THE TALENT SELECTION AND CAREER PROGRESSION OF PROFESSIONAL AUSTRALIAN FOOTBALL PLAYERS

Courtney Sullivan

Bachelor of Human Movement Studies (Honours)

Faculty of Health

University of Technology Sydney (UTS)

Australia

This thesis is submitted for the degree of

Doctor of Philosophy

2019

“Yesterday I was clever, so I wanted to change the world. Today I am wise, so I am changing myself.”

Rumi

CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Courtney Sullivan, declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy in the School of Health at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

This research is supported by the Australian Government Research Training Program.

Production Note:
Signature removed prior to publication.

Courtney Sullivan

19/12/2018

Date

STATEMENT OF CANDIDATE CONTRIBUTION

The contribution of each author to the investigations undertaken as part of the thesis is outlined in Table A below.

Table A: Percentage contribution (%) of each author to the investigations conducted during the candidature

Author	Study 1				Study 2				Study 3			
	Courtney Sullivan	Thomas Kempton	Patrick Ward	Aaron Coutts	Courtney Sullivan	Thomas Kempton	Patrick Ward	Aaron Coutts	Courtney Sullivan	Thomas Kempton	Patrick Ward	Aaron Coutts
Research design	50%	25%		25%	50%	10%		40%	20%		40%	40%
Ethics Application	100%				90%			10%	90%			10%
Data collection & preparation	100%				100%				90%		10%	
Statistical analysis	90%	10%			100%				50%		50%	
Manuscript Preparation	100%				100%				100%			
Manuscript feedback			15%	85%			15%	85%			20%	80%
Manuscript Revision	100%				100%				100%			

PREFACE

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

Based on the research design and data collected by the candidate, two manuscripts have been submitted for publication and one manuscript has been accepted in peer-reviewed journals. These papers are initially brought together by an *Introduction*, which provides background information, defines the research problem and the aim of each study. A *Literature Review* then follows to provide an overview of talent selection in professional team sport and the career progression of professional team sport athletes. The body of the research is presented in manuscript form (*Chapter Three to Chapter Five*), in a logical sequence following the development of research ideas in this thesis. Each manuscript outlines and discusses the individual methodology and the findings of each study separately. The *General Discussion* chapter provides an interpretation of the collective findings, makes some practical recommendations and acknowledges the limitations from the series of investigations that comprise this thesis. Finally, a *Summary and Recommendations* chapter presents the conclusions from each project and suggests directions for future research to build on the findings of this thesis. The APA 6th reference style has been used throughout the document and the reference list is at the end of the thesis.

ACKNOWLEDGEMENTS

Many people have contributed to the completion of this thesis and I am sincerely thankful to you all.

Aaron Coutts. What a journey! I first met you as a student intern and can't quite believe what we have achieved in the 6 years that have followed. Thank you for leading by example, teaching me the value of hard work and being the most sensational mentor.

I am grateful to the Carlton Football club for their support and flexibility in allowing me to balance work commitments and study. Particularly, Johann, Joel and Rexy who gave me my start in Football and provided countless laughs that more often than not, got me through the long days.

Chinchy, you deserve a separate acknowledgement all to yourself! They long days and nights at Carlton were made possible by having you there with me. I am so proud of all that you have achieved since leaving Football and can't wait to see what the future holds for us both.

Pat Ward. Despite only meeting in person once, you have gone above and beyond to help with data analysis and provide feedback for this thesis and for this I am sincerely grateful. Thank you also for being my "go to" when I need to decode American team sport terminology!

An honourable mention goes to Tom Kempton for his assistance with data analysis and for providing feedback.

My family and friends for keeping me grounded and providing an escape from the academic world.

Dean, thank you for being the amazing human that you are.

And finally to River, none of this means anything without you.

LIST OF ARTICLES SUBMITTED FOR PUBLICATION

- **Sullivan, C**., Kempton, T., Ward, P., & Coutts, A.J. (2019). The efficacy of talent selection criteria in the Australian Football League. Journal of Sports Sciences, *in review.*
- **Sullivan, C**., Kempton, T., Ward, P., & Coutts, A.J. (2018). Factors associated with early career progression in professional Australian Football players. Journal of Sports Sciences, 36(19), 2196-2201.
- **Sullivan, C**., Kempton, T., Ward, P., & Coutts, A.J. (2019). Career performance trajectories of professional Australian Football players. Journal of Sports Sciences, *in review*.

ABSTRACT

The ultimate goal of professional Australian Football clubs is to achieve team success by consistently winning matches. This is highly dependent upon selecting the best available talent and implementing an effective player development program. Coaching and recruitment staff seek to identify an objective framework of talent selection and career progression to provide evidence for guiding athletic development, assessing program effectiveness and for supporting decisions regarding the playing roster. This thesis contains one literature review and three independent studies which investigate talent selection and the career progression of professional Australian Football players. The literature review summarised previous research investigating talent identification, talent selection and career progression in professional Australian Football. The review identified an abundance of research investigating talent identification through discriminating between competitive levels but far fewer studies examining talent selection and draft order in the Australian Football League (AFL). Furthermore, despite survival and career progression being assessed in other professional team sports, the review identified that there were no studies examining the career of professional Australian Football players beyond selection in the AFL Draft. *Study One* examined the relationship between common talent selection criteria, draft order and future match performance in the AFL. The results questioned the usefulness of Draft Combine physical performance assessments in current talent selection practices however, confirmed the efficacy of Under-18 All Australian team selection as criteria for selecting players with the potential for success in professional Australian Football. *Study Two* investigated the factors associated with early career progression in Australian Football players. This study identified important individual and team based characteristics related to receiving a second contract in professional Australian Football which can be used to inform decisions regarding the playing roster and guide the development of players recently drafted into the league. *Study Three* examined the age-related career performance trajectories of professional Australian Football players. The results showed that professional Australian Football players peak in match performance between 24 and 27 years of age with age having the largest influence on the midfield position and the least on ruckman. This thesis examined the talent selection and career progression of professional Australian Football players. Results demonstrated that age-related changes in the match performance of professional Australian Football players are position specific. Further, it established that while some individual and team based characteristics are associated with early career progression, little of what is objectively available to coaching and recruitment staff prior to the AFL National Draft, displays efficacy in assisting to select athletes with the potential for success. Finally, the efficacy of talent selection criteria can be established by demonstrating their relationship with future match performance.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

AFL	Australian Football League
AIC	Akaike information criterion
AUC	Area under the curve
β	Beta
BMI	Body mass index
χ^2	Chi square
CI	Confidence interval
cm	Centimetre
CV	Coefficient of variation
ES	Effect size
GPS	Global positioning system
ICC	Intraclass correlation coefficient
in	Inch
kg	Kilograms
$km \cdot h^{-1}$	Kilometres per hour
lb	Pound
m	Metre
min	Minute
$m \cdot min^{-1}$	Metres per minute
MLB	Major League Baseball
n	Number
NBA	National Basketball Association
NCAA	National Collegiate Athletic Association
NFL	National Football League
NHL	National Hockey League
OR	Odds ratio
%	Percentage
pr	Probability
RAE	Relative age effect
ROC	Receiver operating characteristic
R^2	R squared
s	Second
SD	Standard deviation
SWC	Smallest worthwhile change
TDE	Talent development
TID	Talent identification
UTS	University of Technology, Sydney
v	Version
y	Year
yd	Yard

LIST OF APPENDICES

CHAPTER ONE

INTRODUCTION

BACKGROUND

The ultimate goal of professional Australian Football clubs is to achieve team success by consistently winning matches. This is highly dependent upon selecting the best available talent and implementing an effective player development program. Coaching and recruitment staff seek to identify an objective framework of talent selection and career progression to provide evidence for guiding athletic development, assessing program effectiveness and for supporting decisions regarding the playing roster (Figure 1.1). Defined as the ongoing process of identifying players at various stages who demonstrate prerequisite levels of performance for inclusion in a given squad or team (Williams & Reilly, 2000), talent selection in the AFL occurs via a reverse-order draft system whereby teams select players to add to their playing roster from the selections they have been allocated based on ladder position from the previous season. The AFL facilitate the talent selection process by hosting several events including the Draft Combine and Under-18 National Championship tournament to showcase potential draftees. In addition to affording the opportunity to observe prospective draftees, these events also provide objective data to assist in talent selection strategies such as physiological performance testing and physical and technical performance variables from match-play collected by global positional system (GPS) micro-technology and commercial statistical providers.

An increasing number of studies have examined talent selection in the AFL by differentiating between drafted and non-drafted players based on physiological performance (Robertson, Woods, & Gastin, 2014) and match-related physical and technical performance metrics (Woods, Joyce, & Robertson, 2015). However, relatively few studies have investigated the talent selection criteria associated with a more homogenous cohort such as drafted AFL players i.e. draft order (Woods, Veale, Collier, & Robertson, 2016). Furthermore, it is imperative to establish the efficacy of talent selection criteria. However, despite several studies examining associations between talent selection criteria and the number of career matches played and subjective evaluations of potential and value (Burgess, Naughton, & Hopkins, 2012; Pyne, Gardner, Sheehan, & Hopkins, 2005) no studies have investigated the relationship between talent selection criteria and future match performance in the AFL. This is most likely due to the inherent difficulty in identifying an individual measure of match performance within a team sport - given performance in these sports is defined within the context of the team i.e. match outcome (Robertson, Gupta, & McIntosh, 2016). The official statistical provider for the AFL, Champion Data, have developed the "AFL Player Rank" - an objective measure of individual match performance – based upon involvement in selected match activities whereby each involvement is allocated a positive or negative numerical value resulting in a final score that is indicative of an individual's influence upon a match. Although no independent validation of this metric has been completed - given the reported accuracy of player technical skill count data

collected by Champion Data (O'Shaughnessy, 2006) and the prolific use of the AFL Player Rank within scientific literature (Mooney et al., 2011; Sullivan et al., 2013a, 2013b) - the AFL Player Rank is considered the most accepted metric of individual match performance within the AFL.

Although talent identification has been a focus of previous research in Australian Football, there is an emerging body of research in other professional team sport leagues examining the career progression of professional athletes beyond being drafted (Figure 1.1) (Boulier, Stekler, Coburn, & Rankins, 2010; Hendricks, DeBrock, & Koenker, 2003; Staw & Hoang, 1995). These studies have investigated survival in the sport by examining the factors associated with playing more seasons. Unfortunately, few studies in Australian Football have examined the factors associated with career progression beyond being drafted (Burgess et al., 2012; Pyne et al., 2005). These studies have used the number of career matches played as a surrogate measure of career progression and have presented conflicting findings. While some have demonstrated large associations between physiological and physical performance variables and playing more career matches (Burgess et al., 2012), others have shown various physiological and performance indicators have small associations with the number of career matches played in professional Australian Football (Pyne et al., 2005).

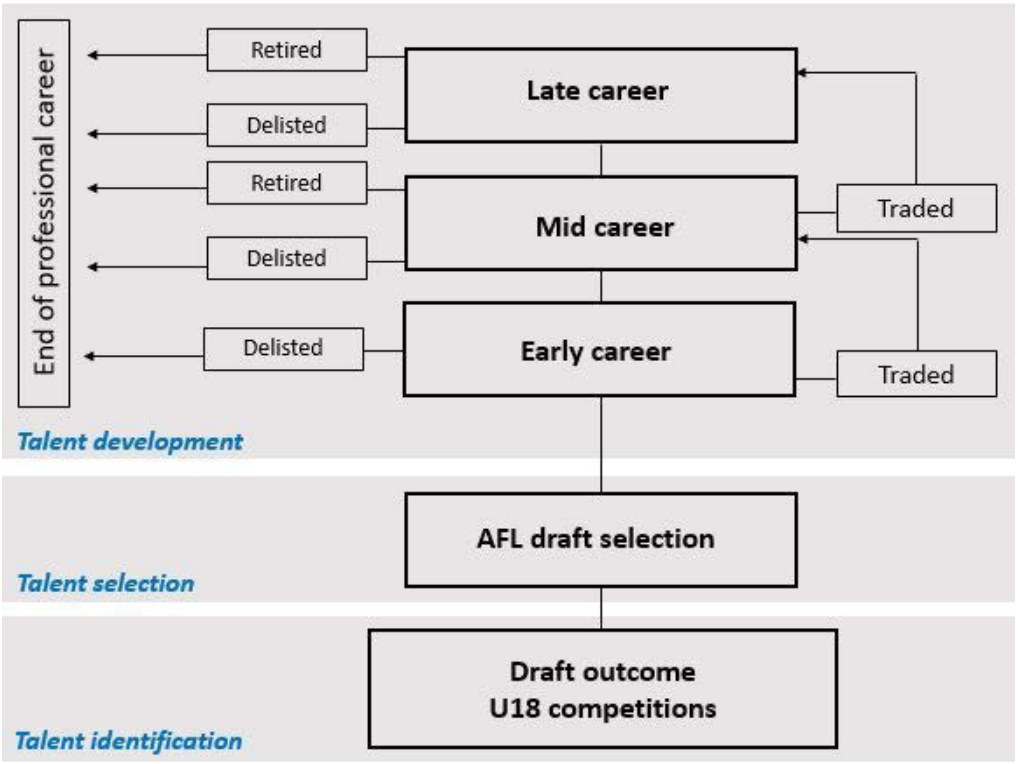

Figure 1.1: Conceptual model of career progression in the AFL.

Developing a successful playing roster requires a framework to assess the performance profile of current players. This can be achieved by tracking the temporal changes in match performance of professional team sport athletes to develop career trajectory profiles. Several studies have examined the age-related changes in performance of team sport athletes in other professional sports however, we are yet to see an investigation examining the career trajectories of professional Australian Football players. Furthermore, previous research suggests that career trajectories vary as a function of playing position (Bradbury, 2009; Brander, Egan, & Yeung, 2014; Dendir, 2016) which necessitates a positional analysis. The investigation of talent selection and career progression has important applications for informing the recruitment process and guiding athletic development in professional Australian Football.

RESEARCH QUESTION

Team success in the AFL is dependent upon selecting the best available talent and implementing an effective player development program. Many studies in Australian Football have examined talent selection by differentiating between drafted and non-drafted players based on physiological and physical performance or match performance variables (Pyne et al., 2005; Robertson et al., 2014; Woods, Joyce, et al., 2015). However, at present, few studies have examined talent selection in the more homogenous cohort of drafted players (Woods, Veale, et al., 2016). Furthermore, the efficacy of talent selection criteria in predicting future success in professional Australian Football players is yet to be investigated. Additionally, despite several studies in other professional team sport leagues examining age-related changes in match performance (Bradbury, 2009; Brander et al., 2014; Dendir, 2016; Fair, 2008; Schulz, Musa, Staszewski, & Siegler, 1994; Wakim & Jin, 2014), the age of peak performance and the career performance trajectory of professional Australian Football players remains unclear. The purpose of this thesis is to establish the efficacy of common physical performance parameters used when selecting talent and to develop a model of career progression in professional Australian Football. The model will consider early career progression in addition to identifying long-term, age-related performance profiles for each playing position within the AFL.

RESEARCH OBJECTIVES

A series of applied research studies were conducted to assess talent selection and develop a model for career progression in professional Australian Football (Figure 1.2). *Study One* examined the relationship between common talent selection criteria, draft order and future match performance. *Study Two* examined early career progression by investigating the individual player and team-based characteristics associated with earning a second contract in professional Australian Football. *Study Three* identified the age of peak performance and career performance trajectories for each positional group within the AFL. It was anticipated that the results of these investigations would provide valuable insight into effective talent selection strategies in the AFL and provide a framework to assess the career performance of professional Australian Football players. The findings will be relevant to coaching and recruitment staff within a professional Australian Football club environment in addition to the wider AFL community.

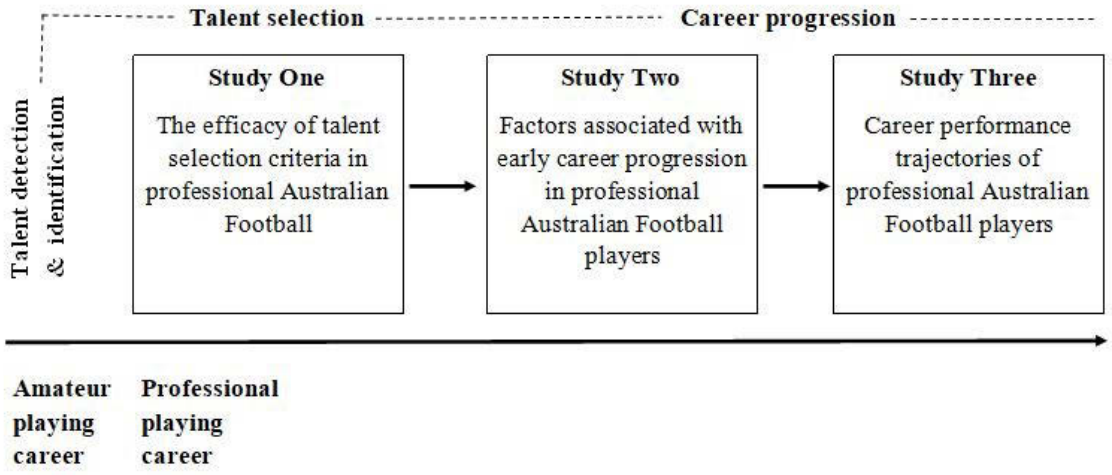

Figure 1.2: Research process linking studies undertaken in this thesis.

STUDY ONE: THE EFFICACY OF TALENT SELECTION CRITERIA IN PROFESSIONAL AUSTRALIAN FOOTBALL

AIM:

The aim of this investigation was to determine the efficacy of talent selection criteria in the AFL by examining the relationship between Draft Combine physical performance assessments, draft order and future match performance using a longitudinal, retrospective research design.

SIGNIFICANCE:

These findings will have implications for informing talent selection practices in the AFL and will assist in identifying the Draft Combine physical performance assessments which are most associated with future match performance.

STUDY TWO: FACTORS ASSOCIATED WITH EARLY CAREER PROGESSION IN PROFESSIONAL AUSTRALIAN FOOTBALL PLAYERS

AIM:

The aim of this study was to identify the association between individual player characteristics and team attributes and the probability of being offered a second contract in professional Australian Football.

SIGNIFICANCE:

These findings will help identify the components of an effective player development program and assist coaching and recruitment staff with developing a successful playing roster.

STUDY THREE: CAREER PERFORMANCE TRAJECTORIES OF PROFESSIONAL AUSTRALIAN FOOTBALL PLAYERS

AIM:

The aims of this study were to: 1) identify the age of peak performance for each positional group in the AFL; and, 2) determine estimates of age-related career progression in professional Australian Football players using AFL Player Rank as a measure of performance.

SIGNIFICANCE:

While career performance trajectories have been developed in other professional team sports such as baseball, soccer and ice hockey, there is currently little understanding of the age-related changes in match performance of professional Australian Football players. This type of information has important applications for guiding and assessing player development in the AFL.

CHAPTER TWO

LITERATURE REVIEW

INTRODUCTION

Team success in the AFL is highly dependent upon selecting the best available talent and implementing an effective player development program. Coaching and recruitment staff seek to identify an objective framework of talent selection and career progression to provide evidence for guiding athletic development, assessing program effectiveness and for supporting decisions regarding the playing roster. Defined as an ongoing process of identifying players at various stages who demonstrate prerequisite levels of performance for inclusion in a given squad or team (Williams & Reilly, 2000), talent selection in the AFL occurs via the National Draft whereby each club selects athletes to add to their playing roster in a reverse order based on final ladder position from the preceding season. Prior to this selection process, athletes are identified as having the potential to be successful through the measurement of physiological, anthropometrical, psychological, technical and psychosocial attributes or abilities (Williams & Reilly, 2000). This highlights the key difference between talent identification and talent selection. The AFL allocates considerable financial resources into the facilitation of identifying and selecting talent, however, the development of talent is a long and complicated process that is influenced by intrapersonal characteristics, environmental catalysts and chance, making future performance difficult to predict (Gagné, 1993). The homogenous nature of professional team sport athletes presents further challenges for scientific research investigating talent in an elite team sport environment (Vaeyens, Lenoir, Williams, & Philippaerts, 2008). An increasing number of studies in Australian Football have examined talent selection by differentiating between drafted and non-drafted players based on physiological, performance and anthropometrical characteristics (Robertson et al., 2014) and also match-related physical activity and technical skill performance metrics (Woods, Joyce, et al., 2015). While such knowledge provides information about recruitment strategies and attaining higher selection in Australian Football, it is important to establish the efficacy of this talent selection criteria. To achieve this a longitudinal research design is required that examines the relationship between talent selection criteria and a measure of future performance (Vaeyens et al., 2008). However, no studies at present have examined the relationship between talent selection criteria and future match performance in professional Australian Football.

The professional career of an Australian Football player begins with the AFL Draft, however, the continuation of that career relies upon the awarding of additional playing contracts. Given a common goal amongst elite sporting teams is to develop a competitive playing roster, a greater understanding of the factors associated with career progression beyond being drafted may provide insight into important attributes for survival in the AFL. Previous studies have shown that some physical performance measures (Burgess et al., 2012; Pyne et al., 2005) and select physical activity metrics during match-play (Burgess et al., 2012) may be associated with

playing more career matches in the AFL over a limited time frame. Furthermore, evidence in other professional team sport leagues suggests that survival is linked to draft order and team quality (Boulier et al., 2010; Hendricks et al., 2003; Staw & Hoang, 1995). However, at present, the factors associated with career progression (i.e. being awarded an additional playing contract) in professional Australian Football are yet to be investigated.

Tracking the temporal changes in performance of team sport athletes allows for the development of career trajectory profiles that may assist coaching staff in assessing current players and developing a competitive playing roster. Career trajectories have been described in baseball (Bradbury, 2009; Fair, 2008; Schulz, Musa, Staszewski, & Siegler, 1994; Wakim & Jin, 2014), soccer (Dendir, 2016), ice hockey (Brander, Egan, & Yeung, 2014) and basketball (Wakim & Jin, 2014), with these studies reporting the age of peak performance of professional team sport athletes and providing benchmarks for talent development. Despite being studied in other professional team sport leagues, no studies have examined the career performance trajectories of professional Australian Football players. Such information would help assess the career performance of Australian Football players and, from an organisational perspective, assist in planning towards the long-term goal of developing a successful playing roster.

Relevant literature was obtained from an online search using the SportDiscus, PubMed and Google Scholar electronic databases. The following keywords were used in various combinations: ‘Australian Football’, ‘talent identification’ ‘talent selection’, ‘talent development’, ‘career progression’, ‘peak performance’, ‘career trajectories’ and ‘team sport’. Electronic database searching was supplemented by examining the reference lists of relevant articles. Only studies examining professional team sport athletes were considered for review.

The purpose of this review was to examine talent selection and career progression in professional Australian Football. The review begins by providing background information on talent identification in the AFL before considering common talent selection criteria used in the recruitment of professional Australian Football players. Following this, we explored different methods of measuring match performance in professional Australian Football. We then reviewed the efficacy of talent selection criteria in team sports by assessing relationships between this criteria and future match performance. Finally, the review examined the career progression and career performance profiles of professional team sport athletes.

TALENT IDENTIFICATION IN THE AFL

The AFL talent pathway allows an individual to progress from youth participation to the elite level of competition (Figure 2.1). The formalised talent pathway commences with regional development squads whereby identified players progress through to state leagues and finally, the AFL National Draft, the system by which AFL clubs recruit talent. Previous research examining the physiological and anthropometrical characteristics that discriminate between competitive levels in the AFL talent pathway has reported that taller and faster (i.e. 20 m sprint time) athletes with greater aerobic capacity (i.e. multi-stage fitness test performance) attain higher selection in professional Australian Football (Robertson et al., 2014; Woods, Cripps, Hopper, & Joyce, 2017; Woods, Raynor, Bruce, McDonald, & Collier, 2015; Woods, Raynor, Bruce, McDonald, & Robertson, 2016). Moreover, elite, youth players demonstrate greater technical skill than their non-elite counterparts both in isolation (kicking and handballing accuracy) (Woods, Raynor, Bruce, & McDonald, 2015) and during competitive match-play (Woods, Joyce, et al., 2015). Although such knowledge is important and may inform training programs at sub-elite levels of competition, it is unclear if these findings represent key predictors of success or are merely a consequence of the talent pathway. Indeed, a crucial element of talent models is the ability to differentiate between an athlete's performance level and their potential for progression (Vaeyens et al., 2008). Furthermore, given these previous investigations have focused on sub-elite levels of competition, the findings may lack relevance for professional Australian Football players. Nonetheless, there appear to be some performance measures that discriminate between competitive levels in junior Australian Football therefore further research examining talent selection in the more homogenous cohort of drafted AFL players is required.

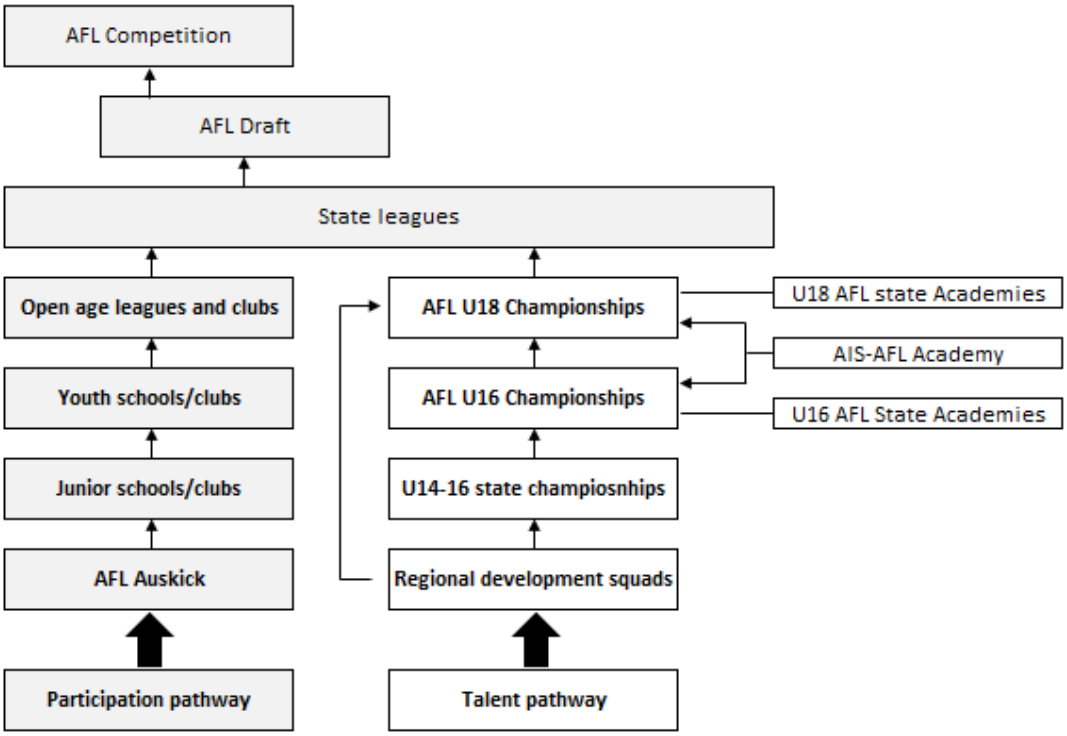

Figure 2.1: The AFL talent pathway ("Australian Football League. *AFL Youth Coaching Manual*," 2012).

TALENT SELECTION IN THE AFL

Talent selection in sport involves the identification of players who demonstrate the necessary performance requirements to be chosen in a given squad or team (Williams & Reilly, 2000). Although an ongoing process, talent selection is initiated at the professional level of Australian Football with the National Draft where teams are given the opportunity to select players to add to their playing roster. There are approximately one hundred players drafted in the AFL National Draft each year with draft selections allocated to clubs in a reverse order based on ladder position from the previous season. This reverse order draft system allows poorer performing teams the opportunity to recruit the best talent for the ensuing season. Players selected earlier in a draft sequence (i.e., a lower selection number) have a greater expectation to provide immediate and long-term success to the club that they are recruited to in comparison to those chosen with later round draft selections. The final draft order provides a rank of the most talented Australian Football players who are yet to begin their professional careers and therefore affords researchers the opportunity to examine the characteristics that discriminate players at the highest standard of competition in Australian Football. Determining the characteristics associated with draft order may inform talent selection strategies for recruitment staff and assist with optimising draft selections.

OVERVIEW OF TALENT SELECTION CRITERIA

Identifying and selecting talent in sport requires a multidimensional approach (Vaeyens et al., 2008; Woods, Raynor, Bruce, McDonald, et al., 2016). In acknowledgement of this, recruiters from professional Australian Football clubs utilise a combination of subjective and objective approaches to assist in talent selection decisions. Major state and regional under-age Australian Football competitions provide an opportunity for talent scouts to observe and track prospective draftees during competitive match-play. The AFL also facilitates the talent selection process through AFL Draft Combine events and the Under-18 National Championship tournament both of which occur prior to the National Draft and are designed to showcase the best available talent for the upcoming draft. The AFL National Draft Combine involves invited players undertaking a series of physiological, technical and psychological assessments under the observation of club representatives (Burgess et al., 2012). In addition, the Under-18 National Championship tournament provides an opportunity for talent scouts to observe prospective draftees during match-play and make subjective judgements about their playing potential and suitability to a given team. To complement the subjective evaluation of talent scouts, physical activity profile data collected from wearable micro-technology is made available following the tournament in addition to technical match statistics which are recorded by Champion Data – the official statistical provider for the AFL. A combination of these measures alongside the subjective evaluation of recruitment and coaching staff form the basis of talent selection in professional Australian Football.

PHYSICAL AND TECHNICAL MATCH PERFORMANCE INDICATORS

Both physical and technical performance indicators recorded during match-play are provided by the AFL to inform the talent selection process. For example, during the Under-18 National Championship tournament, a commercial statistical provider records the technical match statistics of each player. These technical match statistics are typically frequency and efficiency related such as the number of kicks (n) or disposal efficiency (%). Additionally, the physical activity profiles of players are recorded by wearable micro-technology with the variables reported including distances covered and time spent at different speeds (Woods, Joyce, et al., 2015). It has been reported that the most influential technical match statistics in seasons 2013 and 2014 from the Under-18 National Championship tournament in AFL Draft success were contested possessions (i.e. possessions obtained while in congested, and physically pressured situations) and inside 50's (i.e. an action of moving the ball from the midfield into the forward 50 m zone), while no physical activity metrics showed discriminant ability (Woods, Joyce, et al., 2015). In research examining the same metrics in AFL drafted players, it was reported that no physical activity metrics or technical skill statistics were discriminant of draft round (i.e.

draft round 1 - selections 1-10) however, position within a draft round was meaningfully associated with player physical and technical match activity profiles (Woods, Veale, et al., 2016). Specifically, draft position in the first round (i.e. selections 1-10) was negatively associated with contested possessions (possessions obtained while in congested, and physically pressured situations) indicating that players with superior contested ball skills are selected earlier. Similarly, contested marks (a mark recorded while engaging in a congested, physically pressured situation) were negatively associated with draft round 2 (Woods, Veale, et al., 2016). The authors concluded that players demonstrating superior contested skills were prioritised with early round draft selections by recruitment staff in the AFL. Interestingly, physical activity metrics were positively associated with draft position in rounds 1 and 2 with players who demonstrated greater relative distance (m), high speed running distance (m) and high speed running percentage (%) selected later in these rounds. Although speculative, it was suggested that AFL recruiters change the type of player they recruit as the talent selection pool decreases. Specifically, as players with superior contested ball skills were selected with early draft selections in draft rounds 1 and 2, recruiters then prioritised players who displayed high-speed activity profiles in the Under-18 National Championship tournament. When taken together, it appears that technical proficiency and in particular, contested ball skills are important attributes to recruitment staff in the AFL. However, as less technically skilled players become available, those who demonstrate greater physical performance during match-play may become more desirable.

Table 2.1: Summary of published studies examining talent identification and talent selection in Australian Football

Author	Level	Design	Sample size	Variables	Factors	Purpose
Burgess, Naughton and Hopkins (2012)	AFL	Longitudinal	99	Physical and anthropometrical tests Physical and technical match performance Draft order	Matches played	Determine associations between the number of AFL matches played over 5 years and physical Draft Combine tests, draft order and previous match physical performance
Keogh (1999)	U18 State	Cross sectional	40	Physical and anthropometrical tests	Team selection	Compare physical and anthropometrical tests that differentiate between selected and non-selected U18 AF players
Young et al. (2005)	AFL	Cross sectional	34	Physical and anthropometrical tests	Team selection	Compare physical and anthropometrical tests that differentiate between selected and non-selected AFL players
Young and Pryor (2007)	U18 State	Cross sectional	485	Physical and anthropometrical tests	Team selection Technical performance indicators Number of votes received	Determine the relationships between physical and anthropometrical tests and indicators of performance
Robertson, Woods and Gastin (2014)	U18 State	Cross sectional	3846	Physical and anthropometrical tests	Draft status	Identify the physical and anthropometrical tests that discriminate between drafted and non-drafted AF players
Woods, Joyce and Robertson (2015)	U18 State	Cross sectional	55	Physical and technical match performance	Draft status	Identify the physical and technical match performance variables that discriminate between drafted and non-drafted AF players

Table 2.1: Cont.

Author	Level	Design	Sample size	Variables	Factors	Purpose
Woods, Raynor, Bruce et al. (2015)	U18 State	Cross sectional	100	Physical and anthropometrical tests	Playing status (state vs non-state representative)	Determine the physical and anthropometrical fitness tests that discriminate between state and non-state representative U18 AF players
Woods, Raynor, Bruce et al. (2015)	U18 State	Cross sectional	50	Skill tests (AFHB, AFK)	Playing status (state vs non-state representative)	Determine if Draft Combine skill tests discriminate between state and non-state representative U18 AF players
Woods, Raynor, Bruce et al. (2016)	U18 State	Cross sectional	50	Video-based decision-making task	Playing status (state vs non-state representative)	Determine if a video-based decision-making task could discriminate between state and non-state representative U18 AF players
Woods, Raynor, Bruce et al. (2016)	U18 State	Cross sectional	84	Physical fitness tests Skill tests (AFHB, AFK) Video-based decision-making task	Playing status (state vs non-state representative)	Examine relationships between a multi-dimensional talent identification approach and playing status
Woods, Veale, Collier et al. (2016)	AFL	Cross sectional	65	Physical and technical match performance variables	Draft order	Determine the association between physical and technical match performance variables and AFL Draft order
Woods, Banyard, McKeown et al. (2016)	U18 State	Cross sectional	50	Upper and lower body strength	Playing status (state vs non-state representative)	Discriminate state and non-state representative AF players based on a fundamental athletic movement assessment
Gaudion et al. (2017)	U18 State	Cross sectional	77	Physical and anthropometrical tests Fundamental athletic movement assessment	Developmental level (U16 vs U18)	Identify the physical fitness, anthropometric and athletic movements that discriminate between elite U16 and U18 AF players

Table 2.1: Cont.

Author	Level	Design	Sample size	Variables	Factors	Purpose
Woods et al. (2017)	U18 State	Cross sectional	134	Physical and anthropometrical tests	Developmental level (U16 vs U18) Talent identified	To compare the physical and anthropometric qualities explanatory of talent at two developmental levels (U16 and U18) in AF
Tribolet et al. (2018)	U16 State	Cross sectional	277	Anthropometry Maturity Motor competence Physical fitness	Selection into U16 elite development program	To explore the characteristics that influence selection into an elite U16 AF development program
Pyne et al. (2005)	AFL	Longitudinal	283	Physical and anthropometrical tests	Draft status Match debut Matches played Career potential and value	Investigate relationships between physical and anthropometrical tests and various measures of career progression in the AFL

U18: Under 18, U16: Under 16, AF: Australian football, AFL: Australian Football League, AFHB: Australian Football Handball test, AFK: Australian Football kicking test

THE AFL DRAFT COMBINE

The AFL Draft Combine is an annual event whereby the anthropometrical attributes and physical and football-specific technical ability of prospective draftees are assessed. Recent research has demonstrated that some of the physiological and performance assessments performed at the AFL Draft Combine can discriminate between drafted and non-drafted players (Robertson et al., 2014). At present however, the discriminant ability of these measures within the more homogenous cohort of drafted AFL players remains unclear. The relationship between Draft Combine anthropometrical and physical performance assessments and draft order has been examined in American Football and basketball with taller athletes selected with earlier round draft selections in the National Football League (NFL) and the National Basketball Association (NBA) (Berri, Brook, & Fenn, 2011; Berri & Simmons, 2011; Mulholland & Jensen, 2014). Furthermore, speed over 40 yards assessed at the NFL Draft Combine was associated with draft order with faster quarterbacks, tight ends, running backs and wide receivers selected earlier in the NFL draft (Berri & Simmons, 2011; Kuzmits & Adams, 2008; Mulholland & Jensen, 2014). Given the contested ball and aerial requirements of Australian Football (Gray & Jenkins, 2010) and the increasing speed of match-play (Wisbey, Montgomery, Pyne, & Rattray, 2010a) it is possible that assessments of these qualities at the AFL Draft Combine are also associated with draft order. Collectively, it appears that some anthropometrical and physical performance measures demonstrate a relationship with draft order in other professional team sport leagues therefore future research is warranted to determine if these relationships exist in professional Australian Football.

NON-PERFORMANCE BASED VARIABLES

It also is likely that recruitment staff in the AFL are influenced by non-performance based player characteristics (i.e. age, race) in addition to physical and technical abilities when selecting athletes to add to the playing roster. Indeed, studies in other professional team sport leagues have examined player age (Berri et al., 2011), the quality of the team where an athlete played prior to being drafted (Berri et al., 2011; Berri & Simmons, 2011) and race (Berri & Simmons, 2011) as potential predictors of draft order. Identifying the non-performance based variables associated with draft order in Australian Football may provide a greater understanding of current talent selection strategies.

Alongside college game performance indicators, the quality of the team played for in college and the opposition faced in addition to success in amateur competition all demonstrated a relationship to draft order in the NBA (Berri et al., 2011). Specifically, players drafted to the NBA between 1995 and 2009 were drafted with higher round draft selections if they appeared in

the last four teams remaining in the National Collegiate Athletic Association (NCAA) post-season basketball tournament or appeared in the winning team in the year they were drafted (i.e. NCAA Championship team) (Berri et al., 2011). Similarly, quality of the college football team also influenced draft order in the NFL for the quarterback (Berri & Simmons, 2011) and tight end positions (Mulholland & Jensen, 2014). When taken together, it appears that the standard of play that is achieved in the year that a player is drafted may influence draft order in the NBA and the NFL (for the quarterback and tight end positions), however, future research is warranted to determine if such a finding also exists in professional Australian Football.

To be eligible to be drafted into the AFL, players must be at least 18 years of age by December 31 in the year they nominate for the draft. Accordingly, the overwhelming majority of prospective draftees are 18 years of age. However, the AFL Draft also provides a pathway to professional Australian Football for mature age players - those who were previously overlooked or delisted and not traded to another team. Consequently, the pool of prospective draftees includes players of a variety of ages. Despite previous research in the NBA demonstrating a decline in draft order with age (Berri et al., 2011), no research in Australian Football has examined the influence of age on draft order. The relative age effect (RAE) is a phenomenon which relates to selection bias towards individual athletes born earlier in the year. The RAE has been shown to influence selection in a number of team sports (Cobley, Baker, Wattie, & McKenna, 2009) including Australian Football (Coutts, Kempton, & Vaeyens, 2014). Specifically, a bias in the birth distribution was demonstrated in Australian Football draftees towards players born earlier in the year when compared to the Australian national population (Coutts, Kempton, & Vaeyens, 2014). The authors suggested that the selection bias may be attributed to advanced physical and psychological maturity of relatively older draftees, and exposure to higher-level coaching when compared to their younger counterparts (Coutts, Kempton, & Vaeyens, 2014). Although a selection bias towards relatively older players has been identified within the AFL, it is currently unclear if this selection bias also impacts player position within the draft. If found, a selection bias may indicate that recruitment staff are undervaluing relatively younger players in the AFL Draft therefore future research is required to examine if the RAE is an influencing factor on draft order in the AFL.

While the majority of research examining race in sport has been concerned with racial salary discrimination (Berri & Simmons, 2009; Gius & Johnson, 2000), more recent investigations have examined other areas of potential racial discrimination in professional sport. For example, Coleman, DuMond and Lynch, (2008) found no statistically significant effect of race in the NBA on the likelihood that a player would be voted the most valuable player (MVP) in the MVP awards. Similarly, no statistically significant relationship was found between race and draft order for the quarterback position in the NFL despite black quarterbacks demonstrating

superior college match performance relative to their white counterparts (Berri & Simmons, 2011). This finding is in partial agreement with previous research in the AFL that found when matched for position in the draft and playing experience, indigenous AFL players outperformed their non-indigenous counterparts (Mitchell, Stavros, & Stewart, 2011). However the relationship between draft order and race in the AFL has not yet been investigated. Future research is warranted to examine the influence of race on draft order in the AFL.

THE EFFICACY OF TALENT SELECTION CRITERIA

Decisions in the AFL National Draft should be based on talent selection criteria that demonstrates a relationship with future match performance or career success. Unfortunately, this is inhibited by the difficulty in identifying an individual measure of success within a team sport given performance in team sport is often measured in the context of the team e.g. match outcome (Robertson, Back, & Bartlett, 2016; Robertson, Gupta, et al., 2016). Accordingly, a number of surrogate measures of individual success have been proposed, including the number of career games played (Burgess et al., 2012) and subjective measures of player potential and value (Pyne et al., 2005). While several studies have identified the team performance indicators associated with winning matches in the AFL (Heasman, Dawson, Berry, & Stewart, 2008; McIntosh, Kovalchik, & Robertson, 2018b; Robertson, Gupta, et al., 2016), only one study has examined the individual performance indicators related to match outcome (Stewart, Mitchell, & Stavros, 2007). This study used linear regression analysis to determine the individual, discrete performance indicators most associated with a winning score margin in the AFL across 5 seasons (Stewart et al., 2007). The most important performance indicators were then used to develop an 11-variable player ranking model that could be used to compare and assess individual players in the AFL (Stewart et al., 2007). Despite this, the player ranking model only accounted for 41% of the variance in score margins suggesting that other factors, in addition to the performance indicators analysed, influence the score margin in professional Australian Football matches. Using a similar approach to Stewart et al. (2007), the official statistical provider for the AFL - Champion Data - developed the '"AFL Player Rank". This player ranking system provided an objective measure of AFL match performance for individual players. The AFL Player Rank is an aggregate measure of player match performance that is based upon a player's involvement in selected match activities such as ball disposal and defensive actions including tackling and shepherding. The match activities are allocated a pre-determined positive or negative numerical value with the summative score indicative of an individual's influence on a match. The AFL Player Rank remains proprietary owned and therefore no external research to establish the validity of the metric has been performed. Despite this, studies have examined the relationship between the AFL Player Rank and physical capacity (Mooney et al., 2011), physical and technical performance during match-play (Sullivan et al., 2013a) and match

outcome (Sullivan et al., 2013b). Results from these studies showed that the AFL Player Rank was associated with coaches perceptions of player performance in the AFL (Sullivan et al., 2013a) and was higher in quarters won when compared to quarters lost (Sullivan et al., 2013b). Despite this information providing evidence for the logical validity of this measure, caution is required when using the AFL Player Rank to interpret a player's performance given it displays high match-match variability (%CV 26.4 – 37.1) (Kempton, Sullivan, Bilsborough, Cordy, & Coutts, 2015). Another method gaining popularity within the literature is the AFL Player Rating. Also produced by Champion Data, the AFL Player Rating is an objective measure that quantifies an expected value for the next score based on contextual information such as the location of ball possession and the amount of pressure from opponents (McIntosh et al., 2018b). The AFL Player Rating has recently been modelled against match outcome in the AFL with the authors reporting a strong association between score margin and total team AFL Player Ratings (r=0.96, 95% confidence interval=0.95–0.96) (McIntosh et al., 2018b). Given the recent emergence of individual match performance metrics, future research should examine the relationship between talent selection criteria and individual match performance in the AFL.

RELATIONSHIP BETWEEN TALENT SELECTION CRITERIA AND MATCH PERFORMANCE IN TEAM SPORTS

Several studies have examined the relationship between talent selection criteria and future match performance in professional team sports including American Football and basketball (Berri et al., 2011; Berri & Simmons, 2011; Kuzmits & Adams, 2008; Mulholland & Jensen, 2014; Teramoto, Cross, Rieger, Maak, & Willick, 2017; Teramoto, Cross, & Willick, 2016). These studies have used a variety of measures of performance including salary, the number of matches played, aggregate measures of match performance such as the quarterback rating (calculated using a player's passing attempts, completions, yards, touchdowns, and interceptions) and metrics based on econometric models that reflect match outcome such as wins produced (a calculation derived from the relationship between wins and offensive and defensive efficiency) (Berri, 2008). Examining a combination of physical performance assessments and technical performance statistics during junior match-play, these studies have reported conflicting findings with some confirming the efficacy of select talent selection criteria (Kuzmits & Adams, 2008; Mulholland & Jensen, 2014; Teramoto et al., 2017; Teramoto et al., 2016), while others have reported a lack of agreement between the characteristics valued by recruitment staff and those that are associated with future performance in team sport athletes (Berri et al., 2011; Berri & Simmons, 2011). Discrepancies between the results of these studies may be attributed to differences in the measure of individual performance used, variation in the time span of the study, sample size or statistical analysis techniques employed. Furthermore, the variables associated with both draft order and future match performance in team sport athletes

appear to be specific to playing position (Kuzmits & Adams, 2008). For example, multiple regression analysis revealed that faster 10 yards sprint times at the NFL Draft Combine were associated with rushing yards per attempt within the first 3 years of playing careers for the running back position (Teramoto et al., 2016). In contrast, a different combination of NFL Draft Combine measures were associated with future performance (receiving yards per reception) for the wide receiver playing position including height, weight and vertical jump (Teramoto et al., 2016). Such research also enables the identification of characteristics and attributes that are potentially under or overvalued by recruitment staff. For example, while higher draft selection in the NFL draft was related to a superior bench press result assessed at the NFL Draft Combine for the tight end position, the broad jump was associated with future match performance (NFL career score = career receiving yards + 19.3 x career receiving touchdowns) (Mulholland & Jensen, 2014). This led authors to conclude that recruitment staff could improve their drafting strategy when drafting tight ends in the NFL by placing more importance on the broad jump. Similarly, the technical statistic of rebounds accumulated during a players final year of college demonstrated a relationship with future NBA performance but did not appear to be valued by recruitment staff on draft day (Berri et al., 2011). Anthropometry has also been examined in previous research with findings suggesting that taller and heavier athletes are recruited with earlier round draft selections in the NFL (quarterbacks and tight ends) and the NBA (Berri et al., 2011; Berri & Simmons, 2011; Mulholland & Jensen, 2014). However, the lack of a relationship between anthropometry and future career performance suggests that measures of body size may be overvalued in the NFL and the NBA. Collectively, it appears that some measures of physical performance and technical performance during junior match-play may be associated with future career performance for certain position groups in the NFL and the NBA. Unfortunately, we are yet to see an investigation in Australian Football examining the relationship between talent selection criteria and future match performance. Accordingly, further research is warranted to establish the efficacy of current talent selection criteria in the AFL.

CAREER PROGRESSION IN THE AFL

Most scientific research examining talent selection in professional Australian Football has focused on differentiating between drafted and non-drafted players and have therefore utilised a cross sectional research design (Robertson et al., 2014; Woods, Joyce, et al., 2015). Moreover, no studies have examined the trajectory or progression of Australian Football players careers beyond being drafted (Burgess et al., 2012; Pyne et al., 2005). Such a strategy requires a longitudinal approach and may provide important information regarding the factors associated with career progression. Previous research in Australian Football has used the number of career matches played as a measure of career progression (Burgess et al., 2012; Pyne et al., 2005).

These studies have presented conflicting findings with some demonstrating large associations between physiological and performance variables and playing more career matches (Burgess et al., 2012), while others have shown small associations between select physiological and performance indicators with the number of career matches played (Pyne et al., 2005). Despite these discrepancies, both studies found that 20-m sprint times were important in playing more career matches in the AFL in addition to in-match sprint metrics assessed during the Under-18 National Championship tournament (Burgess et al., 2012). Of note, this investigation failed to account for playing position with the findings likely to be most relevant for players in positions that require high-speed activity profiles.

While there is no standard measure to assess career progression in team sports, being awarded a second playing contract in Australian Football is an indicator of value and can be used as a metric of early career progress. At present, no research in any professional team sport league has attempted to identify the factors associated with earning additional playing contracts however, survival has been examined in the NFL, NBA and Major League Baseball (MLB) (Boulier et al., 2010; Hendricks et al., 2003; Staw & Hoang, 1995). Findings from these investigations have demonstrated that players selected with higher round draft selections have longer careers in the league (Boulier et al., 2010; Hendricks et al., 2003; Staw & Hoang, 1995). Furthermore, players who score more points in the NBA survive longer in the league and if they belong to a winning team, are less likely to be traded (Staw & Hoang, 1995). These studies suggest that career progression may be influenced by draft order and team quality however, the factors associated with career progression in professional Australian Football are yet to be investigated.

Tracking the temporal changes in match performance of professional team sport athletes can be used to provide a framework to assess career performance and may allow elite sporting organisations to systematically identify those who are heading towards future success. Several studies have examined the long-term career changes in performance of athletes involved in individual sports such as triathlon (Malcata, Hopkins, & Pearson, 2014), skeleton (Bullock & Hopkins, 2009), swimming (Allen, Vandenbogaerde, & Hopkins, 2014; Berthelot et al., 2012; Pike, Hopkins, & Nottle, 2010), track and field (Berthelot et al., 2012; Hollings, Hopkins, & Hume, 2012; Young & Starkes, 2005) and cross country skiing (Alam, Carling, Chen, & Liang, 2008) however, relatively less is known about the career trajectories of team sport athletes. Of the research that has been performed a variety of measures of match performance have been employed making comparisons between sports challenging. Nonetheless, previous research examining the long-term changes in performance of team sport athletes suggests that professional baseball and ice hockey players' peak in performance between 27 and 29 years of age (Bradbury, 2009; Brander et al., 2014; Fair, 2008; Schulz et al., 1994) while professional

soccer and basketball players peak earlier (25-27 and 26 years, respectively) (Dendir, 2016; Wakim & Jin, 2014). Furthermore, career performance trajectories appear to vary as a function of playing position (Bradbury, 2009; Brander et al., 2014; Dendir, 2016). Previous research in professional soccer suggests that a typical forward peaks in performance prior to defenders and midfielders (Dendir, 2016) while in the National Hockey League (ice hockey, NHL), although peak ages of performance are reportedly similar for both forwards and defenders, previous research suggests that a typical defender maintains near-peak performance (within 10% of peak performance) for longer than a typical forward (Brander et al., 2014). In addition, some studies in soccer and baseball have suggested that better players peak in performance later in their careers (Dendir, 2016; Schulz et al., 1994) and that elite players are better than average players, even at an early age (Schulz et al., 1994). Such findings have important implications for recruitment and talent development in professional team sport however, the age of peak performance in professional Australian Football is yet to be investigated. Research to investigate the career performance trajectories of professional Australian Football players is therefore warranted.

CONCLUSIONS

The formalised talent pathway in Australian Football commences with regional development squads whereby identified players progress through to state leagues and finally, the AFL National Draft. Several studies have investigated the factors relating to players progression along the talent pathway with specific focus on the characteristics and attributes that discriminate between competitive levels in Australian Football. In contrast however, little is known about the selection and career progression of Australian Football players after being drafted. While some studies have examined the match-related physical activity and technical skill performance metrics associated with draft order in professional Australian Football, no studies have investigated the relationship between physical performance assessed at the AFL Draft Combine and draft order. Furthermore, while research from other professional team sport leagues has investigated the relationship between talent selection criteria and future match performance, the efficacy of talent selection criteria in professional Australian Football remains unclear. This gap in knowledge is most likely due to the inherent difficulty of identifying a measure of an individual's match performance within the context of team performance. However, the increased availability of match statistics have allowed for the development of integrated, individual match performance metrics which may provide a means to assess the efficacy of talent selection criteria in professional Australian Football.

In comparison to the emerging body of research examining talent identification, there is a paucity of research investigating the career progression of professional Australian Football

players beyond being drafted. Longer playing careers in other professional team sport leagues have shown a relationship with draft order and team success (Boulier et al., 2010; Hendricks et al., 2003; Staw & Hoang, 1995), however, the factors associated with career progression in professional Australian Football players remain unclear. The lack of research in this area may be due to difficulties in defining career progression and the challenges of a longitudinal research design. The continuation of a professional career in Australian Football is dependent upon being awarded an additional playing contract which provides an objective measure of career progression. Future studies should expand on the talent selection research already performed and assess the factors influencing career progression in professional Australian Football players. Identifying these factors may enhance the current understanding of career progression in professional Australian Football.

A framework for career performance would allow sporting organisations to systematically assess current players and identify those progressing towards future success. By tracking the temporal changes in match performance of team sport athletes, career performance trajectories can be developed to identify the peak age of performance and the influence of age on the performance of players. Practically, career performance trajectories provide a means to compare and assess team sport athletes. The age of peak performance has been identified in several professional team sport leagues, however the age at which professional Australian Football players peak in performance remains unclear. Furthermore, the influence of age on the match performance of professional Australian Football players is yet to be investigated.

CHAPTER THREE

THE EFFICACY OF TALENT SELECTION CRITERIA IN THE AUSTRALIAN FOOTBALL LEAGUE

PREFACE

This study explores the beginning of an AFL playing career and the recruitment process through examining the relationship between common talent selection criteria and draft order in the AFL. It also assesses the relationship between these same variables and the AFL Player Rank metric – a measure of match performance - across the first five seasons of playing careers. This study is currently under review in the Journal of Sport Sciences.

Sullivan, C., Kempton, T., Ward, P., & Coutts, A. J. (2019). The efficacy of talent selection criteria in the Australian Football League. Journal of Sports Sciences, *in review*

ABSTRACT

This study investigated the association between common talent selection criteria, draft order and match performance in professional Australian Football players. Physical performance results from the Australian Football League (AFL) National Draft Combine and non-performance based talent selection criteria were collated for all players drafted in the National Draft with selections 1-80 between 2003 and 2008 (n= 318). Match performance was assessed via the AFL Player Rank score that was provided by a commercial statistical provider. A combination of multiple regression and linear mixed model analyses examined the influence of National Draft Combine physical performance assessments and non-performance based talent selection criteria on draft order and future match performance. Draft order was negatively associated with Under-18 all Australian team selection and height. Age (≥ 20 years) was positively associated with draft order (Adjusted R^2= 0.218; F 3,228=22.44; p <0.001). Under-18 all Australian team selection increased both Player Rank/game and total Player Rank. Draft Combine physical performance assessments were not associated with either draft order or future match performance. Under-18 all Australian team selection is a useful indicator for selecting players with the potential for success. Coaching and recruitment staff should reconsider the use of AFL Draft Combine physical performance and anthropometrical assessments in informing talent selection decisions in the AFL Draft.

INTRODUCTION

Talent selection is a crucial element in the pursuit of success for professional Australian Football clubs. The process of talent selection in the Australian Football League (AFL) occurs via the AFL National Draft which provides AFL teams with the opportunity to select players whom they believe will contribute to immediate and long-term team performance. The AFL Draft can also act as an equalisation strategy for the league with selections allocated to teams in a reverse order based on final ladder position from the preceding season. Specifically, poorer performing AFL teams (ranked lower on the ladder after the previous season) are allocated draft selections further up the selection sequence in contrast to teams who finish higher on the end of season ladder who are allocated draft selections later in the sequence.

To facilitate the talent selection process, the AFL host an annual Draft Combine event whereby talent identified junior players undergo a selection of physiological, technical skill and anthropometrical assessments under the observation of talent scouts. In addition to the Draft Combine, the AFL host the Under-18 National Championship competition whereby talent identified junior players represent their state in a 4-6 week tournament providing teams with the opportunity to observe prospective draftees during competitive match-play. During Under-18 National Championship matches, players are monitored using wearable global positional system (GPS) micro-technology which provides an objective analysis of the physical activity profile of each player and is now routinely performed at the elite level of Australian Football (Coutts, Kempton, Sullivan, et al., 2014; Coutts, Quinn, Hocking, Castagna, & Rampinini, 2010; Wisbey, Montgomery, Pyne, & Rattray, 2010b). Objective feedback on the technical skill involvements of each player during the Under-18 National Championship tournament is also provided to AFL teams by commercial statistical providers. Combined with the subjective assessment of talent scouts during the observation of junior players in competitive match-play, Draft Combine performance and the physical activity and technical skill performance during the Under-18 National Championship tournament provide AFL teams with objective information to facilitate selection decisions within the AFL Draft. In addition to objective information, recent research has demonstrated that recruiting in the AFL is influenced by the recruiters background, their attributes, understanding of team needs and the recruiter–coach relationship (MacMahon, Bailey, Croser, & Weissensteiner, 2019).

Previous research examining draft order in the AFL has reported that players selected with earlier round draft selections play more career matches over 5 years than those taken later in the draft (Burgess et al., 2012). Furthermore, while physical and technical skill match activity profiles from the Under-18 National Championship tournament failed to predict draft round in the AFL, players demonstrating superior contested skills were prioritized within a draft round

(Woods, Veale, et al., 2016). Technical skill performance in the Under-18 National Championship tournament was also reported to be important in draft success, with drafted players demonstrating more contested possessions and inside 50's than their non-drafted counterparts (Woods, Joyce, et al., 2015). Furthermore, draft outcome also appears to be associated with AFL Draft Combine performance with recent research reporting that drafted Australian Football players are taller, faster over 20 m and have greater aerobic capacity as demonstrated by superior performance in the multi-stage fitness test (MSFT) than non-drafted players (Robertson et al., 2014). Despite this, we are yet to see an investigation examining the relationship between Draft Combine performance and draft order in professional Australian Football.

Given one of the aims of selecting players in the AFL Draft is to choose players with the potential to contribute to long-term team performance, it is imperative that talent selection criteria is evidence-based (Abbott & Collins, 2002; Vaeyens et al., 2008). This is however, inhibited by the inherent difficulty of identifying a measure of individual player success within a team as the overall performance of the team (i.e. match outcome) is determined by a myriad of complex inter-related factors. Accordingly, previous research in the AFL has utilized surrogate measures of individual success including the number of career matches played (Burgess et al., 2012; Pyne et al., 2005) and subjective evaluations of player potential and value (Pyne et al., 2005). An alternative approach to identifying an individual measure of success in Australian Football was adopted in earlier research that applied regression analysis to determine the technical match statistics most associated with a winning score margin in Australian Football (Stewart et al., 2007). Using these statistics, the authors developed an 11-variable player ranking model to assess and compare players in the AFL; however, the player ranking model that was developed only accounted for 41% of the variance in score margin (Stewart et al., 2007). Champion Data, a commercial statistics provider who conduct notational analysis on AFL matches, have developed a similar metric, the '"AFL Player Rank". These ranking measures are an aggregate measure of player match performance that is based upon a player's involvement in selected match activities. The match activities are allocated a pre-determined positive or negative numerical value with the summative score indicative of an individual's influence on a match. Although no external validation of the AFL Player Rank has been performed, previous research has examined the relationship between the AFL Player Rank and draft order (Mitchell et al., 2011), physical capacity (Mooney et al., 2011), physical and technical performance during match-play (Sullivan et al., 2013a) and match outcome (Sullivan et al., 2013b). These studies found that earlier draft round selections acquired a greater AFL Player Rank than those selected further down the draft order (Mitchell et al., 2011) and that AFL Player Rank (aggregate score for the team) was higher in quarters won when compared to

quarters lost (Sullivan et al., 2013b). Accordingly, the AFL Player Rank remains the most widely used measure of individual match performance within AFL scientific research.

Previous research examining the relationship between talent selection criteria and individual match performance has been performed in the National Football League (NFL) (Berri & Simmons, 2011; Kuzmits & Adams, 2008; Mulholland & Jensen, 2014; Teramoto et al., 2016) and the National Basketball Association (NBA) (Berri et al., 2011; Teramoto et al., 2017). These studies have presented conflicting findings with some confirming the efficacy of select talent selection criteria (Kuzmits & Adams, 2008; Mulholland & Jensen, 2014; Teramoto et al., 2017; Teramoto et al., 2016) while others have reported a lack of agreement between the characteristics valued by recruitment staff and those that are associated with future performance in team sport athletes (Berri et al., 2011; Berri & Simmons, 2011). These differences may be attributed to variation in match performance measures, time spans, sample sizes and statistical analysis techniques between studies. Furthermore, the variables associated with both draft order and future match performance in team sport athletes appear to be specific to playing position (Kuzmits & Adams, 2008). For example, multiple regression analysis revealed that faster sprint times over 10 yards at the NFL Draft Combine were associated with rushing yards per attempt within the first 3 years of playing careers for the running back position (Teramoto et al., 2016). In contrast, a different combination of NFL Draft Combine measures were associated with future performance (receiving yards per reception) for the wide receiver playing position including height, weight and vertical jump (Teramoto et al., 2016). Given recent research has identified differences in objective match performance data between player roles in the AFL (McIntosh, Kovalchik, & Robertson, 2018a), future research examining match performance in professional Australian Football should account for playing position.

In addition to Draft Combine physical performance assessments, a number of studies have reported an association between non-performance based talent selection criteria and future match performance in the NBA and the NFL including age (Berri et al., 2011), matches played in National Championship tournaments (Berri et al., 2011) and the quality of the team and the competition played in as a junior athlete (Berri et al., 2011; Mulholland & Jensen, 2014). Following the AFL Under-18 National Championship tournament and prior to the AFL Draft, an expert selection panel select the Under-18 all Australian team designed to showcase the best junior Australian Football player talent within the country. Selection in the Under-18 All Australian team represents the highest level of acclaim for a junior Australian Football player however, it is unclear if recruitment staff from AFL clubs value players selected in the Under-18 All Australian team in the AFL Draft. Furthermore, the relationship between Under-18 All Australian team selection and future match performance in professional Australian Football

players is yet to be investigated. Such research would confirm the efficacy of the talent pathway in the AFL.

The relative age effect (RAE) is a phenomenon that relates to selection bias towards individual athletes born earlier in the year with its prevalence demonstrated in a number of team sports (Cobley et al., 2009), including Australian Football (Coutts, Kempton, & Vaeyens, 2014). While previous research has established that a clear bias exists in the birth distribution of adolescent draftees in the AFL towards players born earlier in the year (Coutts, Kempton, & Vaeyens, 2014), no relationship was reported between the RAE and early career progression in professional Australian Football players (Sullivan, Kempton, Ward, & Coutts, 2018) suggesting that once drafted, the RAE may not continue to influence selection in the AFL. Despite this, no studies have yet investigated if this selection bias is prevalent within the AFL Draft therefore further research is warranted to determine if the RAE influences draft order and future match performance within the AFL.

Despite previous research examining the efficacy of talent selection criteria being performed in other professional team sport leagues, we are yet to see a similar investigation in the AFL. Future research is warranted to examine the relationship between talent selection criteria and future match performance in professional Australian Football as such research could hold important implications in talent selection strategies for AFL recruiters. We hypothesise based on previous research in the AFL (Robertson et al., 2014) that Draft Combine physical performance assessments and some non-performance based criteria will be meaningfully associated with draft order and future match performance in the AFL.

METHODS

A retrospective, longitudinal research design examined the relationship between National Draft Combine physical performance assessments and non-performance based talent selection criteria on draft order and match performance in the AFL. Permission to the AFL National Draft, Under-18 National Championship tournament and Draft Combine data was granted by the AFL. Under-18 All Australian team details were retrieved from the relevant AFL Record Season Guide released annually by the AFL. The independent variables selected for analysis were chosen according to previous research in the AFL (Burgess et al., 2012; Robertson et al., 2014) and other professional team sport leagues (Berri et al., 2011; Mulholland & Jensen, 2014). Details of the independent variables used in the current study are presented in table 3.1.

Once retrieved, draft data was delimited to include selections 1-80 drafted for the first time to a professional Australian Football club in the AFL National Draft between 2003 and 2008

(retained n=318, excluded n=117). Season 2008 was the final year used in the analysis to avoid the disadvantage to players yet to complete their careers. For the purposes of our analysis, drafted players were assigned the number representing the order in which they were drafted.

Match performance was assessed by the AFL Player Rank (Champion Data Pty Ltd). Champion Data conducts notational analyses on the technical skill involvements of individual players and teams during professional Australian Football match-play. The Player Rank metric is an aggregate performance score geared towards winning factors. A positive rating is allocated to each effective skill execution and a negative rating is allocated to an ineffective skill execution with the summative score representing the impact that an individual has on a match. The total AFL Player Rank points (total Player Rank) and the average AFL Player Rank points per game (Player Rank/game) achieved within the first five seasons of playing careers (seasons 2004 – 2013 depending on draft year) were retrieved and aligned with National Draft order data in a custom Microsoft Excel spreadsheet (Microsoft®, Redmond, WA, USA). Player Rank/game was included to provide a measure that was independent of career matches played (Teramoto et al., 2016). Ethics approval for secondary analyses was granted by the University of Technology Sydney (UTS) Human Research Ethics Committee prior to the commencement of the study (HREC2014000232).

We first modelled the relationship between talent selection criteria and draft order. To do this, we built a linear mixed model with a random effect for playing position (forward, midfielder, defender, ruckman) using the *lme4* package in R Studio statistical software (Version 0.99.489, R Foundation for Statistical Computing). Prior to analysis, residual plots were observed to ensure that the assumption of normality was not violated. The necessity of the random effect was assessed by a likelihood ratio test statistic representing the difference in the -2 log-likelihood values of a model with the random effect included and a model without (West, Welch, & Galecki, 2014). Initial test diagnostics indicated that a mixed model approach was not required ($x^2(3) = 0.67$, $p = 0.88$, AIC = 2810.70). Multiple linear regression was therefore employed using the *lm* package in R Studio statistical software to determine the individual player characteristics associated with draft order in the AFL.

We also modelled the relationship between talent selection criteria and match performance by building 2 separate models using total Player Rank and Player Rank/game as dependent variables. Linear mixed modelling was used for this part of the analysis with both models including a random effect for playing position (forward, midfielder, defender, ruckman). These models were fitted to the match performance data using the *lme4* package in R Studio statistical software. A forward selection construction strategy was employed, beginning with a reference model containing only a fixed intercept and level 2 random factor (playing position) (West et

al., 2014). The model was then developed by adding each single level 1 fixed effect (performance assessment) with the fixed effect retained if it demonstrated statistical significance ($p < 0.05$) and improved the model information criteria compared to the previous model as determined by a likelihood ratio test (Cnaan, Laird, & Slasor, 1997). Level 1 fixed effects were also tested for random coefficient effects by comparing a model containing the random effect to that containing the fixed effect for each covariate. The intra-class correlation coefficient (ICC) was used to determine the similarity of observed responses within the positional cluster.

Table 3.1: Covariates included in the multiple regression and mixed model specification.

Covariates	Type	Units/classification	n	Mean	SD
Height	Continuous	cm	232	188.0	6.7
Mass	Continuous	kg	207	81.3	6.8
National Draft Combine sum of 7 skinfolds	Continuous	mm	205	52.2	10.0
National Draft Combine 20 m sprint	Continuous	seconds	173	3.0	0.1
National Draft Combine agility	Continuous	seconds	168	8.6	0.3
National Draft Combine multi-stage fitness test	Continuous	metres	157	2491	216
Indigenous	Dichotomous	0=No, 1=Yes	317		
Birth month	Dichotomous	0= Jan-Jun, 1= Jul-Dec	317		
Age at draft	Dichotomous	0=<20, 1=≥20	317		
State of origin at draft	Dichotomous	0= Victorian, 1= other	317		
U18 All Australian selection	Dichotomous	0=No, 1=Yes	317		
U18 National Championship tournament participation	Dichotomous	0=No, 1=Yes	317		
U18 National Championship tournament grand final outcome	Dichotomous	0=Lose, 1=Win	317		

U18: Under 18, Jan: January, Jun: June, Jul: July, Dec: December.

RESULTS

The stepwise multiple regression analysis revealed that 21.8% of the adjusted variance in draft order could be explained by the following individual player characteristics; Under-18 all Australian team selection, height and age (≥ 20 years old) ($Y = 116.7 – 15.8$ Under-18 All Australian team selection - 0.4 height + 15.3 age) [Adjusted $R^2 = 0.218$; $F_{3,228} = 22.44$; $p < 0.001$].

Estimates, exponentiated coefficients and the level of significance of independent variables are shown in Table 3.2. The negative β estimates in Table 3.2 indicate that taller players and those with the acclaim of Under-18 All Australian team selection are selected further up the draft order. In contrast, the positive β estimate associated with age at draft demonstrates that players over the age of 20 years when drafted will be selected with later round draft selections.

Table 3.2: Multiple regression model results. Dependant variable is "AFL Draft order".

Covariate	β (S.E)	Exp (β)	95% CI	*P*
Constant	-116.71 (31.37)		54.89, 178.53	<0.001
U18 All Australian selection	-15.77 (2.43)	-0.39	-20.56, -10.97	<0.001
Height	-0.45 (0.17)	-0.16	-0.78, -0.12	0.007
Age at draft	15.29 (4.45)	0.20	6.52, 24.07	0.001
Adjusted R^2	0.22			

β: estimate ;S.E.: standard error; Exp: exponentiated coefficient; CI: confidence interval; U18: Under 18

Results for the linear mixed model analysis have been reported in Table 3.3. For both linear mixed models investigating match performance, the construction process was optimised by including the random intercept effect for playing position demonstrating that there was statistically significant variance by position in both Player Rank/game and total Player Rank. The level 1 covariate Under-18 All Australian team selection increased both Player Rank/game and total Player Rank. There were no random coefficient effects for any level 1 covariate in either model, indicating that these effects were consistent across positional groups. The ICC for individual players within each position cluster was 0.07 and 0.04 for average and total AFL Player Rank, respectively.

Table 3.3: Effects of significant covariates on Player Rank/game and total Player Rank in professional Australian Football

	Player Rank/game (Model 1)				Total Player Rank (Model 2)			
Fixed Effects	**Coefficient**	**95% CI**	**df**	**t value**	**Coefficient**	**95% CI**	**df**	**t value**
Intercept (au)	57.73	51.83, 63.33	3.15	21.86	2641.0	1957.41, 3296.46	3.6	8.50
U18 All Australian selection	8.81	4.63, 13.12	313.28	4.08	1490.9	891.49, 2111.68	542.0	4.82

CI: confidence interval; df: degrees of freedom; U18: Under 18

DISCUSSION

This study used a mixed model approach to examine the influence of various individual player characteristics on draft order and subsequent match performance in professional Australian Football over a 6 year period. We found that draft order could be predicted by a combination of anthropometry, age and Under-18 All Australian team selection. In addition, only Under-18 All Australian team selection was associated with future match performance. Finally, physical performance assessments completed at the AFL National Draft Combine did not show any association with either draft order or match performance. These findings have important implications for the talent selection process in professional Australian Football.

This study was the first to examine the relationship between non-performance based player characteristics and draft order in professional Australian Football. Age and height were significantly associated with draft order with taller athletes selected earlier in the draft sequence while older players were taken with later round draft selections. These results are in agreement with previous research in the NBA demonstrating that both age and height were associated with draft order with each year of age resulting in a 6 position decline in the draft sequence while a 1 inch increase in height improved the draft order by 1 position (Berri et al., 2011). The importance of height in attaining higher selection is well established at the junior (Keogh, 1999; Veale, Pearce, Koehn, & Carlson, 2008; Woods, Raynor, Bruce, McDonald, et al., 2015) and senior level of Australian Football (Robertson et al., 2014) with height reported to be an important predictor of draft success in the AFL (Robertson et al., 2014). Combined with the present results, this suggests that AFL recruiters consider standing height to be an important requirement for playing professional Australian Football and consequently, prioritise taller athletes within the AFL Draft. This may be attributed to the perceived advantage of a taller

player in performing aerial ball contests (i.e. when the ball is kicked in the air to a pack of players), when compared to their shorter counterparts and therefore AFL recruiters may look more favourably on taller draft prospects. Indeed, players with superior contested skills including contested marks and possessions are prioritized in the AFL National Draft (Woods, Veale, et al., 2016). The influence of age on draft order may be explained by the reluctance of AFL recruiters to use highly-valued, early draft selections on players who were not selected to a professional club in the first year they became eligible for the draft (i.e. at 18 years of age). Relatively older players may be considered a greater risk given the expectation that a player worthy of being drafted would have been identified at the earliest opportunity. Consequently, recruiters may avoid using their highly valued, early-round draft selections on players who have been previously overlooked, instead preferring to select older players later in the draft sequence with selections that are potentially not as valuable.

While the results of our investigation show that age is negatively related to draft order in professional Australian Football, we found no evidence of the influence of the RAE on draft order despite previous research demonstrating a clear selection bias in the birth distribution of professional Australian Football players towards those players born earlier in the year (Coutts, Kempton, & Vaeyens, 2014). The authors from this study reported that the selection bias may be attributed to advanced physical and psychological maturity of relatively older draftees, and exposure to higher-level coaching when compared to their younger counterparts (Coutts, Kempton, & Vaeyens, 2014). Although the RAE appears to be prevalent in the AFL talent pathway, recent research has demonstrated that the RAE has no additional influence on the early career progression of professional Australian Football players (Sullivan et al., 2018). Combined with the present results, this suggests that while a selection bias towards older players is evident in AFL draftees, birth distribution appears to be less of an influencing factor on draft sequence and subsequent career progression in the AFL.

The present results showed that Under-18 All Australian team selection was associated with both draft order and match performance (Player Rank/game and total Player Rank) with team selection resulting in an improvement in the draft sequence by 15 positions. Furthermore, selected players achieved an extra 9 Player Rank points per game and 1490 points over the course of their first 5 seasons when compared to players who were not selected in the Under-18 All Australian team. This confirms the efficacy of talent selection at the junior, elite level of Australian Football and the subsequent effectiveness of recruitment staff in using the talent identification resources facilitated by the AFL to assist in their selection strategies on draft day. The current findings also demonstrated that neither height nor age showed a relationship with match performance. This is supported by previous research in the AFL reporting only trivial differences in the number of career matches played by players 1 standard deviation above and

below the mean for height (1.86 ± 0.07 m) (Burgess et al., 2012). While results from the present study in combination with previous findings may suggest that height is not a prerequisite characteristic for being successful in the AFL, it is also possible that the Player Rank metric is geared toward technical match statistics that are frequently performed by shorter players. For example, midfield players typically accumulate more disposals than key position players and are often the shortest players on the team (Gray & Jenkins, 2010). Given the contribution of disposal count to the Player Rank metric (Sullivan et al., 2013a), it is possible that taller players and the technical match statistics that key position players frequently perform are unrepresented by the Player Rank metric. Collectively, the results show that while height may be perceived to be an important attribute in playing Australian Football at the professional level i.e. talent selection, height does not appear to influence the Player Rank metric over the first five seasons of a players AFL career. Further research is warranted to determine if this finding is representative of a bias with the Player Rank metric or if height is overvalued by recruitment staff in the AFL Draft.

The importance of physical performance assessments in influencing draft outcome in Australian Football has been well established (Robertson et al., 2014; Woods, Raynor, Bruce, McDonald, et al., 2016), however, this was not supported by the present results. This suggests that although draft success appears to be associated with superior physical performance at the National Draft Combine, recruitment staff seem to place less emphasis on these same physical performance assessments when considering draft sequence. This indicates that there are physical performance standards that must be met to qualify for selection in the AFL Draft but superior performance above these thresholds does not result in higher draft selection. There are number of possible explanations for this finding including the homogeneity of drafted Australian Football players, team strategy and/or the belief that physical performance characteristics have a greater capacity to be altered when compared with technical and skill related abilities. Drafted Australian Football players represent the final talent selection pool in Australian Football and therefore drafted players are somewhat homogenous in their physical performance capabilities. Given this, it is possible that while recruitment and coaching staff are influenced by physical performance when deciding on draft sequence, the deviation of physical performance results is so small that the effect is masked. Alternatively, team strategy in the draft may partially account for this finding with physical performance at the AFL Draft Combine overlooked in favour of a specific characteristic required by the team. Indeed, draft strategy is a combination of both selecting the best available talent and choosing players based on both short and long-term team needs (Fry, Lundberg, & Ohlmann, 2007). For example, an Australian Football team lacking in taller, athletic ruckman may strategically prioritise this type of player when using their allocated selections despite a shorter, high-speed midfield player demonstrating greater potential for

success. As a consequence, the importance of physical performance assessed at the AFL Draft Combine may be masked.

Physical performance assessed at the National Draft Combine also showed no meaningful association with future match performance suggesting that AFL National Draft Combine physical performance assessments not only fail to influence draft order but also lack predictive capacity in long-term player success in the AFL. This finding partially contrasts with previous research in Australian Football reporting a small difference in the number of career matches played by players who demonstrated superior performance in National Draft Combine physical performance assessments (Burgess et al., 2012). Team selection and match performance are vastly different in terms of representing player success which likely contributes to the observed discrepancy between these investigations. For example, team selection is a process dependant upon coaching staff who select players to play each match of the season according to player availability, team strategy and player form. Therefore, playing more career games is dependant on being selected in the team however, playing in a competitive match doesn't indicate how a player performed within that match. The Player Rank metric as used in the present study assessed match performance therefore the findings from this investigation suggest that physical performance assessed at the AFL National Draft Combine is not associated with match performance, despite the demonstrated relationship with playing more career games. Importantly, this study only investigated physical performance without acknowledging the multidisciplinary nature of Australian Football match play which requires technical and tactical proficiency in addition to well-developed physical capacities (Gray & Jenkins, 2010). The present results suggest a disconnection between the assessment of physical performance and the contribution to overall match performance highlighting the need for a multidisciplinary approach to talent selection beyond the assessment of physical capacity.

A distinct advantage of the mixed model approach taken in the present study was the ability to account for position – a common limitation of previous research investigating talent identification and selection in Australian Football (Burgess et al., 2012; Robertson et al., 2014). These previous investigations have reported that some physical performance tests performed at the National Draft Combine were associated with various measures of success however, the relevance of the findings for all position groups were unclear. Indeed, the physical requirements of Australian Football match-play have been shown to vary by playing position (Coutts, Kempton, Sullivan, et al., 2014). However, our results suggest that drafted players who were selected in the Under-18 All Australian team – when accounting for playing position - achieve a greater total Player Rank and Player Rank/game in the 5 years after being drafted than players who were drafted without the acclaim of Under-18 All Australian team selection.

The data presented here are the first to show the individual player characteristics that influence draft order and subsequent match performance over a 6-year period in professional Australian Football. There are however, a few limitations which should be acknowledged. First, the present results show that 78.2 % of the variance in draft order could not be explained by the individual player characteristics included in the multiple regression component of this study. Of note, technical skill and decision-making assessments are now included in the AFL National Draft Combine testing schedule (kicking efficiency, 2009; handball, 2010; goal kicking, 2012), however it will be some time before an adequate sample size is available for analysis. Given the results of recent research, it is likely that match-based physical and technical performance measures from the Under-18 National Championship tournament (Woods, Veale, et al., 2016) in addition to tactical abilities related to decision making (Woods, Raynor, Bruce, & McDonald, 2016) may improve the current models. Furthermore, it is likely that game sense and psychological attributes such as leadership and competitiveness contribute to the decisions made in the AFL National Draft ("Australian Football League. *AFL Youth Coaching Manual*," 2012). In regards to match performance, the importance of developmental biography cannot be discounted with recent research demonstrating that super elite athletes (Olympic and World Champion) could be differentiated from elite athletes (International) based on a combination of psychosocial aspects, coach and family relationships and practice (Güllich et al., 2019).While we were unable to determine the influence of these additional individual characteristics on draft order and match performance, they provide direction for future research in this area.

CONCLUSION

Results from this study demonstrate that very few individual player characteristics were associated with draft order indicating that much of what is objectively available to recruitment staff prior to draft day is not used in their talent selection strategies. This finding suggests that recruitment staff are relying on their own experience and expertise to recognize intangible qualities that may not be captured by Draft Combine data. Furthermore, the lack of a relationship between the variables examined in the present study and future match performance question the usefulness of Draft Combine physical performance assessments in current talent selection practices. Nonetheless, Under-18 All Australian team selection appears to be highly valued by recruitment staff and in turn is positively associated with individual player match performance. This finding confirms the efficacy of Under-18 All Australian team selection as criteria for selecting players with the potential for success in professional Australian Football.

CHAPTER FOUR

FACTORS ASSOCIATED WITH EARLY CAREER PROGRESSION IN PROFESSIONAL AUSTRALIAN FOOTBALL

PREFACE

Study Two further explores the playing career of professional Australian Football players and the recruitment process by examining early career progression and the factors associated with being offered a second playing contract. This study was published in the Journal of Sport Sciences in 2018.

Sullivan, C., Kempton, T., Ward, P., & Coutts, A. J. (2018). Factors associated with early career progression in professional Australian Football. Journal of Sports Sciences, 36(19), 2196-2201.

ABSTRACT

This study examined the association between individual and team characteristics and the probability of being offered a second contract in professional Australian Football. Contract status was obtained from the Australian Football League (AFL) for players who were drafted in the AFL National Draft between 1999 and 2013 (n=999). Individual player demographic characteristics were retrieved from the AFL while variables relating to performance were accessed online via Champion Data. A binary logistic regression examined the influence of each characteristic on the probability of a professional Australian Football player receiving a second contract. Receiver operating characteristic (ROC) curves and the associated AUC were used to assess the discriminant ability of both a training (n=938) and test data set (n=61). The characteristics that influenced the probability of receiving a second contract included first year debut (*pr* 0.606), draft order (*pr* - 0.126), draft year (*pr* 0.059), matches played (*pr* 1.848), team state (*pr* 0.458), rising star nomination (*pr* 1.553) and team ladder position (*pr* -0.043) (χ^2 (8) = 198.28, p<0.001). The ROC curve demonstrated an AUC of 82.4% (training) and 76.0% (test). A combination of individual and team based characteristics are associated with early career progression in professional Australian Football.

INTRODUCTION

Talent identification (TID) and talent development (TDE) programs in team sports have recently gained increased research interest (Vaeyens et al., 2008). Whilst many studies have examined issues around TID in professional team sports (Vaeyens et al., 2008), few have investigated the development of team sport athletes beyond being awarded their first playing contract. Australian Football is one team sport where there is considerable research interest in TID (Robertson et al., 2014; Woods, Raynor, Bruce, McDonald, et al., 2015; Woods, Raynor, Bruce, McDonald, et al., 2016) and more recently, TDE (Burgess & Naughton, 2010; Burgess et al., 2012). For example, a previous study has investigated the physiological characteristics assessed at the Australian Football League (AFL) Draft Combine and activity profiles during matches (assessed via global positioning system micro-technology) and their association with the number of career matches played in the AFL over 5 competitive seasons (Burgess et al., 2012). Using a logistic regression approach to estimate magnitudes of the factors affecting the proportion of matches played, the authors found that sprint-related variables during matches (number of sprints performed per minute (n) and time spent sprinting (%) during the Under-18 AFL National Championship tournament) provided the greatest discriminant ability between players (Burgess et al., 2012). Despite this, factors associated with the career progression of professional Australian Football players following selection into the AFL remain unclear.

Professional Australian Football players are recruited in the AFL through the National Draft. The AFL National Draft provides each club the opportunity to recruit new players for the following season(s). Similar to draft systems in other team sports (Boulier et al., 2010), the AFL National Draft is an annual event that determines the order in which prospective draftees are recruited to AFL clubs. Prior to the draft, selection order is allocated to each AFL club in a reverse order based on final ladder finishing position from the previous season. Decisions on player selections within the AFL National Draft are influenced by many factors such as strength and weaknesses of the current playing roster, available talent in the draft and club strategy. To inform decisions of selections, there are large amounts of information about prospective draftees that are available to clubs. Such information includes data on physical and technical abilities, medical history and psychological information which is usually obtained from the AFL National Draft Combine. In addition, clubs also use insights from talent scouts who observe prospective draftees in competitive matches throughout their junior Australian Football careers.

The majority of previous talent identification research in team sports has largely focused on discriminating junior athletes from different playing levels with a variety of physiological, anthropometrical and technical skill assessments demonstrating discriminatory ability in a wide range of team sports (Elferink-Gemser, Visscher, Lemmink, & Mulder, 2004; Robertson et al.,

2014; Sierer, Battaglini, Mihalik, Shields, & Tomasini, 2008; Till et al., 2015; Vaeyens et al., 2006). More recently in Australian Football, there has been a shift within the literature away from uni-dimensional approaches and towards TID models with greater ecological validity (Burgess et al., 2012; Woods, Joyce, et al., 2015). Indeed, greater model success has been reported by incorporating game performance metrics including measures related to technical skill and physical activity profiles from competitive Australian Football match-play (Burgess et al., 2012; Woods, Joyce, et al., 2015). Specifically, contested possessions (i.e. a possession achieved as a result of winning a contest) and inside 50 deliveries (i.e. the act of delivering the ball inside the 50 m arc) demonstrated the largest differences between drafted and non-drafted state academy players in the 2013 and 2014 Australian Football seasons (Woods, Joyce, et al., 2015). Despite these findings providing insight into identifying players who might be selected onto the playing roster of an AFL club, they provide little information regarding longer-term measures of career success. There is very limited research examining TID beyond selection in professional Australian Football however, previous research has suggested that the inclusion of objective match performance data (activity profiles from GPS micro-technology and skill-related match statistics) improved the predictive capacity of a model investigating factors associated with playing more career matches over 5 competitive seasons (Burgess et al., 2012). Despite these findings, there is presently little known about the factors that might contribute to player success after being drafted in Australian Football. Furthermore, investigations in other team sports including soccer (Castellano, Casamichana, & Lago, 2012) and semi-professional rugby league (Gabbett, 2014) have demonstrated differences in the match running demands and technical performance of players belonging to successful and less successful teams however, no study to date has assessed the influence of team success on the career progression of team sport athletes. Such information may provide further knowledge regarding the impact that the end of season ladder position has on the career progression of professional Australian Football players.

A standard playing contract for an AFL player who is drafted for the first time to a professional Australian Football club is a minimum two years in length (Australian Football League & Australian Football League Players' Association Incorporated, 2012). At the end of the initial contract, players are either re-contracted (i.e. offered a new contract) or removed from the playing list (i.e. either delisted and become a free agent or are traded to another club in return for players or future draft picks). Accordingly, a greater understanding of the factors that are associated with earning a second contract may assist both recruitment staff in developing and maintaining a competitive playing roster and current players in identifying the probability they will receive a contract for the upcoming season. Therefore, the aim of the present study was to identify the association between individual and team characteristics and the probability of being offered a second contract in professional Australian Football.

METHODS

A retrospective, longitudinal research design examined the effects of various individual and team characteristics on the probability of a player receiving a new contract at their original club following their first season in professional Australian Football. Data were obtained for all players who were drafted to a professional Australian Football club in the AFL National Draft for the first time between 1999 and 2013 (n=999). Data obtained between 1999 and 2012 (n=938) were used to train the model while data from season 2013 was withheld to test the model (n=61). The contract status of individual players following their initial two-year contract was then determined with a player either being re-contracted (n=762) – offered a second contract – or delisted or traded to another club – not re-contracted (n=176). A player was deemed re-contracted if they were present on their original club's playing list for three or more years. Individual player characteristics were retrieved, with permission, from the AFL National Draft database while variables relating to individual and team performance were accessed online via Champion Data (Victoria, Australia), the official statistical provider for the AFL. For each home and away round of the AFL season a Rising Star Nomination is awarded to one player deemed to have performed well by the AFL during that round. To be eligible for the award a player must be younger than 21 years of age at the 1st of January of the award year and played less than 10 senior matches before the beginning of the season. A list of players who have been nominated for the Rising Star award was retrieved from the relevant AFL prospectus. Details of all of the independent variables used in the current study are presented in Table 4.1. Ethics approval was granted by a university Human Research Ethics Committee prior to the commencement of the study.

Table 4.1: Covariates included in the model.

Variable	Type	Classification	n
Dependent			
Contract status	Dichotomous	0=not re-contracted, 1=re-contracted	0=185, 1=814
Independent			
Birth half year	Dichotomous	1= Jan-Jun, 0=Jul-Dec	0=384, 1=615
Age at draft	Dichotomous	0=<20, 1=≥20	0=952, 1=47
State of origin at draft	Dichotomous	0= Victorian, 1= other	0=540, 1=459
Playing position	Dummy	Mid, fwd, def or ruck	Mid-323, fwd-293, def-308, ruck-75
Draft order	Categorical	Value 1-20	999
Debut in first year	Dichotomous	0=No, 1=Yes	0=459, 1=540
Number of games played in first year	Dichotomous	0=<4, 1=≥4	0=622, 1=377
Number of games played in second year	Dichotomous	0=<8, 1=≥8	0=604, 1=395
Team state	Dichotomous	0=Interstate, 1=Vic	0=382, 1=617
Rising star nominee	Dichotomous	0=No, 1=Yes	0=754, 1=245
Team EOS ladder position 1st year	Discrete	Value between 1-18	999
Team EOS ladder position 2nd year	Discrete	Value between 1-18	999
Indigenous	Dichotomous	0=No, 1=Yes	0=869, 1=130

Jan: January, Jun: June, Jul: July, Dec: December, Vic: Victorian, Mid: midfielder, fwd: forward, def: defender, ruck: ruckman, EOS: end of season *Note:* The threshold for the number of matches played in the first and second seasons were set according to the mean number of matches played. Draft order was a categorical variable where selections were grouped by fives i.e. group 1 included selections 1-5.

A binary logistic regression model was used to examine the influence of each individual and team characteristic on the probability of a professional Australian Football player receiving a second contract. A backward stepwise elimination method was employed to build the model with predictors removed based on the criteria that removal would not increase the Akaike information criterion (AIC). The backward stepwise elimination method was preferred over a forward selection method due to a reduced likelihood of suppressor effects whereby a predictor has a significant effect but only when another variable is held constant (Field, Miles, & Field, 2012). Collinearity tolerance statistics were calculated and any variable less than 0.10 was not included in the model (Menard, 2002). The presence of outliers and influential cases were assessed via observation of the studentised residuals, Cook's distance and leverage statistics (Menard, 2002) with no outliers or cases observed exerting undue influence over the parameters of the model. Model fit was assessed as the model chi-square divided by the baseline -2 log-likelihood representing the proportional reduction in the absolute value of the log-likelihood (Hosmer & Lemeshow, 1989).

The discriminant ability of both models was assessed by generating a receiver operating characteristic (ROC) curve to plot the true positive rate (sensitivity) against the false positive rate (1 – specificity). An area under the curve (AUC) was calculated with an AUC of 1 (100%)

representing perfect discriminant ability. Effect sizes were assessed using odds ratio (OR) defined as the exponential of the regression coefficient e^B. When an OR was >1.0, increased odds of receiving a new contract were reported. Conversely, when an OR was <1.0, decreased odds of receiving a new contract were reported. For an OR to be significant, 95% CI would not contain the null OR of 1.0. All statistical analyses were conducted using the RStudio statistical software package (RStudio Inc., Version 0.99.486, Boston, MA, USA). Statistical significance was set at $P < 0.05$. The data are presented as mean, SD, or 95% confidence interval (CI) unless otherwise stated.

RESULTS

The individual and team characteristics that influenced the probability of being offered a second contract were making a first year debut (*pr* 0.606, OR 1.833), draft order (*pr* -0.126, OR 0.881), draft year (*pr* 0.059, OR 1.060), number of matches played in the second season (*pr* 1.848, OR 6.350), team state (*pr* 0.458, OR 1.581), rising star nomination (*pr* 1.553, OR 4.725), and team ladder position following the conclusion of the second season (*pr* -0.043, OR 0.958) ($\chi^2(8) = 198.28$, $p<0.001$). Positive standardised coefficients (first year debut, draft year, number of matches played in the second season, team state and rising start nomination) were associated with an increased probability of receiving a second contract whereas negative standardised coefficients (draft order and team ladder position following the conclusion of the second season) were associated with not being re-contracted. The ROC curve demonstrated an AUC of 82.4% for the trained data-set and 76.0% for the test data-set (Figure 4.1). Beta coefficients, standard errors, odds ratios, 95% CI's and level of significance of predictors are shown in Table 4.2.

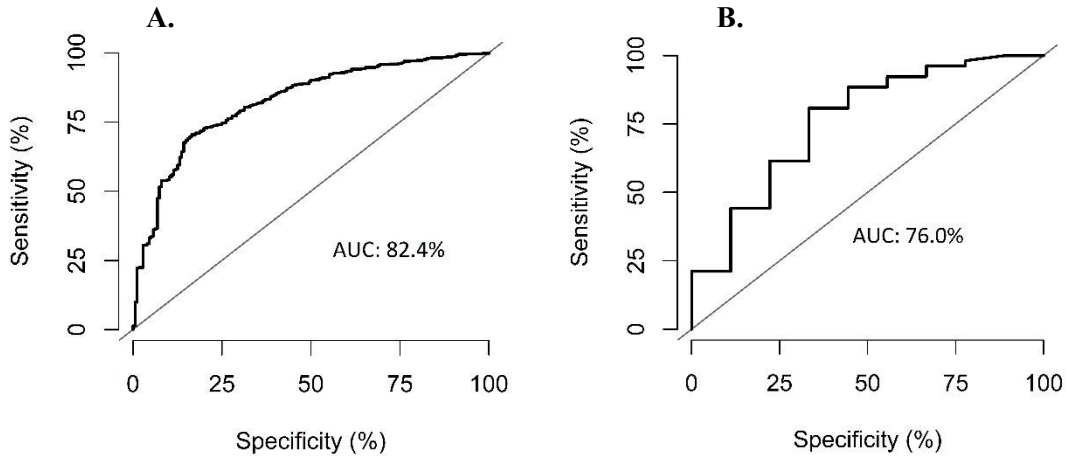

Figure 4.1: (A) ROC curve based on training data (B) ROC curve based on test data. ROC curves indicate the point at which the greatest area under the curve has occurred for predictors of being given a second contract in Australian Football.

Table 4.2: Standardised coefficients, exponentiated coefficients (odds ratios), 95% confidence intervals and level of significance for predictors of earning a second contract in Australian Football.

Predictor	B (S.E.)	EXP (β)	95% CI	*P*
Constant	-115.873 (46.556)	0.000	0.000-0.000	0.013
Matches played in 2nd year	1.848 (0.338)	6.350	3.405-12.984	<0.001
Rising star nominee	1.553 (0.443)	4.725	2.139-12.527	<0.001
First year debut	0.606 (0.211)	1.833	1.217-2.787	0.004
Team state	0.458 (0.193)	1.581	1.083-2.311	0.018
Draft selection	-0.126 (0.023)	0.881	0.842-0.922	<0.001
Draft year	0.059 (0.023)	1.060	1.013-1.110	0.011
Team ladder position 2nd year	-0.043 (0.021)	0.958	0.920-0.997	0.038
Log likelihood function	-353.7			
Chi squared	$\chi^2(8) = 198.28$, p <0.001			

S.E.: Standard error, CI: Confidence interval

DISCUSSION

This study examined the association between individual and team-based characteristics and early career progression in the AFL. The main findings were that (1) individual characteristics weighted in favour of match performance and matches played increased the likelihood of

receiving a second contract, (2) greater team success was positively associated with the likelihood of receiving a second contract, (3) players were more likely to receive a second contract if they were drafted to a Victorian club and, (4) draft year influenced the likelihood of receiving a new contract. The trained model displayed good discriminant ability and model performance remained fair when validated on an out of sample data-set. These results demonstrate that a combination of team and individual characteristics are associated with receiving a second contract in professional Australian Football.

This study is the first to examine the factors related to early career progression in professional Australian Football. Our results show that characteristics related to the number of matches played and performance within these matches have the largest effect on the probability of receiving a new contract in professional Australian Football. Specifically, gaining a Rising Star Nomination, debuting in the first season of a contract and playing more than eight matches in the second season of a contract all enhanced early career progression. The odds of being offered a second contract increased by a factor of 4.7 if a player was nominated for a Rising Star Award in either year of their first contract. This finding is logical given the purpose of the award is to recognize and encourage talented Australian Football players at the beginning of their careers. Similarly, the findings regarding first year debut and matches played in the second contract year follow logic and confirm that draftees who debut in their first year and play more than eight matches in the second year of their first contract have an increased likelihood of being offered a new contract in professional Australian Football. Interestingly however, matches played in the first season of a contract did not increase the likelihood of receiving a second contract. Although this is a novel finding, it is possible that there is less expectation to play senior Australian Football matches in the first season of a contract with coaching and performance staff largely focusing on developing physical capacities (Bilsborough, Kempton, Greenway, Cordy, & Coutts, 2016) in combination with technical skills, game sense and tactical abilities while monitoring training load to prevent injury (Rogalski, Dawson, Heasman, & Gabbett, 2013).

Early career progression in professional Australian Football players also showed an association with team success. The present results indicate that players at less successful teams (as determined by final league ladder position) have reduced odds of receiving a new contract. For each position closer a team is to the bottom of the ladder, the odds of a recent draftee being offered a second contract within that team are reduced by a factor of 1.0. This is the first study in professional team sport to demonstrate the impact that team success has on the career progression of individual players. A possible explanation for this finding may be that less successful teams may make greater changes to their playing roster following an unsuccessful season in an attempt to supplement the roster with new talent. Given the AFL National Draft

awards poorer performing teams with earlier draft selections, these less successful clubs may delist or trade players following the expiry of their first contract to allow for the regeneration of talent achieved through new draftees. Alternatively, poor recruiting and/or player development by less successful teams may also contribute to this finding. It is possible that some drafted players lack the potential to be successful at the professional level of Australian Football and therefore are subsequently traded or delisted at the conclusion of their first contract. Similarly, it is also possible that poorer performing teams are failing to adequately develop recent draftees resulting in these players failing to reach their potential and subsequently being traded or delisted. Indeed, recent research has demonstrated that the physical development of early career players (<21 years) in professional Australian Football is a slow process. For example, it has been shown that early career players usually require more than three years to develop lean muscle mass to levels comparable to mid and late career players (Bilsborough et al., 2016).

A novel finding of the present study was that being drafted to a Victorian-based AFL team when compared to an interstate team increased the odds of receiving a new contract. Although the reasons that underpin this finding are unclear, there were a larger proportion of draftees examined in the present study who originated from Victoria compared to other Australian states (55%). Therefore, one possible explanation may relate to "the go home factor" whereby Victorian based draftees who are recruited to interstate teams, may voluntarily choose to return to their home state at the conclusion of their first contract. Indeed, when first recruited through the AFL National Draft, Australian Football players are typically 18 years of age with many required to re-locate away from their families and live independently for the first time, particularly those recruited to interstate teams (Noblet, Rodwell, & McWilliams, 2003). There is potentially a lack of social and family support in addition to the demands placed on them as a professional athlete in a high performance environment (Noblet et al., 2003). It is therefore possible that the probability of being given a second contract at an interstate club is reduced when compared to a Victorian club due to draftees voluntarily opting to return to their home state. Another explanation for this finding may be attributable to poor recruiting and/or TDE within interstate teams. Both of these explanations are speculative therefore further research is required to investigate 'the go home factor' and to evaluate the mechanisms that underpin why career progression is greater for players who are drafted to Victorian based AFL teams.

The present study is the first to demonstrate that draft year and draft order influence the odds of being offered a second contract in professional Australian Football. For example, the odds of receiving a second contract for draft selections 6-10 (group 2) are reduced compared to draft selections 1-5 (group 1). Specifically, the odds of receiving a new contract decreased by a factor of 0.9 with every one-unit increase in draft order group. Although differences exist in player recruitment and contract policy between the AFL and professional, American team sport

leagues, our findings are in agreement with previous research from the National Football League and the National Basketball Association (NBA) demonstrating an inverse relationship between contract length and draft selection number (Staw & Hoang, 1995; Tang, 2015). This finding is logical, given early round draft selections are often recruited with the expectation that they provide immediate and long-term success to their club. It is also possible that professional clubs are reluctant to delist or trade a player, and more likely to persist with the development of players, who were selected further up the draft order. Indeed, it has been demonstrated that highly drafted NBA players are given more game time and longer contracts even after controlling for playing position, injury and on-court performance (Staw & Hoang, 1995). Although similar research is yet to be conducted in Australian Football, it was recently shown that early round draft selections possess superior contested skill (possessions and marks) when compared to those drafted in later rounds (Woods, Veale, et al., 2016) therefore early round draft selections may simply display better on-field performance resulting in greater opportunity for early career progression. Further research is required to determine the relationship between draft order and early career progression in professional Australian Football while controlling for on-field performance.

The association between individual and team-based characteristics and early career progression in professional Australian Football also appears to vary as a function of draft year. Specifically, the odds of receiving a new contract have increased by 6% with every additional year between 1999 and 2012. Whilst this finding was unexpected, it may be explained by the recent introduction of two new clubs into the AFL – the Gold Coast Suns in 2011 and Greater Western Sydney Giants in 2012 – that caused recruiting staff from other clubs to become aware of the prospect that the AFL Draft talent pool would be limited. These new teams were each given a variety of drafting and player recruitment advantages that compromised the draft choices of the remaining teams. Specifically, the new teams were each allocated six top 10 draft selections prior to their first seasons competing in the AFL - including selections 1, 2 and 3 - enhanced playing list sizes (i.e. more contracted players were allowed at these clubs), a greater salary cap and increased access to recruit players without being selected through the National Draft (i.e. the ability to sign up to 16 current AFL players who were uncontracted at other clubs and 10 players previously nominated in the AFL National Draft that were not selected). It is therefore likely that the remaining established teams retained more draftees, favouring the development of players who have already been selected over drafting from the reduced talent pool on offer in the ensuing National Drafts.

The RAE is a phenomenon that relates to selection bias towards individual athletes born earlier in the year. The prevalence of the RAE has been demonstrated in a number of team sports (Cobley et al., 2009) including Australian Football (Coutts, Kempton, & Vaeyens, 2014).

Despite this, we found no evidence of the influence of birth quarter on the probability of being offered a second contract in professional Australian Football. Research in other team sports investigating the RAE and early career progression is limited however, the influence of the RAE does appear to vary as a function of skill level with an increase in the risk for relative age effects (RAEs) at greater competitive levels (Cobley et al., 2009; McCarthy & Collins, 2014; Vaeyens, Philippaerts, & Malina, 2005). Interestingly, a recent meta-analysis identifying moderators of the RAE in sport found that although the risk for RAE's increase at greater competitive levels, this relationship is not linear (Cobley et al., 2009). Professional and National representative players were found to display a decreased risk for RAEs when compared to recreational, amateur and regional representative athletes (Cobley et al., 2009). The authors suggest that differences in physical maturity may be less discriminating at more elite levels of sport. In agreement, results from the present study in addition to findings from *study one* demonstrate no association between the RAE and talent selection or early career progression in professional Australian Football players. Despite this, a clear bias has been shown in the birth distribution of adolescent draftees in the AFL towards players born earlier in the year (Coutts, Kempton, & Vaeyens, 2014). When taken together it appears that the RAE does exist in the selection of professional Australian Football players but may not influence players receiving a second contract.

The analysis presented in this study used a longitudinal and competition-wide approach to examine a number of objective measures of performance. It is however, important to acknowledge that the early career progression of professional Australian Football players can be influenced by a myriad of individual and team based characteristics, many of which are beyond the scope of this study. For example, tactical abilities relating to game sense and decision-making, psychological traits of individual athletes and club strategy (Woods, Veale, et al., 2016) may also effect the probability of being offered a second contract. Indeed, talent-identified junior Australian Football players appear to have superior decision-making skills during a vision based task when compared to their non-talent identified counterparts (Woods, Raynor, Bruce, & McDonald, 2016). Although technical skill and decision-making assessments are now included in the AFL National Draft Combine testing schedule (kicking efficiency, 2009; handball, 2010; goal kicking, 2012), their recent addition means that it will be some time before an adequate sample size is available for analysis.

CONCLUSION

This study examined the individual and team-based characteristics that were associated with early career progression in professional Australian Football players between 1999 and 2012. The main findings were that debuting in the first season of a contract, playing more than eight

matches in the second season of a contract, gaining a rising star nomination and belonging to a Victorian based team all enhanced early career progression. In contrast, selection further down the draft order and belonging to a less successful team reduced the odds of being given a second contract. These results present new information regarding the most important individual and team-based characteristics associated with early career progression in professional Australian Football players and have the potential to assist in decisions regarding recruitment and player list management within professional Australian Football League clubs.

CHAPTER FIVE

CAREER PERFORMANCE TRAJECTORIES OF PROFESSIONAL AUSTRALIAN FOOTBALL PLAYERS

PREFACE

The final study in this thesis explores the age-related career performance trajectory of professional Australian Football players by examining the age of peak performance for each playing position. In addition, this study developed a series of career performance curves which enabled the mean career trajectory of each positional group in the AFL to be identified. This study is currently under review in the Journal of Sport Sciences.

Sullivan, C., Kempton, T., Ward, P., & Coutts, A. J. (2019). Career performance trajectories of professional Australian Football players. Journal of Sports Sciences, *in review*

ABSTRACT

This study modelled the career performance trajectories of professional Australian Football players by examining the age of peak performance. Match performance data (Champion Data Player Rank) was collected for all Australian Football players drafted via the Australian Football League (AFL) National Draft between 1999 and 2015 and who had played at least four seasons (n=207). Players were subdivided into playing positions; forwards (n=60, age 23 ± 3 years), defenders (n=71, age 24 ± 4 years), midfielders (n=58, age 24 ± 4 years) and ruckman (n=18, age 24 ± 3 years). Linear mixed models were fitted to the data to estimate individual career trajectories. Forwards, midfielders and defenders experienced peak match performance earlier than ruckman (24-25 vs. 27 years). Midfielders demonstrated the greatest between-subject variability (intercept 0.580, age 0.0286) in comparison to ruckman who demonstrated the least variability (intercept 0.112, age 0.005) in AFL Player Rank throughout their careers. Age had the greatest influence on the career trajectory of midfielders (β (SE) = 0.226 (0.023), T = 9.10, $P < 0.01$) and the least effect on ruckman (β (SE) = 0.114 (0.049), T = 2.30, $P = 0.02$). Professional Australian Football players peak in match performance between 24 and 27 years of age with age having the greatest influence on the match performance of midfielders and the least on ruckman.

INTRODUCTION

It is routine practice in an elite sporting environment to assess athletic performance in competition. By tracking the temporal changes in match performance of professional team sport athletes, sporting organisations can identify career performance trajectories and determine the age at which athlete's peak in their performance and when performance is likely to decline. Although career performance trajectories have been developed in a number of professional team sports including baseball (Bradbury, 2009; Fair, 2008; Schulz et al., 1994; Wakim & Jin, 2014), soccer (Dendir, 2016), ice hockey (Brander et al., 2014) and basketball (Wakim & Jin, 2014), relatively little is known about the age-related changes in performance of professional Australian Football players. Such knowledge may assist in athlete development in addition to providing important information for personnel involved in recruitment and player list management within professional sporting clubs.

Where performance in individual sports is defined by competition results, performance in team sports is often measured by the team orientated result of match outcome (Robertson, Back, et al., 2016; Sullivan et al., 2013b). Consequently, the measurement of individual performance within team sport match-play requires the development of a metric that can assess the influence of an individual player upon a match. Several studies have attempted to develop an individual measure of match performance in professional Australian Football (Heasman et al., 2008; Stewart et al., 2007). One study developed a player impact rating by allocating positive or negative numerical values to selected technical skill involvements and reported a significant relationship between the player impact rating and both winning (r=0.69) and a winning score margin (r=0.85) (Heasman et al., 2008). However, the technical skill involvements used in the development of the player impact rating were selected by coaching staff and not based on rigorous scientific analysis (Stewart et al., 2007). Another study used linear regression analysis to identify the individual, discrete performance indicators most associated with a winning score margin across five seasons in Australian Football (Stewart et al., 2007). The most important performance indicators were then used to develop an 11-variable player ranking model that could be used to compare and assess individual players in the Australian Football League (AFL) (Stewart et al., 2007). Despite this, the player ranking model only accounted for 41% of the variance in score margins questioning the usefulness as a measure of individual match performance in professional Australian Football (Stewart et al., 2007). Alternative measures of individual match performance in professional Australian Football have been provided by the official statistical provider for the AFL (Champion Data Pty Ltd, Victoria, Australia). Using a similar approach to Stewart et al., (2007), Champion Data have developed the "AFL Player Ranking" representing an aggregate measure of player match performance that is based upon a player's involvement in selected match activities. The match activities are allocated a pre-

determined positive or negative numerical value with the summative score indicative of an individual's influence on a match. Although no external research to establish the validity of the AFL Player Rank has been performed, previous research has examined the relationship between the AFL Player Rank and physical capacity (Mooney et al., 2011), physical and technical performance during match-play (Sullivan et al., 2013a) and match outcome (Sullivan et al., 2013b). Findings indicated that AFL Player Rank was higher in quarters won when compared to quarters lost (Sullivan et al., 2013b). These results provide some support to the construct validity of AFL Player Rank as a performance measure. Despite recent research demonstrating that the AFL Player Rank displays high match to match variability (%CV 26.4 – 37.1) (Kempton, Sullivan, Bilsborough, Cordy, & Coutts, 2015), the AFL Player Rank remains the most widely accepted method of assessing individual match performance within the AFL.

Previous research examining the peak age of performance in professional team sport has reported that performance in baseball and ice hockey peaks between 27 and 29 years of age (Bradbury, 2009; Brander et al., 2014; Fair, 2008; Schulz et al., 1994) which is later than the peak age of performance reported for soccer and basketball (Dendir, 2016; Wakim & Jin, 2014). Furthermore, the age of peak performance appears to vary as a function of playing position (Bradbury, 2009; Brander et al., 2014; Dendir, 2016). For example, while it was reported that professional soccer players peak in performance between 25 and 27 years of age, a typical forward was shown to attain peak performance prior to defenders and midfielders (Dendir, 2016). In addition to differences noted in the age of peak performance between positional groups, previous research has also reported variation in career performance trajectories between playing positions (Brander et al., 2014; Dendir, 2016). While peak ages of performance in ice hockey are reportedly similar for both forwards and defenders, previous research suggests that a typical defender maintains near-peak performance (within 10% of peak performance) for longer than a typical forward (Brander et al., 2014). Specifically, although both forwards and defenders were shown to reach 90% of peak performance by age 24, a typical forward began a steep decline in performance from 32 years of age, compared with 34 years for a typical defender (Brander et al., 2014). Given recent research in professional Australian Football suggests that player role (McIntosh et al., 2018a) and physical activity profiles (Coutts, Kempton, Sullivan, et al., 2014) vary by playing position, it is likely that the career performance trajectories of professional Australian Football players are specific to playing position – however to date, no studies have investigated the age-related changes in AFL match performance. Therefore the aim of this investigation was to identify the age of peak performance for each position group and to produce estimates of playing position-related performance progression that provide benchmarks for guiding talent development and recruitment strategies in professional Australian Football.

METHODS

The players who were selected for this study were those who were drafted for the first time to a professional Australian Football club via the AFL National Draft between 1999 and 2015 (n=1440). Data was delimited to include players who had completed their careers within the study timeframe and who had played at least 4 seasons (n=207). Players were differentiated by one of four position groups designated by the AFL; forwards (n=60, age 23 ± 3 y), defenders (n=71, age 24 ± 4 y), midfielders (n=58, age 24 ± 4 y) and ruckman (n=18, age 24 ± 3 y) with players assigned to the position group where they played the majority of their professional career. Ethics approval for secondary analyses was granted by the University of Technology Sydney (UTS) Human Research Ethics Committee prior to the commencement of the study (HREC2014000232).

Draftee characteristics including date of birth, draft selection number and draft year were retrieved, with permission, from the AFL National Draft database while match performance variables were accessed online via Champion Data (https://www.championdata.com). Match performance was assessed using the Champion Data AFL Player Rank metric. Mean match performance per season was represented by the average AFL Player Rank achieved by each player with this value then made relative to individual player game time (AFL Player Rank/min).

A polynomial random intercept and random slope mixed model was built for each position group to estimate individual career trajectories using the nlme package in R (Version 3.3.2, Boston, MA, USA) (R Core Team, 2015). A mixed model approach was used to enable the estimation of individual differences in the data in addition to providing an analysis technique that could account for the violation of independence that was evident as a result of multiple observations on the same subjects (Lazic, 2010). The fixed model included a mean quadratic trend for chronological age while random effects were included to estimate the unique effect of age on each players' AFL Player Rank/min modelled as individual quadratic trajectories. A correlation structure was induced from the mixed model to determine the variability in the model for any subject in comparison to the variability in the intercepts across the population. The induced correlation was calculated using the variance of the intercept divided by the sum of the variance for the intercept, age and the residual (Kwok et al., 2008). The appropriateness of using quadratic trends to model Australian Football match performance was assessed by the analysis of the residuals. The quadratic model was deemed appropriate to model the age-related changes in match performance of professional Australian football players.

Between position comparisons were made for both age and age^2 in reference to the magnitude of the observed effect. Different methods were used to evaluate the two effects as age^2 was only included in the model as a fixed effect variable, given it failed to improve the model's Bayesian information criteria (BIC) when added as a random effect (Kwok et al., 2008). To compare positional groups based on age, a summary measure approach was applied based on the average random slope coefficient for this variable for each position group (Matthews, Altman, Campbell, & Royston, 1990). Additionally, between positional group comparisons were investigated for the age quadratic term in the model.

A magnitude-based approach (Batterham & Hopkins, 2006) was used to assess the chances of true differences (i.e. greater than the smallest worthwhile change, SWC) in AFL Player Rank/min between positional groups. Threshold values for a positive or negative change were established by taking 0.20 x the between subject standard deviation from an intercept only mixed model for the age variable and 0.20 x the SD of the fixed effect coefficients for the age^2 variable. Quantitative chances of real differences in variables were assessed qualitatively as : <0.5%, most unlikely; 0.5-5%, very unlikely; 5-25%, unlikely; 25-75%, possibly; 75-95%, likely; 95-99.5%, very likely; >99.5%, most likely (Hopkins, Marshall, Batterham, & Hanin, 2009). If the chances of a variable having higher and lower differences were >5%, the true effect was deemed to be unclear.

RESULTS

Estimates of the age of peak performance and the random effects for each position group are presented in Table 5.1. Forwards, midfielders and defenders achieved peak match performance at a similar age (24, 25 and 24, respectively), however, ruckman were around 3 years older (27 years old) than their counterparts when they achieved peak match performance. The fixed effect intercept line represents performance variability between athletes within that group (Table 5.1). The fixed effect intercepts in Table 5.1 indicate that midfield players demonstrate a large variability in AFL Player Rank/min. Conversely, ruckman are seen to have lower variability in the fixed effect intercept suggesting that match performance (AFL Player Rank/min) is less variable between athletes in this position group. Additionally, ruckman have the largest random effects residual indicating that within individual variability of AFL Player Rank/min is greater for these athletes from one season to the next.

Table 5.1: Age at peak performance and results for the random effects component of the linear mixed model.

Position	Age at peak performance	Intercept	Age	Residual
Forward	24	0.308	0.0141	0.120
Defender	25	0.326	0.0142	0.101
Midfield	24	0.580	0.0286	0.121
Ruck	27	0.112	0.0049	0.156

Mean age-related career trajectories for each position group and benchmarks in AFL Player Rank/min by position group and age are shown in Figure 5.1 and Table 5.2. Analysis of the fixed effect regression coefficients indicate that age had the greatest influence on the career trajectory of midfield players who experienced the fastest rise to peak performance but also the sharpest decline in AFL Player Rank/min throughout their careers. Conversely, age had the least effect on the career trajectory of ruckman while forward and defender players demonstrated similar career trajectories.

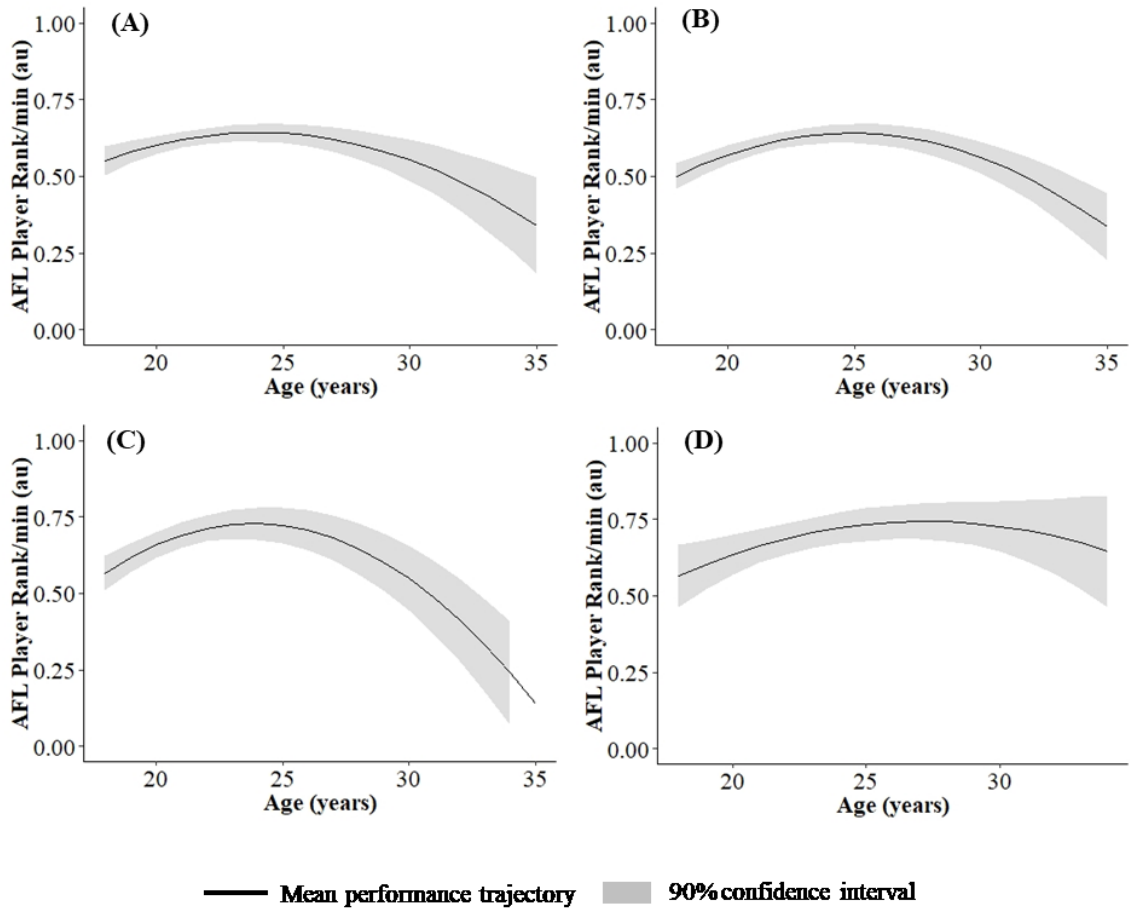

Figure 5.1: Mean AFL Player Rank/min and 90% confidence intervals as a function of age for (A) forwards, (B) defenders, (C) midfielders and (D) ruckman.

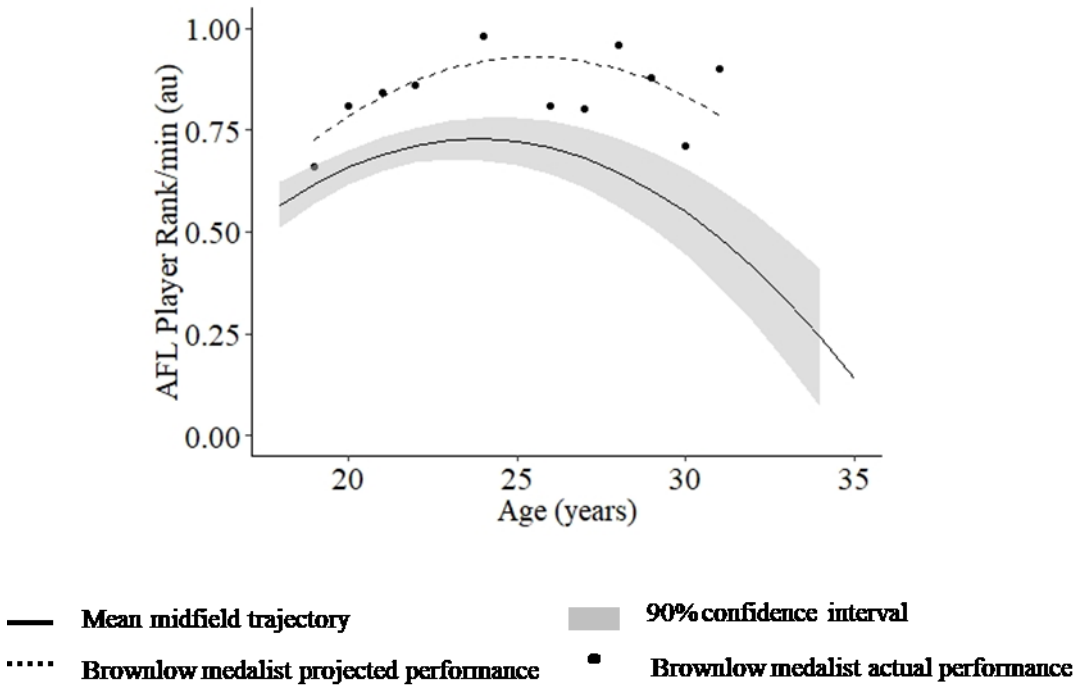

Figure 5.2: Mean AFL Player Rank/min and 90% confidence intervals as a function of age for the midfield position group. An example of actual performance and projected performance is shown for a Brownlow Medallist.

Between position comparisons for the fixed effect of age and age^2 are presented in Table 5.3 and Table 5.4, respectively. Midfield players' most likely experience a faster rise to peak match performance than all other positions while midfielders and defenders most likely peak in match performance earlier than forwards. Midfield players' most likely experience a faster rate of decline in match performance when compared to all other positions. Conversely, ruckman most likely experience the least decline in match performance compared to all other positions while forwards most likely experience a reduced decline in match performance in comparison to defenders.

Table 5.2: Benchmarks in AFL Player Rank/min for each position group by age

	AFL Player Rank/min			
Age (n)	**Forwards**	**Defenders**	**Midfielders**	**Ruckman**
18	0.551	0.500	0.566	0.566
19	0.579	0.538	0.617	0.602
20	0.601	0.570	0.658	0.634
21	0.619	0.596	0.690	0.663
22	0.632	0.616	0.712	0.686
23	0.640	0.630	0.725	0.706
24	0.642	0.638	0.728	0.722
25	0.640	0.640	0.722	0.733
26	0.633	0.636	0.706	0.740
27	0.620	0.626	0.681	0.743
28	0.603	0.611	0.647	0.742
29	0.580	0.589	0.603	0.736
30	0.553	0.561	0.549	0.727
31	0.520	0.528	0.486	0.713
32	0.482	0.488	0.413	0.695
33	0.440	0.443	0.331	0.673
34	0.392	0.391	0.239	0.647
35	0.339	0.334	0.138	

Note: AFL Player Rank/min benchmark for the ruck position at age 35 is missing due to insufficient data

DISCUSSION

In the present study we have modelled the career performances of professional Australian Football players using position specific quadratic trajectories to investigate match performance changes as a function of chronological age. Our main findings were that (1) the age at which professional Australian Football players peak in match performance varies by playing position, (2) age has the largest effect on the match performance of midfield players and the least on ruckman, (3) variability in match performance is greatest between athletes for the midfield position and smallest for the ruck position and (4) the ruck position has the greatest individual differences in age-related performance decline.

Table 5.3: Between Position Comparisons of fixed effects for Age.

Comparison	Diff ± 95% CI	Probability of effect (+ive / trivial/ -ive)	Inference
FWD - DEF	-0.027 [-0.030 to -0.024]	0% / 0%/ 100%	Most likely negative
FWD - MID	-0.105 [-0.110 to -0.100]	0% / 0%/ 100%	Most likely negative
FWD - RUCK	0.008 [0.005 to 0.010]	23.6% / 76.4% / 0%	Likely trivial
DEF - MID	-0.079 [-0.085 to -0.072]	0% / 0%/ 100%	Most likely negative
DEF - RUCK	0.034 [0.032 to 0.036]	100% / 0%/ 0%	Most likely positive
MID - RUCK	0.113 [0.110 to 0.120]	100% / 0%/ 0%	Most likely positive

FWD: forward; DEF: defender; MID: Midfielder; RUCK: ruckman; DIFF: difference; CI: Confidence interval; +ve: positive; -ve: negative

Table 5.4: Between Position Comparisons of fixed effects for Age^2**.**

Comparison	Diff ± 95% CL	Probability of effect (+ive / trivial/ -ive)	Inference
FWD - DEF	0.0005 [0.0013]	100% / 0%/ 0%	Most likely positive
FWD - MID	0.0022 [0.0015]	100% / 0%/ 0%	Most likely positive
FWD - RUCK	-0.0004 [0.0022]	0% / 0%/ 100%	Most likely negative
DEF - MID	0.0018 [0.0013]	100% / 0%/ 0%	Most likely positive
DEF - RUCK	-0.0009 [0.0021]	0% / 0%/ 100%	Most likely negative
MID - RUCK	-0.0027 [0.0022]	0% / 0%/ 100%	Most likely negative

FWD: forward; DEF: defender; MID: Midfielder; RUCK: ruckman; DIFF: difference; CI: Confidence limit; +ve: positive; -ve: negative

This investigation is the first to examine the career performance trajectories of professional Australian Football players. The trajectories predicted a mean age of peak performance in professional Australian Football players of 24 years for forwards, 25 years for defenders, 24 years for midfielders and 27 years for ruckman. Similar ages of peak performance have been identified in professional soccer (Dendir, 2016) however, the current findings demonstrate that the peak age of performance in Australian Football is lower than the estimates of peak performance in baseball (27-29 years) (Bradbury, 2009; Fair, 2008; Schulz et al., 1994) and ice hockey (27-29 years) (Brander et al., 2014). The cause of this difference is likely multifactorial however, the difference in peak ages between team sports may be attributed to variation in the physical, technical and tactical requirements of these sports in comparison to Australian Football. Indeed, previous research has demonstrated that athletes competing in sports that are predominantly skill-based typically peak in performance later than those sports requiring high levels of athleticism (Schulz & Curnow, 1988). This finding could also be explained by the different development pathways evident in the AFL in comparison to other professional team sport leagues. Specifically, Australian Football players generally begin their professional careers at 18 years of age following recruitment via the AFL National Draft. Once drafted, AFL players are embedded within the heavily resourced training and development program of an individual club that is designed to provide the optimal environment for developing talent. This

development pathway is in contrast to many American team sport leagues where it is common to play at the college level or in minor leagues prior to debuting at the professional level. It is therefore possible that the earlier peak in performance for AFL players in comparison to baseball and ice hockey athletes may be attributed to the exposure to a high performance environment that accompanies a professional career at a younger age.

The random effects component of our mixed model allowed us to quantify the variability in age-related match performance of professional Australian Football players by playing position. We found that ruckman demonstrated the smallest variability in comparison to midfielders who displayed the largest variability in AFL Player Rank across their careers. It is possible that differences in player roles may explain these findings (McIntosh et al., 2018a). While both the ruckman and the midfield position are considered nomadic with the general aim of linking offense and defence (Gray & Jenkins, 2010), the ruck position is regarded as a specialist playing position given the unique role they play in competing for hit-outs at stoppages (McIntosh et al., 2018a). Conversely, the midfield role is more heterogeneous with players assuming a variety of sub-roles such as playing a more attacking (midfield-forward) or defensive (defensive midfielder) role for the team and thus possibly more susceptible to team specific tactics and strategy. Recent research examining player role classification in the AFL supports this finding, with a regression tree model and subsequent confusion matrix demonstrating a low classification rate for the midfield/forward position group (McIntosh et al., 2018a) confirming the dynamic nature of this role. Similarly, heterogeneity of the midfield position performance data has also been demonstrated in professional soccer (Dendir, 2016). A recent investigation examining the career trajectories of professional soccer players made comparisons between a fixed effects and a random effects model with estimated peak ages failing to match for the midfield position (Dendir, 2016). Given the random effects component of a mixed model accounts for individual variation, the authors concluded that midfield players in professional soccer may be a more heterogeneous group with greater variation in individual age-performance trajectories than the other positional groups (Dendir, 2016). Although Australian Football and soccer vary considerably in technical and tactical profiles, previous research has confirmed that the midfield position typically has greater activity demands than the other positional groups in both football codes (Coutts, Kempton, Sullivan, et al., 2014; Rampinini, Coutts, Castagna, Sassi, & Impellizzeri, 2007). Furthermore, similarities exist between the midfield roles in both soccer and Australian Football with the general aim of linking offense and defence common characteristics of this playing position between football codes. When taken together, it appears that heterogeneity in the career performance trajectories for the midfield position in the AFL may be attributed to the variety of sub–roles a midfielder may undertake during match-play. It is however, also important to interpret this finding in the context of the considerably lower sample

size used for the ruck position in comparison to the other positional groups. Nonetheless, the present results highlight the large variation in match performance for midfielders in professional Australian Football and suggest that future research should consider more diverse player roles when examining career performance trajectories of professional Australian Football players.

The present study demonstrated that age had the least effect on the match performance of ruckman compared to the other positional groups with ruckman maintaining peak performance for longer and experiencing a reduced decline in match performance in comparison to midfielders, defenders and forwards. This finding was unexpected and may be attributed to the delimitation process that resulted in a relatively low sample size for ruckman. Inclusion criteria included a minimum number of seasons with 30% of the ruck cohort failing to meet this threshold. This may suggest that survivorship bias exists for the ruck position whereby only high quality ruckman survive to play more than four seasons of Australian Football. Indeed, the role of the ruckman is highly specialised with teams generally only fielding 2-3 on the playing roster. Alternatively, differences in the career performance trajectory of ruckman in comparison to the other positional groups may be related to the higher residual variability for the ruck position found in the present study. This shows that ruckman have greater individual differences in their age-related performance decline and suggests that the AFL Player Rank metric does not entirely account for the technical and tactical complexity of the ruck position. Given the match statistics that contribute to the AFL Player Rank metric are protected by proprietary ownership, it is currently unknown if the game activities most frequently completed by ruckman – hit outs and overhead marks (Dawson, Hopkinson, Appleby, Stewart, & Roberts, 2004; McIntosh et al., 2018a) – influence the AFL Player Rank metric. Previous research using multiple regression analysis found that total disposals, effective kicks, pressure points and marks all positively contribute to the AFL Player Rank metric however, technical statistics related to the specific skills and match activities of ruckman were not examined (Sullivan et al., 2013a). The unexpected career performance curve and the higher residual variability in match performance found for the ruck position suggest that future research in the AFL should identify a measure of match performance that has the ability to account for the nuanced roles of specific position groups.

Age was shown to have the greatest influence on the career performance trajectory of the midfield position. This position group experienced the fastest rise to their peak of 24 years of age however, they also declined in match performance more rapidly than forwards, defenders and ruckman. Accordingly, for the average midfielder, the duration of peak performance was shorter when compared to the other position groups. An explanation for this finding is likely multifactorial, however the influence of age on the career trajectory of the midfield position group may be attributed to exposure to injury or the negating effects of attention given to better

quality midfield players. Although no data pertaining to the professional competition and specific to playing position is available, previous research at the community level of Australian Football has demonstrated that midfielders are significantly more likely to sustain an injury than forwards, defenders and ruckman (Braham, Finch, Mclntosh, & McCrory, 2004) potentially due to their greater involvement with the ball (Dawson et al., 2004). The shorter duration of peak performance for midfielders seen in the present study may therefore reflect the impact of cumulative injuries on playing performance and a subsequent inability to perform at peak levels. An alternative explanation for the shorter peak in performance for midfield players that the present study identified could be related to the negating effects of additional attention given to better quality midfielders. Often, a player is given the role of 'tagging' the perceived 'best' or most dangerous midfield player on the opposing team whereby the aim is to reduce their impact upon a match. Such a strategy inhibits the ability of better midfield players to interact with the ball thereby decreasing match performance metrics. Given the sample in the present study was not delimited to include quality midfield players only, this suggestion remains speculative.

A novel finding of the present study was the high induced correlation for the midfield, forward and defender positions. Such a finding indicates that the variability in the model for any subject is less than the variability in intercepts across the population suggesting that the rate at which performance increases is similar for 'elite' players and average players. More specifically, a midfielder, forward or defender who demonstrates superior match performance early in their career, is likely to continue on this career trajectory. Similarly, an average player is likely to maintain mediocre match performance across their career. Previous research examining the relationship between age and professional baseball performance found similar results whereby players were divided into performance categories based on annual batting average (Schulz et al., 1994). Players in the top third performance category consistently maintained a higher annual batting average than those in the middle and bottom performance categories. Likewise, players in the middle third performance category displayed a consistently better annual batting average than bottom third players (Schulz et al., 1994). This finding has important practical applications for talent development and player list management in the AFL however, further research is required to elucidate the individual career trajectories of more and less successful players at each position group in the AFL.

CONCLUSION

We have produced quadratic trajectories to track the career development of professional Australian Football players. This method has provided estimates of the career trajectory and the age of peak performance for each position group in the AFL using league-wide data. Our main findings were that professional Australian Football player's peak in match performance between

24 and 27 years of age. Furthermore, age appears to have the largest influence on the midfield position and the least impact on ruckman. This information may assist high performance staff embedded within Australian Football clubs in developing their players. Additionally, coaching staff may benefit from insights that could inform player list management and recruitment in the AFL.

CHAPTER SIX

GENERAL DISCUSSION

MAIN FINDINGS

Team success in the AFL is highly dependent upon selecting the best available talent and implementing an effective player development program. However, talent selection at the professional level of the sport and the factors associated with career progression in professional Australian Football players remains unclear. Therefore, a series of applied research investigations were conducted to develop a greater understanding of talent selection and career progression in the AFL (Figure 6.1).

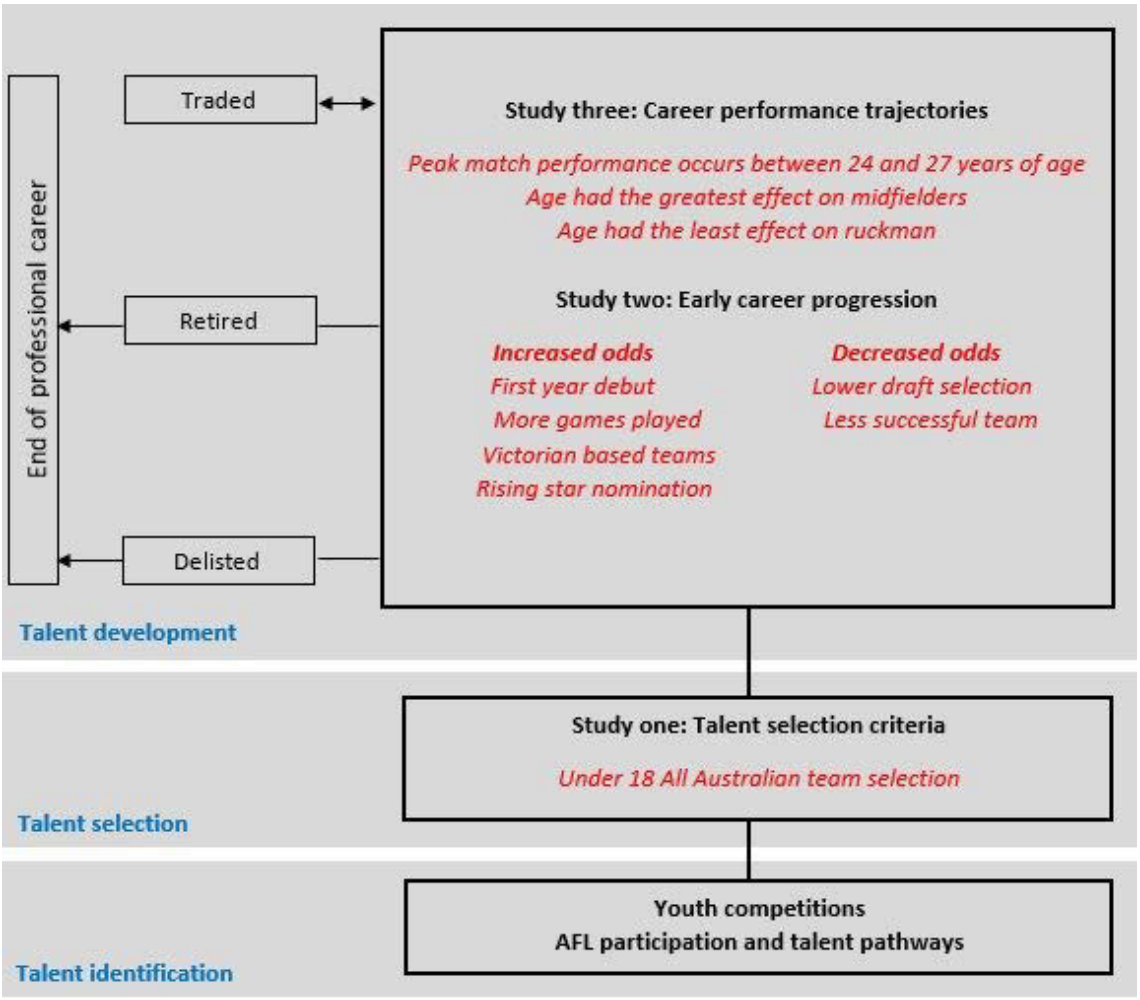

Figure 6.1: Conceptual model of career progression in the AFL. New contributions to the model provided by this thesis are shown in red.

TALENT SELECTION IN PROFESSIONAL AUSTRALIAN FOOTBALL

Talent selection is initiated at the professional level of Australian Football with the AFL National Draft where teams are given the opportunity to select players to add to their playing roster. A combination of subjective and objective approaches are used by professional

Australian Football clubs to assist in talent selection decisions with the ultimate aim to develop a successful playing roster by selecting players with the potential for success. The first study in this thesis examined the efficacy of current talent selection criteria by identifying characteristics and attributes of prospective draftees that were associated with draft order and future match performance (AFL Player Rank) in the AFL. The results of *Study One* showed that Under-18 All Australian team selection was associated with both draft order and future match performance indicating that this variable displays efficacy for selecting players with the potential for success in the AFL. In contrast, the results of *Study One* suggest that player height may be overvalued in the AFL Draft and caution the use of physical performance assessments performed at the AFL Draft Combine as talent selection criteria given these assessments failed to demonstrate a relationship with either draft order or future match performance in the AFL.

EARLY CAREER PROGRESSION IN PROFESSIONAL AUSTRALIAN FOOTBALL PLAYERS

The professional career of an Australian Football player begins with the AFL Draft however, the continuation of that career relies upon the awarding of additional playing contracts. The first playing contract received by a player drafted to the AFL for the first time is typically 2 years in duration and represents the early career progression of a professional Australian Football player. However, no studies to date have examined the factors associated with earning a second contract in the AFL. Accordingly, *Study Two* examined the factors associated with early career progression in professional Australian Football players. The main findings of *Study Two* were that early career progression in the AFL was associated with match performance and increased opportunities to play in matches. Additionally, team based characteristics also influenced early career progression with more additional contracts provided to Victorian based draftees and team success enhancing the probability of being awarded a subsequent playing contract. These results present new information regarding the most important individual and team-based characteristics associated with early career progression in professional Australian Football players.

CAREER PERFORMANCE TRAJECTORIES OF PROFESSIONAL AUSTRALIAN FOOTBALL PLAYERS

Despite research in other professional team sport leagues describing the age related changes in match performance of athletes, no studies have examined the career performance trajectories of professional Australian Football players. To investigate this, career performance trajectories were developed in *Study Three* for each playing position in the AFL using a linear mixed model approach. The results showed that professional Australian Football players peak in match performance between 24 and 27 years of age with ruckman peaking later that the other

positional groups. Furthermore, age had the greatest influence on the match performance of the midfield position and the least on ruckman. Finally, the midfield playing position demonstrated the greatest between subject variability while ruckman displayed the least variability in match performance. The results of *Study Three* highlight differences in the career performance trajectories of the different position groups in the AFL and demonstrate the influence of age on the match performance of professional Australian football players. These findings have applications for informing decisions regarding the playing roster and player development in the AFL. Using the findings from this investigation, coaching and recruitment staff can identify the progression in match performance of players and compare this to expected values thus providing a basis for salary and contract negotiations.

LIMITATIONS

There are several limitations arising from the applied nature of the research studies comprising this thesis that need to be acknowledged. Firstly, given the multidimensional nature of team sport match-play, indicators of individual performance are difficult to ascertain. The AFL Player Rank was used in the present thesis to represent individual match performance given this metric is widely used within the scientific literature. We do however acknowledge, that no information pertaining to the external validity of this measure is available or the appropriateness of the metric for all positional groups. Furthermore, no published information regarding the validity and reliability of data collection methods by the commercial statistics provider is available, and so the accuracy of the data analysed in those studies using this information has not been established. The process of talent selection and recruitment is complex therefore the authors acknowledge that talent selection is likely influenced by technical, tactical, psychological and psychosocial aspects in addition to the physical performance parameters examined in *Study One*. The small sample size for the ruck position used in *Study Three* occurred as a consequence of subject delimitation and reduced statistical power for this positional group. Another limitation of the current thesis is the designation of players into broad positional groups. This limitation is typical for many applied research studies that involve the analysis of Australian Football players by playing position. Players were differentiated by the AFL according to the position where the majority of their career was spent however, it is not uncommon for players to play in multiple positions within a match and throughout their careers. Furthermore, the broad positional groups used in the present thesis were done so to ensure adequate sample size however, a variety of sub-positions are present within modern AFL match-play that may have implications for research using a broad positional approach.

PRACTICAL APPLICATIONS

The studies contained in this thesis have provided practical recommendations regarding the talent selection and career progression of professional Australian Football players:

- Under-18 All Australian team selection is associated with both draft order and future match performance in the AFL. Therefore, AFL recruiters should continue to select players with the acclaim of Under-18 All Australian team selection with early round draft selections. Conversely, coaching and recruitment staff should place less emphasis on player height when selecting players in the AFL National Draft.

- Given physical performance assessments performed at the AFL Draft Combine didn't influence draft order or future match performance in Australian Football players, caution is required when using these performance assessments as talent selection criteria in the AFL.

- AFL clubs should aim to develop players to be ready for senior matches in their first season and perform at AFL standard for at least 8 matches in their second season (representing the average number of matches played for a second year player).

- Coaching and recruitment staff within AFL clubs should consider the influence of team success on early career progression and be aware of potential bias from poor team performance when making player contract decisions.

- The likelihood of large variations in the match performance of Australian Football players beyond the early stages of a career are low.

- Given ruckman don't peak in match performance until 27 years of age, AFL clubs should consider recruiting or acquiring via a trade, a mature age ruckman. Alternatively, coaching and performance staff should be patient in the evolution of the development of players in the ruck position.

- For clubs to maximise the development of their playing roster, the current progression in match performance of a recent draftee should be assessed relative to what is expected of that position group.

- Age has the largest influence on the match performance of midfield players. Consequently, coaching and recruitment staff of AFL clubs need to continually scout

and develop midfielders to ensure that there is an adequate replacement pool of midfield players as existing midfielders enter into the later stages of their careers.

- Career performance trajectories may be useful for negotiating player salaries and allocating monetary values to aging players in specific position groups. In addition, they may help identify players that outperform their positional expectation and who will retain some level of value into later stages of their career.

- When considering trading a player, career performance trajectories may provide a greater understanding of what can be expected relative to match performance of both the player leaving and the player joining the club within the ensuing years.

CHAPTER SEVEN

SUMMARY AND RECOMMENDATIONS

SUMMARY

Achieving the ultimate goal of team success in professional Australian Football involves selecting the best available talent and developing this talent with an effective player development program. An objective framework of talent selection and career progression is required to provide evidence for this development program, to assess program effectiveness and for supporting decisions regarding the playing roster. Previous research in the AFL has focused on talent identification and differentiating between competitive levels. This is the first thesis to examine the careers of professional Australian Football players beyond being drafted. The contribution of this thesis is a model for the talent selection and career progression of professional Australian Football players. The model provides a means for assessing some of the criteria used in current talent selection strategies in addition to a framework that can be used to assess player performance and manage the player roster. The first study examined the efficacy of physical performance assessments in selecting talent in the AFL. The second study further explored the career of professional Australian Football players beyond initial talent selection by examining the individual and team-based characteristics associated with early career progression and earning a second contract. The final study used a linear mixed model approach to identify the age of peak performance of professional Australian Football players and develop individual career performance trajectories for each positional group. A summary of the main findings from each study is presented in Table 7.1.

Table 7.1: Summary of the studies conducted as part of this thesis.

Chapter	Study title	Year span	Sample size	Variables	Findings
3	The efficacy of talent selection criteria in the Australian Football League	2003-2008	318	Draft Combine physical performance & anthropometrical assessments Non-performance based talent selection criteria AFL Draft order AFL Player Rankings (Champion Data)	Draft order was negatively associated with Under-18 All Australian team selection and height. Age was positively associated with draft order. Under-18 All Australian team selection increased both AFL Player Rank/game and Total Player Rank.
4	Factors associated with early career progression in professional Australian Football players	1999-2013	999	Draft Combine physical performance & anthropometrical assessments Individual & team based characteristics Playing contract status	Debuting in the first season, being selected earlier in the AFL Draft, playing more matches in the second season, playing for a Victorian based AFL club, earning a rising start nomination and team success increased the probability of earning a second contract in the AFL.
5	Career performance trajectories of professional Australian Football players	1999-2015	207	Playing position Age AFL Player Rankings (Champion Data)	Forwards, midfielders and defenders experienced peak match performance earlier than ruckman. Midfielders demonstrated the greatest between-subject variability in comparison to ruckman who demonstrated the least variability in AFL Player Rank throughout their careers. Age had the greatest influence on the career trajectory of midfielders and the least effect on ruckman.

DIRECTIONS FOR FUTURE RESEARCH

To expand upon the findings of this thesis, and develop a greater understanding of talent selection and career progression in professional Australian Football, it is recommended that further research investigate the following areas:

- Assessing individual performance in a team sport environment is a complex task. Although we utilised the AFL Player Rank as a measure of match performance, this metric is yet to be validated in peer-reviewed scientific research and therefore a thorough validation of metrics that determine individual Australian Rules football performance is required.

- While we have identified the relationship between Draft Combine physical performance assessments and future match performance using the AFL Player Rank, future research should examine a more comprehensive array of common talent selection criteria such as physical and technical match performance variables from under-age competitions.

- Determine the association of physical activity profiles during match-play from GPS microtechnology and technical match performance statistics (Champion Data) and early career progression (earning a second contract).

- Further investigate the "go home factor" that was identified in *Study Two* to determine if Victorian based AFL draftees who are drafted to interstate clubs are more likely to opt to return to a Victorian club after their first contract.

- The random variation in match performance between position groups identified in *Study Three* demonstrates that the factors that contribute to match performance in professional Australian Football are playing position specific. Future research should seek to develop position-specific match performance metrics. These metrics will enable career performance trajectories to be developed that are more specific to the nuanced roles of each position group.

- *Study Three* identified that significant perturbations in match performance beyond the early stages of a career are likely low, however, this requires further investigation. Specifically, individual career performance trajectories of more and less successful players at each positional group should be developed.

- Match performance in Australian Football is dependent on a combination of physical, technical and tactical skill. While we have demonstrated the influence of age on the career performance trajectories of professional Australian Football players, future research should examine the influence of age on individual player skills. For example, identifying the age at which midfield players reduce the number of clearances they perform or the number of hit-outs a ruckman accumulates within a match may assist coaching staff with game strategy.

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.

Alam, M., Carling, K., Chen, R., & Liang, Y. (2008). How to determine the progression of young skiers? *Chance, 21*(4), 13-19.

Allen, S. V., Vandenbogaerde, T. J., & Hopkins, W. G. (2014). Career performance trajectories of Olympic swimmers: Benchmarks for talent development. *European Journal of Sport Science, 14*(7), 643-651.

Australian Football League & Australian Football League Players' Association Incorporated. (2012). *Collective Bargaining Agreement*

Australian Football League. *AFL Youth Coaching Manual*. (2012). Retrieved from http://www.aflcommunityclub.com.au/fileadmin/user_upload/Coach_AFL/coaching_manual/2012_Youth_Coaching_Manual.pdf

Batterham, A. M., & Hopkins, W. G. (2006). Making meaningful inferences about magnitudes. *International Journal of Sports Physiology and Performance, 1*(1), 50-57.

Berri, D. J. (2008). A simple measure of worker productivity in the National Basketball Association. *The business of sport, 3*, 1-40.

Berri, D. J., Brook, S. L., & Fenn, A. J. (2011). From college to the pros: predicting the NBA amateur player draft. *Journal of Productivity Analysis, 35*(1), 25-35.

Berri, D. J., & Simmons, R. (2009). Race and the evaluation of signal callers in the National Football League. *Journal of Sports Economics, 10*(1), 23-43.

Berri, D. J., & Simmons, R. (2011). Catching a draft: on the process of selecting quarterbacks in the National Football League amateur draft. *Journal of Productivity Analysis, 35*(1), 37-49.

Berthelot, G., Len, S., Hellard, P., Tafflet, M., Guillaume, M., Vollmer, J.-C., . . . Toussaint, J.-F. (2012). Exponential growth combined with exponential decline explains lifetime performance evolution in individual and human species. *Age, 34*(4), 1001-1009.

Bilsborough, J. C., Kempton, T., Greenway, K., Cordy, J., & Coutts, A. J. (2016). Longitudinal changes and seasonal variation in body composition in professional Australian Football players. *International Journal of Sports Physiology & Performance*.

Boulier, B. L., Stekler, H. O., Coburn, J., & Rankins, T. (2010). Evaluating national football league draft choices: The passing game. *International Journal of Forecasting, 26*(3), 589-605.

Bradbury, J. C. (2009). Peak athletic performance and ageing: evidence from baseball. *Journal of Sports Sciences, 27*(6), 599-610.

Braham, R., Finch, C. F., Mclntosh, A., & McCrory, P. (2004). Community level Australian Football: a profile of injuries. *Journal of Science and Medicine in Sport, 7*(1), 96-105.

Brander, J. A., Egan, E. J., & Yeung, L. (2014). Estimating the effects of age on NHL player performance. *Journal of Quantitative Analysis in Sports, 10*(2), 241-259.

Bullock, N., & Hopkins, W. G. (2009). Methods for tracking athletes' competitive performance in skeleton. *Journal of Sports Sciences, 27*(9), 937-940.

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

Burgess, D., Naughton, G., & Hopkins, W. (2012). Draft-camp predictors of subsequent career success in the Australian Football League. *Journal of Science and Medicine in Sport, 15*(6), 561-567.

Castellano, J., Casamichana, D., & Lago, C. (2012). The use of match statistics that discriminate between successful and unsuccessful soccer teams. *Journal of Human Kinetics, 31*, 137-147.

Cnaan, A., Laird, N., & Slasor, P. (1997). Tutorial in biostatistics: using the general linear mixed model to analyse unbalanced repeated measures and longitudinal data. *Statistics in Medicine, 16*, 2349-2380.

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

Coleman, B. J., DuMond, J. M., & Lynch, A. K. (2008). An examination of NBA MVP voting behavior: does race matter? *Journal of Sports Economics, 9*(6), 606-627.

Coutts, A. J., Kempton, T., Sullivan, C., Bilsborough, J. C., Cordy, J., & Rampinini, E. (2014). Metabolic power and energetic costs of professional Australian Football match-play. *Journal of Science and Medicine in Sport, 18*(2), 219-224.

Coutts, A. J., Kempton, T., & Vaeyens, R. (2014). Relative age effects in Australian Football League national draftees. *Journal of Sports Sciences, 32*(7), 623-628.

Coutts, A. J., Quinn, J., Hocking, J., Castagna, C., & Rampinini, E. (2010). Match running performance in elite Australian Rules Football. *Journal of Science and Medicine in Sport, 13*(5), 543-548.

Dawson, B., Hopkinson, R., Appleby, B., Stewart, G., & Roberts, C. (2004). Player movement patterns and game activities in the Australian Football League. *Journal of Science and Medicine in Sport, 7*(3), 278-291.

Dendir, S. (2016). When do soccer players peak? A note. *Journal of Sports Analytics, 2*(2), 89-105.

Elferink-Gemser, M., Visscher, C., Lemmink, K., & Mulder, T. (2004). Relation between multidimensional performance characteristics and level of performance in talented youth field hockey players. *Journal of Sports Sciences, 22*(11-12), 1053-1063.

Fair, R. C. (2008). Estimated age effects in baseball. *Journal of Quantitative Analysis in Sports, 4*(1). doi:https://doi.org/10.2202/1559-0410.1074

Field, A., Miles, J., & Field, Z. (2012). *Discovering Statistics Using R*. London: Sage.

Fry, M. J., Lundberg, A. W., & Ohlmann, J. W. (2007). A player selection heuristic for a sports league draft. *Journal of Quantitative Analysis in Sports, 3*(2), 1-35.

Gabbett, T. J. (2014). Effects of physical, technical, and tactical factors on final ladder position in semiprofessional rugby league. *International Journal of Sports Physiology and Performance, 9*(4).

Gagné, F. (1993). Constructs and models pertaining to exceptional human abilities.

Gaudion, S., Doma, K., Sinclair, W., Banyard, H., & Woods, C. (2017). Identifying the physical fitness, anthropometric and athletic movement qualities discriminant of developmental level in elite junior Australian football: Implications for the development of talent. *The Journal of Strength and Conditioning Research, 31*(7), 1830-1839.

Gius, M., & Johnson, D. (2000). Race and compensation in professional football. *Applied Economics Letters, 7*(2), 73-75.

Gray, A. J., & Jenkins, D. G. (2010). Match analysis and the physiological demands of Australian Football. *Sports Medicine, 40*(4), 347-360.

Güllich, A., Hardy, L., Kuncheva, L., Laing, S., Barlow, M., Evans, L., . . . Warr, C. (2019). Developmental biographies of Olympic Super-Elite and Elite athletes–a multidisciplinary pattern recognition analysis. *Journal of Expertise, 2*(1), 23-46.

Heasman, J., Dawson, B., Berry, J., & Stewart, G. (2008). Development and validation of a player impact ranking system in Australian football. *International Journal of Performance Analysis in Sport, 8*(3), 156-171.

Hendricks, W., DeBrock, L., & Koenker, R. (2003). Uncertainty, hiring, and subsequent performance: The NFL draft. *Journal of Labor Economics, 21*(4), 857-886.

Hollings, S. C., Hopkins, W. G., & Hume, P. A. (2012). Environmental and venue-related factors affecting the performance of elite male track athletes. *European Journal of Sport Science, 12*(3), 201-206.

Hopkins, W. G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise, 41*(1), 3-13.

Hosmer, D. W., & Lemeshow, S. (1989). Applied regression analysis. *New York, John Willey*.

Kempton, T., Sullivan, C., Bilsborough, J. C., Cordy, J., & Coutts, A. J. (2015). Match-to-match variation in physical activity and technical skill measures in professional Australian Football. *Journal of Science and Medicine in Sport*.

Keogh, J. (1999). The use of physical fitness scores and anthropometric data to predict selection in an elite under 18 Australian rules football team. *Journal of Science and Medicine in Sport, 2*(2), 125-133.

Kuzmits, F. E., & Adams, A. J. (2008). The NFL combine: does it predict performance in the National Football League? *The Journal of Strength and Conditioning Research, 22*(6), 1721-1727.

Kwok, O.-M., Underhill, A. T., Berry, J. W., Luo, W., Elliott, T. R., & Yoon, M. (2008). Analyzing longitudinal data with multilevel models: An example with individuals living with lower extremity intra-articular fractures. *Rehabilitation Psychology, 53*(3), 370.

Lazic, S. E. (2010). The problem of pseudoreplication in neuroscientific studies: is it affecting your analysis? *BMC Neuroscience, 11*(1), 5.

MacMahon, C., Bailey, A., Croser, M., & Weissensteiner, J. (2019). Exploring the skill of recruiting in the Australian Football League. *International Journal of Sports Science & Coaching, 14*(1), 72-81.

Malcata, R., Hopkins, W., & Pearson, S. (2014). Tracking career performance of successful triathletes. *Medicine and Science in Sports and Exercise, 46*(6), 1227-1234.

Matthews, J., Altman, D. G., Campbell, M., & Royston, P. (1990). Analysis of serial measurements in medical research. *British Journal of Sports Medicine, 300*(6719), 230-235.

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.

McIntosh, S., Kovalchik, S., & Robertson, S. (2018a). Examination of player role in the Australian Football League using match performance data. *International Journal of Performance Analysis in Sport, 18*(3), 451-462.

McIntosh, S., Kovalchik, S., & Robertson, S. (2018b). Validation of the Australian Football League Player Ratings. *International Journal of Sports Science and Coaching*, 1747954118758000.

Menard, S. (2002). *Applied logistic regression analysis* (2nd ed.). Thousand Oaks, California: Sage Publications, Inc.

Mitchell, H., Stavros, C., & Stewart, M. F. (2011). Does the Australian Football League draft undervalue indigenous Australian footballers? *Journal of Sports Economics, 12*(1), 36-54.

Mooney, M., O'Brien, B., Cormack, S., Coutts, A. J., Berry, J., & Young, W. (2011). The relationship between physical capacity and match performance in elite Australian football: A mediation approach. *Journal of Science and Medicine in Sport, 14*(5), 447-452.

Mulholland, J., & Jensen, S. T. (2014). Predicting the draft and career success of tight ends in the National Football League. *Journal of Quantitative Analysis in Sports, 10*(4), 381-396.

Noblet, A., Rodwell, J., & McWilliams, J. (2003). Predictors of the strain experienced by professional Australian footballers. *Journal of Applied Sport Psychology, 15*(2), 184-193.

O'Shaughnessy, D. (2006). Possession versus position: strategic evaluation in AFL. *Journal of Sports Science and Medicine, 5*, 533-540.

Pike, J., Hopkins, W., & Nottle, C. (2010). *Overall trends and individual trajectories of swimming performances in a decade of New Zealand national championships.* Paper presented at the XIth International Symposium on Biomechanics and Medicine in Swimming, Oslo (Norway).

Pyne, D., Gardner, A., Sheehan, K., & Hopkins, W. (2005). Fitness testing and career progression in AFL football. *Journal of Science and Medicine in Sport, 8*(3), 321-332.

R Core Team. (2015). R: A language and environment for statistical computing: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/

Rampinini, E., Coutts, A. J., Castagna, C., Sassi, R., & Impellizzeri, F. M. (2007). Variation in top level soccer match performance. *International Journal of Sports Medicine, 28*(12), 1018-1024.

Robertson, S., Back, N., & Bartlett, J. D. (2016). Explaining match outcome in elite Australian Rules football using team performance indicators. *Journal of Sports Sciences, 34*(7), 637-644.

Robertson, S., Gupta, R., & McIntosh, S. (2016). A method to assess the influence of individual player performance distribution on match outcome in team sports. *Journal of Sports Sciences, 34*(19), 1893-1900.

Robertson, S., Woods, C., & Gastin, P. (2014). Predicting higher selection in elite junior Australian Rules football: The influence of physical performance and anthropometric attributes. *Journal of Science and Medicine in Sport, 18*(5), 601-606.

Rogalski, B., Dawson, B., Heasman, J., & Gabbett, T. J. (2013). Training and game loads and injury risk in elite Australian footballers. *Journal of Science and Medicine in Sport, 16*(6), 499-503.

Schulz, R., & Curnow, C. (1988). Peak performance and age among superathletes: track and field, swimming, baseball, tennis, and golf. *Journal of Gerontology, 43*(5), 113-120.

Schulz, R., Musa, D., Staszewski, J., & Siegler, R. S. (1994). The relationship between age and major league baseball performance: implications for development. *Psychology and Aging, 9*(2), 274.

Sierer, S. P., Battaglini, C. L., Mihalik, J. P., Shields, E. W., & Tomasini, N. T. (2008). The National Football League Combine: performance differences between drafted and nondrafted players entering the 2004 and 2005 drafts. *The Journal of Strength and Conditioning Research, 22*(1), 6-12.

Staw, B. M., & Hoang, H. (1995). Sunk costs in the NBA: Why draft order affects playing time and survival in professional basketball. *Administrative Science Quarterly*, 474-494.

Stewart, M., Mitchell, H., & Stavros, C. (2007). Moneyball applied: Econometrics and the identification and recruitment of elite Australian footballers. *International Journal of Sport Finance, 2*, 231-248.

Sullivan, C., Bilsborough, J. C., Cianciosi, M., Hocking, J., Cordy, J., & Coutts, A. J. (2013a). Factors affecting match performance in professional Australian Football. *International Journal of Sports Physiology and Performance, 9*(3), 561-566.

Sullivan, C., Bilsborough, J. C., Cianciosi, M., Hocking, J., Cordy, J., & Coutts, A. J. (2013b). Match score affects activity profile and skill performance in professional Australian Football players. *Journal of Science and Medicine in Sport, 17*(3), 326-331.

Sullivan, C., Kempton, T., Ward, P., & Coutts, A. J. (2018). Factors associated with early career progression in professional Australian Football. *Journal of Sports Sciences, 36*(19), 2196-2201.

Tang, M.-C. (2015). Contract length, expected surplus, and specific investments empirical evidence from the National Football League. *Journal of Sports Economics, 16*(3), 295-311.

Teramoto, M., Cross, C. L., Rieger, R. H., Maak, T. G., & Willick, S. E. (2017). Predictive validity of National Basketball Association draft combine on future performance. *The Journal of Strength and Conditioning Research, 32*(2), 396-408.

Teramoto, M., Cross, C. L., & Willick, S. E. (2016). Predictive value of National Football League scouting combine on future performance of running backs and wide receivers. *The Journal of Strength and Conditioning Research, 30*(5), 1379-1390.

Till, K., Cobley, S., O'Hara, J., Morley, D., 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.

Tribolet, R., Bennett, K. J., Watsford, M. L., & Fransen, J. (2018). A multidimensional approach to talent identification and selection in high-level youth Australian Football players. *Journal of Sports Sciences*, 1-7.

Vaeyens, R., Lenoir, M., Williams, A. M., & Philippaerts, R. M. (2008). Talent identification and development programmes in sport : current models and future directions. *Sports Medicine, 38*(9), 703-714.

Vaeyens, R., Malina, R. M., Janssens, M., Van Renterghem, B., Bourgois, J., Vrijens, J., & Philippaerts, R. M. (2006). A multidisciplinary selection model for youth soccer: the Ghent Youth Soccer Project. *British Journal of Sports Medicine, 40*(11), 928-934.

Vaeyens, R., Philippaerts, R., & Malina, R. (2005). The relative age effect in soccer: A match-related perspective. *Journal of Sports Sciences, 23*(7), 747-756.

Veale, J. P., Pearce, A. J., Koehn, S., & Carlson, J. S. (2008). Performance and anthropometric characteristics of prospective elite junior Australian footballers: A case study in one junior team. *Journal of Science and Medicine in Sport, 11*(2), 227-230.

Wakim, A., & Jin, J. (2014). Functional data analysis of aging curves in sports. *arXiv preprint arXiv:1403.7548*.

West, B. T., Welch, K. B., & Galecki, A. T. (2014). *Linear mixed models: a practical guide using statistical software* (2nd ed.). Broken Sound Parkway, NW: CRC Press.

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

Wisbey, B., Montgomery, P. G., Pyne, D. B., & Rattray, B. (2010a). Quantifying movement demands of AFL football using GPS tracking. *Journal of Science and Medicine in Sport, 13*(5), 531-536. doi:10.1016/j.jsams.2009.09.002

Wisbey, B., Montgomery, P. G., Pyne, D. B., & Rattray, B. (2010b). Quantifying movement demands of AFL football using GPS tracking. *Journal of Science and Medicine in Sport, 13*(5), 531-536.

Woods, C., Banyard, H., McKeown, I., Fransen, J., & Robertson, S. (2016). Discriminating talent identified junior Australian footballers using a fundamental gross athletic movement assessment. *Journal of Sports Science and Medicine, 15*(3), 548.

Woods, C., Cripps, A., Hopper, L., & Joyce, C. (2017). A comparison of the physical and anthropometric qualities explanatory of talent in the elite junior Australian football development pathway. *Journal of Science and Medicine in Sport, 20*(7), 684-688.

Woods, C., Joyce, C., & Robertson, S. (2015). What are talent scouts actually identifying? Investigating the physical and technical skill match activity profiles of drafted and non-

drafted U18 Australian footballers. *Journal of Science and Medicine in Sport, 19*(5), 419-423.

Woods, C., Raynor, A., Bruce, L., & McDonald, Z. (2015). The use of skill tests to predict status in junior Australian football. *Journal of Sports Sciences, 33*(11), 1132-1140.

Woods, C., Raynor, A. J., Bruce, L., & McDonald, Z. (2016). Discriminating talent-identified junior Australian football players using a video decision-making task. *Journal of Sports Sciences, 34*(4), 342-347.

Woods, C., Raynor, A. J., Bruce, L., McDonald, Z., & Collier, N. (2015). Predicting playing status in junior Australian Football using physical and anthropometric parameters. *Journal of Science and Medicine in Sport, 18*(2), 225-229.

Woods, C., Raynor, A. J., Bruce, L., McDonald, Z., & Robertson, S. (2016). The application of a multi-dimensional assessment approach to talent identification in Australian football. *Journal of Sports Sciences, 34*(14), 1340-1345.

Woods, C., Veale, J., Collier, N., & Robertson, S. (2016). The use of player physical and technical skill match activity profiles to predict position in the Australian Football League draft. *Journal of Sports Sciences, 35*(4), 325-330.

Young, B. W., & Starkes, J. L. (2005). Career-span analyses of track performance: longitudinal data present a more optimistic view of age-related performance decline. *Experimental Aging Research, 31*(1), 69-90.

Young, W. B., Newton, R. U., Doyle, T. L., Chapman, D., Cormack, S., Stewart, G., & Dawson, B. (2005). Physiological and anthropometric characteristics of starters and non-starters and playing positions in elite Australian Rules Football: a case study. *Journal of Science and Medicine in Sport, 8*(3), 333-345.

Young, W. B., & Pryor, L. (2007). Relationship between pre-season anthropometric and fitness measures and indicators of playing performance in elite junior Australian Rules football. *Journal of Science and Medicine in Sport, 10*(2), 110-118.

APPENDICES

APPENDIX A: UNIVERSITY ETHICS APPROVAL

Dear Applicant,

The Faculty has considered your Nil/Negligible Risk Declaration Form for your project titled, "Career modelling in professional Australian Football", and agree your research does not require review from the UTS Human Research Ethics Committee. Please keep a copy of your Declaration form on file to show you have considered risk.

For tracking purposes, you have been provided with an ethics application number, which is UTS HREC 2014000232.

I also refer you to the AVCC guidelines relating to the storage of data, which require that data be kept for a minimum of 5 years after publication of research. However, in NSW, longer retention requirements are required for research on human subjects with potential long-term effects, research with long-term environmental effects, or research considered of national or international significance, importance, or controversy. If the data from this research project falls into one of these categories, contact University Records for advice on long-term retention.

You should consider this your official letter of noting.

If you or anyone connected with this research have any queries please do not hesitate to contact Research.Ethics@uts.edu.au

Yours sincerely,
Professor Marion Haas
Chairperson
UTS Human Research Ethics Committee
C/- Research & Innovation Office
University of Technology, Sydney