable, and valid method to detect a standard measure of strength in youths. Assessing force generating characteristics during the isomeric pull in RU has also been considered as a safe and useful tool to monitor progress across RU academies, since the technical requirement for these tests are less demanding compared to other traditional whole body strength tests (Darrall-Jones et al., 2015; Owen et al., 2020). Although not significant in multivariate logistic regression, all selected players in this study possessed greater handgrip and IHE measures than non-selected players, and selected forwards outperformed selected backs. However, it was not surprising that forwards possessed higher force than backs, since their playing-position requires them to produce higher isometric force during a game (Quarrie & Wilson, 2000). These results are in agreement with recent findings in RU (Dimundo et al., 2021; Owen et al., 2020), and demonstrate that whole body strength is an important factor to consider when approaching TID in RU due to its application in a multitude of key actions required in this contact sport (Till et al., 2020). Although results of this current study could have been influenced by an overrepresentation of relatively older participants and by the analysis of other characteristics of strength measures (i.e., relative strength), it also reveals how position-specific factors are already being influenced by physiological characteristics during initial entry into an academy at U15.

Sprint speed has been considered an important physiological quality in RU (Dimundo et al., 2021) since it is associated with a range of performance outcomes, such as distance covered, evasion, and line and tackle breaks (Smart et al., 2014). It has been also used as one method to predict future talent in an Italian U16 RU academy (Fontana et al., 2016), indicating that it is worth monitoring this characteristic for optimal TID. In the current investigation, selected players possessed superior 20 m sprint times compared to non-selected players. Importantly, the 20 m sprint was the only predictive characteristic of selection in the current cohort. More specifically, those who possessed a faster 20 m sprint were up to 1.4 times more likely to be selected. A possible explanation for the importance of sprint speed in RU is that greater sprint characteristics have typically been correlated with greater momentum, which is believed to be fundamental in RU (Darrall-Jones et al., 2016; Jones et al., 2018). Thus, although momentum was not considered in this research, it is not surprising that fastest players were selected in the current academy squad. In addition, the present investigation found speed differences among playing positions. For instance, although 20 m sprint speed was an important factor for all players to possess, this was position-dependent whereby backs were generally faster than forwards. Therefore, in agreement to Jones et al.’s (2018) findings, 20 m sprint time can be considered one of the most valuable measures to include in a battery of tests when coaches aim to optimise TID during selection into their U15 cohort.

Cognitive skills are important factors to consider when selecting athletes in different sports (Mann et al., 2007). Although previous research in RU has suggested that superior cognitive skills differentiate playing levels (e.g., Chiwaridzo et al., 2019a,b, 2020; den Hollander et al., 2019; Farrow et al., 2010; Runswick et al., 2020), results from this study did not report any statistical difference between selected and non-selected players. The outcomes of the present investigation could be justified by the fact that perceptual-cognitive qualities in U15 RU players may not have peaked at this stage of development. As an example, players may not have accumulated an adequate volume of hours in practice activities to develop athlete functionality at this entry level (Rothwell et al., 2020). Another explanation for this outcome could be due to the fact that coaches may have been focused on (and perhaps biased by) anthropometrical and physiological characteristics possessed by participants. In contrast, however, present findings on positional differences align with those of Runswick et al. (2020), whereby no statistical differences were reported in anticipation skills between forwards and backs. In summary, perceptual-cognitive skills remain an inconclusive measure for selection into a RU academy. Further study is encouraged to explore the implications of perceptual-cognitive skills on selection into RU academies, as well as incorporating a range of technical and psychosocial characteristics in holistic TID research methodologies.

Based on the common prevalence of RAEs in male RU, it was not surprising that there was an overrepresentation of selected players born between September and February in this current investigation (although this was only statistically significant for non-selected players). Specifically, the birth distribution revealed that almost twice as many players were selected from the first half of the year (n=19; 66%) when compared to the second half of the year (n=10; 34%). Non-selected players were significantly more likely to be born in the first half of the year (n=30; 67%) compared to the second half of the year (n=15; 33%). The percentages obtained reflect those reported in U7–U19 Welsh recreational RU clubs (BQ1=29% vs. BQ4=22%; Lewis et al., 2015), U13–U16 English regional representative squads (BQ1=38% vs. BQ4=10%; Roberts &

Fairclough, 2012), English Regional Academies (BQ1=42% vs. BQ4=8%; McCarthy & Collins, 2014), and senior international levels (BQ1=32% vs. BQ4=20%; Kearney, 2017). Together, these results suggest that early born players may have an advantage over later born athletes during the initial phase of the TID process, since both selected and non-selected players are overrepresented. To be specific, the entry point into the Regional Academy appears to be biased towards their invitations to attend the performance camp; regardless of subsequent (un)successful selection (BQ1+BQ2=66.2%). As such, Regional Academies are encouraged to explore alternative approaches to athlete selection (e.g., age-ordered shirt numbering; selection quotas; avoiding early deselection; flexible chronological approach) and group banding policies (e.g., age and anthropometric bands; bio-banding; playing-up and playing-down; see Webdale et al., 2020 for a review). Indeed, these could offer useful evidence-based guidelines in the future for other organisations and coaches to adopt practical solutions to RAEs as part of their TID procedures.

Limitations and Future Directions

There are often methodological challenges when researching high-performance youth populations. In the context of this current study, although a relatively large representative sample of participants were examined (i.e., one of only fourteen Regional Academies across the country), the sub-analysis for position-specific study (i.e., forwards and backs) could have been influenced due to the sample size. It is also important to recognise that this study is susceptible to the individual academy's approach to TID, thus this sample may not be representative of all Regional Academy selection decisions. There may also be the case that the assessment of perceptual-cognitive skills in this current study could have been influenced by its sensitivity, possibly influencing the final results. Moreover, as the maturation status of the players was not assessed, it is not known to what extent this impacted selection. In addition, this study did not include the measurement of other important characteristics previously shown to be significant predictors of performance and selection (i.e., technical and psychosocial; Dimundo et al., 2021).

Finally, it is also important to note that this study is cross-sectional in design, as such it does not take into account the dynamic, longitudinal nature of athlete development.

Future research is encouraged to include a more holistic and longitudinal protocol when assessing Regional Academy selection. As an example, longitudinal investigations should consider collecting the examined variables from a wider population and include other performance factors (i.e., technical and psychosocial) to study the ecological dynamic characteristics of the TID process (Till, Cobley, Morley et al. 2015; Till, Cobley, O'Hara et al., 2013). The complex nature of the TID process is multitudinous by nature. Thus, selectors should act with caution when interpreting these outcomes, and are recommended not to base their selections *solely* on anthropometric and physiological qualities, and instead use these objective measures to complement their performance camps and decision-making processes on selection. Moreover, literature regarding athlete development suggests that due to greater physical characteristics being associated with early development, coaches should consider benchmarks based on biological age rather than chronological age (Kelly, Till et al., 2021; Malina et al., 2019). Lastly, as reported by Huijgen et al. (2014), coaches cognitive bias should be taken into account when examining players on physiological and technical variables for future researches in TID.

Conclusion

This is the first study that has incorporated a multidisciplinary research design to compare selected and non-selected U15 RU players at an English Premiership Regional Academy. It appears anthropometric and physiological qualities are more predictive of selection when compared to cognitive characteristics and birth quartiles. Specifically, it is suggested that body mass, strength, and speed are part of a battery of tests that formulate part of the TID process during selection into Regional Academies. Moreover, Position-specific differences should also be considered also during early stages of TID. In addition, although birth quartile distribution was only statistically significant in the non-selected cohort, coaches and practitioners employed in youth RU should consider this as part of a holistic selection framework so potential talent is not missed. Future research is encouraged to adopt a multidimensional and longitudinal approach when investigating TID in RU, to build on this current study and better understand the selection processes in Regional Academies.

4. CHAPTER FOUR

The anthropometric, physical, and relative age characteristics of an English Premiership rugby union academy

Dimundo, F., Cole, M., Blagrove, R. C., McAuley, A. B., Till, K., Hall, M., Pacini, D., & Kelly, A. L. (2021). The anthropometric, physical, and relative age characteristics of an English Premiership rugby union academy. *International Journal of Strength and Conditioning*, *1*(1). https://10.47206/ijsc.v1i1.67

Dimundo, F., Cole, M., Hall, M., & Kelly, A. L. (2020, October). The physiological profile of an English Premiership rugby union academy: Implications for long-term athlete development. Poster presented at the 25th anniversary congress of the European College of Sport Science (ECSS). Sevilla, Andalucía, Spain.

Abstract

Long-term athlete development is a primary focus for the England Rugby Football Union (RFU). The purpose of this study was to explore the anthropometric, physical, and relative age characteristics of rugby union academy players based on age group and playing position. Seventy-eight participants were measured for height, body mass, 10 and 20 m sprint, countermovement jump, peak and relative power, sprint momentum for 10 and 20 m, reactive strength index, aerobic capacity, isometric hip extension, dominant handgrip strength, and birth quartile (BQ) across three age categories (i.e., under-16, under-18, and under-21) and two positions (i.e., forwards and backs). ANOVA and Kruskall–Wallis analysis were used to examine differences across each age category and position. TukeyHSD and Dunn's test with Bonferroni correction was used for further post-hoc analysis. BQ distributions were compared against national norms using chi-square analysis. Results revealed that both older forwards (P=0.005) and backs (P=0.002) had significantly greater body mass, momentum, power, and maximal aerobic capacity compared to younger players. However, older forwards had slower 10 m sprint times compared to younger forwards. Moreover, relatively older players were significantly overrepresented across all age groups when compared to relatively younger players. Findings suggest that: (a) players should aim to develop greater parameters of body mass, momentum, power, and aerobic capacity; (b) forwards should aim to develop acceleration, strength, momentum, and power; (c) backs should aim to develop momentum, power, and quickness; and, (d) coaches should consider relative age when recruiting and developing young players.

Key words: talent identification; talent development; expertise; physical development; physiological profile; rugby football

Introduction

The central aims of the World Rugby Federation is to globally improve the participation and growth of young athletes on a long-term basis (World Rugby, 2020). In light of this, the Rugby Football Union's (RFU; governing body of rugby union [RU] in England) objective is to develop more talented English players to maintain a world-leading position (England Rugby, 2020; Till et al., 2020). In order to hold such hegemony, the RFU has adopted a sophisticated talent identification and development system. However, questions remain surrounding the most suitable process to facilitate long-term athlete development (LTAD) towards senior expertise (Till et al., 2020), due to the possible developmental drawbacks of such systems (Cobley et al., 2013). Developmental pathways are mapped by RU academies in England to prepare talented young players for the demands of professional competition in adulthood (Till & Baker, 2020). Selection into a RU academy can be a defining moment for a young player since these contribute to their progression towards senior professional level. LTAD in RU generally follows a pathway considered a *late specialisation model* (Côté & Vierimaa, 2014), since players are selected from the age of 15 to 21 years and are subsequently exposed to a diverse range of physical activities that can have a long-term impact on individual development and performance (Côté & Vierimaa, 2014; Phibbs et al., 2018).

Due to the physical requirements of RU, researchers aimed to advance research on the performance requirements of players, documenting that they need high levels of strength, power, agility, speed, momentum, and aerobic capacity (Darrall-Jones et al., 2015, 2016; Dimundo, Cole, Blagrove, McAuley, et al., 2021; Dimundo, Cole, Blagrove, Till, et al., 2021). Given the importance of physical factors on player progression and game performance (Oliver et al., 2019; Smart et al., 2014), there are some studies focused on the characterisation of these physical qualities in English RU environments (Darrall-Jones et al., 2015, 2016; Jones et al., 2018; Parsonage et al., 2014; Read et al., 2017; Till et al., 2020), although a larger amount of evidence is available within English rugby league (Booth, 2020; Booth et al., 2020; Gabbett et al., 2008; Gabbett & Abernethy, 2013;

Gabbett, 2002, 2005, 2006; McCormack et al., 2020; Rotheram, 2020; Till et al., 2013, 2016a, 2020). Since these two sports have different rules (World.rugby, 2020), physical demands (Gabbett et al., 2008), and positional requirements (Worsnop, 2016), there is a need for more specific athlete development research in RU. In the context of RU, researchers have found that strength (absolute and relative) and power differentiate playing levels (Argus et al., 2012), whilst body mass, acceleration, and momentum characteristics differ between age groups (Darrall-Jones et al., 2015). Since these changes also follow the incremental trajectory of growth and physical development, suitable pathways (e.g., RU academies) that nurture anthropometric and physical performance are a critical component within a professional structure to ensure player progression. Although previous research has outlined characteristics according to positional differences (Darrall-Jones et al., 2016), these are yet to be analysed together with relative age.

It is generally accepted that different positions require different anthropometric and physical characteristics at both academy (Darrall-Jones et al., 2016; Owen et al., 2020) and senior professional (Worldrugby, 2020; Worsnop, 2016) levels. Specifically, forwards possess the greatest body mass and isometric strength, and backs require superior speed, change of direction, and agility. Physical characteristics also differ considerably based on playing level (e.g., age-grade vs. academy), age group (e.g., U16 vs. U18), and position (e.g., forwards vs. backs) (Dimundo, Cole, Blagrove, McAuley, et al., 2021; Fontana et al., 2015; Till et al., 2020; Wood et al., 2018). Thus, it is important to consider the inter-individual disparities in the rate and timing of physical development can result in biases during the athlete development processes (Till & Baker, 2020).

Relative age effects (RAEs) have been highlighted as one of the most frequent biases during selection of RU players (Kelly et al., 2021). This phenomenon explains that when individuals are banded according to (bi)annual-age groups, those who are born near the beginning of the selection year are often overrepresented compared to those who are born towards the end (Musch & Grondin, 2001). Thus, those players born in birth quarter one (BQ1; September, October, and November in England) may have developed enhanced physiological and psychosocial qualities compared to their later born BQ4 peers (i.e., June, July, and August), which subsequently allows them to outperform their younger same-age peers (Doncaster et al., 2020). RAEs have been found in different RU environments regardless of nationality (Dimundo, Cole, Blagrove, McAuley, et al., 2021; Kearney, 2017), gender (Kelly et al., 2021), and age group (Dimundo, Cole, Blagrove, McAuley, et al., 2021; Lewis et al., 2015; McCarthy & Collins, 2014). Moreover, it has been found to impact selection at different levels (Kelly et al., 2021) and playing positions (Kearney, 2017) in RU. However, further enquiry is required to better understand differences by birth quartiles and the impact on the athlete development process based on age group and position since these factors are yet to be analysed together across the academy of an English professional RU club.

To the authors' knowledge, no studies have investigated the anthropometric, physical, and relative age characteristics of academy players in an English academy from a Premiership RU club based on chronological age group and playing position. Understanding the magnitude of anthropometric, physical, and relative age characteristics based on age group and position will assist key stakeholders (i.e., coaches, selectors, practitioners, and policy makers) to better understand the LTAD process. Moreover, the need for more replication studies in order to draw more valid conclusions and help inform possible meta-analysis from studies in RU academies is also required; mainly due to the limited sample sizes that are generally available within these single case studies. This may also help observe the evolutionary trends of the LTAD process across professional RU academies by providing an updated physical profile of RU academy cohorts. Thus, the purpose of this study was to evaluate the anthropometric, physical, and relative age characteristics of English Premiership RU academy players based on age group (i.e., U16 vs. U18 vs. U21) and position (i.e., forward vs. backs) to offer recommendations for LTAD in RU.

Materials and Methods

Three age groups (i.e., U16, U18, and U21) and two playing positions (i.e., forwards and backs) within an English Premiership RU academy were assessed on fourteen parameters from three overarching characteristics: (a) anthropometric (i.e., height and body mass), (b) physical (i.e., 10 and 20 m sprint, countermovement jump [CMJ], peak and relative power, sprint momentum for 10 and 20 m, reactive strength index [RSI], aerobic capacity via the 30-15 intermittent fitness test [30-15IFT], isometric hip extension [IHE], and dominant handgrip strength), and (c) relative age (i.e., BQ). The accumulation of measures were specifically used to examine rugby-related characteristics that have been previously highlighted as influential during the TD processes in RU (Till et al., 2020).

Participants

Seventy-eight Premiership RU academy players participated in this study. Players were separated by age group and playing position (forwards: U16=12, U18=17, U21=4; backs: U16=16, U18=25, U21=4). Institutional ethical approval was granted by Birmingham City University via the Health, Education, and Life Sciences (HELS) Academic Ethics Committee.

Procedures

All testing parameters were collected across six sessions during the first 6-weeks of the pre-season period. Subjects were instructed to follow a standardised training and recovery procedure in the 48-hours before the testing (e.g., not training to exhaustion, avoiding maximal loads, and re-fuelling appropriately post exercises). A standardised RAMP warm-up was completed and each test was fully explained and demonstrated prior to assessment. Data was gathered in the following order: BQ, body mass, height, CMJ, RSI, 10 and 20 m sprint, handgrip strength, IHE, and 30-15IFT. Peak power, relative peak power, and sprint momentum over 10 m and 20 m were calculated using a combination of these tests.

Body mass and height

Body mass and height, wearing only shorts, were measured to the nearest 0.1 kg and 0.1 cm using calibrated Seca Alpha (model 220) scales and Seca Alpha stadiometer (Seca, Hamburg, Germany), respectively. The practitioner intraclass correlation coefficient (ICC) and coefficient of variation (CV) had previously been calculated as $r = 0.99$ and CV = 2.9%.

Countermovement jump, reactive strength index, peak and relative power

Subjects performed the CMJ with hands on their hips positioned between two parallel infrared beams (Microgate, OptoGait, Italy). Subjects were instructed to complete the CMJ starting from a standing position, flex at the ankle-knee-hip to a self-selected depth, and to jump as high as possible. Subjects were familiar with the CMJ as this was used frequently in training. Subjects then completed the RSI test whereby they performed ten consecutive jumps for height whilst spending as little time in contact with the ground between jumps as possible. RSI was calculated for each jump as the ratio between height (in metres) and contact time (in seconds). The best score of the three attempts on both tests was recorded. Peak power was calculated using Sayers equation (Sayers et al., 1999):

$$Peak\ power\ (W) = (60.7 \cdot H) + (45.3 \cdot W) - 2055$$

“H” refers to the CMJ height in cm; and, “W” refers to body mass in kg. Relative peak power (W/kg) was also calculated dividing peak power by the player’s body mass. The ICC and CV were $r = 0.95$ and CV = 5% for the CMJ and $r = 0.99$ and CV = 4.5% for the RSI.

10 and 20 m sprint and momentum

Sprint time over 10 and 20 m were recorded using timing gates (Brower Timing Systems, IR Emit. Draper, UT, USA). These distances were habitually used by the club to test their players and have been used previously (Darrall-Jones et al., 2016). After the standardised warm-up, the participants completed three maximal sprints with a 3-minute passive rest between attempts, as previously reported in literature (Darrall-Jones et al., 2016). Each sprint started 0.3 m behind the initial timing gate, with players instructed to set off in their own time and run maximally through the final 20 m timing gate. The best of the three attempts was taken for analysis with times measured to the nearest 0.01-second. The body mass of the athlete was multiplied by 10 and 20 m sprint velocities ($kg \cdot m^{-1} \cdot s^{-1}$) to obtain sprint momentum on those distances. The ICC and CV were $r = 0.93$ and CV = 1.3% and $r = 0.91$ and CV = 1.8% for the 10 and 20 m sprint, respectively.

30-15 intermittent fitness test

The 30-15IFT consisted of a 30-second shuttle run over a 40 m distance, interspersed with a 15-second recovery. The test began at 8 km·h^{-1} and is increased by 0.5 km·h^{-1} at each successive running shuttle. All procedures were followed as reported in previous literature (Buchheit et al., 2008). The test was terminated when subjects were no longer able to maintain the imposed speed of the test or when they did not reach a 3 m tolerance zone on three consecutive occasions. Previous research has shown the ICC of the 30-15IFT r = 0.96 and CV=1.6% (Buchheit et al., 2008). The velocity from the last completed stage was noted and used to the estimate $\dot{V}O_2max$ (mL·kg^{-1}·min^{-1}) through the following formula (Buchheit et al., 2008):

$$\dot{V}O_2max\ (mL \cdot kg^{-1} \cdot min^{-1}) = 28.3 - (2.15 \cdot G) - (0.741 \cdot A) - (0.0357 \cdot W) + (0.0586 \cdot A \cdot V_{IFT}) + (1.03 \cdot V_{IFT})$$

"V_{IFT}" is the final running velocity; "G" refers to gender (male = 1; female = 2); "A" is age; and, "W" is subject's body mass (kg).

Isometric hip extension and dominant handgrip strength

Isometric hip extension strength was measured using a portable Takei Back and Leg Dynamometer (Takei Scientific Instruments Co., Ltd, Tokyo, Japan), whereby participants stood on a portable platform with knees fully extended, back in a neutral position, and hips flexed. Participants gripped a handle connected to the platform by an adjustable chain and were instructed to pull as hard and as fast as possible, after a 3-second countdown, for 5-seconds. This test followed the procedure explained in previous literature (Coldwells et al., 1994) and related to various aspects of sport performance (Beardsley & Contreras, 2014; Lacome et al., 2020; Marchiori et al., 2021). Dominant handgrip strength was measured using the Takei 5401 Handgrip Dynamometer (Takei Scientific Instruments Co., Ltd, Tokyo, Japan). Participants performed the test sitting and holding their dominant hand's elbow squared, following standard procedure (Massy-Westropp et al., 2011). Participants were instructed to "squeeze" as hard as possible after a 3-second countdown for 5-seconds. The best results of three attempts with a 3-minute rest for each test was recorded. Strong verbal encouragement was provided during each repetition. Similar portable isometric strength tests have been performed previously in athlete development literature (Darrall-Jones et al., 2015; Owen et al., 2020; Quarrie et al., 1995). The ICC and CV were r = 0.97 and CV = 4.5% and r = 0.98 and CV= 3.4% for IHE and dominant hand grip strength, respectively.

Birth quartile

Each subjects' BQ was calculated using their date of birth. The English annual selection year (i.e., September to August) was used to allocate subjects into four quartiles: (a) BQ1 (i.e., September to November), (b) BQ2 (i.e., December to February), BQ3 (i.e., March to May), and BQ4 (i.e., June to August) (McCarthy & Collins, 2014). Participants' birth distribution was then compared against birth national norms as previously used in literature (Kelly et al., 2021; Lewis et al., 2015).

Statistical analyses

Data are presented as mean ± standard deviation (SD) values using parametric (one-way ANOVA) and non-parametric (Kruskall–Wallis) analysis for each age category and a *t*-test and Wilcox test to analyse differences based on position. A Shapiro–Wilk test was used to determine if data were parametric or non-parametric according to a normal distribution of characteristics. Post-hoc analysis was performed to examine the effect size and statistical significance between both groups and positions using TukeyHSD and Dunn's test with Bonferroni correction, respectively. Significance was set for α level of 0.05, with Cohen's f calculated with ranges of 0.10 (small), 0.25 (medium), 0.40 (large), whilst a Cohen's *d* effect size (*d*) calculated with threshold values of 0.2 (small), 0.5 (medium), 0.8 (large), and 1.2 (very large) (Cohen, 1988). Subjects' age group, forwards, backs, and combined BQ distributions were analysed and compared against national norms using a chi-square (χ^2) goodness-of-fit, with odds ratios (OR) and 95% confidence intervals (CI) to estimate reliability. Since the χ^2 does not reveal the magnitude of difference between quartile distributions, a Cramer's V was also used to report the effect size (0.00 and under 0.10, negligible; 0.10 and under 0.20, weak; 0.20 and under 0.40, moderate; 0.40 and under 0.60, relatively strong;

0.60 and under 0.80, strong; and, 0.80 and under 1.00, very strong) (Kotrlik et al., 2011). Statistical analysis was conducted using IBM SPSS Statistics version 24.

Results

Age group differences

Forwards

Results showed U16 forwards were significantly lighter than U21s (P=0.004) with a very strong effect size. Very large effect sizes were also found for the U16 (*f*=-1.6) and U18 (*f*=-1.4) forwards compared with the U21s for dominant handgrip strength, with U21s significantly stronger than U16s and U18s (P=0.018). Moreover, a significant difference and very strong effect size was noted for RSI between older (U21) forwards and U16s (P=0.014; *V*=-2.3). In addition, a strong effect size was found between the U16 and U21 forwards for 10 m sprint (*V*=-1.9), with U16s significantly quicker than U21s (P=0.015). Moderate to large effect size was reported in peak power (*f*=0.4) and sprint momentum on 10 m (*f*=– 0.9), with older players being significantly more powerful and impactful. Lastly, a very strong effect size was found for the U16 forwards compared with U18 (*V* =-1.8) and U21 (*V*=-4.5) forwards for $\dot{V}O_2$max, with U16s possessing significantly lower aerobic capacity than U18s (P=0.009) and U21s (P<0.001). Height, IHE, and CMJ reported non-statistical significance.

Backs

Significant differences and strong to very strong effect sizes were recorded for body mass characteristics between U16 and U21 (P=0.002; *V*=-3.0) and U18 and U21 (P=0.042; *V*=-1.4) backs. In addition, strong to very strong effect sizes were found in U21s compared to U16s for CMJ (P=0.004; *V*=-1.9), RSI (P=0.016; *V*=-1.5), and $\dot{V}O_2$max (P=0.003; *d*=-2.7). Small to moderate effect size was reported for peak power and sprint momentum on 10 and 20 m, with older players possessing greater values. There were no other significant differences between U18 and U21 forwards or backs. Table 4.1 presents the age group characteristics for forwards and backs.

Table 4. 1. Anthropometric and physical characteristics by age group and position.

Factor	Under 16 (1) Mean±SD	Under 18 (2) Mean±SD	Under 21 (3) Mean±SD	One-way ANOVA P	Kruskall -Wallis P	Post-hoc	U16 vs. U18 effect size	U16 vs. U21 effect size	U18 vs. U21 effect size
Forwards									
Body mass (kg)	88.9±10	97.4±7.63	111.7 ± 7.3		0.005	1 < 3	-0.9 (-1.7 to -0.2)	-2.3 (-3.7 to -0.9)	-1.9 (-3.1 to -0.6)
Height (cm)	183.9±6.9	183.7±4.8	186 ±8.9		0.945		0.04 (-0.7 to 0.8)	-0.3 (-1.4 to 0.9)	-0.4 (-1.5 to 0.7)
IHE (kg)	145.3±25	157.1±26.09	180.3± 22.1		0.111		-0.46 (-1.2 to 0.3)	-1.4 (-2.7 to 0.2)	-0.9 (-2.0 to 0.2)
Handgrip (kg)	45.8±7.6	48.6±6	57.9±7.5	0.018		1, 2 < 3	-0.4 (-1.15 to 0.3)	-1.6 (-2.8 to -0.3)	-1.4 (-2.6 to -0.2)
CMJ (cm)	31.8±4.4	35.7±6.95	38.7±3.0		0.081		-0.6 (-1.4 to 0.13)	- 1.7 (2.9 to - 0.4)	-0.4 (-1.6 to 0.6)
Peak power (W)	3907.6±306.9	4522.0±569.6	5356.8±502.1	0.000*		1 < 2 < 3	-0.9 (-1.7 to -0.1)	-2.3 (-3.7 to -0.9)	-2.0 (-3.2 to -0.7)
Relative peak power (W/kg)	44.1±2.9	46.4±4.5	47.9 ±1.5	0.945			0.0 (-0.7 to 0.7)	-0.2 (-1.4 to 0.8)	-0.4 (-1.4 to 0.6
RSI (m/ms)	1.12±0.20	1.34±0.37	1.61±0.37		0.014	1 < 3	-0.7 (-1.4 to 0.0)	-2.3 (-3.7 to -0.8)	-0.6 (-1.8 to 0.5)
10 m sprint (s)	1.71±0.10	1.82±0.13	1.93±0.10		0.011	1 < 3	-0.8 (-1.6 to -0.0)	-1.9 (-3.3 to -0.6)	-0.9 (-1.9 to 0.3)
20 m sprint (s)	3.11±0.20	3.23±0.21	3.13±0.23	0.445			-0.4 (-1.2 to 0.3)	0.0 (-1.1 to 1.1)	0.4 (-0.7 to 1.5)
Sprint momentum 10 m (kg·m^{-1}·s^{-1})	521.6±49.9	541.9±39.9	588.2 ±55.0	0.002		1< 3	-0.4 (-1.2 to 0.2)	-1.3 (-2.5 to -0.0)	-1.0 (-2.2 to 0.0)
Sprint momentum 20 m (kg·m^{-1}·s^{-1})	579.0 ±52.9	637.6±91.9	727.1 ± 41.1	0.031		1< 3	-0.7 (-1.5 to 0.0)	-2.9 (-4.4 to -1.3)	-1.0 (-2.1 to 0.1)
$\dot{V}O_2$max (mL·kg^{-1}·min^{-1})	58.8±1.7	61.2±0.99	65.9±0.8		0.001	1 < 2, 3	- 1.8 (-2.6 to -0.9)	-4.5 (-6.4 to -2.4)	-4.9 (-6.7 to -2.9)
Backs									
Body mass (kg)	71.7±6.3	77±8.9	89.3±1.8		0.002	1 < 3, 2 < 3	-0.7 (-1.31 to -0.0)	-3.0 (-4.4 to -1.5)	-1.4 (-2.6 to -0.3)
Height (cm)	176.9±7.7	176.9±6.8	182±3.4		0.241		-0.0 (-0.6 to 0.6)	-0.7 (-1.8 to 0.4)	0.8 (-1.8 to 0.3)
IHE (kg)	127.5±17.3	142.1±25.5	135.8±14.3		0.112		-0.6 (-1.3 to 0.0)	-0.5 (-1.6 to 0.6)	0.3 (-0.8 to 1.3)
Handgrip (kg)	44.9±5.1	46.5±7.7	51.7±5.1	0.212			-0.2 (-0.8 to 0.4)	-1.3 (-2.5 to -0.1)	-0.7 (-1.7 to 0.4)
CMJ (cm)	35.8±5.1	39.7±4.6	44.8±2.5		0.003	1 < 3	-0.8 (-1.5 to -0.1)	-1.9 (-3.1 to -0.6)	-1.1 (-2.2 to -0.0)
Peak power (W)	3365.6± 457.3	3822.1±600.7	4708.9±220.3	0.002		1 < 2 < 3	-0.5 (-1.1 to 0.1)	-2.4 (-3.8 to -1.1)	-1.3 (-2.4 to -0.22)
Relative peak power (W/kg)	46.9±4.3	49.6 ±4.6	52.7±1.6	0.783			0.0 (-0.5 to 0.6)	-0.6 (-1.8 to 0.4)	-0.7 (-1.8 to 0.3)
RSI (m/ms)	1.51±0.32	1.64±0.38	2.01±0.54		0.036	1 < 3	-0.6 (-1.2 to 0.0)	-1.5 (-2.7 to - 0.3)	-1.0 (-2.1 to 0.1)
10 m sprint (s)	1.61±0.11	1.71±0.12	1.73±0.07		0.333		-0.4 (1.1 to 0.2)	-0.4 (-1.5 to 0.7)	0.0 (-1.0 to 1.1)
20 m sprint (s)	2.93±0.14	2.93±0.14	3.00±0.11	0.609			-0.2 (-0.8 to 0.4)	-0.5 (-1.6 to 0.6)	-0.3 (-1.3 to 0.8)
Sprint momentum 10 m (kg·m^{-1}·s^{-1})	445.8±50.2	445.8±50.2	538.6 ±31.3	0.001		1 < 2 < 3	-0.3 (-0.9 to 0.2)	-1.9 (-3.1 to -0,6)	-1.3 (-2.4 to -0.1)
Sprint momentum 20 m (kg·m^{-1}·s^{-1})	494.7±48.0	494.7±48.0	601.0 ±23.1	0.030		1 < 3	-0.5 (-1.2 to 0.0)	-2.3 (-3.6 to -1.0)	-0.8 (-1.9 to 0.2)
$\dot{V}O_2$max (mL·kg^{-1}·min^{-1})	62±2.2	64.6±2.6	69±2.7		0.002	1 < 3	-0.7 (-1.4 to -0.1)	-2.7 (-4.0 to -1.3)	-1.7 (-3 to - 0.5)

Note: The column headings indicate overall effects (significance set for P = 0.05), post hoc, and effect size odd ratio (OR) set at 95% of CI, between age categories and characterise positions. IHE = isometric hip extension; CMJ = counter movement jump; RSI = reactive strength index; $\dot{V}O_2$max = maximal oxygen uptake; ANOVA = analysis of variance.

Positional differences

U16 forwards vs. backs

Within the U16 age group, strong to very strong effect sizes were found in body mass and height. Specifically, forwards were heavier (P<0.001; *V*=2.1) and taller (P=0.031; *V*=0.9) than backs. In regard to strength, U16 forwards were stronger than backs in the IHE (145±24.6 vs. 128±17.3, *V*=0.9), however statistical significance was not reached (P=0.052). Large to very large effect size was also reported for peak power (P<0.001; *d*=2.1), relative power (P=0.026; *d*=0.9), and both sprint momentum on 10 (P<0.001; *d*=1.5) and 20 m (P<0.001; *d*=1.6), with forwards recording greater scores. Lastly, the difference between U16 backs compared to forwards was significantly different for RSI (P=0.001; *V*=-1.4), 10 m sprint (P=0.014; *V*=0.8), 20 m sprint (P=0.008; *d*=1.1), and $\dot{V}O_2$max (P<0.001; *V*=-1.9) in favour of the backs.

U18 forwards vs. backs

Within the U18 age group, forwards were heavier (P<0.001; *V*=2.4) and taller (P=0.001; *V*= 1.1) than backs. Regarding peak power (P<0.001; *d*=2.3), relative power (P=0.001; *d*=1.0), and both sprint momentum on 10 m (P<0.001; *d*=1.4) and 20 m (P<0.001; *d*=1.2), forwards reported a statistically significant higher scores than backs. Moreover, significant differences and large effect sizes were found between U18 forwards and backs for CMJ (P=0.021; *V*=-0.7), RSI (P<0.001; *V*=-0.9), 10 m sprint (P=0.001; *V*=1.1), 20 m sprint (P<0.001; *d*=1.3), and $\dot{V}O_2$max (P<0.001; *V*=-1.6) in favour of the backs.

U21 forwards vs. backs

Within the U21 age group, forwards were heavier (P=0.028; *V*=4.2) and stronger (IHE; P=0.029; *V*=2.3) than backs, recorded greater peak power (P=0.002; *d*=3.5) and sprint momentum on 20 m (P=0.002; *d*=3.7), were slower over 10 m sprint (P=0.029; *d*=2.6), and possessed lower $\dot{V}O_2$max (P=0.028; *V*=-1.5) scores than backs. Table 4.2 reports significant differences between U16, U18, and U21 forwards and backs.

Table 4. 2. Anthropometric and physical characteristics based on age group and position.

Factor	Forwards Mean±SD	Backs Mean±SD	t	df	Wilcox test W	P	Effect size
U16							
Body mass (kg)	88.9±10.4	72±6.3			181	0.000*	2.1 (1.1 to 3.0)
Height (cm)	184±6.9	177±7.7			144	0.031*	0.9 (0.1 to 1.7)
CMJ (cm)	31.8±4.4	36±5.1			55	0.066	-0.8 (-1.6 to -0.0)
Peak power (W)	3907.6±306.9	3365.6±457.3	5.5	26		0.000*	2.1 (1.1 to 3.0)
Relative peak power (W/kg)	44.1±2.9	46.9±4.3	2.3	26		0.026*	0.9 (0.1 to 1.6)
RSI (mm/ms)	1.12±0.20	1.51±0.32			25	0.001*	-1.4 (-2.2 to -0.5)
IHE (kg)	145±24.6	128±17.3			139.5	0.052	0.9 (0.1 to 1.6)
Handgrip (kg)	45.8±7.6	45±5.1	0.4	18.2		0.725	0.1 (-0.6 to 0.9)
10 m sprint (s)	1.71±0.10	1.61±0.11			149	0.014*	0.8 (0.1 to 1.6)
20 m sprint (s)	3.11±0.20	2.93±0.14	2.9	23.3		0.008*	1.1 (0.3 to 1.9)
Sprint momentum 10 m (kg·m^{-1}·s^{-1})	521.6±49.9	445.8±50.2	3.9	26		0.000*	1.5 (0.6 to 2.3)
Sprint momentum 20 m (kg·m^{-1}·s^{-1})	579.0±52.9	494.7±48.0	4.4	26		0.000*	1.6 (0.7 to 2.5)
$\dot{V}O_2$max (mL·kg^{-1}·min^{-1})	58.8±1.7	62±2.2			13	0.000*	-1.9 (-2.8 to -1.0)
U18							
Body mass (kg)	97.4±7.6	77±8.9			412	0.000*	2.4 (1.6. to 3.2)
Height (cm)	184±4.8	177±6.8			335	0.000*	1.1 (0.4. to 1.8)
CMJ (cm)	35.7±7.0	40±4.6			122	0.021*	-0.7 (-1.3. to -0.1)
Peak power (W)	4522.0±569.6	3822.1±600.7	7.4	40		0.000*	2.3 (1.5 to 3.1)
Relative peak power (W/kg)	46.4±4.5	49.6±4.6	3.4	40		0.001*	1.0 (0.4 to 1.7)
RSI (mm/ms)	1.34±0.37	1.64±0.38			110.5	0.009*	-0.9 (-1.5. to -0.3)
IHE (kg)	157±26.1	142±25.5			278	0.095	0.6 (-0.0. to 1.2)
Handgrip (kg)	48.6±6	47±7.7	1	38.3		0.333	0.3 (-0.3. to 0.9)
10 m sprint (s)	1.82±0.13	1.71±0.12			334.5	0.001*	1.1 (0.4. to 1.7)
20 m sprint (s)	3.23±0.21	2.93±0.14	3.8	25.9		0.000*	1.3 (0.6. to 1.9)
Sprint momentum 10 m (kg·m^{-1}·s^{-1})	541.9 ±39.9	464.9 ±58.5	4.7	40		0.000*	1.4 (0.7 to 2.1)
Sprint momentum 20 m (kg·m^{-1}·s^{-1})	637.6 ±91.9	535.1 ±79.6	3.8	40		0.000*	1.2 (0.5 to 1.8)
$\dot{V}O_2$max (mL·kg^{-1}·min^{-1})	61.2±1.0	65±2.6			37	0.000*	-1.6 (-2.3. to -0.9)
U21							
Body mass (kg)	112±7.3	89±1.8			16	0.028*	4.2 (1.4. to 6.8)
Height (cm)	186±8.9	182±3.4			10	0.666	0.6 (-0.8. to 2.0
CMJ (cm)	38.7±3.0	45±2.5			1	0.059	-2.2 (-3.9. to -0.3)
Peak power (W)	5334.5±612.5	4708.9±220.3	5.0	6		0.002*	3.5 (1.1 to 5.9)
Relative peak power (W/kg)	47.9±1.9	52.7±1.6	0.8	6		0.448	0.5 (-0.8 to 1.9)

RSI (mm/ms)	1.61±0.37	2.01±0.54			4.5	0.387	-0.9 (-2.3. to 0.6)
IHE (kg)	180±22.1	135.7±14.3			16	0.029*	2.3 (0.4. to 4.2)
Handgrip (kg)	57.9±7.5	51.7±5.1	1.4	5.3		0.222	0.9 (-0.5. to 2.4)
10 m sprint (s)	1.93±0.10	1.73±0.07			16	0.029*	2.6 (0.5. to 4.6)
20 m sprint (s)	3.13±0.23	3.00±0.11	1	5		0.376	0.6 (-0.7. to 2.1)
Sprint momentum 10 m ($kg \cdot m^{-1} \cdot s^{-1}$)	588.2 ±55.0	538.6 ±31.3	1.5	6		0.168	1.1 (-0.4 to 2.5)
Sprint momentum 20 m ($kg \cdot m^{-1} \cdot s^{-1}$)	727.1 ±41.1	601.0 ±23.1	5.3	6		0.002*	3.7 (1.2 to 6.2)
$\dot{V}O_2$max ($mL \cdot kg^{-1} \cdot min^{-1}$)	65.9±0.8	69±2.7			0	0.028*	-1.5 (-3.1. to 0.1)

Note: Post-hoc tests: t-test for parametrics and Wilcox test for non-parametrics variables. Positions' differences for the same age group is reported for anthropometrical and physical parameters mean ± SD. Significance set for P = 0.05 and Cohen's *V* and Cohen's *d* effect size odd ratio (OR) set at 95% of CI between age categories. IHE = isometric hip extension; CMJ = counter movement jump; RSI = reactive strength index; $\dot{V}O_2$max = maximal oxygen uptake; t = t-distribution for t-test; df = degree of freedom for t-test.

Birth quartiles

Within the U16 age group, significant differences were reported among BQs distribution (P=0.004; *V*=0.5). Specifically, 50% of players were born in BQ1, 32.2% were born in BQ2, 10.7% were born in BQ3, and 7.1% were born in BQ4. For the U18 age group, significant differences were reported (P=0.017; *V*=0.3). To be specific, 40.4% of players were born in BQ1, 21.5% were born in BQ2, 31% were born in BQ3, and 7.1% were born in BQ4. Taken together, cumulative data for forwards and backs showed weak effect sizes but statistically significant differences, with 42.3% of players born in BQ1, 27% born in BQ2, 20.5% born in BQ3, and 10.2% born in BQ4 (P<0.001; *V*=0.3). Birth quartile distributions for age groups and positions compared to national norms are reported in Table 4.3.

Table 4.3. Descriptive statistics of the birth quartile distributions based on age group and position vs. national norms.

	BQ1 (*n*=) %	**BQ2 (*n*=) %**	**BQ3 (*n*=) %**	**BQ4 (*n*=) %**	**Total players (*n*=)**	**X^2 (df = 3)**	**Cramer's *V***	**P**	**Q1 vs. Q4 (OR = 95% CI)**	**Q2 vs. Q4 (OR = 95% CI)**	**Q3 vs. Q4 (OR = 95% CI)**
Under 16	14 (50%)	9 (32.2%)	3 (10.7%)	2 (7.1%)	28	13.1	0.5	0.004*	6.9 (1.1; 42.6)	4.6 (0.7; 29.9)	1.5 (0.1; 12.2)
Under 18	17 (40.4%)	9 (21.5%)	13 (31%)	3 (7.1%)	42	10.7	0.3	0.017*	5.6 (1.2; 25.1)	3.1 (0.6; 14.8)	4.4 (0.9; 20.4)
Under 21	2 (25%)	3 (37.5%)	0	3 (37.5%)	8	2.9	0.4	0.393	0.6 (0.0; 9.3)	1.0 (0.0; 13.0)	-
All players	33 (42.3%)	21 (27%)	16 (20.5%)	8 (10.2%)	78	16.4	0.3	0.000*	4.1(1.5; 11.1)	2.7 (0.9; 7.6)	2.0 (0.7; 5.9)
Forwards	12 (36.4%)	10 (30.3%)	8 (24.2%)	3 (9.1%)	33	5.4	0.2	0.130	3.9 (0.8; 19.5)	3.4 (0.6; 17.3)	2.7 (0.5; 14.1)
Backs	21 (46.7%)	11 (24.4%)	8 (17.8%)	5 (11.1%)	45	12.4	0.3	0.004*	4.1 (1.1; 14.9)	2.2 (0.5; 8.7)	1.6 (0.4; 6.6)

Note: BQ1 = September to November; BQ2 = December to February; BQ3 = March to May; BQ4 = June to August; Cramer's *V* effect size odd ratio (OR) set at 95% of CI between categories; Significance set at P = 0.05.

Discussion

There is currently limited research that has investigated the anthropometric, physical, and relative age characteristics based on age group and position in English RU academy players. Moreover, the need for replication studies to inform possible meta-analysis is underscored by the limited sample sizes available to these types of case studies, whilst providing a novel physical profile will also help inform evolutionary trends when compared to older studies (Darrall-Jones et al., 2015, 2016). Thus, the purpose of this investigation was to evaluate these characteristics in an English Premiership RU academy across multiple age categories (i.e., U16, U18, and U21) and playing positions (i.e., forwards and backs). Similar to previous literature (Darrall-Jones et al., 2015; Zabaloy et al., 2021), key findings revealed how anthropometric (i.e., body mass and height) and physical (i.e., power, momentum and aerobic capacity) characteristics differed across the three age groups. Results based on positional differences showed forwards were generally heavier, taller, stronger, more powerful, and more disruptive when compared to backs. In contrast, backs were quicker, faster, and possessed superior aerobic capacity. These findings are also in agreement with previous studies analysing similar RU players (e.g. Dimundo, Cole, Blagrove, McAuley, et al., 2021; Owen et al., 2020). Moreover, an interesting result of this investigation, in accordance with previous findings (Kearney, 2017; Kelly et al., 2021), was that there was an overrepresentation of relatively older players compared to relatively younger players in the U16 and U18 age groups. In addition, birth quartile analysis by position also showed that backs reported a significantly skewed BQ distribution favouring relatively older players, while a similar trend was also found when all players were combined.

Regarding the anthropometric measures, there was an increase in body mass and height across the three groups, with U21 recording the highest value for both characteristics. This is unsurprising, since changes in body mass and height are in accordance to the normal trajectory of growth and maturation, although they are generally more pronounced during adolescence (i.e., age 13 to 16 years) following peak height velocity (Vanttinen et al., 2011). The anthropometric results of the current study are in agreement with previous age group findings from an English RU academy at a professional club (body mass: U16=79.4±12.8 kg, U18=88.3±11.9 kg, U21=98.3±10.4 kg; height: U16=178.8±7.1 cm, U18=183.5±7.2 cm, U21=186.7±6.61 cm) (Darrall-Jones et al., 2015). Moreover, the anthropometric findings in the present study based on position are similar to those previously shown in English RU academy players (forwards body mass: U16=87.6±8.1 kg, U18=93.8±7.0 kg, U21=105.5±8.5 kg; backs body mass: U16=70.5±10.8, U18=78.7±6.9, U21=87.6±10.7; forwards height: U16=181.9±6.3 cm, U18=188.1±6.2 cm, U21=190.1±5.6 cm; backs height: U16=175.6±6.6 cm, U18=178.9±3.9 cm, U21=181.6± 4.4 cm) (Darrall-Jones et al., 2016). Since these previous studies were conducted in 2015, these current findings suggest that there are little evolutionary differences in anthropometric characteristics over half a decade on. Moreover, it could be speculated that a certain consistency in the acute:chronic training and playing load has been maintained in the sport of RU through this time. In light of this cumulative data, a systematic review and meta-analysis may be warranted to help draw more valid conclusions since it would comprise a larger representative sample.

The U18 group in this study was slightly lighter and shorter compared to the same-age international Irish players of Wood and colleagues' (2018) investigation (forwards: 98.9±9 kg, backs: 91.9±7 kg; forwards: 185±1 cm, backs: 179±0.0 cm). This possibly suggests that the higher the level of U18 rugby (i.e., international youth vs. academy), the more important anthropometric characteristics are during the recruitment process (Quarrie et al., 1995). From a position-specific perspective, forwards were significantly heavier and taller than backs, with the exception of the U21s, whereby there was no significant difference in height. Together, these findings provide further evidence that there are increases in body mass and height across the three age groups, as well as further suggesting that backs are generally shorter and lighter compared to forwards. Only forwards reported a significant difference (P=0.015) for sprint time between U16 and U21 (1.71±0.10 s vs. 1.93±0.10 s). Interestingly, U16s were in fact faster over the initial 10 m. This result may be explained by differences in power-weight ratio across age-groups that result from the timing of peak weight velocity, which tends to occur around age 16 (Owen et al., 2020). Indeed, this is particularly important for coaches and practitioners to recognise, since the perception of a slower sprint score with increasing age may be negatively reflected on a player. As such, height, body mass, and sprint time should be considered as part of a battery of tests when planning the LTAD pathway in a RU academy (Dimundo, Cole, Blagrove, McAuley, et al., 2021).

Similar to previous literature investigating characteristics in an English (Darrall-Jones et al., 2015) and Argentinian (Zabaloy et al., 2021) RU academy, results regarding sprint momentum reported statistically differences among age groups. In the present study, U21 forwards recorded a greater momentum than U16 forwards both on 10 and 20 m sprint. However, this was slightly dissimilar to that found in the English academy (Darrall-Jones et al., 2015), since they reported statistical significance differences among *all* age groups (i.e., U16<U18<U21), whereas we only found it in some (i.e., U16<U21). Similarly, Zabaloy and colleagues (Zabaloy et al., 2021) showed how younger Argentinian forwards possessed inferior sprint momentum compared to their older counterparts (i.e., U14<U16<U18<Senior). Thus, from the results of the present study, it could be speculated that forwards should train accelerations and impacts on longer (i.e., 20 m) distances. Interestingly, in the current research, backs were statistically more impactful over 10 m as they became older (U16<U18<U21), suggesting that: (a) older players' sprint momentum was influenced by greater body mass and (possibly) better running mechanics, (b) the normal trajectory of growth affected each age-group on this performance variable, and (c) coaches should include accelerations over short distances (i.e., 10 m) in a LTAD program if they aim to optimise backs' progression through the academy. To the author's knowledge, there is a lack of studies that treat sprint momentum specifically over 20 m in RU academies, therefore present discussion on this parameter is limited. From a positional standpoint, forwards generally possessed greater momentum than backs both on 10 and 20 m sprint. However, in the U21 group, sprint momentum on 10 m was not significantly different (P=0.168) for the two positions. This can be explained by the fact that at an older age, both positions accumulated enough sprint training to mitigate acceleration discrepancies

on short distances. These findings on positional differences are in line with previous works (Owen et al., 2020; Zabaloy et al., 2021), and indicate that if academy players attempt to be classified as a forward, they need to possess exceptional momentum characteristics over both 10 m and 20 m distances. Altogether, it is possible to say that academy RU players should possess an optimal combination of body mass and speed and that sprint momentum should be trained over 10 and 20 m regardless age and playing position.

The handgrip and IHE strength tests are generally considered as two strength tests that have low risk of injury and have an acceptable reliability (Coldwells et al., 1994; Massy-Westropp et al., 2011). In the present study, with the exception of handgrip strength in forwards (U16 and U18 < U21), there were no significant differences in strength scores across the age groups. Whereas, when comparing positions, U21 forwards had a significantly higher IHE score when compared with backs; although it was not statistically significant in U16 and U18 groups. The absence of significant differences for handgrip strength between U16 and U18 groups, as well as reported across all groups for IHE, may be explained by the high presence of early born players across U16s and U18s which could have enhanced the standard for the parameter of strength within the group. In particular, data regarding dominant handgrip strength revealed that it could discriminate forwards by age groups (U16s and U18s vs. U21s). In-line with position-specific requirements in RU (Darrall-Jones et al., 2016), dominant handgrip strength could reflect the fact that generally this type of strength may be associated to the superior upper body strength required by forwards during match-play (i.e., scrums and line-out). Thus, normative data for handgrip strength is required for athletes to progress to the last-age group in a professional academy. The results regarding IHE strength parameters also indicate that a specific level of maximal isometric force is required to distinguish players by position at an older age (U21). This is due to the fact that, although strength is an important parameter for all RU players (Dimundo, Cole, Blagrove, McAuley, et al., 2021), forwards require specific benchmarks for this quality; as already displayed in a recent study (Owen et al., 2020).

Results from this research show that CMJ differentiated age groups, with U16 backs scoring significantly lower than U21 backs (35.8±5.1 cm vs. 44.8±2.5 cm). This could reflect that older players possess greater power qualities and may have a better jumping skill, suggesting that both power development and jump technique progression should be structured in the LTAD continuum. From a positional viewpoint, backs jumped higher than forwards across all age groups; although this difference was only statistically significant in U18s (forwards: 35.7±7.0 cm; backs: 40±4.6 cm). Importantly, this reflect the fact that body mass is associated with jump height and instantaneous power production, thus, different quantities of work are performed by players with different body mass to achieve that height. These findings are in agreement with those of adolescent international Irish players (Wood et al., 2018), whereby backs jumped higher than forwards. An explanation for positional difference emerged in this research could be explained by the fact that forwards are typically required to produce a greater amount of power from semi-static actions during game (e.g., ruck, mauls, and scrums) (Quarrie & Wilson, 2000; Wood et al., 2018) whereas backs only spend 25% of their activity generating power from isometric contractions (Wood et al., 2018). Moreover, their power qualities contribute to optimise linear sprints, change of directions, and to achieve higher speed from different starting positions during games (Quarrie & Wilson, 2000; Young et al., 2015). Thus, present results shows that power qualities assessed by CMJ can be an important factor during backs' LTAD and progression across an academy, and that specific benchmark should be used to distinguish players by position in U18s.

Power qualities assessed in this investigation reported that peak power but not relative peak power distinguished age groups among forwards, with older players scoring higher than younger players (U16<U18<U21). In backs, statistically significance differences were found only among some age groups (i.e. U16 and U18 < U21). Together, these results are in line with a study of Howards and colleagues (*2016)*, which analysed the physical characteristics of the academy (U14 to U17) of a Premiership RU club, where mean values for peak power demonstrated a trend towards increasing with age group. From a positional perspective, peak power was greater in all-age forwards compared to backs (U16: P<0.001; U18: P<0.001; U21: P=0.002), whereas relative peak power was significantly greater only for forwards in both U16 (P=0.026), and U18 (P=0.001) groups. Although forwards' peak power results reflect the same outcome of that reported in an investigation surrounding the incidence of injury in forwards and backs in RU (Ball et al., 2018) , in regards to the relative peak power, there no previous study that has examined this attribute within a RU population. Thus, the present research showed that both U16 and U18 forwards expressed more power per kilogram than their back counterpart, forwards were more powerful than backs and that there is more diversity among younger players than U21s. Therefore, these findings, along with information relative to the CMJ, suggest that diverse aspects of power should be trained in a RU academy for an adequate LTAD, as well as adding new benchmarking guidelines for practitioners.

Reactive strength index is defined as the ratio between jump height and contact time (m/ms) (McClymont, 2003) and reflects an athlete's lower limb stiffness and stretch-shortening cycle capabilities (McClymont, 2003). The RSI has been largely used both in RU clubs, and has been linked with jump, sprint, and change of direction abilities (McClymont, 2003; Young et al., 2015). Results from this investigation demonstrated that the RSI discriminated both age groups and positions, whereby older players (P=0.014) and backs (U16: P=0.001; U18: P=0.009) demonstrated significantly greater values compared to their respective counterparts. This may be due to the accumulation of RU practice and plyometric-based training that older players have accumulated. Moreover, positional differences could reflect the greater stretch-shortening cycle (SSC) that players require in this role (Wood et al., 2018; Worsnop, 2016). Differences among groups and positions emerged in the current study suggest that athletic qualities linked to RSI should be planned and integrated across age-grade players for a more accurate LTAD in RU. To the authors' knowledge, although this test has been used routinely in professional clubs, there is no comparative data for RU players. Therefore, RSI score from this study could help practitioners of professional clubs in identifying normative measures for RU academies.

Aerobic capacity was estimated from the 30-15IFT. The results of this study confirm those of a previous investigation regarding the aerobic characteristics of English senior professional RU players (Scott et al., 2017), where it was found that backs had greater aerobic qualities compared to forwards. Thus, irrespective of age group, backs appear to possess significantly greater parameters of $\dot{V}O_2max$ from entry (i.e., U16) to expertise (i.e., professional level). Indeed, backs are normally leaner and have less body fat percentage compared to forwards, which facilitates their superior aerobic profile when expressed relative to body mass (Owen et al., 2020). Moreover, forwards' lower aerobic capacity is associated with the specific demand of their role, which generally requires them to cover less distance compared to backs (Owen et al., 2020; Phibbs et al., 2018). The present study aligns with findings from a recent review on applied sport science in age-grade RU players in England (Till et al., 2020). Till and colleagues (2020), reported that older age groups have greater $\dot{V}O_2max$ scores and indicate that in order to progress to the U21 squad, it is necessary for players to possess excellent oxidative capacities to sustain the intensity of the game that increases alongside age.

The current study found a selection bias towards relatively older players. Indeed, similar findings were reported in: (a) senior international RU players (BQ1= 36% vs. BQ4= 27%) (Kearney, 2017), (b) Welsh academy RU players (BQ1=29% vs. BQ4=21%) (Kelly et al., 2021), and (c) English regional youth players (BQ1=60% vs. BQ4=23.4%) (Roberts & Fairclough, 2012). Relative age effect phenomena was also found in the present developmental academy, in agreement with what was found in other similar academy environments (Kelly & Williams, 2020). More specifically, descriptive statistics in this current study show that early born U16 and U18 players were overrepresented (U16: BQ1=50% vs. BQ4=7.1%; U18: BQ1=40.4% vs. BQ4=7.1%), Moreover, in accordance with Kearney's (2017) findings, this current study reported that 71.1% of backs were born in the first half of the year (BQ1 and BQ2). This may be due to selectors recruiting backs based on physical advantages (e.g., anthropometric and physical characteristics) that relatively older players often possess when compared to same age but later born peers (Worsnop, 2016). Interestingly, however, this was not the same for U21 group (BQ1=25% vs. BQ4=37.5%). In fact, present findings align with the results McCarthy and Collins (2014), whereby possible *reversal effects* of relative were evident. This suggests that a relative age bias plateaus towards adulthood and perhaps other technical, tactical, psychosocial, and perceptual characteristics (combined with results discussed) become more important for selection and progression after maturity. However, further research is required to substantiate these suggestions.

Limitations and Future Directions

It is important to consider the limitations of this study when interpreting its findings. It was not possible for this current study to analyse the specific on-field positions of forwards (e.g., prop, hooker, and flanker) and backs (e.g., scrum-half, fly-half, and wing) due to sample size restrictions. The conclusions for this study are also based on the restricted population of a single English Premiership RU academy, thus it is not possible to suggest these findings are representative of other academies, limiting their external validity. Moreover, due to the RAEs that were present within the sample, it is plausible to suggest that an academy with a younger relative age (i.e., no RAEs) may have lower mean values of the anthropometric and physical parameters, thus these benchmarks are not necessarily representative of potential to achieve senior status at adulthood. Future research should use a similar approach including specific on-field positions, a higher number of participants, comprise other physical parameters (e.g., peak height velocity, relative strength), and offer a longitudinal examination of these trends.

Conclusion

This investigation provides an insight into the anthropometric, physical, and relative age characteristics of English Premiership rugby union academy players based on age group (i.e., U16 vs. U18 vs. U21) and position (i.e., forward vs. backs). Data can be used as benchmarks to identify potential players for U16, U18, and U21 academy teams, as well as informing LTAD processes. Results show, in line with other studies (Owen et al., 2020), that anthropometric and physical parameters increase with age at different rates following the growth maturational trend, as well as demonstrating the positional differences that exist. Specifically, key findings suggest that all players should aim to develop greater parameters of body mass, power, sprint momentum, and aerobic capacity in order to meet the key prerequisites imposed by RU. Moreover, individual characteristics should be consider among playing positions. However, coaches and practitioners should act with caution, since there could be variation around the positional mean data presented, depending on training experience and age group.

There appears to be RAEs within academy RU. In particular, backs born in the first half of the year seem to be considerably overrepresented; possibly because superior anthropometric and physical characteristics are advantageous when facing forwards of a similar age. However, signs of possible *reversal effects* of relative age are prevalent due to RAEs plateauing towards adulthood, and thus a greater proportion of relatively younger players may be benefitting by the system. As such, coaches and practitioners should consider relative age when recruiting young players in RU academies, since relatively older players may be selected due to the current performance rather than their potential to develop into a senior professional. Future research is required on a larger population analysing the same characteristics based on age group and position to understand the external validity of these current findings.

5. CHAPTER FIVE

A Multidisciplinary Investigation into the Talent Development Processes in an English Premiership Rugby Union Academy: A Preliminary Study through an Ecological Lens

Dimundo, F., Cole, M., Blagrove, R. C., Till, K., & Kelly, A. L. (2022). A Multidisciplinary Investigation into the Talent Development Processes in an English Premiership Rugby Union Academy: A Preliminary Study through an Ecological Lens. Sports, 10(2), 13. https://10.3390/sports10020013

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Abstract

The progression of youth rugby union (RU) players towards senior professional levels can be the result of various different constraints. The aim of this study was to examine characteristics that differentiated playing positions and player rankings in an English Premiership RU academy. Thirty players (mean age = 18.5±2.8 years) were divided by playing positions (forwards = 18, backs = 12) and ranked (one to thirty) by coaches based on their potential to achieve senior professional status. Players were analysed across 32 characteristics from eight overreaching factors based on task, environmental, and performer constraints. MANOVA and ANOVA were used to calculate differences among variables in players' positions (i.e., forwards vs. backs) and ranks (i.e., top-10 vs. bottom-10), with a Welch's *t*-test applied to identify individual differences amongst groups and effect sizes calculated. Large effect sizes were found between groups for socioeconomic, sport activity, anthropometric, physical, and psychological factors. Moreover, environmental and performer constraints differentiated playing positions, whereas task and environmental constraints discriminated player ranks. Present findings showed that playing positions and player ranks can be distinguished according to specific constraints.

Keywords: psychology; socioeconomic; social identity; physical; cognitive skills

Introduction

One of the main challenges of youth development in rugby union (RU) is to predict future talents at both professional club and national governing body levels (Sherwood et al., 2018). The talent development (TD) processes have been observed in sports' literature (Clarke et al., 2018; Cobley et al., 2013; Côté, Baker, et al., 2007; McCarthy & Collins, 2014; Reilly et al., 2000; Vaeyens et al., 2008) and more recently applied to the context of RU (Till, Barrell, et al., 2020). There is currently an acceptance by clubs and organisations that the progression of RU players towards the top-levels of competition is multifactorial, which can be underscored using an ecological dynamics theoretical approach (Davids et al., 2012). This implies that developing expertise in RU cannot be the result of a single independent factor and is instead the result of a combination of *task* (i.e., participation history), *performer* (i.e., psychological, technical-tactical, anthropometric, physiological), and *environmental* (i.e., relative age, sociocultural) constraints (Araújo et al., 2010; Sarmento et al., 2018).

The weaknesses of the TD processes in RU are represented by the limited multidimensional examinations of players within the current literature (Dimundo, Cole, Blagrove, Till, et al., 2021; Till et al., 2019; Till, Barrell, et al., 2020; Till & Baker, 2020), which often do not take into account all the ecological constraints or analyse players' positions or playing levels (Dimundo, Cole, Blagrove, Till, et al., 2021). This is despite evidence indicating that athletes' progression is largely affected by a range of factors, such as anthropometric (Fontana et al., 2015), physiological (Darrall-Jones et al., 2015; Jones et al., 2018), psychological (Doré et al., 2019; Hill et al., 2018), social identity (Bruner & Benson, 2018), socioeconomic (Arkell, 2016; Lambert, 2010), and perceptual-cognitive expertise (PCE) (Farrow et al., 2010; Sherwood et al., 2018) traits. Moreover, it has been found that the participation in adult-led practice and peer-led play in sport-specific and multisport activities (Côté et al., 2013; Côté & Lidor, 2013), as well as the accumulation of hours of game-exposure at different ages (Bjørndal et al., 2018), can impact the development of a young player. In addition, population density in the town of growth (Cobley et al., 2014; MacDonald et al., 2009) and levels of deprivation (Winn et al., 2016) have been shown to have a significant impact on the TD opportunities and outcomes in RU. Indeed, researchers have recommended that future investigations in RU should consider these aspects in unison when studying professional academy contexts, in order to better understand the holistic demands of the TD process (Baker et al., 2013; Cobley et al., 2013).

A RU team is comprised of 15 playing athletes with a maximum of eight substitute. The squad is generally split into forward (e.g., props, hooker, flankers) and back (e.g., inside centre, outside centre, full back) players. Forwards are those who normally engage first with opponents and are involved into set pieces and close high-force collisions. In contrast, backs are players who tackle the opposition at a later stage of the game, are engaged in rapid actions, and cover longer distances in high speed running (Quarrie & Wilson, 2000; Owen et al., 2020). Since the two main playing positions require the development of specific characteristics, a different TD path is often needed for these players (Owen et al., 2020). Existing investigations on long-term athlete development (LTAD) pathways in RU are yet to elucidate the most suitable qualities to train forward and back players through an ecological lens (Dimundo, Cole, Blagrove, McAuley, Till, Hall, et al., 2021). In addition, there are only limited suggestions on how to differentiate playing levels based on player rankings in RU (Vaz et al., 2017). Indeed, questions remain surrounding the most appropriate processes that facilitate players' progression towards RU senior professional status, since sport organisations' *modus operandi* can often result in missing future professionals due to the pyramidal structure of the TID system, in which, at each stage of selection, the number of places for players to follow a development path, decreases (Till, Weakley, et al., 2020). Unfortunately, existing research is yet to report a multidisciplinary investigation based on the aforementioned areas that are important for TD in RU. Thus, the present investigation aimed to examine a range of task, environmental, and performer constraints in an English Premiership RU academy. Specifically, both playing positions (i.e., forwards and backs) and player rankings (i.e., top-10 potentials vs. bottom-10 potentials) were analysed to: (a) offer a preliminary study to better understand the TD processes in RU, (b) provide professional RU academies a novel approach of assessing players, and (c) establish a methodological framework that may be useful for other researchers in the future.

Materials and Methods

Participants

Thirty players (under-16 [U16] = 11, U18 = 9, U21 = 10) from an English Premiership RU academy agreed to participate in this study. Table 5.1 reports the descriptive statistics of the participants. All participants were analysed based on playing position to compare possible differences (forwards = 18, backs = 12). They were also ranked on their potential to become a senior professional RU player, regardless of playing position and age, from one to thirty by three Level 4 academy coaches. Coaches ranked players using subjective criteria based on both their own vision of the game and personal philosophy of coaching. This produced a linear classification of higher-ranked players down to their lower-ranked peers, which were then split into thirds using tertiles. This created a cohort of 'top-10 potentials' (n = 10), who represent the top third, and a cohort of 'bottom-10 potentials' (n = 10), who represent the bottom third. This enabled a distinct comparison between the higher- and lower-ranked potentials across the group, with the middle third discarded from the player rank analysis (n = 10). Ethical approval was granted by the Faculty of Health, Education, and Life Sciences Research Ethics Committee at Birmingham City University.

Procedure

Data were collected during the first 9-weeks of the 2019 pre-season where athletes were tested before afternoon training. Participants were instructed to follow a standardised training and recovery procedure in the 48-hours before each physical testing session. All physical tests were proceeded by a familiarisation trial and were conducted during the same day. Each anthropometric and physical test was explained and demonstrated with physical assessment preceded by a standardised RAMP warm-up, a type of activation similar to what players were usual to perform before training and competition (e.g., mobility, dynamic stretching, low level plyometrics, and running drills). The PCE video simulation test was performed in a room that comprised a setting similar to a classroom to enhance players' concentration and comfort at the club. Psychological, socioeconomic, social identity, and participation history were collected using validated questionnaires distributed via an online platform (Online surveys Jisc, Bristol, UK), which participants were asked to complete in their own time. In total, players were analysed over 32 characteristics from eight overreaching factors based on task (i.e., participation history and sport activities), environmental (i.e., socioeconomic), and performer (i.e., anthropometrical, physical, PCE, and social identity) constraints.

Task Constraints

Participation History and Sport Activities

An adapted participation history and sport activities questionnaire was used to gather the participants' engagement in activities throughout their youth (Ford et al., 2009). Following the Developmental Model of Sport Participation (DMSP: (Côté et al., 2013; Côté, Strachan, et al., 2007)), data was collected using estimated time (in hours) spent in RU competition, coach-led practice, and peer-led play between the ages of 8-11 and 12-15 years. The number of sports played until the age of 15 years was also recorded to provide information on the variety of players' motor ability and competency in basic and complex motor athletic skills. This study followed guidelines indicated previously (Ford et al., 2009).

Environmental Constraints

Socioeconomic Factors

The town where participants spent the most of their life during childhood and adolescence was recorded via an online questionnaire. The number of inhabitants and index of multiple deprivation decile was calculated using the UK government data available online (*English Indices of Deprivation*, n.d.). The size of the town was ranked using the classification adopted by Cobley et al. (Cobley et al., 2014), where the crescent number of inhabitant per town was labelled according to a number ranging from 1 to 5: 1 = 0-9,999, 2 = 10,000-19,999, 3 = 20,000-49,999, 4 = 50,000-99,999, and 5 = 100,000-199,999. Moreover, according to the government norms, the index of multiple deprivation (IMD) decile reflected the players' socioeconomic situation from the most deprived (scored with "1") to the least deprived (scored with "10").

Performer Constraints

Anthropometric

Body mass and height were measured to the nearest 0.1 kg and 0.1 cm using calibrated Seca Alpha (model 220) scales and Seca Alpha stadiometer (Seca, Hamburg, Germany), respectively.

Physical

Isometric hip extension (IHE) strength was measured using a portable Takei Back and Leg Dynamometer (Takei Scientific Instruments Co., Ltd, Tokyo, Japan). This test required the participant to stand on a portable scale platform with knees fully extended, back in a neutral position, and hips flexed. The chain with an handle was attached at the platform and the length was set according to the participants' height by positioning the grip at the height of the intra-articular space of the knee joint. Subjects were instructed to lift vertically in order to generate an isometric pulling contraction for 5-seconds. Dominant handgrip strength was measured using the Takei 5401 Handgrip Dynamometer (Takei Scientific Instruments Co., Ltd, Tokyo, Japan). Participants performed the test sitting and holding the shoulder at approximately 0° flexion, abduction and rotation, the elbow flexed at 90° and wrist positioned between 0° and 30° dorsiflexion and between 0° and 15° of ulnar deviation. Participants were instructed to "squeeze" as hard as possible for 5-seconds and the best results of three attempts was recorded, with a 3-minute rest between tests. Thus, the muscle strength primarily generated by the flexor muscles of the hand and the forearm could have been recorded. Strong verbal encouragement was provided during each repetition. These tests followed standardised validated procedure explained in previous literature (Coldwells et al., 1994; Massy-Westropp et al., 2011). All participants' positions for both the isometric hip extension and handgrip strength test were checked previous recording. The dominant hand was determined by asking the participants with which hand they normally write. Recorded measure from the two dynamometers consisted in the maximal force expressed in kg.

All participants were familiar with the CMJ as this was used frequently in testing and training at the club. Players performed three trials of a CMJ by jumping as high as possible while positioned between two parallel infra-red beams (Microgate, OptoGait, Italy) and following a standard procedure already used in literature (e.g. (Román et al., 2018)). After circa ninety seconds of recovery, players then completed three attempts for the reactive strength index (RSI) test whereby they performed ten consecutive jumps trying to spend as little time in contact with the ground as possible. Participants were instructed to reach maximal height for every bounce. RSI was calculated for each jump as the ratio between height (in metres) and contact time (in seconds). The best score of the three attempts on both tests was recorded. The Sayers equation (Sayers et al., 1999), was then used to explore the expression of the peak power for each participant:

$$Peak\ power\ (W) = (60.7 \cdot H) + (45.3 \cdot W) - 2055$$

Where "H" refers to the CMJ height in cm; "W" to body mass in kg.

Relative peak power ($W \cdot kg^{-1}$) was calculated dividing peak power by player's body mass. Sprint time over 20 m were recorded using timing gates (Brower Timing Systems, IR Emit. Draper, UT, USA). Timing gates were placed at starting point and at 20 m distance. Following the warm-up, participants completed three maximal sprints from a staggered start with a 3 min passive rest between attempts. Each sprint started behind the initial timing gate (0.3 m), with players instructed to set off in their own time and run maximally through the final 20 m timing gate. Participants' starting point was checked before they were allowed to proceed. The best of the three attempts was taken for analysis with times measured to the nearest 0.01s. Momentum was simply calculated by multiplying body mass and estimated final velocity over 20 m sprint, as previously used (Darrall-Jones et al., 2015).

The 30-15IFT consisted of a 30 s shuttle run over a 40 m distance, interspersed with a 15-second recovery. Starting speed was set at 8 $km \cdot h^{-1}$ and increased by 0.5 $km \cdot h^{-1}$ at each successive running stage as reported in previous literature (Buchheit et al., 2008). When participants were no longer able to run at the imposed speed or when they did not reach a 3 m tolerance zone on three consecutive occasions, the test was terminated. The velocity from the last completed stage was noted and used in the formula (Buchheit et al., 2008) to the estimate the $\dot{V}O_2max$ (mL·kg^{-1}·min^{-1}):

$$\dot{V}O2max\ (mL \cdot kg\text{-}1 \cdot min\text{-}1) = 28.3 - (2.15 \cdot G) - (0.741 \cdot A) - (0.0357 \cdot W) + (0.0586 \cdot A \cdot VIFT) + (1.03 \cdot VIFT)$$

Where "V_{IFT}" is the final running velocity; "G" refers to gender (male = 1; female = 2); "A" is age; "W" is subject's body mass (kg).

Perceptual-Cognitive Expertise (PCE)

The participants' decision-making skill based on a combination of tactical situations was examined using a perceptual-cognitive video simulation test, already used in RU literature (Sherwood et al., 2018) and demonstrated to produce valid and reliable measures for PCE research in several sport environments (Kelly et al., 2020). Fifteen specific game situations were chosen from live rugby match footage and video clips were then created. To provide a wide-range view of the pitch, each clip was filmed from different elevated angles. Following moments of build-up play, the screen unexpectedly froze for 8 s prior to a critical decision-making moment. A multiple choice question related to the frozen clip appeared with four possible answers and participants were required to select what they believed to be the most appropriate answer on their response sheet before the next clip automatically began. As per examination conditions, participants were seated and were unable to communicate with each other. Participants overall score was ranked using percentiles (i.e., 90th, 75th, 50th, and 25th) and then classified (i.e., 1 = excellent, 2 = good, 3 = average, 4 = low, and 5 = poor) for analysis. The total accuracy of the participants' responses was recorded for analysis.

Psychological Characteristics of Developing Excellence Questionnaire Version 2 (PCDEQ2)

To measure psychological characteristics, the seven factor (factor 1 = adverse response to failure, factor 2 = imagery and active preparation, factor 3 = self-directed control and management, factor 4 = self-directed control and management, factor 5 = seeking and using social support, factor 6 = active coping, and factor 7 = clinical indicators) and 88 item PCDEQ2 was used (Hill et al., 2018). The answers were ranked with a Likert score ranging from 1 ("very unlike me") to 6 ("very like me") and then were converted into final scores on the seven factors. This conversion finally led to a score of one to ten for each of the seven items as explained by Hill et al. (Hill et al., 2018S).

Social Identity Questionnaire for Sport (SIQS)

The SIQS was used to evaluate players' social identity within their respective academy team. Nine items in a Likert score system (1= "strongly disagree" and 7 "strongly agree") reflected three underlying dimensions: (a) in-group ties (items 1-3), (b) cognitive centrality (items 4-6), and (c) in-group affect (items 7-9). SIQS total score was also calculated (Bruner & Benson, 2018). These data were collected via an online questionnaire that players were requested to complete in their own time.

Statistical analysis

The Shapiro–Wilk test was used to check data normal distribution. Anthropometrical, physical, psychological, PCE, and SIQS scores were then normalised using *z*-scores ($z=(x- \mu)/\delta$), where x is the raw score, μ is the population (U16, U18, and U21) mean, and δ is the population standard deviation. A multivariate analysis of variance (MANOVA) was used to calculate difference among the combined sport activities, socioeconomic, social identity, psychological, anthropometric, and physical factors between both forwards and backs and top-10 and bottom-10 potential players. Whereas a one-way analysis of variance (ANOVA) was used to explore the differences for the participation history and cognitive test as them were comprised of one variable. A Welch's *t*-test was then conducted for all the variables to compare differences among players' positions and ranks. A Cohen's *d* was also used to calculate the effect size of these factors. Cohen's *d* effect size was calculated as reported in previous literature (Cohen, 1988) with threshold values of 0.20 (small), 0.50 (medium), and 0.80 (large), with corresponding 95% confidence intervals (CIs). Significance was set for an α level of 0.05 with the statistical analysis conducted using IBM SPSS Statistics Version 24.

Results

The descriptive statistics are reported in Table 5.1. The MANOVA for sport activities factors, socioeconomic factors, social identity factor, psychological factors, anthropometric and physical factors and the ANOVA for participation history and cognitive factor are reported in Table 5.2. The Welch's t-test analysis is reported in Table 5.3.

Table 5.1. Descriptive statistics for forwards and backs and top-10 potentials and bottom-10 potentials.

Constraints	**All forwards (n=18)**	**All backs (n=12)**	**Top-10 potentials**	**Bottom-10 potentials**
	Mean±SD (*z*-score)	Mean±SD (*z*-score)	Mean±SD (*z*-score)	Mean±SD (*z*-score)
Age (year)	18.1±3.1	18.4±2.9	19.0±2.9	18.7 ±2.3
BQs	1.9±1.1	2.0±1.1	1.7±1.0	2.0±1.0
Task constraints				
Participation history				
Number of sports	2.9 ±1.8	3.7±1.9	3.5±2.1	3.5±2.2
Sport activities				
Game exposure U8-U11 (hours)	74.1±47.5	99.0±50.1	120.7±52.3	59.8±24.3
Coach-led U8-U11 (hours)	300.8±182.3	216.5±131.3	296.4±112.1	216.0±193.8
Peer-led U8-U11 (hours)	126.8±159.0	81.0±72.3	139.0±209.1	82.7±62.9
Game exposure U12-U15 (hours)	226.1±114.4	222.4±93.0	234.8±122.2	215.5±71.7
Coach-led U12-U15 (hours)	411.9±274.1	343.6±150.7	391.0±175.5	368.4±225.3
Peer-led U12-U15 (hours)	255.2±233.1	287.5±316.2	311.5±274.8	124.1±48.3
Environmental constraints				
Socioeconomic				
Town population (AU)	4.7±0.5	4.2±1.0	4.3±1.0	4.3±0.8
IMD decile	7.7±1.8	6.3±1.2	6.7±1.5	8.3±1.2
Performer constraints				
Anthropometric				
Body mass (kg)	98.7±11.6 (0.606±0.745)	85.4±7.5 (-0.908±0.390)	96.0±11.2 (-0.118±0.906)	94.4±11.9 (0.234±1.017)
Height (cm)	180.4±4.7 (0.025±0.737)	171.9±42.9 (-0.022±1.114)	178.3±6.2 (-0.304±1.057)	163.6±56.8 (0.001±1.017)
Physical factors				
Hand grip (kg)	48.2±5.7 (0.022±0.966)	50.4±5.0 (-0.025±1.004)	52.6±4.3 (0.072±1.016)	46.1±5.5 (-0.252±1.102)

IHE (kg)	144.1±16.7 (0.389±0.650)	131.5±20.2 (-0.583±1.091)	147.2±22.8 (-0.088±1.035)	130.5±13.5 (0.057±1.067)
CMJ (cm)	35.6±5.7 (-0.261±0.862)	41.3±3.5 (0.417±1.014)	40.3±4.8 (-0.225±0.999)	35.4±5.4 (-0.209±0.734)
Peak power (W)	4585.53±654.94 (0.539±0.769)	4323.81±476.07 (-0.927±0.695)	4743.9±644.5 (-0.218±1.012)	4339.53±586.3 (-0.084±1.194)
Relative peak power (W/kg)	46.44±3.62 (-0.366±0.797)	50.55±2.27 (0.291±0.829)	49.36±3.15 (-0.201±0.930)	46.30±3.56 (-0.356±0.567)
RSI (m/m·s)	1.2±0.3 (-0.256±0.988)	1.7±0.4 (0.383±0.846)	1.8±0.4 (0.219±0.863)	1.2±0.4 (-0.202±0.845)
20 m sprint (s)	3.11±0.19 (0.233±0.949)	2.98±0.13 (-0.333±0.942)	2.97±0.09 (-0.328±0.537)	3.18±0.19 (0.312±0.906)
20 m momentum ($m \cdot s^{-1}$)	635.4±76.7 (0.517±0.745)	574.5±57.1 (-0.792±0.709)	647.6±85.5 (-0.036±0.952)	592.8±68.8 (0.075±1.176)
$\dot{V}O_2max$ ($mL \cdot kg^{-1} \cdot min^{-1}$)	47.6±5.0 (-0.333±0.973)	52.7±3.1 (0.517±0.748)	54.2±5.1 (0.299±1.006)	46.7±2.9 (-0.323±0.844)
Psychological				
Factor 1 - adverse response to failure (AU)	2.7±0.6 (-0.083±0.691)	3.2±0.9 (0.117±1.321)	3.1±0.7 (-0.099±1.003)	2.7±0.7 (-0.285±0.822)
Factor 2 - imagery and active preparation (AU)	3.8±0.8 (0.006±0.978)	3.7±0.9 (1.619±0.990)	3.6±0.7 (-0.262±0.757)	3.7±1.1 (0.050±1.194)
Factor 3 - self-directed control and management (AU)	4.4±0.6 (-0.239±0.996)	4.7±0.5 (0.350±0.847)	4.5±0.8 (0.242±0.971)	4.6±0.6 (0.162±1.072)
Factor 4 - perfectionistic tendencies (AU)	3.1±0.6 (-0.078±0.869)	3.3±0.6 (0.117±1.128)	3.3±0.4 (-0.025±0.999)	3.0±0.8 (-0.379±0.997)
Factor 5 - seeking and using social support (AU)	4.6±0.6 (0.117±0.875)	4.4±0.7 (-0.158±1.108)	4.5±0.6 (-0.014±0.938)	4.6±0.6 (0.116±0.836)
Factor 6 - active coping (AU)	4.4±0.5 (-0.289±0.896)	4.7±0.6 (0.442±0.931)	4.3±0.5 (-0.099±0.962)	4.6±0.6 (0.299±1.005)
Factor 7 - clinical indicators (AU)	2.0±0.5 (0.167±0.999)	2.0±0.5 (-0.242±0.866)	2.2±0.4 (-0.012±0.742)	1.8±0.5 (-0.252±0.987)
Perceptual-cognitive expertise				

PCE (AU)	3.1±1.3 (0.033±0.970)	2.8±1.5 (-0.067±1.013)	2.3±1.5 (-0.431±0.960)	2.7±1.1 (-0.188±0.907)
Social identity				
In group ties (AU)	6.1±1.0 (0.128±0.883)	5.7±1.1 (-0.208±1.052)	5.9±0.8 (-0.047±0.912)	5.8±1.4 (-0.117±1.212)
Cognitive centrality (AU)	4.9±1.5 (0.083±0.978)	5.2±1.5 (-0.100±0.989)	5.3±1.7 (0.004±1.034)	5.3±1.6 (0.045±1.160)
In group affect (AU)	6.6±0.7 (0.061±1.035)	6.5±0.5 (-0.050±0.923)	6.6±0.5 (0.178±0.871)	6.7±0.4 (0.222±0.818)
Total score SIQ (AU)	5.8±0.9 (0.094±0.967)	5.8±0.9 (-0.158±1.000)	5.9±1.0 (0.030±0.959)	5.9±0.9 (0.037±1.112)

Note: Shows descriptive difference between forwards and backs and top-10 and bottom-10 potentials. BQs = birth quartiles; IMD decile = index of multiple deprivation decile; SIQ = social identity questionnaire; IHE = isometric hip extension; CMJ = countermovement jump; RSI = reactive strength index; PCE = perceptual-cognitive expertise; V̇O2max = maximal aerobic capacity; AU = arbitrary unit.

Table 5.2. MANOVA results for socioeconomic, social identity, anthropometric, physical, psychological, and sport activity factors, as well as ANOVA results for perceptual-cognitive expertise and participation history.

Factor	**All forwards vs. backs**		**Top-10 vs. bottom-10 potentials**	
	P	**F**	**P**	**F**
Socioeconomic	0.030*	3.985	0.049*	3.581
Social identity	0.918	0.231	0.963	0.144
Anthropometric	< .001**	22.135	0.604	0.519
Physical	0.004*	4.340	0.784	0.548
Psychological	0.273	1.354	0.954	0.273
Perceptual-cognitive expertise	0.788	0.074	0.550	0.371
Sport activities	0.172	1.678	0.018*	3.820
Participation history	0.270	1.268	0.963	0.002

Note: Significance set for P = 0.05; *denotes a statistical significance of ≤. 05; **denotes a statistical significance of ≤. 001.

Table 5.3. Welch's *t*-tests for forwards and backs and top-10 and bottom-10 potentials.

Characteristic	Welch's *t*-test (P)	Cohen's d
Number of sports		
Forwards vs. backs	0.275	-0.41 (-1.15; 0.32)
Top-10 potentials vs. bottom-10 potentials	0.963	-0.21 (-0.87; 0.83)
Game exposure U8-U11		
Forwards vs. backs	0.187	-0.51 (-1.25; 0.24)
Ranked top-10 vs. ranked bottom-10	0.003*	0.80 (0.52; 2.48)
Coach-led U8-U11		
Forwards vs. backs	0.153	0.53 (-0.21; 1.26)
Top-10 potentials vs. bottom-10 potentials	0.266	0.50 (-0.37; 1.36)
Peer-led U8-U11		
Forwards vs. backs	0.296	0.37 (-0.37; 1.10)
Top-10 potentials vs. bottom-10 potentials	0.404	0.37 (-0.49; 1.23)
Game exposure U12-U15		
Forwards vs. backs	0.922	0.03 (-0.69; 0.76)
Top-10 potentials vs. bottom-10 potentials	0.661	0.19 (-0.66; 1.05)
Coach-led U12-U15		
Forwards vs. backs	0.439	0.29 (-0.44; 1.02)
Top-10 potentials vs. bottom-10 potentials	0.802	0.11 (-0.74; 0.96)
Peer-led U12-U15		
Forwards vs. backs	0.765	-0.11 (-0.84; 0.61)
Top-10 potentials vs. bottom-10 potentials	0.038*	0.97 (0.05; 1.87)
Town population		
Forwards vs. backs	0.177	0.55 (-0.20; 1.30)
Top-10 potentials vs. bottom-10 potentials	0.880	-0.06 (-0.92; 0.79)

IMD decile		
Forwards vs. backs	0.020*	0.88 (0.11; 1.64)
Top-10 potentials vs. bottom-10 potentials	0.015*	-0.79 (-1.08; -0.22)
In group ties		
Forwards vs. backs	0.372	0.34 (-0.39; 1.08)
Top-10 potentials vs. bottom-10 potentials	0.870	0.07 (-0.78; 0.92)
Cognitive centrality		
Forwards vs. backs	0.622	0.18 (-0.54; 0.91)
Top-10 potentials vs. bottom-10 potentials	0.913	-0.04 (-0.90; 0.80)
In group affect		
Forwards vs. backs	0.761	0.11 (-0.61; 0.84)
Top-10 potentials vs. bottom-10 potentials	0.905	-0.05 (-0.90; 0.80)
Total score SIQ		
Forwards vs. backs	0.499	0.25 (-0.48; 0.98)
Top-10 potentials vs. bottom-10 potentials	0.939	-0.03 (-0.89; 0.82)
Body mass		
Forwards vs. backs	< .001**	0.82 (0.53; 1.53)
Top-10 potentials vs. bottom-10 potentials	0.427	-0.35 (-1.21; 0.51)
Height		
Forwards vs. backs	0.890	-0.05 (-0.78; 0.68)
Top-10 potentials vs. bottom-10 potentials	0.504	0.29 (-0.56; 1.15)
Handgrip		
Forwards vs. backs	0.899	0.04 (-0.68; 0.77)
Top-10 potentials vs. bottom-10 potentials	0.505	0.29 (-0.56; 1.15)
IHE		
Forwards vs. backs	0.013*	0.81 (0.25; 1.88)

Top-10 potentials vs. bottom-10 potentials	0.741	-0.14 (-1.00; 0.71)
CMJ		
Forwards vs. backs	0.050*	-0.73 (-1.48; 0.02)
Top-10 potentials vs. bottom-10 potentials	0.959	-0.02 (-0.87; 0.83)
Peak power		
Forwards vs. backs	< .001**	0.81 (0.73; 0.90)
Top-10 potentials vs. bottom-10 potentials	0.718	-0.16 (-1.01; 0.70)
Relative peak power		
Forwards vs. backs	0.041*	-0.80 (-1.56; -0.03)
Top-10 potentials vs. bottom-10 potentials	0.633	0.21 (-0.64; 1.07)
RSI		
Forwards vs. backs	0.070	-0.69 (-1.44; 0.06)
Top-10 potentials vs. bottom-10 potentials	0.280	0.48 (-0.39; 1.35)
20 m sprint		
Forwards vs. backs	0.121	0.59 (-0.15; 1.34)
Top-10 potentials vs. bottom-10 potentials	0.049*	-0.83 (-1.72; 0.06)
20 m momentum		
Forwards vs. backs	< .001**	0.89 (0.90; 2.67)
Top-10 potentials vs. bottom-10 potentials	0.827	-0.09 (-0.95; 0.76)
$\dot{V}O_2max$		
Forwards vs. backs	0.012*	-0.98 (-1.74; -0.19)
Top-10 potentials vs. bottom-10 potentials	0.128	0.69 (-0.19; 1.57)
Factor 1		
Forwards vs. backs	0.637	-0.19 (-0.92; 0.54)
Top-10 potentials vs. bottom-10 potentials	0.624	0.21 (-0.64; 1.07)
Factor 2		

Forwards vs. backs	0.988	0.00 (-0.72; 0.73)
Top-10 potentials vs. bottom-10 potentials	0.459	-0.33 (-1.18; 0.53)
Factor 3		
Forwards vs. backs	0.094	-0.63 (-1.38; 0.11)
Top-10 potentials vs. bottom-10 potentials	0.851	0.08 (-0.77; 0.93)
Factor 4		
Forwards vs. backs	0.619	-0.19 (-0.92; 0.54)
Top-10 potentials vs. bottom-10 potentials	0.417	0.36 (-0.50; 1.22)
Factor 5		
Forwards vs. backs	0.478	0.27 (-0.46; 1.00)
Top-10 potentials vs. bottom-10 potentials	0.744	-0.14 (-1.00; 0.71)
Factor 6		
Forwards vs. backs	0.043*	-0.80 (-1.55; 0.02)
Top-10 potentials vs. bottom-10 potentials	0.351	-0.41 (-1.27; 0.45)
Factor 7		
Forwards vs. backs	0.245	0.43 (-0.30; 1.17)
Top-10 potentials vs. bottom-10 potentials	0.544	0.27 (-0.59; 1.12)
PCE		
Forwards vs. backs	0.790	0.86 (0.10; -0.63)
Top-10 potentials vs. bottom-10 potentials	0.550	-0.26 (-1.12; 0.59)

Note. Shows difference between forwards and backs and top-10 and bottom-10 potentials Post-hoc and Cohen's d effect size (90% confidence interval). IMD decile = index of multiple deprivation decile; SIQ = social identity questionnaire; IHE = isometric hip extension; CMJ = countermovement jump; RSI = reactive strength index; PCE = perceptual-cognitive expertise; $\dot{V}O_2$max = maximal aerobic capacity; *denotes a statistical significance of ≤. 05; **denotes a statistical significance of ≤. 001.

Forwards vs. Backs

Results showed that there was a significant difference between playing positions for both anthropometric ($P < 0.001$) and physical ($P = 0.004$) factors. The Welch's *t*-tests reported large differences between players for IMD decile (forwards = 7.7±1.8 vs. backs = 6.3±1.2; $P = 0.020$, d =

0.88), body mass (forwards = 98.7±11.6 kg vs. backs = 85.4±7.5 kg; $P < 0.001$, d = 0.82), IHE (forwards = 144.1±16.7 kg vs. backs = 131.5±20.2 kg; P = 0.013, d = 0.81), CMJ (forwards = 35.6±5.7 cm vs. backs = 41.3±3.5 cm; P = 0.050, d = 0.73), peak power (forward = 4585±654.9 W vs. backs = 4323±476.0 W; $P < 0.001$, d=2.00), relative peak power (forwards = 46.4±3.6 W/kg, backs = 50.6±2.3 W/kg; P = 0.041), 20 m momentum (forwards = 635.4±76.7 $m \cdot s^{-1}$vs. backs = 574.6±57.2 $m \cdot s^{-1}$; $P < 0.001$, d = 0.89), $\dot{V}O_2$max (forwards = 47.6±5.0 $mL \cdot kg^{-1} \cdot min^{-1}$ vs. backs = 52.7±3.1 $mL \cdot kg^{-1} \cdot min^{-1}$; P = 0.012, d = 0.98), and factor 6 (forwards = 4.4±0.5 vs. backs = 4.7±0.6; P = 0.043, d = 0.80). In addition, there was no significant differences between positions for the other variables.

Top-10 vs. Bottom-10

When examining groups based on coaches' rank, the analysis displayed statistical significance for socioeconomic (P = 0.049) and sport activities (P = 0.018) cumulative variables. The Welch's *t*-test showed significant differences among four different factors, whereby the top-10 players: (a) came from a more deprived area (6.7±1.5 vs. 8.3±1.2; P = 0.015, d = 0.79), (b) were more exposed to hours of rugby game when they aged between 8 and 11 years (120.7±52.3 vs. 59.8±24.3 h; P = 0.003, d = 0.80), (c) accumulated greater amount of time in training led by peers between aged 12 and 15 years (311.5±274.8 vs. 124.1±48.3 h; P = 0.038, d = 0.97), and (d) were faster over 20 m sprint (2.97±0.09 s vs. 3.18±0.19 s; P = 0.049 , d = 0.83) compared to bottom-10 players. Moreover, despite small to moderate effect sizes among other variables, these were not statistically significant.

Discussion

Key findings revealed that environmental and performer constraints differentiated players based on positions. Academy forwards derived from a less deprived areas, were heavier, stronger, more powerful, and possessed greater momentum. Whereas, backs possessed greater relative peak power, RSI, $\dot{V}O_2$max, and were characterised by superior active coping strategies (PCDEQ2 Factor 6) compared to forwards. Moreover, task and environmental constraints discriminated player ranks, whereby the top-10 potentials players derived from more deprived areas, were exposed to more RU competition between aged 8 to 11 years, accumulated a greater amount of engagement in peer-led play between aged 12 and 15 years, and were significantly faster over the 20 m sprint when compared to the bottom-10 potential players.

The IMD decile indicated that forwards originate from *less deprived* areas compared to backs (i.e., higher IMD score), possibly implying developmental differences in these players. Previous research from Winn et al. (Winn et al., 2016) found that more deprived young Welsh players engaged in less sports and accumulated less hours of rugby-specific training. In contrast to Winn et al. (Winn et al., 2016), however, although the present study revealed that backs originated from a *more deprived* areas, it does not reflect the fact that backs were excluded from sports (mean number of sports = 3.7±1.9) and RU activities (e.g., games, coach-led practice, and peer-led play from U8 to U15), nor were *critically deprived* (e.g., IMD below 5). Several studies have attempted to analyse the influence of socioeconomic status on anthropometrical qualities in young RU players (Arkell, 2016; Armstrong et al., 2011; Krause et al., 2015; Lambert, 2010). These investigations revealed that players with a lower socioeconomic status were physically smaller and lighter than those players from a higher status. According to present findings and the importance that some qualities have in characterising players in RU (Owen et al., 2020), the results on IMD decile provide an important indicator to consider when researching and developing young RU players in relation to their position, suggesting more investigation on this aspect.

When analysing players according to their ranking, top-10 potentials came from *more deprived* areas compared to bottom-10 potentials (IMD decile = 6.7±1.5 vs. 8.3±1.2). Thus, it could be suspected that deprivation *may* help somehow in shaping characteristics useful to unlock players' potential. As explained in the rocky road theory of Collins et al. (Collins et al., 2016), it is possible that the top-10 potentials had both the opportunity to challenge themselves and to have adequate social support to interpret adversities as positive growth experiences. Moreover, it could be speculated that deprivation reduces the engagement of young players with organised sport environments (Winn et al., 2016), whereas from another perspective, it might increase vital opportunities of practice sport related activities in *deliberate play* settings with parents, peers, and siblings (Fraser-Thomas et al., 2017). In fact, a more enjoyable and peer-led environment has already been adopted from international professional RU teams to stimulate self-awareness, decision-making, tactical awareness, and in general, *athlete's functionality* in adult players (Rothwell et al., 2020). Therefore, this social discrepancy can lead to the possible theory that the IMD decile variable could help in forming attributes relevant to diverse playing positions (e.g., anthropometric, physical, psychological, social identity, PCE), as well as a higher ranking in RU academies. In this light, professional RU environments could add this parameter in a novel format of players' assessment.

From an anthropometric perspective, this investigation revealed that forwards were heavier than backs (98.7±11.6 kg vs. 85.4±7.5 kg, $P < 0.001$). This is in agreement with previous results across RU academies (Owen et al., 2020), senior squads (Argus et al., 2012), and clubs from different countries (Dimundo, Cole, Blagrove, Till, et al., 2021). Due to players' positional requirements, a higher body mass in forwards aids in attenuating impacts during tackles and collisions (Durandt et al., 2006). The variation in anthropometric measures among playing positions consolidates how forwards and backs require diverse anthropometric characteristics in order to perform position-specific tasks during games (Owen et al., 2020). From a ranking viewpoint, although not statistically significant, top-10 potentials were heavier than bottom-10 potentials, indicating this may be important for players to succeed in an academy. Recent studies demonstrated how body mass was pivotal to distinguish selected and non-selected academy players in England (Dimundo, Cole, Blagrove, McAuley, Till, & Kelly, 2021), predict players' progression in an Italian academy (Fontana et al., 2016), as well as to discriminate positions in South African (Durandt et al., 2006), Zimbabwean (Chiwaridzo et al., 2019), and Argentinian (Zabaloy et al., 2021) academy environments. Therefore, coaches should consider the importance of body mass in developing players and their progression across an academy. However, practitioners should be aware that players of the same chronological age can differ in their maturity status, and therefore caution should be placed when selecting players based on morphology parameters only.

Physical parameters have been shown to differentiate both playing positions (Owen et al., 2020) and age-grade players (Zabaloy et al., 2021), as well as to distinguish levels (Dimundo, Cole, Blagrove, McAuley, Till, & Kelly, 2021) in RU academies. In the present investigation, forwards were significantly stronger than backs in the IHE test (144.1±16.7 kg vs. 131.5±20.2 kg, $P = 0.013$), demonstrating the importance of this physical characteristic for this playing position. One of the reasons why forwards are typically stronger than backs is because these players are required to produce higher maximal isometric force during games in holding scrums and competing for the ball in rucks and mauls when compared to backs (Durandt et al., 2006; L. Quarrie & Wilson, 2000). Together, these findings indicate that different aspects of strength should be developed in RU academies according to players' individual needs.

Sprint momentum has been defined as a key parameter for performance in RU, as well as differentiating playing levels (Barr et al., 2014; Zabaloy et al., 2021) and playing positions (Owen et al., 2020) in various academy settings across the globe. In the current study, forwards performed 20 m sprint momentum similar to results from U18 forwards in a previous investigation (Dimundo, Cole, Blagrove, McAuley, Till, Hall, et al., 2021) (637.6±91.9 $m \cdot s^{-1}$ vs. 635.4±76.7 $m \cdot s^{-1}$). Present results suggest that forwards outperformed backs due to their heavier body mass. Specifically, when a heavier body reaches a higher velocity, it possesses a greater kinetic energy compared to a lighter body. For instance, maximising sprint momentum through increasing body mass while maintaining linear speed capabilities appears to be an important characteristic for forwards to possess, since such position involves ball carrying in situations where contact is unavoidable (Barr et al., 2014). From a ranking point of view, momentum did not statistically differentiate top-10 from bottom-10 potentials, however, top-10 potentials recorded a medium effect size difference compared to bottom-10 potentials, suggesting that this parameter should be trained in TD environments.

Findings from the CMJ and power-related measures reported that backs jumped significantly higher and possessed greater relative peak power than forwards, indicating that these players could had superior jumping technique and were able to express more power per kg of body mass when compared to forwards (CMJ = 35.6±5.7 cm vs. 41.3±3.5 cm, P = 0.05, d = -0.73; relative peak power = 46.44±3.62 W/kg vs. 50.55±2.27 W/kg, P = 0.041, d = -0.80). Similar results were found between positions in a LTAD study within RU academies on CMJ (Wood et al., 2018) and relative peak power analysis (Dimundo, Cole, Blagrove, McAuley, Till, Hall, et al., 2021). An explanation for backs' possessing greater jumping performance and relative peak power is that these factors contributes to optimise linear sprints, changes of direction, agility, and to achieve higher speed from different starting positions during games. Similar to the findings of Howard et al. (Howard et al., 2016), peak power was significantly greater in forwards than backs in this current study (4585±654 W vs. 4323±476 W), indicating that, in general, players from this playing position often rely on this physical parameter during powerful actions of a match (e.g., closer stance explosive tackles). From a rank perspective, although top-10 potentials recorded superior CMJ, peak power, and relative peak power compared to bottom-10 potentials players, it was not statistically significant. Together, these results indicate that the evaluation and development of power-related qualities should be included in the RU TD process.

In the present study, 20 m sprint was the only physical factor that distinguished the top-10 and bottom-10 potentials, whilst no significant differences found among positions. Sprint time has recently been shown to be a key factor in TID and TD processes in RU (Dimundo, Cole, Blagrove, McAuley, Till, & Kelly, 2021). Moreover, sprint ability was linked both to different levels of RU (Barr et al., 2014; Jones et al., 2018), as well as different age groups and positions in different countries (Barr et al., 2014; Chiwaridzo et al., 2020; Owen et al., 2020; Zabaloy et al., 2021). Speed has been increasingly recognised as important by RU practitioners since RU games are becoming more dynamic and faster than previous years (Vahed et al., 2014). Another possible explanation is that, as per body mass characteristics, sprinting speed has been correlated to momentum, which is a key component in RU matches (Barr et al., 2014). Therefore, practitioners are encouraged to focus on maximising the development of the different phases of sprint mechanics in academies.

Aerobic capacity was estimated using the 30-15IFT. The only statistical significant difference was found between positions, whereby backs had a greater $\dot{V}O_2max$ when compared to forwards (52.7±3.1 mL·kg^{-1}·min^{-1} vs. 47.6±5.0 mL·kg^{-1}·min^{-1}, P = 0.012), which aligns with previous literature (Scott et al., 2003). Indeed, backs are generally leaner and have a lower body fat percentage when compared to forwards, which may have facilitated a superior aerobic profile when expressed relative to body mass (Owen et al., 2020). Moreover, the specific demands of forwards requires them to cover less distance in a game when compared to backs (Phibbs et al., 2018), which may be explained with the present findings. Although not statistically significant, the top-10 potentials possessed greater $\dot{V}O_2max$ when compared to the bottom-10 potentials (d = 0.69), suggesting that this may have a certain degree of importance to differentiate ranks in players. Therefore, aerobic capacity should be trained based on position during a LTAD pathway (Till, Weakley, et al., 2020) and be part of an assessment battery in RU.

Previous studies attempted to distinguish psychological traits in different playing positions (Andrew et al., 2007; Batista et al., 2019; Vaz et al., 2017), ranking (Andrew et al., 2007; Potgieter et al., 2008; Vaz et al., 2017), and based on coaches perspectives (Hill et al., 2015) across RU players. Specifically, existing literature shows that forwards generally possess greater psychological skills, such as relaxation, stress reaction, and fear control (Andrew et al., 2007; Batista et al., 2019), when compared to backs. Indeed, only one study (Vaz et al., 2017) has shown that both forwards and backs possessed equally good psychological traits (i.e., determination, goal directedness, self-confidence, concentration, and mental preparation). On the contrary, however, the results from the present study showed how backs were characterised by superior perceived active coping strategies (PCDEQ2 Factor 6) when compared to forwards. It is plausible to suggest that backs may experience more pressurised situations during competitive match-play when compared to forwards, since their role includes critical moments, such as executing penalty kicks, kicking conversions, and require quick decision-making skills. Moreover, since the current study showed how backs come from higher deprivation, it could be speculated that a greater perceived active coping was a result of an adaptation to a more challenging socioeconomic environment during their development. However, further research is required to substantiate these suggestions and explore the association between socioeconomic status and the development of psychological characteristics in talent pathways. No significant differences were reported in psychological variables between top-10 and bottom-10 potentials players. Thus, the present findings could be used to help explain the role of the environment and psychological development in RU players and guide future research.

With regards to the engagement in sport activities (i.e., game exposure, coach-led practice, and peer-led play), there were no positional differences at both aged 8-11 and 12-15 years. In comparison, however, the top-10 potentials engaged in more hours of game exposure at a younger age (i.e., aged 8-11 years) and accumulated more time in peer-led play during late childhood and early adolescence (i.e., aged 12-15 years) when compared to the bottom-10 potentials. An early exposure to competition has been considered an important part of the athlete development process (Bjørndal et al., 2018; Güllich et al., 2021), which aligns with the understanding that young players should be exposed to various enjoyable games that gradually produce more demanding performance-specific situations with an older age (Doré et al., 2019). Similar to the present results, in a recent meta-analysis from Güllich et al. (Güllich et al., 2021), it was reported that although world champions started their main sport at a later stage in life, higher performing athletes accumulated significant early exposure of their main sport than lower performers ($P = 0.010$; $d = 0.20$). In handball, for instance, Bjørndal et al. (Bjørndal et al., 2018) stated that an early exposure to the competitive experience represented a vital part for player development towards their *high performer* status. Thus, coaches should take into account the potential long-term benefits that high-quality game exposure could have on players' status. With regards to player rankings, the top-10 potential accumulated a greater number of hours in peer-led play between aged 12-15 years when compared to the bottom-10 potentials. Although these findings report controversies with conclusions of a recent study on athletes' progression (Barth & Güllich, 2021), they align with rugby league research that has shown the importance of peer-led activities in development of professional players (Andrew et al., 2007; Cupples et al., 2018). Thus, a more varied learning experiences during early-adolescence could facilitate a later rugby-specific skill learning and refinement (Bransford & Schwartz, 1999). From an ecological dynamic perspective (Araújo et al., 2010; Davids et al., 2012), it is possible to explain present results through the variation in learning tasks and environments, which may facilitate a players' ability to adapt their actions in learning and to familiarise their movement across various unpredictable environments (i.e., enhanced *athletes functionality*, see Rothwell et al., (Rothwell et al., 2020)). As such, a players' later exposure to peer-led play may continue during the transition from childhood to adolescence, which is a crucial stage for young RU players since they are generally selected to be part of a professional academy for the first time (i.e., at U15).

Overall, these findings offer a preliminary study to better understand the TD processes in RU, provide professional RU academies a novel approach of assessing players, and establish a methodological framework that may be useful for other researchers in the future.

Limitations and Future Directions

One limitation of this study was the small number of participants. A larger sample may have altered the outcomes of the current findings, especially those in relation to ranked players (Hecksteden et al., 2021). Another limitation of this study was that no age-related differences were investigated (i.e., it could be possible that different age influenced players' ranks). However, the novelty of this study also compares those who have already been selected into an academy environment through analysing potential to achieve senior professional status, rather than the traditional approach of comparing 'elite' vs. 'non-elite' or 'selected' vs. 'non-selected'. Thus, further limiting the prospective pool of participants. Moreover, it is important to mention that present results only reflect the status of a single Premiership RU academy, and thus it is possible that this is not representative of other environments in RU. However, other studies surrounding TD in RU (Darrall-Jones et al., 2015) and football (Kelly et al., 2020), adopted similar methodological procedures when analysing academies of professional clubs. Furthermore, some data was collected retrospectively (e.g., game exposure, peer-led play, and coach-led training), and therefore recall bias may have influenced findings. Nevertheless, previous research has applied these tools and demonstrated a good level of reliability and validity (e.g., (Barth & Güllich, 2021)). In addition, due to the large number of data collection methods required to be completed in order to be included in the current study, only those academy players who conducted all the measures were analysed. Therefore, it is important to recognise that this study may have not considered participants whose results may have changed the outcomes should they have completed all the protocols. However, due to these limitations, this study was denoted as a preliminary investigation to ensure the reader acknowledges the exploratory nature of the research being performed. Thus, the present investigation can be used to guide future research methodologies, which are encouraged to maintain a multidisciplinary approach and use a longitudinal protocol with a greater and more diverse sample.

Conclusions

To the author's knowledge, this is the first multidisciplinary study that has analysed 32 characteristics from eight overarching factors in an English Premiership RU academy through an ecological dynamics lens. Present findings showed how playing positions can be differentiated by environmental and performer constraints. Moreover, top-10 potential players were distinguished from bottom-10 potential players in task and environmental constraints. Rugby practitioners are encouraged to follow a similar multidisciplinary approach and use these findings as framework when assessing professional academy players. Researchers could also use the methodology employed in this investigation as the basis for future work in this area.

6. CHAPTER SIX

Talent identification and development in an English Premiership rugby union club: The perspectives of players and coaches

Dimundo, F., Cole, M., Blagrove, R. C., Herbison, D. J., Turnnidge, J., Vitali, F., Till, K., & Kelly, A. L. (n.d.). Talent identification and development in an English Premiership rugby union club: The perspectives of players and coaches. *In preparation*.

Abstract

The path towards the senior professional status in sport is affected by a multitude of factors. An abductive examination of the talent identification and development processes at an English Premiership Rugby Union (RU) club was undertaken. *Part one* of this study researched the perspectives on the selection and development processes of a group of senior academy male players (split in PG1: n = 4; PG2: n = 4), whereas *part two* explored the perceptions of one group of male coaches (CG: n = 7). A total of three focus groups were used. Three main themes were identified by players and coaches: task constraints, performer constraints, and environmental constraints. Although athletes and coaches believed that performer constraints were highly impactful on players' career in RU, there was an inconsistency surrounding the task, and environmental constraints. Although there was an indication that three common themes affect an athlete path, this preliminary study shows an imbalance in the understanding of some of the key factors perceived to be important for talent progression in the present rugby academy. More research using similar exploration qualitative methods is recommended, meanwhile, practitioners could implement holistic strategies to improve the progression process in English RU academies.

Keywords: qualitative; long-term athlete development; multidimensional analysis; sport psychology; performance environment

Introduction

Becoming a senior professional player is the ambition of many young athletes practicing organised youth sports. Several authors have attempted to provide guidelines to optimise the Talent Identification (TID) and Talent Development (TD) paths to support this journey (Till & Baker, 2020). Although the two terms are used interchangeably, the first is defined as the process of recognising current participants with the potential to excel in a particular sport, whereas the second is the process of providing the most appropriate learning environment to realise this potential (Williams & Reilly, 2000). Unsurprisingly, TID and TD literature in sport reports that professional playing status is affected by a multitude of factors (Kelly, Till et al., 2021; Sarmento et al., 2018; Till & Baker, 2020). However, the possible drawbacks of TID and TD systems have led key stakeholders (e.g., academy managers, coaches, players, kinesiologists, sport psychologists and parents) to question the efficacy of these strategies (Cobley et al., 2013).

The increasing popularity of Rugby Union (RU) has led to large financial investment in TID and TD systems from World Rugby Union (World Rugby Union, 2020) and national governing bodies (England Rugby, 2021; Till et al., 2020) which impacted different areas of performance (e.g. physical, technical, tactical) in youngsters. In England, TID and TD systems follow a *wide and emergent* (e.g., offer a broad range of developmental opportunities and a focus on players remaining in their own environment until adolescence), and *narrow and focused* (e.g., identify players with an individualised focused programme for long-term development) model, which is managed by the fourteen regional academies aligned to the respective professional RU clubs (Till, Barrell et al., 2020). Moreover, a recent systematic review of TID and TD in RU (Dimundo, Cole, Blagrove, Till et al., 2021) which included studies conducted on English RU clubs, underscored the holistic nature of these processes. In fact, Dimundo, Cole, Blagrove, Till, et al. (2021) found that independent of playing position, those academy players who progressed towards senior professional status (a) possessed greater body mass, (b) were physically stronger, more powerful, and faster, (c) were technically and tactically superior (e.g., advanced passing and catching accuracy, collective effectiveness), (d) possessed specific psychological characteristics (e.g., greater resilience, cohesiveness, coping skills, and determination), and (e) were derived from more advantaged socioeconomic backgrounds (e.g., received higher social and economic support by coaches, clubs, schools, and family).

Despite the growing body of literature exploring TID and TD in RU (e.g., Dimundo, Cole, Blagrove, Till, et al., 2021), further examination of players' and coaches' perceptions of TID and TD processes in this sport is required to deeply investigate the current state of the art from both selectors' and selected' perspective (McAuliffe et al., 2021). It is well known that the TID and TD in sport should be analysed diverse methodological perspectives since outcomes are affected by objective (e.g., measurable data from tests), and subjective (e.g., how players perceive sport situations and decisions (Collins et al., 2016), and interpretations of events (Toohey et al., 2018). The most connected populations in an academy setup, and in a certain sense, the main '*actors on the talent stage*' are those acting as 'selectors' (i.e., coaches), and 'selected' (i.e., players). For this reason, investigating the TID and TD topic using one perspective only (i.e., coaches' viewpoint; Chiwaridzo et al., 2019) limits the knowledge on the optimal TID and TD strategy to use by clubs. Thus, to answer the call that research on TID and TD should also provide practical applications to managers, coaches and players (Toohey et al., 2018), a qualitative approach was considered critical to inform and maximise the strategic management of talent programs while increasing knowledge in sport expertise (Toohey et al., 2018; Weissensteiner, 2013). To the authors' knowledge, there are only three published studies that have used a qualitative approach to investigate TID and TD in RU (Chiwaridzo et al., 2019; Hill et al., 2015; Roberts & Fairclough, 2012). However, these studies focused on coaches' perceptions in regards to specific TID and TD topics (i.e., anthropometrical, physical, technical-tactical, and psychological, or maturational and relative age), leaving unexplored other important fields (e.g., environmental, socioeconomic background, sport participation history, and activity type) that can influence the talent path. Moreover, a major gaps in the mentioned researches consists in ignoring the perception of players on the TID and TD paths. In fact, Chiwaridzo et al. (2019) examined the anthropometrical, physical, technical-tactical, and psychological characteristics that Zimbabwean coaches perceived important for the TID and TD in adolescent RU school players. They found that coaches considered a range of fundamental qualities underpinning the above mentioned areas as decisive factors for players progression. Furthermore, Hill et al. (2015) interviewed English Premiership RU coaches on psychological traits requested for players and found that a range of positive (e.g., self-regulated learning strategies, ownership and independence, motivation), negative (e.g., lack of commitment, lack of development awareness, mental health issues), and dual-effect (e.g., perfectionism, obsessive passion, over-commitment) characteristics were identified as essential for academy players' progression towards senior professional level. Additionally, Roberts and Fairclough (2012) explored English regional development officer who were responsible for TID and TD processes awareness of relative age effects (RAEs) in RU. Surprisingly though, the interviewed group revealed a general lack of knowledge, understanding, and awareness of RAEs. Thus, implications from these studies remain limited to certain analysed factors and represent only the coaches' perspective.

The advantage of using a qualitative approach in this field of research is that it can draw from different key stakeholders' perspectives, to hear the participant's voice while exploring emerging topics more in-depth, as well as help to inform researchers and practitioners on planning, practice and decision-making (Gaber, 2020; Vatousios & Happonen, 2022) with evidence that cannot be captured using quantitative methods (e.g., player profiling, testing, questionnaires; Powell & Single, 1996). Moreover, Strean (1998) reported that qualitative research could be extremely important in sport performance since it provides information to stakeholders that could be connected to their own performance practice, and thus help translate knowledge into practical action. For instance, several steps have been outlined in the *Knowledge to Action* process in order for problem solving knowledge and give rise to action in applied settings (see Graham et al., 2006) for an overview). Furthermore, it has been reported that the perspectives of the two main samples from the TID and TD processes in sport academies (i.e., players *and* coaches) are rarely featured in the literature to understand how organisational approaches actually affect TID and TD, despite their ability to offer valuable insights into the transition to the professional level (Jones et al., 2014). In addition to the paucity of qualitative research on TID and TD in RU, the current investigations only concern the perspectives of coaches, leaving unanswered questions surrounding what players perceive important for selection and development in professional RU settings. As such, the aim of this paper was to evaluate the perspectives of both academy players (under-21 [U21]) and academy coaches on the TID and TD processes in an English Premiership RU club.

Materials and Methods

Participants

Eight U21 male academy players (PG1: n = 2 forwards, 2 backs, age = 19.9±0.8 years, experience in professional academies = 4.0±0.8 years, age when started playing RU = 4.7±0.5 years; PG2: n = 1 forward, 3 backs, age = 19.7±0.8 years, experience in professional academies = 5.7±0.5 years, age when started playing RU = 8.0±3.1 years) and seven academy male coaches (CG: U15 n = 2, U16 n = 2, U18 and U21 n = 2; RFU level 2 n = 3, RFU level 3 n = 2, RFU level 4 n = 2; age = 37.4±9.5 years, experience in coaching academy RU = 5.0±3.6 years). Ethical approval was granted by Birmingham City University via the Faculty of Health, Education, and Life Sciences Research Ethics Committee. Since all participants were adults, a detailed participant information sheet and informed consent form was provided and signed by all participants prior data collection.

Procedure

The current study was comprised of two parts in order to collect and analyse the data from both players and coaches' separately. Specifically, two focus groups for players (i.e., PG1 and PG2) were used for the first part, while a single focus group for coaches (i.e., CG) was used for the second part. All group discussions were organised by the lead author on three different days across two consecutive weeks in February 2020. Each focus group lasted approximately 60-minutes and was held in a meeting room at the club training ground, which had a comfortable setting that encouraged open discussion and interaction. Holding the focus groups at the club's facility allowed participants to feel in a familiar setting and in a space where they were more focused and had more confidence to share information. Each focus group conversation was recorded by two video cameras (Sony HDR-CX240E Handycam), and two microphones (7RYMS RimoMic Lite LN Mini) in order to collect details of the discussions and facilitate subsequent anonymised transcription of dialogue. While data collection was set by the first author, the conversation was facilitated by the first author for PG1 and PG2, and by the fifth author for the CG. Other authors (i.e., AK, and JH) were present during the focus groups to assist where required. All focus groups followed a semi-structured design, whereby participants had the opportunity to discuss and reflect upon their experiences within an organised, yet flexible structure (Powell & Single, 1996). During the focus groups discussions, the facilitator helped the flow of the conversation by encouraging participants to develop on initial interactions and promoting responses that reflected participants' perspectives on TID and TD processes in their RU academy (e.g., "How would you describe what role a coach plays in facilitating athlete development?", "What do you think is important to take into account when developing a player?"). It was emphasised throughout the focus groups that there were no 'correct' or 'incorrect' answers to the questions and that confidentiality would be preserved.

Data Analysis

The epistemological approach of the present investigation consisted in using an abductive analysis in the attempt to *explain* causality of the TID and TD phenomenon within the examined English Premiership RU club providing an 'insider' perception on players' path towards the senior professional status. This approach, has been recommended when analysing data concerning multifaceted topics (e.g., Brandt & Timmermans, 2021; Dubois & Gadde, 2002; Lindgren & Barker-Ruchti, 2017; Ong, 2012; Ren et al., 2018; Tavory & Timmermans, 2014; Timmermans & Tavory, 2012; Tomasella, 2019). This analysis enables information to emerge abductively (i.e., confirming existing theories from the data), which is a strategy that has been found important in qualitative research since it provides the development of theories based on empirical data collection in a specific context (Ong, 2012).

The literature confirms that it is arguably not possible to conduct an exclusively inductive analysis, as the researcher would require some form of criteria to identify whether or not a piece of information may be conducive to addressing the research question(s) (Byrne, 2022). For this reason, the present study followed an adapted coding reliability (also known as *small q* post-positivist) approach to thematic analysis (Braun & Clarke, 2022; Byrne, 2022). Four main steps were followed and adapted from previous literature (Braun & Clarke, 2006; Timmermans & Tavory, 2012; Tomasella, 2019), including: (a) recording and transcribing focus groups, (b) creating codes, (c) defining and merging code and categories, and (d) refining themes. Specifically, this process included: (a) finding holistic theories in TID and TD in sport, (b) creating tags, (c) creating sub-categories, (d) creating categories, and (e) refining themes. Before refining final themes, discussion topics were organised into categories and sub-categories. The first stage consisted in recording and transcribing the focus groups using NVivo 12 (QSR International, Melbourne, Australia). The second stage consisted in identifying basic conceptual units called 'meaning units'. These were established based on part of the text that contained one idea that was coded with a descriptive name (Côté et al., 1993). Tags were created with words containing the meaning units and were 'flagged' when important information was established. NVivo enabled to label meaning unit that could have been easily search for content check by authors and eventually replaced with adequate modification. The third stage consisted in the creation of 'sub-categories' involving a higher level of tags, which comprised a similar type of description to the initial level of analysis. Where there were similarities across each sub-category, tags were assembled into 'categories', representing a higher level of inspection. The software enabled to quantify contents in order to number each category, which was useful for authors during final interpretation of data. Finally, further analysis of the data consisted of merging similarities between flagged groups to determine 'themes', whereby relationships were identified and organised into higher-order groups. All themes were then independently reviewed before being agreed by the research team. Anonymised example quotations have been provided throughout the results. A similar structure for analysis and reporting of data has been used previously in sport literature (e.g., Carter et al., 2021; Chiwaridzo et al., 2019).

Establishing Trustworthiness and Methodological Rigor

The aim of qualitative research is not to produce replicability in the same way as quantitative research, but (as also for the quantitative approach) to provide results that are consistent with the data collected (Merriam, 1998). For this reason, to improve reliability of data and to minimise the possibility of misrepresentation while improving rigour in analysis, the universal criteria and criteriological approach (Tracy, 2010) was used after member checking strategy (Smith & McGannon, 2018). Moreover, it is worth to mention that rigour was improved by the fact that the lead author of this work had an insider perspective of the data of this study, whereas the other team members and co-authors, offered a more outsider perspective during the analysis process. Furthermore, detailed descriptions and peer examination (through video or audio) of findings and member checking techniques were performed (Patton, 2014). Additionally, to enhance the rigour of the research, it is important to mention that the lead facilitators were skilled in working with, communicating with, listening to, and understanding young athletes and professional coaches. Indeed, these skills that have been previously identified as being useful for engaging dialogues with specific populations (Clarke et al., 2018). The research lead also had an extensive knowledge of the team, coaches, and players at the RU club, which promoted access to participants and facilitated the flow of the discussions.

To reinforce the rigor and credibility in the present research, regular peer debriefing with the research team were programmed while using the universal eight criteria of analysis, since limitations raised using only the member checking approach (Smith & McGannon, 2018). This entailed exploring the methods, data analysis, and decision-making processes at every stage of the investigation. Thus, effective qualitative research practices were ensured by using the universal eight criteria (Tracy 2010): (a) worthy topic, (b) rich rigor, (c) sincerity, (d) credibility, (e) resonance, (f) significant contribution, (g) ethical, and (h) meaningful coherence. This research is part of a three years exploration on the topic of TID and TD processes authorised by an English Premiership RU club. Therefore, this qualitative work, which is the first on TID and TD in RU science analysing both players and coaches, was considered a *worthy topic*. The use of two independent focus groups for the players and a separate one for the coaches provided both similarities and contrasting perspectives on the selection and development processes in one of the few English Premiership RU academies, which ensured that the study met the criteria for *rich rigor*. The criterion of s*incerity* was encompassed throughout all the steps of the research process whereby each author avoided bias during data collection and analysis. *Credibility* in the present study was met through the accuracy of the reported data and the reflections from all participants, whilst following and adapting widely used thematic guidelines ((Braun & Clarke, 2006, 2022; Byrne, 2022) alongside using contemporary transcription and coding software (i.e., NVivo 12). The nature of the present findings embraced the criterion of *resonance* since they recalled the perceptions of academy players within the RU environment, which could be familiar to readers. Moreover, this investigation represents an attempt in advancing practitioners' knowledge on the topic of TID and TD in RU, which could provide a *significant contribution* to the applied sport science field. Since this piece of work received both organisational and institutional ethical approval from their respective administrative and ethics board, adequate *ethical* procedures were always followed. Finally, to ensure *meaningful coherence*, the research group believed this study achieved its stated goals and interconnected each stage of the research process so as to accomplish the intended outcomes.

Results

Part One: Players' Focus Groups

Table 6.1 reports the PG1 and PG2 results and provides additional examples of relevant quotations for each of the categories identified. It should be noted that since it was not possible to report examples of quotations for each of the sub-categories, some quotes are duplicated in Table 6.1 to offer a complete overview. A total of 49 raw-data sub-categories cumulatively emerged from the initial inductive sweep from the PG1 and PG2 transcripts. Conceptualisation of the raw-data sub-categories revealed ten categories in total: (a) sport participation history, (b) activity type, (c) game exposure, (d) anthropometric, (e) physiological, (f) psychological and psychosocial, (g) technical-tactical, (h) national, (i) socio-economic, and (j) family. Finally, three higher-order themes were formed, which resulted the three constraints from the ecological dynamics framework, including: task constraints, performer constraints, and environmental constraints. According to each thematic description, TID and TD paths seem influenced by a multitude of factors that impact professional players' trajectory in unison. These themes were in line with constraints found in previous works on TID and TD in sport (Dimundo, Cole, Blagrove, Till, et al., 2021; Sarmento et al., 2018). As such, the following results are presented using these higher order themes.

Table 6.1. Players' focus groups results.

Theme	Categories	Sub-categories (*n* of times mentioned)	Categories' additional example quotation
Task constraints	Sport participation history	Multisport background (9)	"I preferred football up until I was 11, probably, then changed to rugby. And cricket, I preferred cricket until […] I started enjoying rugby and I started rugby. And a bit of athletics as well, on the side". PG1
	Activity type	Exposure to training (3) Consistency in good performance (2) Position specific requirements (2) Repetition of skills (2) Dedication to improve skills (2) Enjoy the skills (1) Handling skills (1) Skill transferability (1) Skill-set variety (1)	" […] It's then what people are actually doing away from training and away from the club. […] So, it's those players who do that extra training bit, who have that extra want to not lose that are the ones that end up coming through and out the other end". PG1
	Game exposure	Game played (2)	"Because I think the more you're out on the pitch, the better you get as a player". PG2
Performer constraints	Anthropometric	Height (2)	"Because I feel like rugby is not that specialised, i.e. you've got to have loads of different qualities about yourself a part being tall". PG2
	Physiological	Multitude of physical factors (3) Individual characteristics (2) Speed (2) Fitness (2) Strength (2) Agility (1) Physicality (1) Work rate (1) Jump qualities (1) Quickness (1)	"Like you've got to have speed, be quick, you've got to be agile". PG2
	Psychological and psychosocial	Hard work (8) Mindset (5) Ask for feedback (5) Communication (4) Teamwork (3) Consistency (3) Improvement (3) Competitiveness (2) Player-coach relationship (2) Grit (1) Effort (1) Lifestyle (1) Aggressiveness (1) Coachability (1)	"[…] when you first come in, you've got to understand, you've got to look at the people who are seniors in the team, and understand the amount of hard work they put in to be where they are. And that you're going to have to put in easily that much, if not more, if you want to eventually get to that position. And if you can just get it in your head that it's going to take a hell of a lot of hard work to get into that position, then that's a good start. Because you get your first professional contract, that's just the beginning, you haven't even done anything yet at that stage. That's where all your hard work begins. So, the faster you can understand that, the faster you can start getting better". PG2
	Technical-tactical	Position specific technical differences (2) Good at basic drills (2) Ball carrying (2) Kicking skills for back (1) Passing ball for width for forwards (1) Decision making (1) Big tackles (1) Turnovers (1) Great breakdowns (1)	"You've got one or two things that you're really good at and some other stuff you're good at but it's not brilliant […]. Whereas in world class players, they make big tackles, make big carries, turnovers, work great at breakdowns, they've got everything". PG1
Environmental constraints	National	Culture (2)	"So, I started playing there, but yeah once again, all the way through secondary school probably did every single sport I could possibly do because it is how we do here [in England]". PG2
	Socio-economic	Type of school (4)	"If you really want to stick with rugby, it's kind of a private school thing…" PG1
	Family	Parents (3) Brothers (2)	"So, my dad was an actual ex-professional scrum-half as well so I used to do a lot with him. So, we'd go and that would be where I'd kind of get my basic pattern and kicking stuff done till I'd prepare myself to go and play in the academy in Wales". PG1

Task Constraints

Task constraints consisted of three categories: (a) sport participation history, (b) activity type, and (c) game exposure. From a *sport participation history* perspective, it was evident that all players practiced different sports at various levels at a young age before or in concomitance with specialising in RU. For instance, a player from PG2 reported that:

> "[…] But the biggest thing is making sure you do as many sports as possible because there's so many different skills that are transferable to the game of rugby […]. So, I think it's good to do as many sports as possible, just to increase your variety of skillsets."

Moreover, a player from PG2 reported his diverse sporting background while focusing more specifically on RU:

> "So, rugby is probably the main sport that I've really done. Done football, done kickboxing, done most sports, golf, but rugby's the main one".

It also emerged that the *activity type* performed (e.g., in the form both of deliberate play and deliberate practice), was seen to have an advantageous effect on progression throughout a professional academy. As an example, it was reported that a larger accumulation of hours towards RU-specific activities was considered important for a player from PG1:

> "I think mine was just definitely dedicating more time to it [training] than anyone else, really, when I was in those school kind of years. I was always kind of semi obsessed with going and getting passing and kicking done. In all my spare time it was just me and a couple of mates going to the local rugby club and kick for hours and hours. And it was our way of socialising as well through summers and stuff. So yeah, I think for me it was just kind of dedicating that time to go and develop my skills".

Similarly, a player from PG2 reinforced the importance of engaging in additional RU-specific activities:

> "So, you just find yourself doing extra gym sessions, extra kicking, like tackling with coaches and asking for more time and more feedback and stuff than like your peers around you who are not doing that".

A player from PG1 reported that training similar in the form of deliberate play was what made the difference in his career:

> "For me it was probably more enjoyment. When I was at school, I played it with my friends and we all went like training after school, which would be quite fun and we'd go back home. Then weekends, we'd play a game and then we'd go out for food or something afterwards and it was kind of like a fun activity to do […]. But for me, I think it was just making sure I kept enjoying it and didn't like overdo it and take it too seriously and ruin it for myself".

The fact that the RU academy players had a large amount of *game exposure* was believed important for growth and development from a participant of PG2:

> "So, I was playing like a Saturday, Sunday, sometimes on a Wednesday as well for the school. And when I look back on it and think you might say, "It was too much". But I actually think it actually helped me a lot, because if you're tired and you physically don't feel as strong going into a game, it encourages you to challenge your skillset and do something in a different way".

Performer Constraints

Performer constraints consisted of four categories: (a) anthropometric, (b) physiological, (c) psychological and psychosocial, and (d) technical-tactical. From an *anthropometric* viewpoint, a player from PG2 reported that being tall was a prerequisite to be a successful rugby player:

> "[…] you've got to be people that are tall [to play professional rugby…]".

Regarding *physiological* requirement important for the different game-positions in RU, a player from PG1 reported:

> "[…] it's specific. It's not like football where, "Oh you'll pass, you'll shoot." Like the front row have just got to be big strong brutes, if you be a strong brute, you can [carry,

attack and scrum], that's what you've got to bring. If you're a 9, you've got to bring your quick kicking game and your fast passing game. If you're a back, you've got to bring just speed in everything, over the top everything, just fast get in people's faces and stuff. I think you've got to bring that in your position and when you spend time with your mentor, you just learn off him".

Players also require *psychological and psychosocial* characteristics, such as cohesiveness with the rest of the team, in order to progress and set apart from less successful academy players. For example, a player from PG2 reported:

> "It's like the things that we're describing are sort of like the skeleton of the ideal player. But I feel like each individual person in that skeleton has got their own like flare or specific thing that they're good at. So, I feel like as a team we sort of fit into that skeleton by bringing our own like individual attributes. So, I feel like that's the best thing about being here, everyone has those individual attributes that just fit into that ideal player. So, I think there's no like specific, "He's the ideal player". Everyone's got their own ability to become that ideal player, it's just fitting into that skeleton. […] It's more an ideal team".

Moreover, results from the players' focus groups showed that several other *psychological and psychosocial* characteristics (e.g., hard work, communication, teamwork) had an important role in the TD process throughout the academy. These helped both in creating a successful teamwork environment and gaining trustworthiness. An example was provided from a player in PG1:

> "If you're working hard and the guys around you know you're working hard they can trust you. And then if everyone's doing that together, then you'll work together well and it just makes a better team".

The communication and the capacity to be resilient when asking for individual feedback was recognised by players to be a fundamental *psychological and psychosocial* characteristic both for the TID and TD process. For example, a player from PG mentioned:

"So, I think selection is a massive part of what we do in terms of like speaking to the coach and stuff, that's where you can get on their backs and say, "What do I need to do better to play? What can I improve? Where are my opportunities?" that kind of thing".

Mindset was also considered a *psychological and psychosocial* characteristic that differentiated standards of players. As an example, a player from PG1 stated:

"I think that's the difference between a really good club player and sort of the senior academy and making the first team. It's just that mentality".

Another example confirming the importance of *psychological and psychosocial* characteristics in RU, was reported by a participant from PG2 when they stated that several other behavioural characteristics were considered beneficial to distinguish level of players (e.g., competitiveness, aggressiveness, grit):

"[…] And I think one thing that sets boys apart, so, from that jump where you go from academy to senior academy, you kind of see the boys that want it more. They go out on the field, they're more aggressive, they don't want to lose. So, when you've got some people that are just kind of there, they're good rugby players, they're talented, they're not going to make it because they don't have that extra little bit of grit".

Regarding *technical-tactical* skills, a player from PG1 stated that practising basic RU drills was the prerequisite to be successful during the TID and TD process:

"If you don't have your basics [skills] then you don't have any chance, really".

The connection between these four categories, which underscores the impact of a multitude of factors on the TID and TD processes in RU and the existing individual differences among players and positions, was explained by a player from PG1:

"I think around the table [focus group participants], like *player's name* sort of like brings a lot of physicality and work rate to games because he's like a very fit number 8. Like *player's name* brings a lot of speed like sort of around rucks and stuff like that and, like he says, with his kicking game. And *player's name* is just sort of like a wall in defence and like a strong runner. And personally, me, I like ball carrying, stuff like that is what I like to pride myself on".

Another quote that supported the previous statement reported that every player has their own strengths relevant for the TID process. However, participants reported that for each player, there could be multiple important factors that could have influenced their personal progression across a professional academy, which was suggested by a player from PG1:

> "But it's just everyone has their own individual thing that they're good at. There could be like two or three things, but I've just named one for each of us that I've seen in them. But there could be three or four, there isn't just one thing that you pride yourself on so there could be like a whole lot of various things".

Environmental Constraints

Environmental constraints consisted of three categories: (a) national, (b) socio-economic, and (c) family. From a *national* outlook, a statement from a player from PG2 proposed how he may have played rugby due to his national sport tradition:

> "But probably because rugby is the main sport in Wales as well, so everybody does rugby [...] Because rugby's much bigger in Wales for kids than football […]".

From a *socio-economic* perspective, in a sentence from a player in PG1 it was evident the clear impact of the sport orientation that different type of schools (e.g., private and state) could have on a RU player pathway:

> "[…] Yeah well, not really [rugby] at state school, it was just football, everyone played football. Yeah, there was no rugby. It was literally the only sport you did; it was the only sport anyone did. And then, obviously, when I went to [private] school, it was just school rugby, nothing else. Unless it was cricket and so on but I hate cricket".

Family was considered from PG2 one of the most important factors affecting progression in RU and in general in sports:

> "Probably, a huge thing for I guess everyone round the country [England] would be family input because if you're raised up in a household of football then you're more than likely to be going into football and playing football more often. So, I was quite lucky in that sense because my family are massively into rugby and sort of like a wide range of different sports. So, they were open to me to play whatever sport I wanted to play and support me in whatever I wanted to do. And it turned out to be rugby and they were very happy about that. So, I think family is a huge thing for sportsmen to start off their career".

A useful connection among these categories was highlighted throughout various statements. More specifically, a player from PG1 suggested:

> "I went to a state school until Year 7 and then private school [in England] because all my brothers went there so I just followed the family. And then that's where I picked up rugby and started enjoying it".

Part Two: Coaches Focus Group

Table 6.2 reports the CG results and provides additional examples of relevant quotations for each of the categories identified and presented a complete overview of each sub-categories. Cumulatively, 34 sub-categories emerged from the initial analysis of the raw data for CG. Further analysis revealed a total of eight categories perceived important by coaches for players' TID and TD: (a) sport participation history, (b) game exposure, (c) anthropometric, (d) physiological, (e) psychological and psychosocial, (f) technical-tactical, (g) socio-economic, and (h) culture. Lastly, three themes represented the factors perceived to be determinant for CG on selection and progression of players in a professional RU academy. Three higher-order themes were formed, which resulted the three constraints from the ecological dynamics framework (Dimundo, Cole, Blagrove, Till, et al., 2021; Sarmento et al., 2018), including: task constraints, performer constraints, and environmental constraints (see Figure 6.1). As such, the proceeding results are presented using these higher order themes.

Table 6.2. Coaches' focus groups results.

Theme	Categories	Sub-categories (*n* of times mentioned)	Categories' additional example quotation
Task constraints	Sport participation history	Multisport background (2)	"I think I'd just tell them to trust their instincts, try things they've learned from other sports, because so many of the young lads I have, they're trying to fit to a certain concept that they think is the right person to be and by doing so inhibit themselves quite a lot".
	Game exposure	Amount of exposure to rugby play (2) Exposure to play against older players (1)	"I think it's good that we get them to compete against each other every now and again. So, we'll have the different centres come, and sometimes, if you're in your little bubble in your centre because at the younger [** 0:36:50] centres, they get a sense that they might be very good. But actually, it's when you put yourself out there and you're playing against the other centres, that you realise that, actually, we've got some things to work on. And then as we go into those older age groups […], I know it's really bad. Let's say as under-16s, we're going away to play other academy teams because, again, you get used to what your group is like but actually we need to see what that challenge is like, because, again, it's not just referencing the strength of our group, but it's referencing what it looks like nationally".
Performer constraints	Anthropometric	Size (5) Height (1) Exclude late mature players (1)	"I think, […], some of it is those behaviours, and [*coach's name*] mentioned as well, some of it is physical attributes. Basically, there are certain sized, shaped players that need to be in certain positions and if they don't have those attributes, it doesn't really matter how good their skillset is at that […]".
	Physiological	Physical qualities over skillset (4) Individual characteristics (2) Fast (2)	"So, again, it might be that Player A has good some really good skillsets, but Player B hasn't got them but he's got the physical attributes and size to be a premiership rugby player, so that's where we're going to have to put our resources".
	Psychological and psychosocial	Hard work (5) Work ethic (4) Select players who ask feedback (3) Commitment (3) Select more coachable players (2) Position specific requirements (2) Slow processing players difficult to progress (1) Mindset (1) Behaviour (1) Confidence (1) Fearless (1)	"When the ball's in the air and you're 50 metres away from the ball but you're working as hard as you can to go and make a tackle or get a position to prevent to opposition scoring. Make a try-saving tackle or running 50 metres to get an [offload] scrum, a score-winning try, whatever it is, but to see people work off the ball is a massive thing for the way I watch rugby and see behaviours within the children as well as the players".
	Technical-tactical	Good at basics (3) Sense of game (1) Catch (1) Pass (1) Manipulate defence (1) Footwork around the contact areas (1)	"Do the simple things well. I think sometimes kids think that they've got to do the spectacular to showcase themselves, but actually just doing the basics really well [all the time]".
Environmental constraints	Socio-economic	Type of school (2)	"Actually being able to see every player play, whether it's a state school that plays [rugby] six weeks of the year and that's it or it's rugby clubs or big private schools, is having relationships with other schools and the guys out on the ground".
	Culture	Positive and supportive environment (3) Engagement with players (2) Challenged but fun environment (1) Quality of coaching (1) Connection with local community (1) Coaches teamwork (1) Full-time environment (1)	"I think, as *coach's name* touched on just now, it's the people that they have here. It's not as such just bringing in quantity of anyone with a rugby background and interest; it's making sure it's the quality and culture that comes in. So, everyone is here to work as part of that rugby family rather than individual interest just to try and beat each other".

Task Constraints

Task constraints consisted of two categories: (a) sport participation history, and (b) game exposure. From a *sport participation history* perspective, one coach highlighted the importance of a multi-sport background:

> "Just through my background and what I like to see in a player. If I see someone that plays [standoff or scrumhalf] in rugby, who's naturally a good footballer as an identified space from a young age, then you're like, "Yeah, we can work with this kid". A lot of fly-halves that are at the standoff position in rugby have come through a football background. They will start with football and then be encouraged to see things and then move into rugby, and when you see them from an early age, they've usually got a good skillset, they've come from a background where they've been encouraged to work. And then it's just trying to give them more fine detail about the tactical stuff. And if they can take that on board, then usually you've got a bit of hope for them".

Moreover, the connection between *game exposure* and developmental opportunities was explained by another coach:

> "We do look at the scale of how much rugby they're playing week to week to keep it fair, when you're comparing them [for selection]".

Performer Constraints

Performer consisted of four main categories: (a) anthropometric, (b) physiological, (c) psychological and psychosocial, and (d) technical-tactical. The CG highlighted the implications of *anthropometric* and long-term change upon TD outcomes. For instance, one coach reported that those players who did not mature physically in the time of three years would not progress across the academy:

> "There are some kids who, through their athletic, their size, they haven't grown in a year or two or three, and they just won't fit into it naturally and we can't see any growth in them

sometimes, physically, which is upsetting for them sometimes, but that's the way the modern game is going".

From a *physiological* viewpoint, coaches reported that players' physical attributes have a key role during TID and TD processes. In fact, an example of statement confirming this concept is:

> "Really just looking if a player's got an X factor. We talk about physical attributes. They might be really tall, you might have a guy who is really fast, they're not always the best rugby player but we might just have a look at someone athletically".

The *psychological and psychosocial* area was also connected to TID and TD. In particular, coaches were unanimous on the topic of work ethic. As an example, one coach suggested:

> "Just within that, once they come a bit older, it's also seeing a work ethic in them. So, when you're doing any hard work, and regardless if they're X factor or they're not, when you see a kid working, then it gives you a bit of hope that they'll learn and want to do better and they'd be competitive and they've got a work ethic to try and improve and get better […]. So, when you see the people graft and work hard, then you've probably got an eye for them as well when they stand out in bits and pieces that are not a glamorous part of the game. You realise that they've got an edge to them, and that usually stands out for me, which helps put them in a good place moving forward, as well".

Confirming the importance of this *psychological and psychosocial* characteristics in young RU players, another coach specifically reported that the commitment to work hard was essential for successful players:

> "So, […] is about having people who are really committed to working hard".

Another *psychological and psychosocial characteristics* believed pivotal for a player to be selected and be able to progress across the academy was their capacity to ask for feedback and engage with training putting in practice information provided by coaches:

> "[…] during the sessions, making sure that… little things like they're listening when we're talking to them as a group, making sure that they're paying attention, they're listening and maybe asking good questions and feedback around what we're trying to deliver to them. And for us, being able to see them trying to implement any points we're trying to work on with them. So, if we're looking at a certain skill, whatever it might be, seeing them actually trying to work on that and trying improve that when we then put them back into the game or the drill or whatever it might be; then seeing if they can, as the weeks go by, slowly take their individual points off everything and just keep adding to their game".

On this basis, players with *psychological and psychosocial* deficiencies seemed to be less successful during the selection process, whereby a coach reported that:

> "We also take into account […] learning difficulties and things like that. Because we've had kids who we don't necessarily think are listening in the summer [which is the period when U15 first selection take place], but then we've had a chat with them and we've realised that they're really dyslexic or they're slow in processing things. I think the most important thing is knowing your [player] that you're working with to boost the selection process".

Technical-tactical factors were also an important element for TD. For instance, one of the coaches commented:

> "We spend a lot of time on the 14s, 15s stage that we're at, the basics if you like, so being able to catch, pass well, manipulate defenders, footwork around the contact area, that sort of thing. Which hopefully then later in the years […] but how then we put that into, when the players get to more of the senior levels of the academy or into more of the first team area, whether they're still holding onto those points and hopefully adding to them as they go through, I would say".

Environmental Constraints

Environmental constraints consisted of two categories: (a) socio-economic and (b) culture. An example of *socio-economic* factors, which references the type of school, is highlighted by the following statement of a coach:

> "For example, when you compare a state school kid to a private school kid, the difference is how much rugby they play is very different. But that state school kid, you might be able to look at him and go, "Well, he's got more potential if we put a bit more rugby into him." So, we take that into account, and we look at where they go to school […]".

The club's *culture* also appears to influence the TD process. For instance, one coach reported:

> "I think the whole culture of *club's name* adds to it [referred to the TD path] massively […]. But it's that whole culture of there's a friendship and quality there, so you feel comfortable, and you feel comfortable in whatever you do, which adds to the strength of what we're trying to achieve in the bigger picture".

Furthermore, another coach suggested the importance of creating a developmentally appropriate *culture* for young players to flourish:

> "the environments we have for them are challenging but actually are fun environments, such as the coaching groups that we have within the pathway".

Additionally, another coach provided a similar sentiment to reiterate the importance of club culture and quality of coaches in developing young RU players:

> "[…] it's the people that they have here. It's not as such just bringing in quantity of anyone with a rugby background and interest; it's making sure it's the quality that comes in […].

Interestingly, a statement from a coach outlined the connection among the high-order themes emerged:

> "We've just offered some academy players contracts, and a couple of them have been given contracts just because of the size of them, and we think that they're going to grow. We're hoping that they're going to grow, being in a professional environment. So,

they've been at school every day, and they've not had a chance to go to gym every day. They're restricted to how much training they can do, and hopefully by bringing them into this environment, they will grow physically as well as athletically and they'll fit into that".

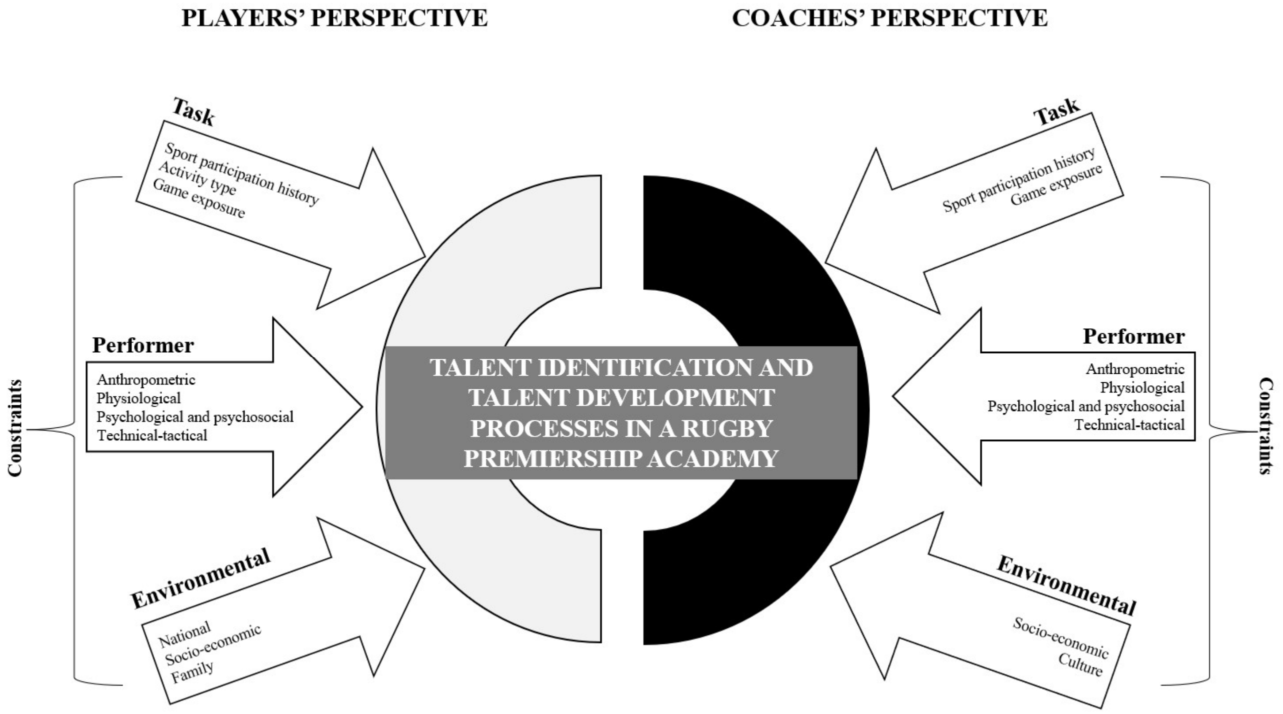

Figure 6.1. Summary of players' and coaches' perspective on TID and TD process in a Premiership RU academy.

Discussion

The aim of this qualitative study was to explore the perceptions of the TID and TD processes in senior academy players (part one), and academy coaches (part two) from an English Premiership RU club. Findings revealed that both players and coaches perceived task, performer, and environmental constraints to be important aspects of players progression. Previous studies indicated that, although not always analysed in unison, these three areas were the most researched in different countries during the TID and TD processes in RU (Dimundo, Cole, Blagrove, Till, et al., 2021). Overall, this reinforces the suggestion that a holistic approach is required when identifying and developing talents in RU (Davids et al., 2012).

Despite differences amongst players' and coaches' groups, *task constraints* were expressed as important aspects across both cohorts. In fact, all participants suggested that sport participation history and game exposure were characteristics that would discriminate players progressions across a RU talent path since, as found in previous studies, these aspects facilitated skill acquisition, skill transfer, and were decisive in reaching high performance status (Bjørndal et al., 2018; Côté & Lidor, 2013; Côté et al., 2008). Whereas diverse opinions were found among players on the impact of the extra type of activities (e.g., engagement in RU or multisport activities) on TID and TD processes. Interestingly, the majority of the participants stated that the dedication, and sometimes the 'obsession', for performing additional, repetitive drills following scheduled training was believed an important part of the self-improvement process. Only one player had the opinion that, to avoid burnout, he preferred to be involved in extra training that he perceived enjoyable. These concepts recall the existing activity framework in sport and training that indicate that both *deliberate play* and *deliberate practice* are fundamental parts during acquisition of skills and athlete progression in sports (Güllich et al., 2020). Moreover, these findings are in line with a recent multi-disciplinary work on an English Premiership RU academy, which demonstrated that greater exposure to different activities during childhood and early adolescence had a positive impact on higher player rankings (Dimundo et al., 2022). Present findings suggest that: (a) a varied learning experiences could facilitate rugby-specific skill acquisition (Bransford & Schwartz, 1999), (b) enhance general athletes functionality (Rothwell et al., 2020), (c) practitioners should understand the pathways young players have taken during the TID process, and (d) integrate both types of activities (e.g., deliberate play and deliberate practice) during all phases of development.

Performer constraints was one of the present theme of the qualitative analysis. All participants highlighted those factors related to anthropometric, physical, psychological and psychosocial, and technical-tactical skills were integral to TID and TD processes. Body height was an anthropometrical parameter recognised necessary for a successful RU performer by both players groups. However, although literature has reported that this variable has some degrees of importance in RU (Holway & Garavaglia, 2009; Pienaar et al., 1998), it has not been recognised significantly impactful for progression as players' body mass (Fontana et al., 2015). Importantly, the coaches reported that one of the essential aspects for players to be selected was that, over every other performance factor, players should possess specific 'body sizes'. Unsurprisingly, they reported that late maturing players had more difficulties in progressing across a RU academy environment, confirming the fact that maturation status could bias selection of future talents in RU (Kelly, Jackson, et al., 2021). This indicates that coaches generally recognised the importance of anthropometric measures in RU. Thus, present results suggest that (a) anthropometric measures (e.g., height, and body mass; referred as *size*) along with (b) players' maturation status, should be carefully monitored during TID and TD assessments in order to observe progression and avoid potential bias.

Position-specific physiological traits were considered important for players' progression from both players and coaches. While players outlined that, despite the position individual characteristics of a player, a multitude of physical aspects (e.g., speed, strength, fitness level) contribute to players' success, coaches indicated that physicality was the most important attribute (even more than RU skills) to distinguish young talents in RU. These findings are in line with recent research on regional English RU academies (Dimundo, Cole, Blagrove, McAuley, Till, Hall, et al., 2021; Dimundo, Cole, Blagrove, McAuley, Till, & Kelly, 2021; Owen et al., 2022), which consolidates the understanding that specific physical variables can determine the successful progression of RU players across an academy. Overall, present physiological findings further inform the research field that physicality (e.g., anthropometric and physiological qualities) are more predictive of selection when compared to other qualities in RU.

Both players and coaches believed psychological and psychosocial characteristics to be part of a holistic set of pivotal characteristics for TID and TD in RU, which aligns with recent findings in sport psychology (Batista et al., 2019; Dimundo et al., 2022; McAuliffe et al., 2021). In particular, the recognised capacity of working hard (from PG1, PG2, and CG), having the right mindset (from PG1 and PG2), possessing a strong work ethic (i.e., a set of values centred on the importance of doing work and reflected especially in a desire or determination to work hard; from CG only), and the capacity of asking for feedback (from PG1, PG2, and CG) were viewed as fundamental behavioural characteristics to become a professional RU player in the present academy. Moreover, similar psychological traits emerged from the analysis of the behavioural characteristics considered important by coaches and staff in English (Hill et al., 2015) and Zimbabwean (Chiwaridzo et al., 2019) RU environments (e.g., capacity of working hard, possessing the right mindset in- and out-game situations, the ability to communicate effectively, and the skillset to display an high level of resilience during critical situations). In particular, in the present work, among all psychological and psychosocial characteristics, the concept of *hard work* (i.e. the ability of a player to be constantly, regularly, or habitually engaged in working hard toward a pre-set objective) was the most cited by both cohorts, indicating that, in line with previous findings in sports (Johnson et al., 2008), the persistence and dedication to 'do extras' to become a better player was one of the most important qualities a players should possess to reach professional status. However, this characteristic should be monitored by coaches and players since it could represent a possible trigger of player burnout in RU (Cresswell & Eklund, 2006). In conclusion, results on the psychological and psychosocial characteristics that are perceived by players and coaches as important to becoming a professional player indicated that individualised sport psychology programmes (a) should be incorporated to assess and help develop these characteristics in young players, (b) should be regularly structured across RU academies to optimise players progression, and (c) should be focussed in implementing the players capacity of working hard.

Technical-tactical attributes were considered an important parameter for TID and TD in RU. For this category, while both players focus groups reinforced the concept that each playing position has its own technical-tactical requirements, they also highlighted that player's success is relative to how successful groups of RU players play together rather than individually (i.e., tactical playing cohesion and collective effectiveness; Sedeaud et al., 2017). In contrast, coaches suggested that when assessing technical-tactical competencies during TID and TD, their evaluation focused on players' capacity to perform the basic RU drills well (e.g., passing, catching, kicking, tackling). It has previously been reported that basic technical drills discriminate levels of RU athletes in schoolboy (Pienaar & Spamer, 1998), and academy players (van Gent & Spamer, 2005) in RU, thus confirming the importance that basic skills have during players' progression. Altogether, present findings suggest that: (a) players must develop basic technical drills, (b) players and coaches should consider the importance of tactical collective effectiveness, (c) coaches are encouraged to include a range of technical and tactical activities into their session design to achieve these outcomes.

Regarding the *environmental constraints*, participants of this current study recognised national, socio-economic, family, and culture as vital aspects for players progression. Interviewed players believed that one of the reasons for an initial successful identification and development in RU was the nation of provenience, since an elevated popularity of RU in the area of origin could offer more chance of initiation and continuous engagement. This concept is in agreement with Winn et al. (2016), which reported that, despite the impact of social deprivation, an important effect on RU players' career in Wales, initial youngsters' participation in recreational non-controlled RU activities was still high in areas far from adult-led environments. This phenomenon was due to the elevated popularity of RU across all local communities in Welsh provinces. Similarly, Marsters and Tiatia-Seath, (2019) documented how both RU and rugby league were activities largely entrenched in most poor Pacific Island communities, which could have influenced the tendency of young Pacific Island players to pursue a career in either type of rugby code. Thus, the results of the present work indicate that the level of popularity of a sport in a country could affect the trajectory of talented players.

Therefore, RU coaches operating in nations where RU is not of a major national interest, should implement meticulous and effective strategies to optimise TID and TD operations.

Socio-economic status was the only category among the environmental constraint believed important both from players and coaches. In particular, all the examined groups differentiated the aspect of players attending private and state schools, indicating that those athletes deriving from private schools had several more chances to progress in RU than those who studied in state schools, which is due to the different investment of the two types of institutions in this sport. Previous research supported this concept, reporting that both in the context of RU and rugby league, private schools in the South-Eastern Hemisphere (i.e., Australia and Pacific Islands), were often considered ‘better schools’ and were more oriented to either form of rugby training than state schools placed in poorer areas of the country (Marsters & Tiatia-Seath, 2019; McDonald, 2014; Schaaf, 2006). Present results lead to some practical suggestions that should be considered with caution, including: (a) managers of professional RU academies should include a socio-economic assessment when initially selecting RU players in order to avoid TID bias linked to type of school of provenience, and (b) attempt to develop partnerships with local state schools in order to avoid missing potential talents.

Family support was seen as an important factor from both player groups. Specifically, they suggested that both parents and brothers provided the right motivation, attitude, and economic support to engage in RU activities. This result was in line with TID and TD literature in sport (Henriksen & Stambulova, 2017) and RU (Winn et al., 2016), whereby it has been shown that family (i.e., parents and siblings) had a strong impact on player’s sport initiation, engagement in activities, and consequent progression. Similarly, research on Pacific Islands players from both RU and rugby league codes reported that players considered their families a source of support to remain grounded, focused, motivate them to self-improve (Marsters & Tiatia-Seath, 2019), and represented a decisive financial aid in their development (Schaaf, 2006). Therefore, RU organisations and practitioner should educate relatives to ensure they are aware of the important role they play in the life of young RU players, since emotional and economical support could impact significantly on players' career.

According to coaches, the culture surrounding the academy environment of a Premiership RU club is a fundamental aspect for players' growth. The interviewed members of staff mentioned that a challenging, positive, and supportive full-time RU academy environment was the key for optimal TD. However, in the coaches' opinion, these environments could only be created by clubs who recruit high-quality coaches. In fact, the importance of the appropriateness of personnel in elite sport academies has been already reported by several authors investigating the TID and TD processes. For example, in order to potentiate the athletic development of an athlete, Lloyd et al. (2016) reported that personnel aiming to work in professional academies should possess an appropriate understanding of technical aspects of training (e.g., strength and conditioning knowledge), relevant working experience in the field and an appropriate qualification path. In this view, coaches could be considered the 'architects' of the performance environment (Rynne et al., 2017), and thus they should possess both the intra- and inter-personal skills (e.g., effectiveness and experience) to face the responsibilities required in an elite long-term athlete development environment (Lloyd et al., 2019). Therefore, these results suggest that managers should focus on their staffs' coaching effectiveness (i.e., interpersonal, intrapersonal, and professional skills; Côté & Gilbert, 2009) to create an effective RU environment.

Limitations and Future Directions

The number of participants is often an element of limitation in those investigations exploring professional sports environments. A similar number of individuals has previously been recommended for focus groups (Powell & Single, 1996), yet a higher number of participants in the present investigation may have decreased discrepancies within groups findings, as well as potentially added additional findings or inconsistency in disagreements. It is also important to mention that although all coaches were qualified according to RFU criteria, and players regularly followed club's theoretical developmental workshops surrounding sport sciences, their knowledge of the scientific terminology regarding anthropometric, physiological, and psychological and psychosocial characteristics (e.g., 'size', 'fitness level', 'hard work', 'work ethic', 'mentality' and 'mindset') could have been used inappropriately during focus groups discussions. For this reason, in the attempt to provide a better understanding of concepts and to improve consistency in the language, Table 6.3 reports the definition of the main descriptors. Importantly, it should be mentioned that despite players reported information on their weekly competition routine (e.g., number of games played in two or three consecutive days), the authors do not necessarily intend to promote as much game exposure as referred in a PG's quote due to the potential risk of physical and psychological injuries many consecutive matches could lead to. Moreover, due to the novelty of this manuscript, comparison with similar investigations in RU was difficult, therefore it was not possible for authors to make further connections with other qualitative studies in this sport that could have better highlighted participants' positions in regards of TID and TD processes. This aspect represented a constraint that limits the ecological validity of present findings. It is also worth considering that RU players and coaches of different countries may have different perceptions on TID and TD paths, since the understanding, vision and philosophy of the game may change depending upon social context. In addition, players' age and playing position could have addressed focus groups' discussion towards themes that would not reflect necessarily the opinion of younger academy players, therefore different voices could have led the present research to different conclusions. Another important limitation is the one regarding the research approach used. In fact, while a cross-sectional analysis provided an immediate insight into the vision of an English Premiership RU academy, a longitudinal investigation on this topic could consolidate the validity of present findings. In this light, more qualitative investigations in academies of professional RU clubs are needed.

Table 6.3. Definition of sub-categories, categories, and themes.

Descriptor	Definition
Activity type	The category of activity practiced (e.g., peer-led, coach-led)
Aggressiveness	A range of behaviours that can result in both physical and psychological harm to opponents in order to have a potential performance advantage
Agility	The ability to change direction in response to a sport-specific stimulus, incorporating physical, technical, perceptual and decision-making skills (Turner, 2011)
Amount of exposure to rugby play	The time spent by a player to any type of rugby activity
Anthropometric	The measurements and proportions of the human body
Ask for feedback	The capacity of a player to be resilient
Ball carrying	To run with the ball in hand towards the opposition team's in-goal area
Behaviour	The way in which one acts or conducts oneself, especially towards others. Also referred to a particular response in a specific situation or stimulus
Big tackles	The ability of a player to perform a successful and powerful tackle during a game and his constancy in this performance
Brothers	A person who has the same parents as another or one parent in common with another
Catch	The ability of a player to catch and secure the ball once received
Challenged but fun environment	The type of environment coaches and stuff attempt to recreate in the club they work
Coachability	The combination of the mindsets and behaviours for continuously integrating feedback to drive growth and change within a rugby player
Coaches teamwork	The ability of coaches to combine actions resulting effective and efficient
Commitment	The state or quality of being dedicated to an activity or cause
Communication	The capacity of players or coaches to explain and make personnel aware of certain situations
Competitiveness	The grit, the characteristic or ability of a player to achieve a goal, more successfully than competing players
Confidence	The feeling or belief that a player can have faith in or rely on himself
Connection with local community	The diverse type of interactions the club has with the area in which is geographically located
Consistency	The quality or fact of staying the same at different times
Consistency in good performance	The persistency in displaying a good rugby performance
Culture	The shared values, beliefs, expectations and practices of something (in this case it refers of rugby union). It's the way athletes, staff and participants interact together on and off the field. It also refers to the team's identity

Decision making	The ability of a player to act after processing an information coming from a situation during a game. Usually this is connected to the velocity at which a player process and act.
Dedication to improve skills	The motivation an consistency in improving rugby skills
Effort	The measure of how much ability the player uses at one time
Engagement with players	The type of attitude members of stuff have with athletes
Enjoy the skills	The deliberate play activities of skills
Environmental constraints	The factors concerning the environment that could influence the talent path (e.g., type of school, family support, socio-economic status)
Exclude late mature players	The selection criteria coaches use to assess talents
Exposure to training	The amount of all type of training a player is/was exposed to
Exposure to play against older players	The practice of rugby with or against an older player which is generally believed to possess more rugby experience, superior technical-tactical skills, greater anthropometrical, physical and psychological characteristics than a younger player
Family	The component of the familiar nucleus
Fast	The physical component of being fast in movement and with speed
Fearless	The psychological characteristic of a player. It is considered the lack of fear in performing actions that could be linked to injuries
Fitness	The cardio-pulmonary status of a player
Footwork around the contact areas	The series of actions involving a rapid change of direction, agility and speed (i.e. footwork) before during and after a contact to maintain the control of the ball while preserving advantage
Full-time environment	A characteristic of a professional rugby union club in which staff and players have a full-time contract and could dedicate the vast majority of their working time to rugby training
Game exposure	The time a player was exposed to any type of rugby match
Game played	The amount of game played
Good at basic drills	The ability of rugby player to possess solid basic rugby drills
Good at basics	The ability of a rugby player to excel in basic movements, attitudes and general skills
Great breakdowns	A colloquial term for the short period of open play immediately after a tackle and before and during the ensuing ruck. During this time teams compete for possession of the ball, initially with their hands and then using feet in the ruck.
Grit	The characteristic of a player to possess passion and perseverance while working for a specific goal
Handling skills	A set of rugby movements including passing, catching, feinting with a rugby ball

Hard work	The ability of a player to be constantly, regularly, or habitually engaged in working hard toward a pre-set objective
Height	The body stature
Improvement	The act or process of improving
Individual characteristics	A combination of individual characteristics (e.g., technical-tactical requirement, physical factors, inter- intra-subject behaviour)
Jump qualities	The different types and components of a jump (e.g., CMJ, RSI, concentric phase, landing phase)
Kicking skills for back	The set of skill that is generally required for backs players to possess in order to perform a set piece kick (e.g., conversion after a try)
Lifestyle	A particular way of living
Manipulate defence	A series of strategic actions a team could perform to gain an advantage on the opposition's defence
Mindset	The mental outlook and how it helps or hinders sport performance in competition and training activities
Multisport background	The activities involving two or more different sports
Multitude of physical factors	The amount of physical aspects that a player has
National	All characteristics popular in a country
Parents	The familiar nucleus (i.e. father or mother)
Pass	A technical rugby skill involving the throw of the ball to a teammate
Passing ball for width for forwards	The technical proficiency of passing the ball on a long distance in the most precise and accurate manner during a game
Performer constraints	The factors concerning the player that could influence talent trajectory (e.g. physical, psychological, technical-tactical, perceptive cognitive experience)
Physical qualities over skillset	The concept that for coaches it is more important for players to possess anthropometrical and physical attributes than manage complex rugby skills
Physicality	A combination of physical factors that a player could display
Physiological	The measurements of physical characteristic of a player such as (but not restricted to) strength, power, speed, and endurance.
Player-coach relationship	The relationship in which both the coach and the player could benefit
Position specific requirements	The amount of characteristics needed to play a specific role
Position specific technical differences	The different and specific differences that there exist among rugby playing positions
Positive and supportive environment	The type of environment coaches attempt to recreate while developing players
Psychological and psychosocial	The assessment of mental and behavioural characteristics of a players and groups of players
Quality of coaching	The characteristic of coaching

Quickness	A multi-planar or multidirectional skill that combines acceleration, explosiveness, and reactiveness (Moreno, 1995)
Repetition of skills	The deliberate practice activities of skills
Select more coachable players	The element used by coaches to select academy players
Select players who ask feedback	The characteristic used by coaches to individualise academy talents
Sense of game	A characteristic coaches refers to when describing the ability of a player to read the play and be in the right place at the right time (Burgess & Naughton, 2010)
Size	The anthropometrical characteristic of a player in terms of stature and body mass
Skill transferability	The transfer of technical skills from one sport to another
Skill-set variety	The amount of different technical skills
Slow processing players difficult to progress	A characteristic coaches take into account when deselecting academy players
Socio-economic	The level of social and economic situation of a player
Speed	The velocity of running
Sport participation history	The purposeful active participation in sports related physical activities (Deelen et al., 2018)
Strength	The level of force a player could produce
Task constraints	All the factors concerning the task that could influence talent (e.g. number of sport practiced, hour of game played)
Teamwork	The process of working collaboratively with a group of people in order to achieve a goal
Technical-tactical	The assessment of technical and tactical characteristic of a player. For example this could refers to precision of a pass, tackle, conversion kick or tactical scheme of game
Training exposure	The amount of time players spent in different types of exercises
Turnovers	A technical terminology used in rugby union when the ball possession is transferred to the defending team from the attacking team
Type of school	The type of school a players went to (i.e. private or state school)
Work ethic	A set of values centred on the importance of doing work and reflected especially in a desire or determination to work hard
Work rate	The rate at which a rugby related work is performed

Conclusion

This is the first published study that has analysed the perceptions of senior academy players and academy coaches on the TID and TD processes in an English Premiership RU club. These preliminary findings demonstrate that task, performer, and environmental constraints were the parameters considered important during the players journey towards senior professional status. Despite results aligning to previous holistic findings (Dimundo, Cole, Blagrove, Till, et al., 2021), there was an equal emphasis from both players and coaches on the impact of performer constraints on TID and TD paths. Whereas the difference in task and environmental constraints showed some inconsistencies among the two populations of this study. This could reveal important implications on the TID and TD approach in English RU academies, since it appears that players are not always aware of all factors that coaches believe are important for the selection and development processes. Therefore, although more qualitative research is required in this population, the present study could be used by practitioners as a guideline to optimize a multidisciplinary approach to TID and TD in RU. Moreover, the implementation of these recommendations will be key both in ensuring that players become more aware of the holistic requirements needed during TID and TD in a professional academy, and coaches adequately support athletes in pursuing the journey towards the senior professional status.

7. CHAPTER SEVEN

Overall Discussion and Practical Applications

The current thesis highlighted that the TID and TD in the academy of WWRFC is affected by three constraints: (a) task, (b) performer, (c) and environmental. It is important to recognise that these constraints appear to be contingent on several factors (e.g., age-grade, playing position, and nationality). Results from the systematic review revealed that physical characteristics are very much central to the TID and TD research in RU, and in comparison to the other performer constraints, they have been more extensively studied. Importantly, findings showed that successful RU young players across the globe are heavier, taller, stronger, faster, more powerful, aerobically fitter, technically and tactically superior, psychologically stronger, and socially more supported than less successful players. Moreover, the systematic review showed that national and cultural characteristics could play an important role on players' progression in different countries, since individuals from areas with high participation rates in RU could have more chances to be engaged in such sport and proceeding senior performance levels. Similarly, in some countries, selection policies may be heavily biased by RAEs with consequences on the local overall talent trajectory. Thus, the review reported in Chapter Two of the current thesis represents the first-published systematic analysis of the most common TID and TD approaches used across the globe in male RU. The review both highlights and discuss several recurrent constraints of the talent paths and evidences some of the strengths and weaknesses of the different assessments in use yet by clubs and institutions at different levels of male RU. Therefore, stakeholders are recommended to consider these constraints and contextual factors when planning TID and TD processes to ensure they suit their respective environment and maximise the potential of every young player.

In the context of English Premiership RU, it appears that TID at the WWRFC U15 level may be based on enhanced physical attributes rather than cognitive abilities. In particular, in agreement with previous literature (discussed in the chapters of this thesis), anthropometric and physiological factors were found to be more influential upon selection than PCE skills probably due to the contact nature of the sport. Specifically, coaches operating in Premiership academies are advised to monitor body mass, strength, and 20 m sprint together with the relative age of players. However, at this age, a central role for players' 20 m sprint was identified. Practitioners should be aware that 20 m sprint was the only variable that predicted selection in the WWRFC U15 cohort, therefore this key parameter should be one particular test that have to be prioritised by selectors during the U15 TID procedures (i.e., training camps, trials). Within this same group, differences between RU positions indicated that WWRFC U15 forwards were heavier, taller, stronger, slower, and relatively younger than backs. In general, it should be said that the position-specific predictive value of physical traits possessed at younger ages on future career attainment may be of interest to practitioners since this imply several practical considerations during training plan cycles. Particularly, anthropometrical characteristics (e.g., body mass, stature, hypertrophy and more in general '*size*') may have a significant relevance during TID in some countries where national youth sport coaching philosophies tend to create local policies that favour players with specific physical parameters rather than technical-tactical characteristics (please also see results in Chapter Two, Three, and Six). Thus, considering the importance that anthropometrical and physical factors could have in a contact sport such as RU (e.g., sprint momentum characteristics that could affect selection depending by national culture and coaches' interpretation of the game), coaches are also recommended to use these parameters (e.g., body mass and stature) to monitor players' development over time (e.g., mesocycles and seasons). In addition, it is critical that the evolution of sport is always considered, as predictive positional-specific characteristics in the past may not be as important in the present, or indeed the future. Therefore, along with the evolution of the game, coaches working in Premiership academy environments are advised to consider positional-specific characteristics during U15 TID and TD processes.

From a development point of view, results from the WWRFC academy indicated that with players ranging from the U16 to U21 age groups, coaches operating in Premiership academies are recommended to help: (a) develop greater body mass, momentum (i.e. sprint momentum), power, and aerobic capacity (all players) (b) develop acceleration, strength, momentum, and power (forwards), and (c) develop momentum, power, and quickness (e.g., stiffness, reactiveness, and change of direction) (backs). Importantly, in order to optimise the LTAD process, coaches should consider the impact of RAEs, since this aspect could bias selections. It is important to reinforce, here, the concept that findings obtained from the '*developmental chapter*' (i.e., Chapter Four) of the current thesis, expand the pre-existing knowledge in the LTAD field (e.g., Darrall-Jones et al. 2016; McCarthy & Collins, 2014) since, in that chapter, for the first time in male RU, anthropometric, physical, and RAE characteristics have been analysed in unison across an English Premiership academy. Gather these data as part of a holistic TID and TD processes will help ensure selectors are aware of each individual's status and therefore it could provide the *best-practice* for how they compare amongst aged-matched peers players.

From a players' rank outlook, despite differences among WWRFC academy's top- and bottom-10 potential players, significant discrepancies regarding game exposure between age U8-U11, peer-led activities between age U12-U15, IMD decile, and 20 m sprint were identified. Moreover, coaches should be conscious that, despite the 20 m sprint variable being the only physical parameter to differentiate players' rank, the identification of Premiership academy top-10 potential player can be based on task (i.e., sport activities) and environmental (i.e., socioeconomic) constraints. Instead, despite active coping strategies being the only psychological parameter that differentiated playing position (i.e., greater in backs), environmental (i.e., socioeconomic) and performer (i.e., anthropometrical, and physical) constraints could consistently discriminate forwards and backs. In this light, coaches should be aware of the high impact that sport experiences and pre-adolescence activities can have on decision making skills, self- and tactical-awareness and athlete functionality at a later stage of players' career in RU. In regards to the IMD, the parameter for the whole cohort analysed ranged from mild to low deprivation. This reflected the fact that, in that specific regional area, the sport of RU was played by the wealthy social class of the population. Thus, a practical feedback for RU managers could be that a more inclusive talent path should be applied by professional clubs in order to avoid talent's *a priori* exclusion (i.e., early exclusion based on player's socioeconomic status). Therefore, present findings can help Premiership academy managers and coaches in shaping appropriate developing policies.

From a WWRFC players and coaches' perspective, results showed that a combination of variables pertaining to task, performer, and environmental constraints are pivotal during TID and TD processes. It is important to mention that in this part of the investigation, the valuable testimonial of qualified coaches and U21 players was considered fundamental for the validity of our results since this population was believed both to enclose youngsters' opinion on the talent path and, for the most, to have already experienced previous phases of TID and TD processes. Specifically, results reported that position-specific differences, practicing more sports, being involved in deliberate practice and play activities, exposed to competitions, and possessing greater body mass, strength, power, and speed represent all the aspects to become a successful RU player. Moreover, specific psychological trait were found to be central for academy players to reach the senior team since these could help during development phases (e.g., training and games situations). Players with superior hard work capacity, possessing a strong working ethic, being mentally strong, being cohesive, and being able to perform good technical and tactical skills, were equally advantaged towards the senior professional status. Similarly, being supported by family members, appertaining to a higher socioeconomic class, being supported by national sporting trends, and training within a professional sporting culture, differentiate talents in Premiership RU. As such, these characteristics may prove beneficial for practitioners to profile and train Premiership academy players to identify and develop such features when operating in RU academy environments.

In summary, to the author knowledge, this study represent the *first-ever* mix-method and holistic analysis to an English Premiership RU club which analyses together macro-areas never explored in unison and often investigated in isolation. This work can be consider unique in its gender since the whole academy of an English professional RU club has been explored using a novel approach across different stages of players' progression towards professionalism (i.e., from

U15 to U21) providing practical applications for clubs operating at same level of rugby in England. Present results show that within the TID and TD processes of an English Premiership RU club, despite position-specific levels of body mass, general strength, sprint and aerobic capacity represent the paramount base for successful age-grade RU players, other factors (i.e., speed momentum, active coping, cohesion, hard work, work ethic, deprivation levels, type of school, RAEs, game exposure, peer-led activities, effectiveness of basic technical skills, family support, club culture, and RU national standards) belonging to different areas of constraints have a significant impact on players' future career at different points of the LTAD.

The present work provides an initial Premiership RU ecological dynamic framework for TID and TD operations for forwards (see Figure 7.1) and backs (see Figure 7.2), which could be used both by club managers to shape organisational' *best practice* and practitioners during selection moments and LTAD planning. Overall, this thesis has showed that TID and TD in a Premiership academy cannot be based upon any single performance characteristic in isolation. Therefore, a highly effective approach when investigating, identifying, and developing talented RU players is adopting a mixed methods (i.e., both quantitative and qualitative) approach. The mixed-methods approach used in the current work reflected the multifaceted nature of talent and represented a key aspect in a Premiership RU academy since it was able to connect data from areas belonging to task, performer, and environmental constraints. Moreover, the interaction amongst ecological constraints (see Figure 7.3) should be considered by organisational structures and key stakeholders when identifying and developing Premiership RU talents.

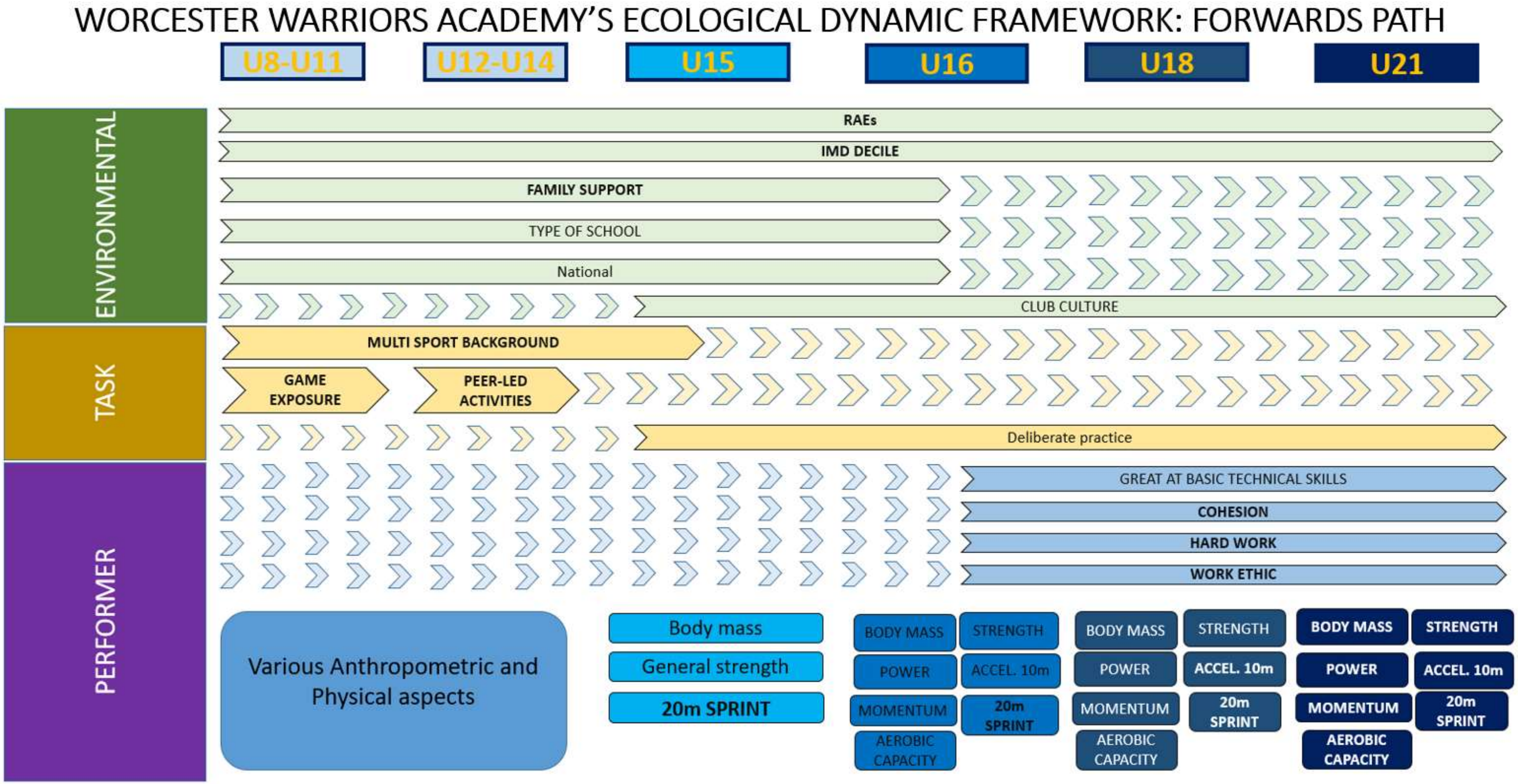

Figure 7. 1. Shows how constraints impact on forwards' TID and TD processes at Worcester Warriors Rugby Football Club academy. Font size refers to relative importance. Progressive darker blue boxes refers to older player groups. Continuative arrows indicate when that factor become significatively important.

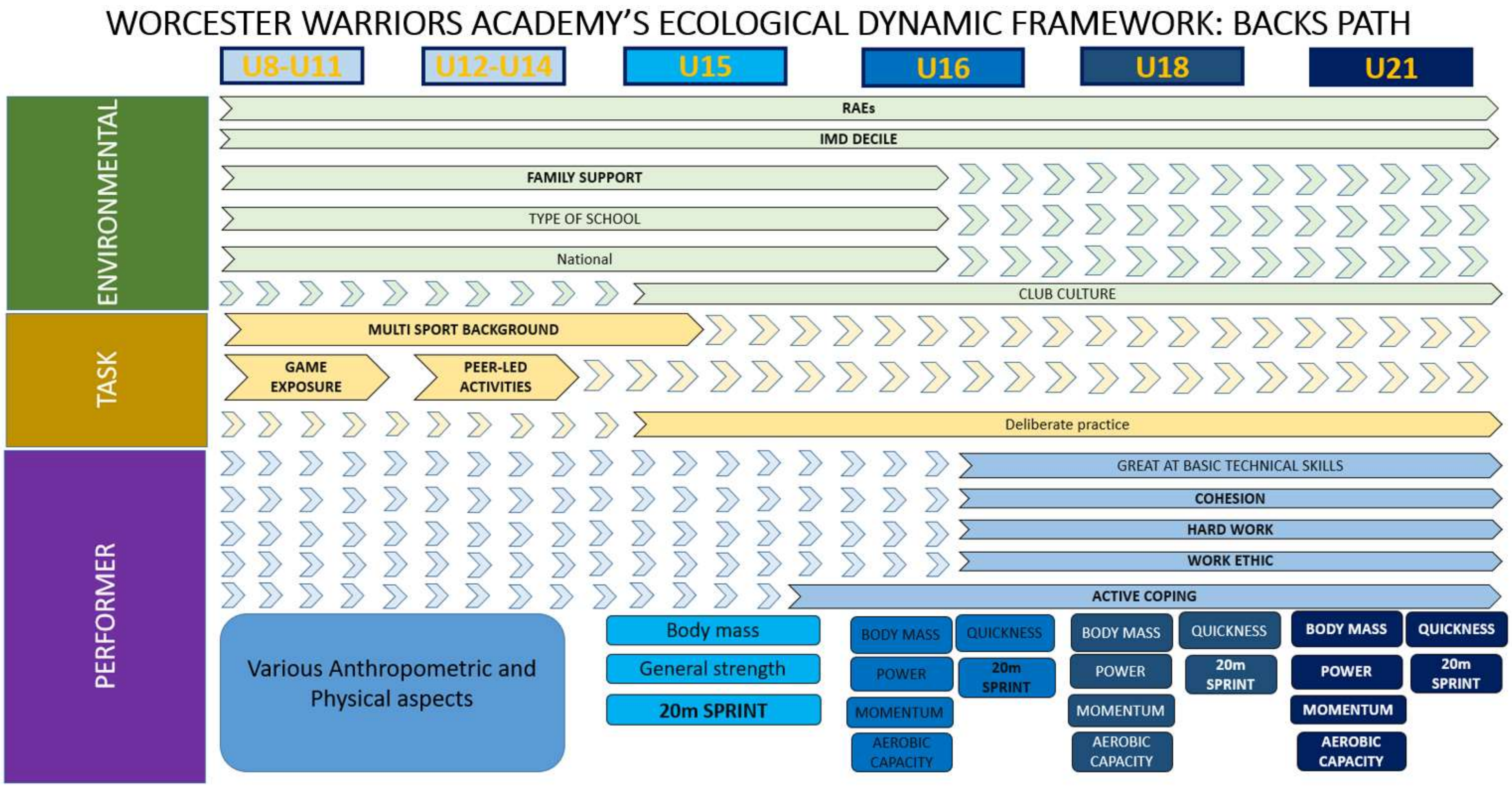

Figure 7.2. Shows how constraints impact on backs' TID and TD processes at Worcester Warriors Rugby Football Club academy. Font size refers to relative importance. Progressive darker blue boxes refers to older player groups. Continuative arrows indicate when that factor become significatively important.

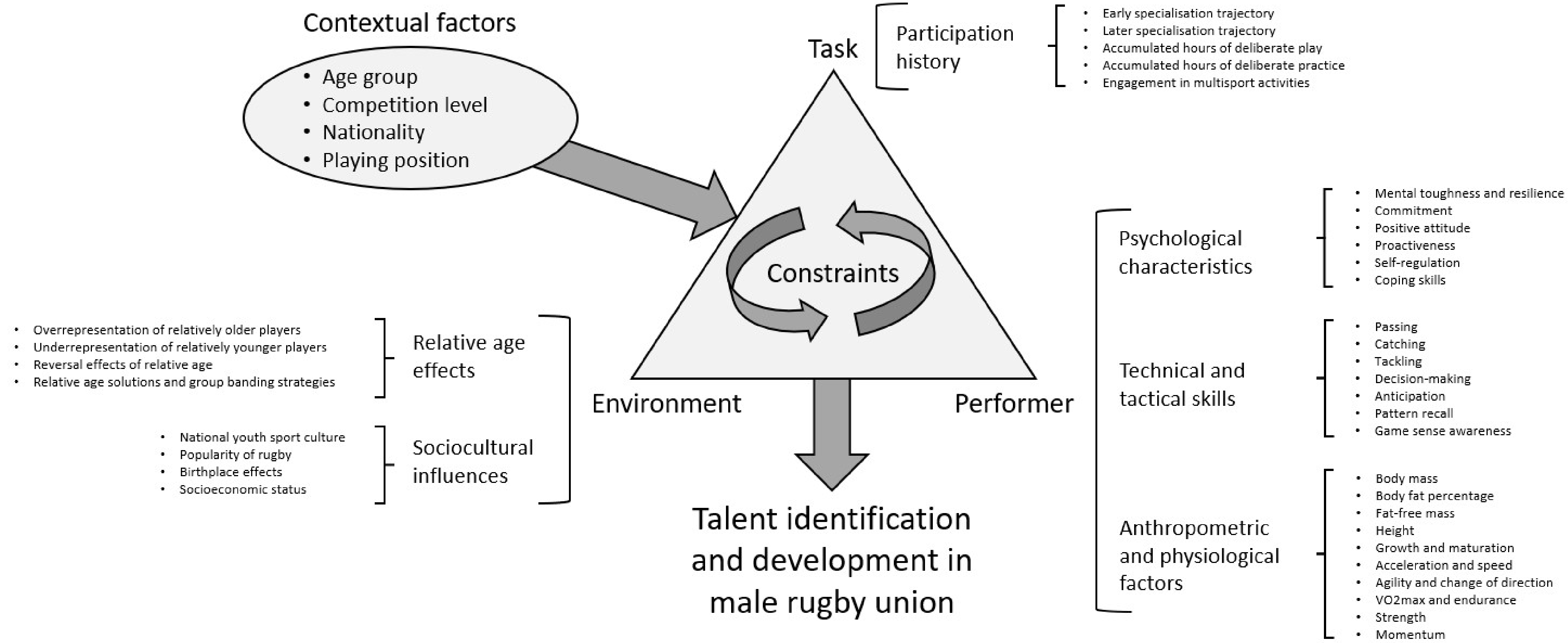

Figure 7.3. Interaction amongst ecological constraints for TID and TD in male RU (adapted from Kelly, McAuley, Dimundo et al., 2022).

8. CHAPTER EIGHT

Limitations and Future Directions

Despite this thesis representing an innovative approach to research into TID and TD in RU, certain limitations are evident. First, an estimation of maturity status was not included in measurements, which makes comparisons between age groups and playing positions more challenging. Second, the studies in this thesis were cross-sectional in design, which provides limited insight into how TID decisions and TD change longitudinally. Finally, there was a greater focus on collecting physical characteristics compared to other factors (e.g., psychological traits, technical skills, sociocultural influences). Therefore, since the TID and TD processes are multifactorial, future research should adopt more balanced multidisciplinary research methodologies across the three constraints.

It is important to reinforce the fact that (a) present findings could be used for reference during assessment processes in Premiership RU environments using similar paths, and (b) academies of different level may find inappropriate the exposed TID and TD frameworks. For instance, all players used in the current investigation were already familiar with testing procedure (e.g., type of tests, organisation and logistic before and during tests – for example, players were acknowledged that had to follow standardised procedures before and during assessments and that the best value of the trials for each test was recorded by coaches). This was the result of the approach that Worcester Warriors already applied across their wide regional area of influence (please see the Introduction Chapter for a deeper explanation in regards to how Premiership academies operate in England). In this light, one of the major limitations can certainly refers to the variation of inter-rater reliability of some data. However, to limit this, data collection was managed by the author of this thesis which had years of experience in testing athletes.

Pre-season was the period agreed with the club for data collection in most of the studies presented in this work. For this reason, in some circumstances, the whole test battery was spread across different weeks of this training phase. In practice, information regarding BQs and body height were generally collected during the first two weeks, body mass and physical tests were detected between week four and five, and data obtained with formulas were usually calculated by the end of week six. However, the author is aware that a limitation following this procedure could be due to the variation in physical parameters occurring among days of trainings after the off-season phase.

In general, participants' minimum number in sport science research seems to range between twenty and forty subjects (Sauro and Lewis, 2016). However, the author of this thesis recognises that not calculating the power for sample size in the above chapters could have increase errors. Nevertheless, previous studies used same sample size with similar population (e.g., Darrall-Jones al. 2015, 2016; Pienaar and Spamer 1998) and in some circumstances even smaller than those reported in this thesis (e.g., Hill et al. 2015; and in a qualitative study Clarke, Cushion, and Harwood, 2018). Despite it is recommended to calculate sample size power in sport and exercise science research, it seems to be an un-practical routine to adopt (e.g., time investment vs. benefits, real-world reflection) when investigating professional sport environments (Abt et al. 2020).

Ultimately, limitations on the systematic review search have to be acknowledged in this section since it could have affected initial interpretation of the talent paths in RU. In fact, the exclusion of studies written in another language than English could have predominantly investigated those clubs using a 'British system' or a *Commonwealth way of playing rugby* and therefore, it could have strengthened a specific interpretation of the game (e.g., the majority of studies examined countries such as UK, South Africa, Australia with no references to Asian teams). This could have reinforced some aspects that could have been predominant in some countries and not in others (e.g. papers written in English exploring how talent paths are structured in Asia are nearly inexistent). Moreover, to shape the exploration, during the Boolean search only few specific terms were insert in databases. This could have restricted the initial results and addressed final conclusions for that systematic review.

Based upon the above limitations, and the aspects explored in the present thesis, it is clear that future research needs more ambitiously designed, collaborative, TID and TD interventions that can help practitioners better operate in a RU academy environment. Profiling players with a holistic approach through mixed method research designs from pre-pubertal to senior level is recommended to deeply operate across TID and TD pathways. Moving forward, diverse methodological considerations are encouraged (e.g. both quantitative and qualitative approach to be used, estimation of minimum sample size are required) to better understand the mechanisms of the TID and TD processes in RU, as well as exploring possible challenges and solutions that existing organisational structures face, including: (a) multidisciplinary approaches, and (b) longitudinal and retrospective designs.

9. References

Abbott, A., & Collins, D. (2002). A theoretical and empirical analysis of a 'state of the art' talent identification model. *High Ability Studies, 13*(2), 157-178. doi: 10.1080/1359813022000048798

Abt, G., Boreham, C., Davison, G., Jackson, R., Nevill, A., Wallace, E., & Williams, M. (2020). Power, precision, and sample size estimation in sport and exercise science research. *Journal of Sports Sciences*, 38(17), 1933-1935. https://doi.org/10.1080/02640414.2020.1776002

Albaladejo-Saura, M., Vaquero-Cristóbal, R., García-Roca, J. A., & Esparza-Ros, F. (2022). The effect of age, biological maturation and birth quartile in the kinanthropometric and physical fitness differences between male and female adolescent volleyball players. *Children*, *9*(1), 58. https://doi.org/10.3390/children9010058

Andrew, M., Grobbelaar, H. W., & Potgieter, J. C. (2007). Sport psychological skill levels and related psychosocial factors that distinguish between rugby union players of different participation levels. *South African Journal for Research in Sport, Physical Education and Recreation*, *29*(1), 1–14.

Araújo, D., Fonseca, C., Davids, K., Garganta, J., Volossovitch, A., Brandão, R., & Krebs, R. (2010). The role of ecological constraints on expertise development. *Talent Development and Excellence*, *2*(2), 165–179.

Argus, C. K., Gill, N. D., & Keogh, J. W. (2012). Characterization of the differences in strength and power between different levels of competition in rugby union athletes. *The Journal of Strength & Conditioning Research*, *26*(10), 2698–2704.

Arkell, R. (2016). *Body size, socioeconomic status and training background of a select group of U16 South African rugby union players (2010-2013): The impact on national selection* [Master's Thesis]. University of Cape Town.

Armstrong, M. E., Lambert, E. V., & Lambert, M. I. (2011). Physical fitness of South African primary school children, 6 to 13 years of age: Discovery vitality health of the nation study. *Perceptual and Motor Skills*, *113*(3), 999–1016.

Baker, J., & Horton, S. (2004). A review of primary and secondary influences on sport expertise. *High Ability Studies, 15*(2), 211-228. doi: 10.1080/1359813042000314781

Baker, J., Cobley, S., Schorer, J., & Wattie, N. (2013). Talent Identification and Development in Sport. In J. Backer, S. Cobley, J. Schorer, & N. Wattie (Eds.), *Routledge Handbook of Talent Identification and Development in Sport* (pp. 1-7). London: Routledge.

Baker, J., Cobley, S., Schorer, J., & Wattie, N. (2017). *Routledge Handbook of Talent Identification and Development in Sport*. Routledge.

Ball, S., Halaki, M., Sharp, T., & Orr, R. (2018). Injury Patterns, Physiological Profile, and Performance in University Rugby Union. *International Journal of Sports Physiology and Performance*, *13*(1), 69–74. https://doi.org/10.1123/ijspp.2017-0023

Barnsley, R. H., Thompson, A. H., & Barnsley, P. E. (1985). Hockey success and birthdate: The relative age effect. *CAHPER Journal, 51*(8), 23-28.

Barr, M. J., Sheppard, J. M., Gabbett, T. J., & Newton, R. U. (2014). Long-term training-induced changes in sprinting speed and sprint momentum in elite rugby union players. *The Journal of Strength & Conditioning Research, 28*(10), 2724-2731 doi: 10.1519/JSC.0000000000000364.

Barth, M., & Güllich, A. (2021). Non-linear association of efficiency of practice of adult elite athletes with their youth multi-sport practice. *Journal of Sports Sciences*, *39*(8), 915–925.

Batista, M., Honório, S., Catarino, J., Vaz, L., Fernandes, H., & Petrica, J. M. (2019). Psychological profile of rugby players-analysis between athletes of the u18 and u20 national elite teams in the positions of forwards and defenders. *Revista Iberoamericana de Psicología Del Ejercicio y El Deporte*, *14*(2), 108–111.

Beardsley, C., & Contreras, B. (2014). The increasing role of the hip extensor musculature with heavier compound lower-body movements and more explosive sport actions. *Strength & Conditioning Journal*, *36*(2), 49–55.

Bennett, K. J. M., Vaeyens, R., & Fransen, J. (2019). Creating a framework for talent identification and development in emerging football nations. *Science and Medicine in Football, 3*(1), 36-42.

Bjørndal, C. T., Luteberget, L. S., & Holm, S. (2018). The relationship between early and senior level participation in international women's and men's handball. *Journal of Human Kinetics*, *63*(1), 73–84.

Booth M. (2020). Relationships between training age, training load, performance measures and injury characteristics in elite junior rugby league players (*Doctoral dissertation, University of Sydney*).

Booth, M., Cobley, S., Halaki, M., & Orr, R. (2020). Is training age predictive of physiological performance changes in developmental rugby league players? A prospective longitudinal study. *International Journal of Sports Science & Coaching*, *15*(3), 306-315. https://doi/abs/10.1177/1747954120919909

Bowers, B., Cohen, L. W., Elliot, A. E., Grabowski, D. C., Fishman, N. W., Sharkey, S. S., Zimmerman, S., Horn, S. D., & Kemper, P. (2013). Creating and supporting a mixed methods health services research team. *Health Services Research*, *48*(6 Pt 2), 2157–2180. https://doi.org/10.1111/1475-6773.12118

Brandt, P., & Timmermans, S. (2021). Abductive Logic of Inquiry for Quantitative Research in the Digital Age. *Sociological Science*, *8*, 191–210. https://doi.org/10.15195/v8.a10

Bransford, J. D., & Schwartz, D. L. (1999). Chapter 3: Rethinking transfer: A simple proposal with multiple implications. *Review of Research in Education*, *24*(1), 61–100.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Braun, V., & Clarke, V. (2022). Conceptual and design thinking for thematic analysis. *Qualitative Psychology*, *9*(1), 3.

Bronfenbrenner, U. (1974). Developmental research, public policy, and the ecology of childhood. *Child Development*, *45*(1), 1–5.

Bruner, M. W., & Benson, A. J. (2018). Evaluating the psychometric properties of the Social Identity Questionnaire for Sport (SIQS). *Psychology of Sport and Exercise*, *35*, 181–188.

Buchheit, M., Laursen, P. B., Millet, G. P., Pactat, F., & Ahmaidi, S. (2008). Predicting intermittent running performance: Critical velocity versus endurance index. *International Journal of Sports Medicine*, *29*(04), 307–315.

Burgess, D. J., & Naughton, G. A. (2010). Talent development in adolescent team sports: A review. *International Journal of Sports Physiology and Performance*, *5*(1), 103–116.

Byrne, D. (2022). A worked example of Braun and Clarke's approach to reflexive thematic analysis. *Quality & Quantity*, *56*(3), 1391–1412. https://doi.org/10.1007/s11135-021-01182-y

Carter, J. L., Kelly, A. L., Williams, R. A., Ford, T. J., & Cole, M. (2021). Exploring sports nutritionists' and players' perspectives of nutrition practice within English professional football during the COVID-19 pandemic. *Science and Medicine in Football*, *5*(sup1), 32–37.

Chiwaridzo, M., Ferguson, G. D., & Smits-Engelsman, B. C. M. (2019a). Anthropometric, physiological characteristics and rugby-specific game skills discriminating Zimbabwean under-16 male adolescent rugby players by level of competition. *BMJ Open Sport & Exercise Medicine, 5*(1), e000576.

Chiwaridzo, M., Ferguson, G. D., & Smits-Engelsman, B. C. M. (2019b). Qualities or skills discriminating under 19 rugby players by playing standards: A comparative analysis of elite, sub-elite and non-rugby players using the SCRuM test battery. *BMC Research Notes, 12*(1), 536.

Chiwaridzo, M., Ferguson, G. D., & Smits-Engelsman, B. C. M. (2020). Anthropometric, physiological characteristics and rugby-specific game skills of schoolboy players of different age categories and playing standards. *BMC Sports Science, Medicine and Rehabilitation, 12*(1), 3.

Chiwaridzo, M., Ferguson, G. D., & Smits-Engelsman, B. C. M. (2020). Anthropometric, physiological characteristics and rugby-specific game skills of schoolboy players of different age categories and playing standards. *BMC Sports Science, Medicine and Rehabilitation*, *12*(1), 3. https://doi.org/10.1186/s13102-019-0155-3

Chiwaridzo, M., Munambah, N., Oorschot, S., Magume, D., Dambi, J. M., Ferguson, G., & Smits-Engelsman, B. C. M. (2019). Coaches' perceptions on qualities defining good adolescent rugby players and are important for player recruitment in talent identification programs: The SCRuM project. *BMC Research Notes*, *12*(1), 1–8.

Clarke, N. J., Cushion, C. J., & Harwood, C. G. (2018). Players' understanding of talent identification in early specialization youth football. *Soccer & Society*, 1–15. https://doi.org/10.1080/14660970.2018.1432388

Cobley, S., Baker, J., & Schorer, J. (2020). Talent identification and development in sport: An introduction to a field of expanding research and practice. In *Talent Identification and Development in Sport* (pp. 1–16). Routledge.

Cobley, S., Baker, J., Wattie, N., & McKenna, J. (2009). Annual age-grouping and athlete development. *Sports Medicine, 39*(3), 235-256.

Cobley, S., Hanratty, M., O'Connor, D., & Cotton, W. (2014). First club location and relative age as influences on being a professional Australian rugby league player. *International Journal of Sports Science & Coaching*, *9*(2), 335–346.

Cobley, S., Schorer, J., & Baker, J. (2013). Identification and development of sport talent: A brief introduction to a growing field of research and practice. In *Talent identification and development in sport* (pp. 21–30). Routledge.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed). L. Erlbaum Associates.

Coldwells, A., Atkinson, G., & Reilly, T. (1994). Sources of variation in back and leg dynamometry. *Ergonomics*, *37*(1), 79–86.

Collins, D. J., Macnamara, A., & McCarthy, N. (2016). Putting the bumps in the rocky road: optimizing the pathway to excellence. *Frontiers in Psychology*, *7*. https://www.frontiersin.org/article/10.3389/fpsyg.2016.01482

Collins, T. (1998). *Rugby's Great Split: Class, Culture and the Origins of Rugby League Football*. Routledge. https://doi.org/10.4324/9780203044650

Côté, J., & Gilbert, W. (2009). An integrative definition of coaching effectiveness and expertise. *International Journal of Sports Science & Coaching*, *4*(3), 307–323.

Côté, J., & Lidor, R. (2013). Early talent development in sport: A multifaceted approach. *Conditions of Children's Talent Development in Sport*, 1–8.

Côté, J., & Vierimaa, M. (2014). The developmental model of sport participation: 15 years after its first conceptualization. *Science & Sports*, *29*, S63–S69.

Côté, J., Baker, J. & Abernethy, B. (2007). Practice and Play in the Development of Sport Expertise. In R. Eklund & G. Tenenbaum (Eds.) *Handbook of Sport Psychology* (3rd Ed.), (pp.184-202). Hoboken, NJ: Wiley.

Côté, J., Erickson, K., & Abernethy, B. (2013). *Côté, J., Erickson, K., & Abernethy, B. (2013). Play and practice during childhood. In J. Côté & R. Lidor (Eds.), Conditions of children's talent development in sport (pp. 9-20). Morgantown, WV: Fitness Information Technology.* (pp. 9–20).

Côté, J., Macdonald, D. J., Baker, J., & Abernethy, B. (2006). When "where" is more important than "when": Birthplace and birthdate effects on the achievement of sporting expertise. *Journal of Sports Sciences*, *24*(10), 1065-1073 doi: 10.1080/02640410500432490.

Côté, J., Salmela, J. H., Baria, A., & Russell, S. J. (1993). Organizing and interpreting unstructured qualitative data. *The Sport Psychologist*, *7*(2), 127–137.

Côté, J., Strachan, L., & Fraser-Thomas, J. (2007). Participation, personal development, and performance through youth sport. In *Positive youth development through sport* (pp. 48–60). Routledge.

Côté, J., Turnnidge, J., & Evans, M.B. (2014). The dynamic process of development through sport. *Kinesiologica Slovenica: Scientific Journal on Sport, 20,* 14-26.

Cresswell, S. L., & Eklund, R. C. (2006). The Nature of Player Burnout in Rugby: Key Characteristics and Attributions. *Journal of Applied Sport Psychology*, *18*(3), 219–239. https://doi.org/10.1080/10413200600830299

Cumming, S. P., Sherar, L. B., Pindus, D. M., Coelho-e-Silva, M. J., Malina, R. M., & Jardine, P. R. (2012). A biocultural model of maturity-associated variance in adolescent physical activity. *International Review of Sport and Exercise Psychology*, *5*(1), 23-43 doi: 10.1080/1750984X.2011.630481.

Cupples, B., O'Connor, D., & Cobley, S. (2018). Distinct trajectories of athlete development: A retrospective analysis of professional rugby league players. *Journal of Sports Sciences*, *36*(22), 2558-2566. doi: 10.1080/02640414.2018.1469227.

Darrall-Jones, J. D., Jones, B., & Till, K. (2015). Anthropometric and physical profiles of English academy rugby union players. *The Journal of Strength & Conditioning Research*, *29*(8), 2086-2096 https://doi.org/10.1519/JSC.0000000000000872.

Darrall-Jones, J. D., Jones, B., & Till, K. (2016). Anthropometric, sprint, and high-intensity running profiles of English academy rugby union players by position. *The Journal of Strength &*

Conditioning Research, 30(5), 1348-1358. https://doi.org/10.1519/JSC.0000000000001234.

Davids, K., Araújo, D., Correia, V., & Vilar, L. (2013a). How small-sided and conditioned games enhance acquisition of movement and decision-making skills. *Exercise and Sport Sciences Reviews*, *41*(3), 154-161. doi: 10.1097/jes.0b013e318292f3ec.

Davids, K., Araújo, D., Hristovski, R., Passos, P., & Chow, J. Y. (2012). Ecological dynamics and motor learning design in sport. *Skill Acquisition in Sport: Research, Theory and Practice*, 112–130.

Davids, K., Araújo, D., Vilar, L., Renshaw, I., & Pinder, R. (2013b). An ecological dynamics approach to skill acquisition: implications for development of talent in sport. *Talent Development and Excellence*, *5*(1), 21-34.

Davids, K., Güllich, A., Shuttleworth, R., & Araújo, D. (2017). Understanding environmental and task constraints on talent development: analysis of micro-structure of practice and macro-structure of development histories. In J. Baker, S. Cobley, J. Schorer, N. Wattie, *Routledge Handbook of Talent Identification and Development in Sport*, (pp. 192-206). London, Routledge.

Deelen, I., Ettema, D., & Kamphuis, C. B. (2018). Sports participation in sport clubs, gyms or public spaces: How users of different sports settings differ in their motivations, goals, and sports frequency. *PloS One*, *13*(10), e0205198.

Delahunt, E., Byrne, R., Doolin, R., McInerney, R., Ruddock, C., & Green, B. (2013). Anthropometric profile and body composition of Irish adolescent rugby union players aged 16–18. *Journal of Strength & Conditioning Research*, *27*(12), 3252-3258. doi: 10.1519/jsc.0b013e3182915ea6.

den Hollander, S., Lambert, M., Jones, B., & Hendricks, S. (2019). Tackle and ruck technique proficiency within academy and senior club rugby union. *Journal of Sports Sciences, 37*(22), 2578-2587.

Deutsch, M., Kearney, G., & Rehrer, N. (2007). Time – motion analysis of professional rugby union players during match-play. *Journal of Sports Sciences*, *25*(4), 461-472. doi: 10.1080/02640410600631298.

Dimundo, F., Cole, M., Blagrove, R. C., McAuley, A. B., Till, K., & Kelly, A. L. (2021). Talent identification in an English Premiership rugby union academy: Multidisciplinary characteristics of selected and non-selected male under-15 players. *Frontiers in Sports and Active Living*, *3*, 162.

Dimundo, F., Cole, M., Blagrove, R. C., McAuley, A. B., Till, K., Hall, M., Pacini, D., & Kelly, A. L. (2021). The anthropometric, physical, and relative age characteristics of an English Premiership rugby union academy. *International Journal of Strength and Conditioning*, *1*(1).

Dimundo, F., Cole, M., Blagrove, R. C., Till, K., & Kelly, A. L. (2022). A Multidisciplinary Investigation into the Talent Development Processes in an English Premiership Rugby Union Academy: A Preliminary Study through an Ecological Lens. *Sports*, *10*(2), 13.

Dimundo, F., Cole, M., Blagrove, R. C., Till, K., McAuley, A. B. T., Hall, M., Gale, C., & Kelly, A. L. (2021). Talent identification and development in male rugby union: A systematic review. *Journal of Expertise*, 4(1), 33-55.

Dobbin, N., Hunwicks, R., Jones, B., Till, K., Highton, J., & Twist, C. (2017). Criterion and construct validity of an isometric midthigh-pull dynamometer for assessing whole-body strength in professional rugby league players. *International Journal of Sports Physiology and Performance*, *13*(2), 235-239. doi: 10.1123/ijspp.2017-0166.

Doncaster, G., Medina, D., Drobnic, F., Gómez-Díaz, A. J., & Unnithan, V. (2020). Appreciating factors beyond the physical in talent identification and development: Insights from the FC Barcelona sporting model. *Frontiers in Sports and Active Living*, *2*, 91.

Doré, I., Sabiston, C. M., Sylvestre, M.-P., Brunet, J., O'Loughlin, J., Abi Nader, P., Gallant, F., & Bélanger, M. (2019). Years participating in sports during childhood predicts mental health in adolescence: A 5-year longitudinal study. *Journal of Adolescent Health*, *64*(6), 790–796.

Dubois, A., & Gadde, L.-E. (2002). Systematic combining: An abductive approach to case research. *Journal of Business Research*, *55*(7), 553–560. https://doi.org/10.1016/S0148-2963(00)00195-8

Durandt, J., Du Toit, S., Borresen, J., Hew-Butler, T., Masimla, H., Jokoet, I., & Lambert, M. (2006). Fitness and body composition profiling of elite junior South African rugby players. *South African Journal of Sports Medicine*, *18*(2), 38–45.

Durandt, J., Parker, Z., Masimla, H., & Lambert, M. (2011). Rugby-playing history at the national U13 level and subsequent participation at the national U16 and U18 rugby tournaments. *South African Journal of Sports Medicine*, *23*(4). doi: 10.17159/2078-516x/2011/v23i4a321.

Duthie, G., Pyne, D., & Hooper, S. (2003). Applied physiology and game analysis of rugby union. *Sports Medicine (Auckland, N.Z.)*, *33*(13), 973–991. https://doi.org/10.2165/00007256-200333130-00003

England Rugby (2017). Age grade rugby. Retrieved from: https://www. englandrugby.com/my-rugby/players/age-grade-rugby/about-age-graderugby/.

Englandrugby.com. (2020). Strategic Plan [Internet]. Available at: https://www.englandrugby.com/b60e6e31-e1cd-4d88-a268-4b6e76fb6593/about-rfu/strategic-plan; [7 September 2020]

Faber, I., Bustin, P., Oosterveld, F., Elferink-Gemser, M., & Nijhuis-Van der Sanden, M. (2015). Assessing personal talent determinants in young racquet sport players: a systematic review. *Journal of Sports Sciences*, *34*(5), 395-410. doi: 10.1080/02640414.2015.1061201.

Faber, I., Damsma, T., & Pion, J. (2021). Finding talent and estabilishing the road to excellence in table tennis – the Dutch case. In J. Baker, S. Cobley, & J. Schorer (Eds.), *Talent*

Identification and Development in Sport: International Perspectives 115-129. London: Routledge.

Farrow, D., McCrae, J., Gross, J., & Abernethy, B. (2010). Revisiting the relationship between pattern recall and anticipatory skill. *International Journal of Sport Psychology, 41*, 91-106.

Ferguson, C. J. (2009). An effect size primer: a guide for clinicians and researchers. *Professional Psychology: Research and Practice, 4*(5), 532-538.

Fetters, M. D., & Molina-Azorin, J. F. (2020). Utilizing a Mixed Methods Approach for Conducting Interventional Evaluations. *Journal of Mixed Methods Research*, *14*(2), 131–144. https://doi.org/10.1177/1558689820912856

Fontana, F. Y., Colosio, A. L., Da Lozzo, G., & Pogliaghi, S. (2016). Player's success prediction in rugby union: From youth performance to senior level placing. *Journal of Science and Medicine in Sport*, *20*(4), 409-414 doi: 10.1016/j.jsams.2016.08.017.

Fontana, F. Y., Colosio, A., De Roia, G. F., Da Lozzo, G., & Pogliaghi, S. (2015). Anthropometrics of Italian senior male rugby union players: from elite to second division. *International Journal of Sports Physiology and Performance, 10*(6), 674-680.

Ford, P. R., & Williams, M. (2017). Sport activity in childhood. In J. Baker, S. Cobley, J. Schorer, N. Wattie, *Routledge Handbook of Talent Identification and Development in Sport*, (pp. 117-132). London, Routledge.

Ford, P. R., Ward, P., Hodges, N. J., & Williams, A. M. (2009). The role of deliberate practice and play in career progression in sport: The early engagement hypothesis. *High Ability Studies*, *20*(1), 65–75.

Fraser-Thomas, J., Beesley, T., Dickler, L., Harlow, M., Mosher, A., Preston, C., & Wolman, L. (2017). Developing talent while promoting positive youth development: A balancing act. In *Routledge handbook of talent identification and development in sport* (pp. 377–393). Routledge.

Freitag, A., Kirkwood, G., & Pollock, A. (2015). Rugby injury surveillance and prevention programmes: are they effective? *BMJ (Clinical research ed.)*, *350*(apr21 6), h1587-h1587. doi: 10.1136/bmj.h1587.

Gabbett T. J. (2002). Physiological characteristics of junior and senior rugby league players. *British Journal of Sports Medicine*. Retrieved 8 May 2022, from https://bjsm.bmj.com/content/36/5/334

Gabbett, T. (2006). A comparison of physiological and anthropometric characteristics among playing positions in sub-elite rugby league players. *Journal of Sports Sciences*, *24*(12), 1273-1280. doi: 10.1080/02640410500497675.

Gabbett, T. J. (2005). A comparison of physiological and anthropometric characteristics among playing positions in junior rugby league players. *British Journal of Sports Medicine*, *39*(9), 675–680. https://doi.org/10.1136/bjsm.2005.018275

Gabbett, T. J. (2006). Skill-based conditioning games as an alternative to traditional conditioning for rugby league players. *Journal of Strength and Conditioning Research*, *20*(2), 309–315. https://doi.org/10.1519/R-17655.1

Gabbett, T. J., & Abernethy, B. (2013). Expert-Novice Differences in the Anticipatory Skill of Rugby League Players. *Sport, Exercise, and Performance Psychology*, *2*, 138. https://doi.org/10.1037/a0031221

Gabbett, T. J., King, T., & Jenkins, D. (2008). Applied physiology of rugby league. *Sports Medicine (Auckland, N.Z.)*, *38*(2), 119–138. https://doi.org/10.2165/00007256-200838020-00003

Gaber, J. (2020). *Qualitative Analysis for Planning & Policy: Beyond the Numbers* (2nd ed.). Routledge. https://doi.org/10.4324/9780429290190

Gál-Pottyondy, A., Petró, B., Czétényi, A., Négyesi, J., Nagatomi, R., & Kiss, R. M. (2021). Field Testing Protocols for Talent Identification and Development in Basketball—A

Systematic Review. *Applied Sciences*, *11*(10), 4340. https://doi.org/10.3390/app11104340

Gov.Uk. *English indices of deprivation*. (n.d.). Retrieved 23 September 2021, from https://www.gov.uk/government/collections/english-indices-of-deprivation

Graham, I. D., Logan, J., Harrison, M. B., Straus, S. E., Tetroe, J., Caswell, W., & Robinson, N. (2006). Lost in knowledge translation: Time for a map? *Journal of Continuing Education in the Health Professions*, *26*(1), 13–24.

Grobler, T. D., Shaw, B. S., & Coopoo, Y. (2017). Influence of physical fitness parameters on relative age effect on amateur secondary school rugby union players. *South African Journal for Research in Sport, Physical Education and Recreation, 39*(3), 29-39.

Grobler, T. D., Shaw, B. S., & Coopoo, Y. (2017). Influence of physical fitness parameters on relative age effect on amateur secondary school rugby union players. *South African Journal for Research in Sport, Physical Education and Recreation*, *39*(3), 29-39.

Güllich, A., Faß, L., Gies, C., & Wald, V. (2020). *On the Empirical Substantiation of the Definition of "Deliberate Practice" (Ericsson et al., 1993) and "Deliberate Play" (Côté et al., 2007) in Youth Athletes*. *3*, 19.

Güllich, A., Macnamara, B. N., & Hambrick, D. Z. (2021). What Makes a Champion? Early Multidisciplinary Practice, Not Early Specialization, Predicts World-Class Performance. *Perspectives on Psychological Science*, 1745691620974772.

Hambrick, D. Z., Burgoyne, A. P., Macnamara, B. N., & Ullén, F. (2018). Toward a multifactorial model of expertise: Beyond born versus made. *Annals of the New York Academy of Sciences*. doi: 10.1111/nyas.13586

Hancock, D. J., Adler, A. L., & Côté, J. (2013). A proposed theoretical model to explain relative age effects in sport. *European Journal of Sport Science*, *13*(6), 630–637 doi: 10.1080/17461391.2013.775352.

Hansen, K. T., Cronin, J. B., Pickering, S. L., & Douglas, L. (2011). Do force–time and power–time measures in a loaded jump squat differentiate between speed performance and playing level in elite and elite junior rugby union players? *The Journal of Strength & Conditioning Research, 25*(9), 2382-2391.

Hecksteden, A., Kellner, R., & Donath, L. (2021). Dealing with small samples in football research. *Science and Medicine in Football*, 1–9.

Hendricks, S. (2012). Trainability of junior rugby union players. *South African Journal of Sports Medicine*, *24*(4). doi: 10.17159/2078-516x/2012/v24i4a525.

Hendricks, S., Roode, B., Matthews, B., & Lambert, M. (2013). Defensive strategies in rugby union. *Perceptual and Motor Skills*, *117*(1), 65-87. doi: 10.2466/30.25.pms.117x17z6.

Henriksen, K., & Stambulova, N. (2017). Creating optimal environments for talent development: A holistic ecological approach. In *Routledge handbook of talent identification and development in sport* (pp. 270-284). Routledge.

Henriksen, K., Stambulova, N., & Roessler, K. K. (2010). Holistic approach to athletic talent development environments: A successful sailing milieu. *Psychology of Sport and Exercise*, *11*(3), 212–222.

Higham, D. G., Pyne, D. B., Anson, J. M., & Eddy, A. (2013). Physiological, anthropometric, and performance characteristics of rugby sevens players. *International journal of sports physiology and performance*, *8*(1), 19-27 doi:10.1123/ijspp.8.1.19.

Hill, A., MacNamara, Á., & Collins, D. (2015). Psychobehaviorally based features of effective talent development in rugby union: A coach's perspective. *The Sport Psychologist*, *29*(3), 201-212. doi: 10.1123/tsp.2014-0103.

Hill, A., MacNamara, Á., & Collins, D. (2018). Development and initial validation of the psychological characteristics of developing excellence questionnaire version 2 (PCDEQ2). *European Journal of Sport Science*, *19*(4), 517-528 doi: 10.1080/17461391.2018.1535627.

Hogan, K., & Norton, K. (2000). The ‘price’ of Olympic gold. *Journal of Science and Medicine in Sport / Sports Medicine Australia*, *3*, 203–218. https://doi.org/10.1016/S1440-2440(00)80082-1

Holway, F. E., & Garavaglia, R. (2009). Kinanthropometry of group I rugby players in Buenos Aires, Argentina. *Journal of Sports Sciences*, *27*(11), 1211-1220 doi: 10.1080/02640410903207408.

Howard, S. M., Cumming, S. P., Atkinson, M., & Malina, R. M. (2016). Biological maturity-associated variance in peak power output and momentum in academy rugby union players. *European Journal of Sport Science*, *16*(8), 972–980.

Huijgen, B. C., Elferink-Gemser, M. T., Lemmink, K. A., & Visscher, C. (2014). Multidimensional performance characteristics in selected and deselected talented soccer players. *European Journal of Sport Science, 14*(1), 2-10.

Ireton, M., Till, K., Weaving, D., and Jones, B. (2017). Differences in the movement skills and physical qualities of elite senior & academy rugby league players. *Journal of Strength & Conditioning Research*, [Publish Ahead of Print doi: 10.1519/JSC.0000000000002016]. Online access [December, 2018].

Johnson, M. B., Castillo, Y., Sacks, D. N., Cavazos Jr, J., Edmonds, W. A., & Tenenbaum, G. (2008). “Hard work beats talent until talent decides to work hard”: coaches’ perspectives regarding differentiating elite and non-elite swimmers. *International Journal of Sports Science & Coaching*, *3*(3), 417–430.

Jones, B., Weaving, D., Tee, J., Darrall-Jones, J., Weakley, J., Phibbs, P., Read, D., Roe, G., Hendricks, S., & Till, K. (2018). Bigger, stronger, faster, fitter: The differences in physical qualities of school and academy rugby union players. *Journal of Sports Sciences*, *36*(21), 2399–2404. https://doi.org/10.1080/02640414.2018.1458589

Jones, R. A., Mahoney, J. W., & Gucciardi, D. F. (2014). On the transition into elite rugby league: Perceptions of players and coaching staff. *Sport, Exercise, and Performance Psychology*, *3*(1), 28.

Jones, T., Keane, K., Smith, A., Dent, J., McShane, K., & , Williams, L., Maguire, P., Marshall, S. J., Graham-Smith, P., & Payne, T. (2018)b. Which anthropometric and lower body power variables are predictive of professional and amateur playing status in male rugby union players?. *International Journal of Sports Science & Coaching*, *14*(1), 82-90. doi: 10.1177/1747954118805956.

Karoly, P. (1993). Mechanisms of self-regulation: A systems view. *Annual Review of Psychology*, *44*(1), 23-52.

Kearney, P. E. (2017). The influence of nationality and playing position on relative age effects in rugby union: A cross-cultural comparison. *South African Journal of Sports Medicine*, *29*(1), Article 1. https://www.ajol.info/index.php/sasma/article/view/168590

Kelly, A. L., & Williams, C. A. (2020). Physical characteristics and the talent identification and development processes in youth soccer: A narrative review. *Strength & Conditioning Journal* [ePub ahead of print] doi: 10.1519/SSC.0000000000000576.

Kelly, A. L., Barrell, D., Burke, K., & Till, K. (2021). Relative Age Effects In Rugby Union: A Narrative Review. In A. L. Kelly, J. Côté, M. Jeffreys, & J. Turnnidge (Eds.), *Birth Advantages and Relative Age Effects in Sport: Exploring Organizational Structures and Creating Appropriate Settings*, *3*, (pp.12). London: Routledge.

Kelly, A. L., Brown, T., Reed, R., Côté, J., & Turnnidge, J. (2022). Relative Age Effects in male cricket: a personal assets approach to explain immediate, short-term, and long-term developmental outcomes. *Sports*, *10*(3), 39. https://doi.org/10.3390/sports10030039

Kelly, A. L., Côté, J., Jeffreys, M., & Turnnidge, J. (n.d.). *Birth Advantages and Relative Age Effects in Sport*.

Kelly, A. L., McAuley, A. B., Dimundo, F., & Till, K. (2022). Talent Identification in Male Youth Rugby: An Ecological Perspective. In K. Till, J. Weakley, S. Whitehead, B. Jones (Eds.), *Youth Rugby* (pp. 40-55). London: Routledge.

Kelly, A. L., Till, K., Jackson, D., Barrell, D., Burke, K., & Turnnidge, J. (2021). Talent identification and relative age effects in English male rugby union pathways: From entry to expertise. *Frontiers in Sports and Active Living, 3*, 1-12.

Kelly, A. L., Wilson, M. R., Jackson, D. T., Turnnidge, J., & Williams, C. A. (2020). Speed of Thought and Speed of Feet: Examining Perceptual-Cognitive Expertise and Physical Performance in an English Football Academy. *Journal of Science in Sport and Exercise*, 1–10.

Kobal, R., Nakamura, F., Moraes, J. E., Coelho, M., Kitamura, K., Abad, C., Pereira, L., & Loturco, I. (2016). Physical performance of Brazilian rugby players from different age categories and competitive levels. *The Journal of Strength and Conditioning Research, 30*(9), 2433-2439.

Kotrlik, J. W., Williams, H. A., & Jabor, M. K. (2011). Reporting and Interpreting Effect Size in Quantitative Agricultural Education Research. *Journal of Agricultural Education*, *52*(1), 132–142.

Krause, L. M., Naughton, G. A., Denny, G., Patton, D., Hartwig, T., & Gabbett, T. J. (2015). Understanding mismatches in body size, speed and power among adolescent rugby union players. *Journal of Science and Medicine in Sport*, *18*(3), 358–363.

Lacome, M., Avrillon, S., Cholley, Y., Simpson, B. M., Guilhem, G., & Buchheit, M. (2020). Hamstring eccentric strengthening program: Does training volume matter? *International Journal of Sports Physiology and Performance*, *15*(1), 81–90.

Lambert, M. I. (2010). Long-term player development in rugby-how are we doing in South Africa? *South African Journal of Sports Medicine*, *22*(3), 67–68.

Law, M., Stewart, D., Letts, L., Pollock, N., Bosch, J., & Westmorland, M. (1998). Guidelines for critical review of qualitative studies. *McMaster University Occupational Therapy Evidence-Based Practice Research Group*.

Letts, L., Wilkins, S., Law, M., Stewart, D., Bosch, J., & Westmorland, M. (2007). Guidelines for critical review form: Qualitative studies (Version 2.0). *McMaster University Occupational Therapy Evidence-Based Practice Research Group*.

Lewis, J., Morgan, K., & Cooper, S. (2015). Relative age effects in welsh age grade rugby union. *International Journal of Sports Science & Coaching*, *10*(5), 797-813. doi: 10.1260/1747-9541.10.5.797.

Lindgren, E.-C., & Barker-Ruchti, N. (2017). Balancing performance-based expectations with a holistic perspective on coaching: A qualitative study of Swedish women's national football team coaches' practice experiences. *International Journal of Qualitative Studies on Health and Well-Being*, *12*(sup2), 1358580. https://doi.org/10.1080/17482631.2017.1358580

Lloyd, R. S., Cronin, J. B., Faigenbaum, A. D., Haff, G. G., Howard, R., Kraemer, W. J., Micheli, L. J., Myer, G. D., & Oliver, J. L. (2016). National Strength and Conditioning Association position statement on long-term athletic development. *Journal of Strength and Conditioning Research*, *30*(6), 1491–1509.

Lloyd, R. S., Moeskops, S., Cropley, B., Faigenbaum, A. D., & Oliver, J. L. (2019). Coaching young athletes. *Strength and Conditioning for Young Athletes: Science and Application. Lloyd RS, Oliver JL, Eds. Oxon, England: Routledge*.

MacDonald, D. J., Cheung, M., Côté, J., & Abernethy, B. (2009). Place but not date of birth influences the development and emergence of athletic talent in American football. *Journal of Applied Sport Psychology*, *21*(1), 80–90.

Malina, R. M., Bouchard, C., & Bar-Or, O. (2004). *Growth, Maturation, and Physical Activity*. Human kinetics.

Malina, R. M., Cumming, S. P., Rogol, A. D., Coelho-e-Silva, M. J., Figueiredo, A. J., Konarski, J. M., & Kozieł, S. M. (2019). Bio-banding in youth sports: background, concept, and application. *Sports Medicine*, *49*(11), 1671-1685.

Mann, D. T. Y., Williams, A. M., Ward, P., & Janelle, C. M. (2007). Perceptual-cognitive expertise in sport: A meta-analysis. *Journal of Sport and Exercise Psychology, 29*(4), 457-478.

Marchiori, C. L., Medeiros, D. M., Severo-Silveira, L., dos Santos Oliveira, G., Medeiros, T. M., de Araujo Ribeiro-Alvares, J. B., & Baroni, B. M. (2021). Muscular adaptations to training programs using the Nordic hamstring exercise or the stiff-leg deadlift in rugby players. *Sport Sciences for Health*, 1–9.

Marsters, C., & Tiatia-Seath, J. (2019). Young Pacific male rugby players' perceptions and experiences of mental wellbeing. *Sports*, *7*(4), 83.

Massy-Westropp, N. M., Gill, T. K., Taylor, A. W., Bohannon, R. W., & Hill, C. L. (2011). Hand grip strength: Age and gender stratified normative data in a population-based study. *BMC Research Notes*, *4*(1), 127.

McAuliffe, J., Lavallee, D., & Campbell, M. J. (2021). A narrative review of the role of psychological skills and characteristics in navigating the pathway to professional rugby union. *International Journal of Sport and Exercise Psychology*, 1–23.

McCarthy, N., & Collins, D. (2014). Initial identification & selection bias versus the eventual confirmation of talent: evidence for the benefits of a rocky road?. *Journal of Sports Sciences*, *32*(17), 1604-1610. doi: 10.1080/02640414.2014.908322.

McClymont D. (2003). Use of the reactive strength index (RSI) as an indicator of plyometric training conditions. In: *Science and Football V: The proceedings of the fifth World Congress on Sports Science and Football*, Lisbon, Portugal, 408–16..

McCormack, S., Jones, B., Scantlebury, S., Rotheram, D., & Till, K. (2020). "It's important, but It's not everything": Practitioners' use, analysis and perceptions of fitness testing in academy rugby league. *Sports*, *8*(9), 130.

McDonald, B. (2014). Developing 'home-grown'talent: Pacific island rugby labour and the Victorian rugby union. *The International Journal of the History of Sport*, *31*(11), 1332–1344.

McHugh, M. L. (2013). The Chi-square test of independence. *Biochemia Medica,* 143-149.

McLellan, C., Lovell, D., & Gass, G. (2011). Performance analysis of elite rugby league match play using global positioning systems. *Journal of Strength & Conditioning Research*, *25*(6), 1703-1710. doi: 10.1519/jsc.0b013e3181ddf678.

McMahon, J., Murphy, S., Rej, S., & Comfort, P. (2017). Countermovement-jump-phase characteristics of senior and academy rugby league players. *International Journal of Sports Physiology and Performance*, *12*(6), 803-811. doi: 10.1123/ijspp.2016-0467.

Merriam, S. B. (1998). *Qualitative Research and Case Study Applications in Education. Revised and Expanded from" Case Study Research in Education.".* ERIC.

Moreno, E. (1995). High school corner: Developing Quickness, Part II. *Strength & Conditioning Journal*, *17*(1), 38–39.

Musch, J., & Grondin, S. (2001). Unequal Competition as an Impediment to Personal Development: A Review of the Relative Age Effect in Sport. *Developmental Review*, *21*(2), 147–167. https://doi.org/10.1006/drev.2000.0516

Nutton, R. W., Hamilton, D. F., Hutchison, J. D., Mitchell, M. J., Simpson, A. H. R., & MacLean, J. G. (2012). Variation in physical development in schoolboy rugby players: Can maturity testing reduce mismatch? *BMJ Open*, *2*(4) e001149.

Office for National Statistics. (2015). Number of Live Births by Date, 1995 to 2014, in England and Wales [online]. Retrieved from: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/livebirths/adhocs/005149numberoflivebirthsbydate1995to2014inenglandandwales [accessed 12th December 2020].

Oliver, J. L., Cahill, M., & Uthoff, A. (2019). Speed training for young athletes. In: *Strength and Conditioning for Young Athletes: Science and Application. Lloyd RS, Oliver JL, Eds. Oxon, England: Routledge,* 207-227.

Ong, B. K. (2012). Grounded Theory Method (GTM) and the Abductive Research Strategy (ARS): A critical analysis of their differences. *International Journal of Social Research Methodology*, *15*(5), 417–432.

Owen, C., Till, K., Phibbs, P., Read, D. J., Weakley, J., Atkinson, M., Cross, M., Kemp, S., Sawczuk, T., Stokes, K., Williams, S., & Jones, B. (2022). A multidimensional approach to identifying the physical qualities of male English regional academy rugby union players; considerations of position, chronological age, relative age and maturation. *European Journal of Sport Science*, 1–10. https://doi.org/10.1080/17461391.2021.2023658

Owen, C., Till, K., Weakley, J., & Jones, B. (2020). Testing methods and physical qualities of male age grade rugby union players: A systematic review. *PLOS ONE*, *15*(6), e0233796. https://doi.org/10.1371/journal.pone.0233796

Parsonage, J. R., Williams, R. S., Rainer, P., McKeown, I., & Williams, M. D. (2014). Assessment of conditioning-specific movement tasks and physical fitness measures in talent identified under 16-year-old rugby union players. *Journal of Strength and Conditioning Research*, *28*(6), 1497–1506. https://doi.org/10.1519/JSC.0000000000000298

Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice*. Sage publications.

Petlichkoff, L. M. (2004). Self-regulation Skills for Children and Adolescents. *Developmental sport and exercise psychology: A lifespan perspective*, 269-288.

Phibbs, P. J., Jones, B., Read, D. B., Roe, G. A., Darrall-Jones, J., Weakley, J. J., Rock, A., & Till, K. (2018). The appropriateness of training exposures for match-play preparation in adolescent schoolboy and academy rugby union players. *Journal of Sports Sciences*, *36*(6), 704–709.

Phibbs, P. J., Jones, B., Roe, G., Read, D. B., Darrall-Jones, J., Weakley, J., Rock, A., & Till, K. (2018). Organized chaos in late specialization team sports: weekly training loads of elite adolescent rugby union players. *Journal of Strength and Conditioning Research*, *32*(5), 1316–1323. https://doi.org/10.1519/JSC.0000000000001965

Pienaar, A., & Spamer, M. (1998). A longitudinal study of talented young rugby players as regards their rugby skills, physical and motor abilities and anthropometric data. *Journal of Human Movement Studies*, *34*, 13–32.

Pienaar, A., Spamer, M., & Steyn Jr, H. (1998). Identifying and developing rugby talent among 10-year-old boys: A practical model. *Journal of Sports Sciences*, *16*(8), 691-699. doi: 10.1080/026404198366326.

Plotz, A., & Spamer, M. (2006). A comparison of talented South African and English youth rugby players with reference to game-specific-, anthropometric-, physical and motor variables. *South African Journal for Research in Sport, Physical Education and Recreation*, *28*(1). doi: 10.4314/sajrs.v28i1.25934.

Potgieter, J. C., Grobbelaar, H. W., & Andrew, M. (2008). Sport psychological skill levels and related psychosocial factors that distinguish between rugby union players of different participation levels. *Journal of Social & Psychological Sciences*, *1*(1).

Powell, R. A., & Single, H. M. (1996). Focus groups. *International Journal for Quality in Health Care*, *8*(5), 499–504.

Quarrie, K. L., & Wilson, B. D. (2000). Force production in the rugby union scrum. *Journal of Sports Sciences*, *18*(4), 237–246. https://doi.org/10.1080/026404100364974

Quarrie, K. L., Handcock, P., Toomey, M. J., & Waller, A. E. (1996). The New Zealand rugby injury and performance project. IV. Anthropometric and physical performance comparisons between positional categories of senior A rugby players. *British Journal of Sports Medicine, 30*(1), 53-56.

Quarrie, K. L., Handcock, P., Waller, A. E., Chalmers, D. J., Toomey, M. J., & Wilson, B. D. (1995). The New Zealand rugby injury and performance project. III. Anthropometric and physical performance characteristics of players. *British Journal of Sports Medicine*, *29*(4), 263–270.

Quarrie, K., Handcock, P., Toomey, M., & Waller, A. (1996). The New Zealand rugby injury and performance project. IV. Anthropometric and physical performance comparisons between positional categories of senior A rugby players. *British Journal of Sports Medicine*, *30*(1), 53-56. doi: 10.1136/bjsm.30.1.53.

Read, D. B., Jones, B., Phibbs, P. J., Roe, G. A. B., Darrall-Jones, J. D., Weakley, J. J. S., & Till, K. (2017). Physical demands of representative match-play in adolescent rugby union. *Journal of Strength and Conditioning Research*, *31*(5), 1290–1296. https://doi.org/10.1519/JSC.0000000000001600

Read, D., Jones, B., Phibbs, P., Roe, G., Darrall-Jones, J., Weakley, J., & Till, K. (2017). The physical characteristics of match-play in English schoolboy and academy rugby union. *Journal of Sports Sciences*, *36*(6), 645-650. doi: 10.1080/02640414.2017.1329546.

Reilly, T., Williams, A., Nevill, A., & Franks, A. (2000). A multidisciplinary approach to talent identification in soccer. *Journal of Sports Sciences*, *18*(9), 695-702. doi: 10.1080/02640410050120078.

Ren, Y., Cedeno-Mieles, V., Hu, Z., Deng, X., Adiga, A., Barrett, C., Ekanayake, S., Goode, B. J., Korkmaz, G., Kuhlman, C. J., Machi, D., Marathe, M. V., Ramakrishnan, N., Ravi, S. S., Sarat, P., Selt, N., Contractor, N., Epstein, J., & Macy, M. W. (2018). Generative modeling of human behavior and social interactions using abductive analysis: 10th IEEE/ACM International Conference on Advances in Social Networks Analysis and

Mining, ASONAM 2018. *Proceedings of the 2018 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining, ASONAM 2018*, 413–420. https://doi.org/10.1109/ASONAM.2018.8508282

Roberts, S. J., & Fairclough, S. J. (2012). The influence of relative age effects in representative youth rugby union in the North West of England. *Asian Journal of Exercise & Sports Science, 9*(2).

Román, P. Á. L., Macias, F. J. V., & Pinillos, F. G. (2018). Effects of a contrast training programme on jumping, sprinting and agility performance of prepubertal basketball players. *J Sports Sci, 36*(7), 802-808.

Ross, A., Gill, N., & Cronin, J. (2014). Match analysis and player characteristics in rugby sevens. *Sports Medicine*, *44*(3), 357-367 doi: 10.1007/s40279-013-0123-0.

Rotheram, D. (2020). *Talent identification and development in male rugby league* [PhD Thesis]. University of Central Lancashire.

Rothwell, M., Davids, K., Stone, J., Araujo, D., & Shuttleworth, R. (2020). The Talent Development Process as Enhancing Athlete Functionality: Creating Forms of Life in an Ecological Niche. In J. Backer, S. Cobley, J. Schorer. *Talent Identification and Development in Sport*. Routledge Handbook, (pp.34-49).

Runswick, O. R., Green, R., & North, J. S. (2020). The effects of skill-level and playing-position on the anticipation of ball-bounce in rugby union. *Human Movement Science, 69*, 102-544.

Rynne, S., Crudgington, R., Dickinson, R. K., & Mallett, C. J. (2017). On the (potential) value of coaching. In J. Baker, S. Cobley, J. Schorer, N. Wattie, *Routledge Handbook of Talent Identification and Development in Sport*, (pp. 285-300). London, Routledge.

Sarmento, H., Anguera, M., Pereira, A., & Araújo, D. (2018). Talent identification and development in male football: A systematic review. *Sports Medicine*, *48*(4), 907-931. doi: 10.1007/s40279-017-0851-7.

Sauro, J., & Lewis, J. R. (2016). *Quantifying the user experience: Practical statistics for user research*. Morgan Kaufmann.

Sayers, S. P., Harackiewicz, D. V., Harman, E. A., Frykman, P. N., & Rosenstein, M. T. (1999). Cross-validation of three jump power equations. *Medicine and Science in Sports and Exercise*, *31*(4), 572–577.

Schaaf, M. (2006). Elite Pacific male rugby players' perceptions and experiences of professional rugby. *Junctures: The Journal for Thematic Dialogue*, *7*.

Schorer, J., Wattie, N., Cobley, S., & Baker, J. (2017). Concluding, but definitely not conclusive, remarks on talent identification and development. In *Routledge handbook of talent identification and development in sport* (pp. 466–476). Routledge.

Scott, A., Roe, N., Coats, A., & Piepoli, M. (2003). Aerobic exercise physiology in a professional rugby union team. *International Journal of Cardiology*, *87*(2-3), 173-177. doi: 10.1016/s0167-5273(02)00211-5.

Scott, T. J., Dascombe, B. J., Delaney, J. A., Sanctuary, C. E., Scott, M. T. U., Hickmans, J. A., & Duthie, G. M. (2017). Running momentum: A new method to quantify prolonged high-intensity intermittent running performance in collision sports. *Science and Medicine in Football*, *1*(3), 244–250. https://doi.org/10.1080/24733938.2017.1331044

Sedeaud, A., Saulière, G., Marquet, L., Del Vecchio, S., Bar-Hen, A., & Toussaint, J. (2017). Collective effectiveness in the XV de France: selections and time matter. *European Journal of Sport Science*, *17*(6), 656-664. doi: 10.1080/17461391.2017.1291742.

Sedeaud, A., Vidalin, H., Tafflet, M., Marc, A., & Toussaint, J. F. (2013). Rugby morphologies: "bigger and taller", reflects an early directional selection. *Journal of Sports Medicine and Physical Fitness*, *53*(2), 185-91 PMID: 23584326.

Sewry, N., Lambert, M., Roode, B., Matthews, B., & Hendricks, S. (2015). The relationship between playing situation, defence and tackle technique in rugby union. *International*

Journal of Sports Science & Coaching, *10*(6), 1115-1128. doi: 10.1260/1747-9541.10.6.1115.

Sherwood, S., Smith, T., & Masters, R. (2018). Pattern recall, decision making and talent identification in rugby union. *European Journal of Sport Science*, *19*(6), 834-841. doi: 10.1080/17461391.2018.1545051.

Smart, D., Hopkins, W. G., Quarrie, K. L., & Gill, N. (2014). The relationship between physical fitness and game behaviours in rugby union players. *European Journal of Sport Science*, *14 Suppl 1*, S8-17. https://doi.org/10.1080/17461391.2011.635812

Smart, D., Hopkins, W., & Gill, N. (2013). Differences and changes in the physical characteristics of professional and amateur rugby union players. *Journal of Strength & Conditioning Research*, *27*(11), 3033-3044. doi: 10.1519/jsc.0b013e31828c26d3.

Smith, B., & McGannon, K. R. (2018). Developing rigor in qualitative research: Problems and opportunities within sport and exercise psychology. *International Review of Sport and Exercise Psychology*, *11*(1), 101–121.

Spamer, E. J., & De la Port, Y. (2006). Anthropometric, physical, motor, and game-specific profiles of elite U 16 and U 18 year-old South African schoolboy rugby players. *Kinesiology: International Journal of Fundamental and Applied Kinesiology*, *38*(2), 176-184.

Spamer, E. J., Du Plessis, D. J., & Kruger, E. H. (2009). Comparative characteristics of elite New Zealand and South African u/16 rugby players with reference to game specific skills, physical abilities and anthropometric data. *South African Journal of Sports Medicine*, *21*(2).

Strean, W. B. (1998). Possibilities for qualitative research in sport psychology. *The Sport Psychologist*, *12*(3), 333–345.

Suarez-Arrones, L., Portillo, J., Pareja-Blanco, F., de Villareal, E. S., Sánchez-Medina, L., & Munguía-Izquierdo, D. (2014). Match-play activity profile in elite women's rugby union players. *The Journal of Strength & Conditioning Research*, *28*(2), 452-458 doi: 10.1519/JSC.0b013e3182999e2b.

Tavory, I., & Timmermans, S. (2014). *Abductive Analysis: Theorizing Qualitative Research*. University of Chicago Press.

Te Wierike, S. C. M., Van der Sluis, A., van den Akker-Scheek, I., Elferink-Gemser, M. T., & Visscher, C. (2013). Psychosocial factors influencing the recovery of athletes with anterior cruciate ligament injury: a systematic review. *Scandinavian Journal of Medicine & Science in Sports*, *23*(5), 527-540 doi: 10.1111/sms.12010.

Thompson, F., Rongen, F., Cowburn, I., & Till, K. (2022). The Impacts of Sports Schools on Holistic Athlete Development: A Mixed Methods Systematic Review. *Sports Medicine*. https://doi.org/10.1007/s40279-022-01664-5

Till, K., Jones, B., & Geeson-Brown, T. (2016)a. Do physical qualities influence the attainment of professional status within elite 16–19 year old rugby league players? *Journal of Science and Medicine in Sport*, 19(7):585– 589. doi: 10.1016/j.jsams.2015.07.001.

Till, K., & Baker, J. (2020). Challenges and [possible] solutions to optimizing talent identification and development in sport. *Frontiers in Psychology*, *11*, 664. https://doi.org/10.3389/fpsyg.2020.00664

Till, K., Barrell, D., Lawn, J., Lazenby, B., Rock, A., & Cobley, S. (2020). ‘Wide and emergent – narrow and focussed’: a dual-pathway approach to talent identification and development in England rugby union. In *Talent Identification and Development in Sport* (2nd ed.). Routledge.

Till, K., Cobley, S., Morley, D., O'Hara, J., Chapman, C., & Cooke, C. (2015). Retrospective analysis of anthropometric and fitness characteristics associated with long-term career progression in Rugby League. *Journal of Science and Medicine in Sport. 18*(3), 310-314.

Till, K., Cobley, S., Morley, D., O'Hara, J., Chapman, C., & Cooke, C. (2016)b. The influence of age, playing position, anthropometry and fitness on career attainment outcomes in rugby league. *Journal of Sports Science,* 34(13), 1240-1245 doi.org/10.1080/02640414.2015.1105380.

Till, K., Cobley, S., O'Hara, J., Brightmore, A., Cooke, C., & Chapman, C. (2011). Using anthropometric and performance characteristics to predict selection in junior UK Rugby League players. *Journal of Science and Medicine in Sport*, *14*(3), 264-269. doi: 10.1016/j.jsams.2011.01.006.

Till, K., Cobley, S., O'Hara, J., Chapman, C., & Cooke, C. (2013). A longitudinal evaluation of anthropometric and fitness characteristics in junior rugby league players considering playing position and selection level. *Journal of Science and Medicine in Sport*, *16*(5), 438-443. doi: 10.1016/j.jsams.2012.09.002.

Till, K., Cobley, S., O'Hara, J., Chapman, C., and Cooke, C. (2010). Anthropometric, physiological and selection characteristics in high performance UK junior rugby league players. *Talent Development and Excellence*, *2*(2), 193-207.

Till, K., Emmonds, S., & Jones, B. (2019). Talent identification. *Strength and Conditioning for Young Athletes*, 21–44.

Till, K., Jones, B., Cobley, S., Morley, D., O'Hara, J., & Chapman, C. et al. (2016)c. Identifying talent in youth sport: a novel methodology using higher-dimensional analysis. *Plos One*, *11*(5), e0155047. doi: 10.1371/journal.pone.0155047.

Till, K., Morley, D., O'Hara, J., Jones, B., Chapman, C., Beggs, C., Cooke, C. & Cobley S. (2017)a. A retrospective longitudinal analysis of anthropometric and physical qualities that associate with adult career attainment in junior rugby league players. Journal of Science and Medicine in Sport. 20, 1029-1033. doi.org/10.1016/j.jsams.2017.03.018.

Till, K., Scantlebury, S., & Jones, B. (2017)b. Anthropometric and physical qualities of elite male youth rugby league players. *Sports Medicine*, *47*(11), 2171-2186. doi: 10.1007/s40279-017-0745-8.

Till, K., Weakley, J., Read, D. B., Phibbs, P., Darrall-Jones, J., Roe, G., Chantler, S., Mellalieu, S., Hislop, M., Stokes, K., Rock, A., & Jones, B. (2020). Applied sport science for male youth rugby union in England. *Sports Medicine – Open, 6*, 14 doi: 10.1186/s40798-020-0236-6.

Till, K., Weakley, J., Read, D. B., Phibbs, P., Darrall-Jones, J., Roe, G., Chantler, S., Mellalieu, S., Hislop, M., Stokes, K., Rock, A., & Jones, B. (2020a). Applied Sport Science for Male Age-Grade Rugby Union in England. *Sports Medicine - Open*, *6*(1), 14. https://doi.org/10.1186/s40798-020-0236-6

Timmermans, S., & Tavory, I. (2012). Theory Construction in Qualitative Research: From Grounded Theory to Abductive Analysis. *Sociological Theory*, *30*(3), 167–186. https://doi.org/10.1177/0735275112457914

Tomasella, B. (2019). *A critical analysis of small business social responsibility in independent foodservice businesses* [PhD, Sheffield Hallam University]. https://doi.org/10.7190/shu-thesis-00251

Toohey, K., MacMahon, C., Weissensteiner, J., Thomson, A., Auld, C., Beaton, A., Burke, M., & Woolcock, G. (2018). Using transdisciplinary research to examine talent identification and development in sport. *Sport in Society*, *21*(2), 356–375. https://doi.org/10.1080/17430437.2017.1310199

Tracy, S. J. (2010). Qualitative quality: Eight “big-tent” criteria for excellent qualitative research. *Qualitative Inquiry*, *16*(10), 837–851.

Turner, A. (2011). Defining, developing and measuring agility. *Prof Strength Cond*, *22*, 26–28.

Vaeyens, R., Lenoir, M., Williams, A. M., & Philippaerts, R. M. (2008). Talent identification and development programmes in sport. *Sports Medicine*, *38*(9), 703–714.

Vahed, Y., Kraak, W., & Venter, R. (2014). The effect of the law changes on time variables of the South African Currie Cup Tournament during 2007 and 2013. *International Journal of Performance Analysis in Sport*, *14*(3), 866–883.

van Gent, M., & Spamer, E. J. (2005). Comparisons of positional groups in terms of anthropometric, rugby-specific skills, physical and motor components among u 13, u 16, u 18 and u 19 elite rugby players. *Kinesiology, 37*(1), 50-63.

van Maarseveen, M., Oudejans, R., Mann, D., & Savelsbergh, G. (2018). Perceptual-cognitive skill and the in situ performance of soccer players. *Quarterly Journal of Experimental Psychology*, *71*(2), 455-470. doi: 10.1080/17470218.2016.1255236.

Vanttinen T, Blomqvist M, Nyman K, Hakkinen K. (2011). Changes in body composition, hormonal status, and physical fitness in 11-, 13-, and 15-year-old Finnish regional youth soccer players during a two-year follow-up. The Journal of Strength & Conditioning Research, 25: 3342–3351. doi: 10.1519/JSC.0b013e318236d0c2

Vatousios, A., & Happonen, A. (2022). Transforming HR and Improving Talent Profiling with Qualitative Analysis Digitalization on Candidates for Career and Team Development Efforts. In K. Arai (Ed.), *Intelligent Computing* (pp. 1149–1166). Springer International Publishing. https://doi.org/10.1007/978-3-030-80119-9_78

Vaz, L., Batista, M., Honório, S., & Fernandes, H. M. (2019). Physical performance tests and anthropometric data to predict selection in U19 rugby union players. *Journal of Human Sport and Exercise*, *14*(4), 1250-1252.

Vaz, L., Martín, I., Batista, M., Almeida, L., & Fernandes, H. M. (2017). Differences in the psychological skills and strategies used by elite male under-19 rugby union players in competition according to playing position. *Revista Iberoamericana de Psicología Del Ejercicio y El Deporte*, *12*(2), 225–230.

Vaz, L., Vasilica, I., Carreras, D., Kraak, W., & Nakamura, F. Y. (2016). Physical fitness profiles of elite under-19 rugby union players. *Journal Sports Medicine and Physical Fitness*, *56*(4), 415-421 PMID: 25651896.

Waldron, M., Worsfold, P. R., Twist, C., & Lamb, K. (2014). The relationship between physical abilities, ball-carrying and tackling among elite youth rugby league players. *Journal of Sports Sciences*, *32*(6), 542-549.

Webdale, K., Baker, J., Schorer, J., & Wattie, N. (2020). Solving sport's 'relative age'problem: A systematic review of proposed solutions. *International Review of Sport and Exercise Psychology*, *13*(1), 187-204 doi.org/10.1080/1750984X.2019.1675083.

Weissensteiner, J. R. (2013). Functional Sport Expertise Systems. In D. Farrow, J. Baker, & C. MacMahon (Eds.), *Developing Sport Expertise: Researchers and Coaches Put Theory Into Practice* (pp. 45-67). London: Routledge (pp. 45–67). Routledge. https://arbor.bfh.ch/10528/

Williams, A., & Reilly, T. (2000). Talent identification and development in soccer. *Journal of Sports Sciences*, *18*(9), 657-667. doi: 10.1080/02640410050120041.

Winn, C., Ford, P., McNarry, M., Lewis, J., & Stratton, G. (2016). The effect of deprivation on the developmental activities of adolescent rugby union players in Wales. *Journal of Sports Sciences*, *35*(24), 2390-2396. doi: 10.1080/02640414.2016.1271136.

Wood, D. J., Coughlan, G. F., & Delahunt, E. (2018). Fitness profiles of elite adolescent Irish rugby union players. *The Journal of Strength & Conditioning Research*, *32*(1), 105–112. https://doi.org/10.1519/JSC.0000000000001694

World Rugby. (2018). *Strength and Conditioning* [online]. Retrieved 1 December 2019 from: https://www.world.rugby/.

World Rugby. (2020). *Player Numbers*. World Rugby [online]. Retrieved 7 September 2020 from: www.world.rugby/development/player-numbers.

World Rugby.org. (2022). *World Rugby sets four-year blueprint to develop future stars of the emerging unions.* World Rugby [online]. Retrieved 5 January 2022 from: https://www.world.rugby/news/567217?lang=en

Worsnop, S. A. (2016). Rugby talent development. *International Sport Coaching Journal*, *3*(1), 75–82. https://doi.org/10.1123/iscj.2015-0101

Young, W. B., Miller, I. R., & Talpey, S. W. (2015). Physical qualities predict change-of-direction speed but not defensive agility in Australian rules football. *The Journal of Strength & Conditioning Research*, *29*(1), 206–212.

Zabaloy, S., Alcaraz, P. E., Pereira, L. A., Giráldez, J., González, J. G., Loturco, I., & Freitas, T. T. (2021). Anthropometric and physical performance of amateur rugby players within specific playing positions. *Isokinetics and Exercise Science*, *Preprint*, 1–13.

Zabaloy, S., Giráldez, J., Gazzo, F., Villaseca-Vicuña, R., & González, J. G. (2021). In-season assessment of sprint speed and sprint momentum in rugby players according to the age category and playing position. *Journal of Human Kinetics*, *77*(1), 274–286.