

2015

The development of an objective multi-dimensional approach to talent identification in junior Australian football

Carl T C Woods
Edith Cowan University

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**The development of an objective multi-dimensional approach to talent
identification in junior Australian football**

Carl Thomas Eddington Woods

B. App. Sci. (Human Movement) (Hons) (University of South Australia)



A thesis submitted for the degree of Doctor of Philosophy (Sports Science) at the
School of Exercise and Health Sciences, Edith Cowan University, Western Australia,
Australia

16th April 2015

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GLOSSARY AND ABBREVIATED TERMINOLOGY

AF	Australian Football
AFHB	Australian Football Handballing
AFK	Australian Football Kicking
AFL	Australian Football League
AIC	Akaike Information Criterion
ANOVA	Analysis of Variance
au	Arbitrary Unit
AUC	Area Under the Curve
df	Degrees of Freedom
DMGT	Differentiated Model of Giftedness and Talent
DVJ	Dynamic Vertical Jump
DVJDL	Dynamic Vertical Jump Dominant Leg
DVJNDL	Dynamic Vertical Jump Non-dominant Leg
ICC	Intra-class Correlation Coefficient
MANOVA	Multivariate Analysis of Variance
MSFT	Multistage Fitness Test
RAE	Relative Age Effect
ROC	Receiver Operating Curve
SVJ	Stationary Vertical Jump
TID	Talent Identification
U18	Under 18
WAFL	West Australian Football League
w_i	Akaike Weight

THESIS SUMMARY

Talent identification (TID) is a pertinent component of the sports science discipline given the considerable influence it may have within the pursuit of excellence. Thus, research has attempted to identify the determinants of a talented performance through the use of objective testing procedures. However, many of these ‘traditional’ approaches have been operationalised by mono-dimensional objective physical performance tests that do not inherently account for the multi-dimensional requisites of game-play, particularly within a team sporting context. This is problematic when attempting to identify talent, as a successful performance in team sports is often the combination of physical, technical and tactical elements. For example, a physically inferior junior may still succeed against their physically superior counterparts given additional technical and tactical skills; commonly referred to as a *compensation phenomenon*. Hence, forecasting longitudinal performance based upon one element of effective play (e.g. physical) will likely lead to an unsubstantiated and biased identification.

Despite the aforementioned, TID practices in junior Australian football (AF) are predominately facilitated by physically biased objective performance tests. Given the combative nature of game-play, physicality is an important attribute, but solely basing identification and selection on isolated physical attributes can be misleading given the previously mentioned *compensation phenomenon*. This mono-dimensionality is somewhat expected as to date there is a scarcity of objective tests measuring the multi-dimensional characteristics of AF game-play. Thus, through the consolidation of a number of theoretical concepts and recommendations proposed within the literature, this

thesis aimed to develop a multi-dimensional objective approach to TID in junior AF, and in doing so, identify the determinants of a talented performance.

To address this aim, objective physical, technical and tactical measurements were taken on both talent identified and non-talent identified junior AF players through the use of representative performance tests. Indeed, this reflected the first stage of the *Expert Performance Approach* (Ericsson & Williams, 1991; Williams & Ericsson, 2005) and the *Model of a Skilful Player* (Lauder, 2001). Throughout each research study, talent identified players were defined through participation within the West Australian Football League (WAFL) State Under 18 (U18) Academy (an elite talent development program), whilst non-talent identified players were randomly chosen from the remaining cohort of WAFL U18 players not participating in the State Academy program. Thus, a cross-sectional observational research design was employed for each experimental procedure used throughout this thesis. It is of note that the first three studies utilised players from the 2013 sample, whilst the fourth research study utilised players from the 2014 sample.

In the first of four research studies, a range of sport specific physical characteristics were found to differ between talent identified and non-talent identified junior AF players. However, a binary logistic regression model indicated that it was the measurements of standing height, lower body power and maximal aerobic capacity that provided the greatest prediction of talent, and thus important physical determinants of talent in AF at an U18 level.

The second study investigated if measurements of technical skill could be used to accurately identify talent in junior AF. Despite the range of technical skills required in AF, the two modes of ball disposal (kicking and handballing) have been deemed

critical for success based upon recent research (Parrington, Ball, MacMahon, 2013; Sullivan et al., 2014). Consequently, two representative skill tests were described; the Australian Football Kicking (AFK) test and the Australian Football Handballing (AFHB) test. Results indicated that the majority of the talent identified players possessed superior ball disposal skills in comparison to their non-talent identified counterparts. Specifically, measures of accuracy and ball speed on both the dominant and non-dominant sides reflected the strongest prediction of talent for the AFK test, and measures of accuracy on both dominant and non-dominant sides reflected the strongest prediction of talent for the AFHB test. These results reinforced the construct of each test, and highlighted their effectiveness for use as an objective TID tool in AF.

Research had yet to investigate if decision-making skill was predictive of talent in junior AF despite its suggested importance for the exhibition of an expert performance in the game. The third study in this research series attempted to fill this remaining gap and objectively quantify decision-making skill through the use of a video-based decision-making task. In order to construct such a task, video footage was obtained from the Australian Football League (AFL) using an aerial behind-the-goal camera perspective. Through the use of an expert coaching panel, 26 clips out of an initial sample of 52 were deemed applicable, as each consisted of approximately three to five possible decision-making options. Results indicated that the talent identified players performed the task more accurately in comparison to their non-talent identified counterparts, and was thus a valuable objective tool for identifying talent at an U18 level.

The fourth and final study in this research series investigated if the application of a multi-dimensional battery of objective performance tests provided more accurate TID in AF when compared to isolated performance measures. The construction of this

test battery was informed by the results of studies one, two and three, but to ensure the translation of this test battery, it was applied to the 2014 U18 cohort, not the 2013 cohort which was done in the previous studies. However, the definition of talent identified and non-talent identified remained consistent with the previous studies. Results indicated that the majority of the talent identified players possessed a superior combination of physical, technical and tactical characteristics in comparison to their non-talent identified counterparts. Specifically, a receiver operating curve indicated a classification accuracy of 95% when summing the total scores obtained for each physical, technical and tactical test. This classification accuracy supports the implementation of multi-dimensional objective designs over the traditional mono-dimensional designs when attempting to identify talent in team sporting contexts.

This thesis was motivated by the need to enhance the accuracy and reliability of current TID practices in AF by developing an objective multi-dimensional approach. In doing so, it contributes an important body of research to the study of TID by providing a conceptually translatable means in which the development of such an approach can be undertaken in other team sports.

LIST OF PUBLICATIONS AND PRESENTATIONS

Publications forming part of this thesis

Chapter Three

Woods, C. T., 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*, 9, 225-229.

Chapter Four

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

Chapter Five

Woods, C. T., Raynor, A. J., Bruce, L., & McDonald, Z. (2015). Discriminating talent identified junior Australian football players using a video decision-making task. *Journal of Sports Sciences*, (in-press), doi: 10.1080/02640414.2015.1053512.

Chapter Six

Woods, C. T., Raynor, A. J., Bruce, L., McDonald, Z., & Robertson, S. (2015). The application of a multi-dimensional battery of objective performance tests to identify talent in junior Australian football. *Journal of Sports Sciences: Science and Medicine in Football* (under-review).

Scientific conference presentations related to this thesis

Woods, C. T., Raynor, A. J., Bruce, L., McDonald, Z. (2014). *Technical skill testing predicts status in junior Australian Football*. Poster presented at the 6th Exercise and Sports Science Australia (ESSA) Conference, Adelaide, Australia.

Industry presentations

Woods, C. T. (2013) *Talent Identification in Junior Australian Football: current practice and corresponding limitations*. Presented to the High Performance Department at the West Australian Football Commission, Perth, Australia.

Woods, C. T. (2014) *Talent Identification in Junior Australian Football: the common pitfalls leading to the construction of a multi-dimensional approach*. Presented at the University of Notre Dame School of Exercise and Health Sciences Research Seminar Series, Perth, Australia.

Woods, C. T. (2014) *Physical Preparation of Youth Australian Footballers*. Presented at the Level Two AFL Coaching Accreditation Course, Perth, Australia.

Woods, C. T. (2014) *Physical Preparation of Senior Australian Footballers*. Presented at the Level Two AFL Coaching Accreditation Course, Perth, Australia.

Additional publications relevant to, but not forming part of, this thesis

McKeown, I., Taylor-McKeown, K., **Woods, C. T.,** & Ball, N. (2014). Athletic ability assessment: a movement assessment protocol for athletes. *International Journal of Sports Physical Therapy*, 9, 862.

Robertson, S. J., **Woods, C. T.,** & Gustin, P. B. (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*, (in-press), doi: 10.1016/j.jsams.2014.07.019.

Woods, C. T., Joyce, C., & Robertson, S. J. (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*, (in-press), doi: 10.1016/j.jsams.2015.04.013.

SIGNED DECLARATION

I declare that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university of higher education, and that to the best of my knowledge it does not contain any materials previously published or written by another person except where due reference is made in the text.

Date: 23/07/2015

Carl Thomas Eddington Woods

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CHAPTER ONE: Introduction

1.1 Introduction

Expertise in sport is highly prized, but its attainment is time and resource consuming. As such, methods for which its acquisition could be accelerated would be of considerable interest to athletes, coaches, officials, and administrators. Echoing this statement, National sporting bodies, such as the Australian Institute of Sport, are prioritising the identification of juniors who possess performance qualities likely to develop into exceptional performance characteristics in elite senior competitions (Kozel, 1996; Régnier, Salmela, & Russell, 1993; Vaeyens, Güllich, Warr, & Philippaerts, 2009). Thus, talent identification (TID); defined as the recognition of current individuals who possess the potential for excellence (Williams & Reilly, 2000), is a pertinent component of the sports science discipline. Nevertheless, TID is a complex practice, requiring both a profound understanding of the ‘gift-to-talent’ development process, and the sport specific requisites to allow the establishment of objective representative performance tests (Breitbach, Tug, & Simon, 2014; Burgess & Naughton, 2010; Pearson, Naughton, & Torode, 2006; Vaeyens, Lenoir, Williams, & Philippaerts, 2008).

Since originating in the mid 1800’s, Australian football (AF) has evolved from a state league competition (Victorian Football League) into a nationally recognised sporting competition, the Australian Football League (AFL). Stemming from this, the game has developed into a highly diverse team invasion sport, combining a unique physical profile with an intricate display of technical and tactical skill (Dawson, Hopkinson, Appleby, Stewart, & Roberts, 2004; Gray & Jenkins, 2010). It is played on an oval field, with the dimensions of each field ranging between 130 to 150 m by 150 to 190 m. A game consists of four quarters, being separated by two five minute quarter intervals and a 15 minute half-time interval. Consequently, the game times range from

100 to 120 minutes. At any stage throughout a game there are 18 players from each team on the field, with both teams having three players on the bench available for rotation, and one player available for permanent substitution. Thus, 22 players (inclusive of a substitutable player) are selected to play each game. Within the AFL, a recently imposed rotation cap has limited each team to a maximum of 120 rotations per game. Although specific field positions exist; namely 'forward', 'defender', and 'midfielder', players are able to move freely across the field during game-play.

Given its popularity amongst the Australian public, AF has seen a progressive increase in junior participation rates, with over 180,000 registered participants within junior competitions (i.e. 'Auskick[®]') in 2015 (AFL Auskick[®], 2015). Such vast participation has driven the establishment of effective development programs designed to nurture prospective talent. This 'grass roots' approach to development is underpinned by the desire for AFL teams' to win an AFL Premiership (performance pinnacle). As illustrated in Figure 1, talent identified juniors are invited to participate in elite talent development programs (referred to as State Academies), where they are exposed to expert coaching and scientific intervention designed to accelerate the acquisition of skills required for success in elite senior competitions. Within the 2014 West Australian Football League (WAFL) season, there were approximately 370 Under 18 (U18) listed players. However, owing to external constraints (financial and resource), only 35 places were available on the U18 State Academy. Given this competition for places, it is imperative that the talented juniors most likely to attain excellence (i.e. play within the AFL) are identified.

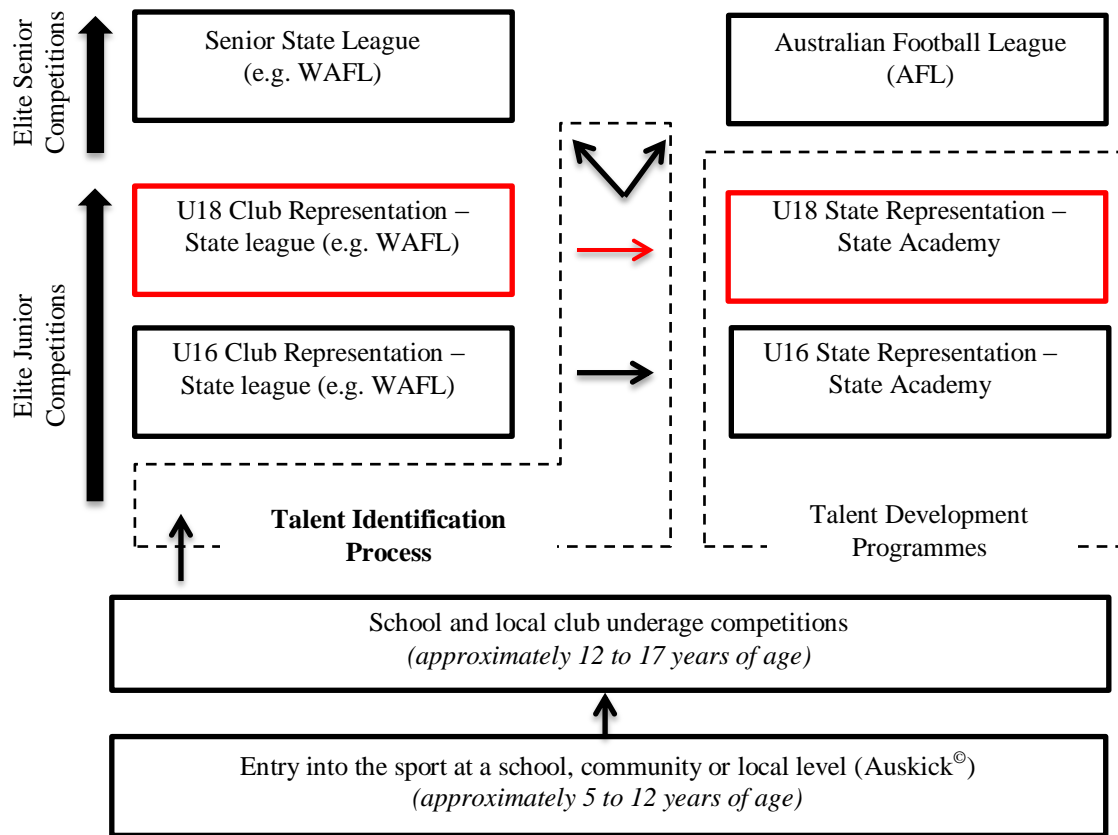


Figure 1. The common talent identification and development pathway in AF

Acknowledging the importance of TID in the attainment of sporting excellence, a wealth of research has attempted to uncover the determinants of a talented performance (e.g. Hoare, 2000; Holway & Guerici, 2012; Keogh, 1999; Kevin et al., 2011; McLaughlin, Howley, Bassett, Thompson, & Fitzhugh, 2010; Mohamed et al., 2009; Nieuwenhuis, Spamer, & Van Rossum, 2002). However, in cogent commentaries, both MacNamara and Collins (2011) and Vaeyens et al. (2009) were critical of these ‘traditional’ TID programs; citing a number of limitations hindering their identification accuracy. Specifically, MacNamara and Collins (2011) noted that the majority of TID programs discount the dynamic talent development process by attempting to identify talent in pre-pubescent populations through the use of cross-sectional designs. Thus, accurately forecasting prospective performance would appear difficult given the highly dynamic development process pre-pubescent individuals will likely encounter.

The early identification of talent (e.g. identification between 6 to 15 years of age) is thought to enable the provision of long-term athlete development programs presumed to translate into sporting excellence in senior competitions (Güllich & Emrich, 2006). However when conducted using cross-sectional designs, this practice may lack scientific rationale by inferring that early identification is positively associated with longitudinal success, and expertise acquisition is monotonically proportionate to the volume and type of practice (Güllich & Emrich, 2006; Güllich & Emrich, 2012). In part, these inferences may be based upon the domain-specific *Deliberate Practice Theory* (Ericsson, Krampe, & Tesch-Römer, 1993), which proposes that the attainment of excellence may simply be monotonically proportionate to the number of accumulated deliberate practice hours (e.g. 10 year or 10,000 hour rule) (Ericsson, 1996; 2004; Ford, Ward, Hodges, & Williams, 2009; Helson, Hodges, Van Winckel, & Starkes, 2000; Helson, Starkes, & Hodges, 1998; Hodge & Deakin, 1998; Ward, Hodges, Starkes, & Williams, 2007).

However, the *Deliberate Practice Theory* may not align with the multi-dimensional manner in which talent is thought to be developed from its initial gifted state within the sporting domain (Gulbin, Weissensteiner, Oldenziel, & Gagné, 2013). Specifically, Gagné (1993) proposed that both genetic and environmental factors are influential in the talent development process in the *Differentiated Model of Giftedness and Talent* (DMGT). This model demonstrates that three dynamic catalysts, namely intrapersonal, environmental and chance, either advantageously or disadvantageously influence the gift-to-talent developmental process, and thus the overall pursuit of excellence (Tranckle & Cushion, 2006). Although the recognition of chance in this model complicates the prediction of longitudinal performance, acknowledging that all developmental components are subject to chance warrants a multi-dimensional

approach to the examination of talent. Moreover, given that the diverse contextual requirements of certain sports lend themselves to a potential positive skill transfer (i.e. transferring certain skills from one sport to another) (for example, see Bullock et al., 2009), the aforementioned *Deliberate Practice Theory* may not comprehensively fit here. As such, it is unsurprising to note the wealth of literature contesting this theory and its role in the attainment of excellence in a team sporting context (for examples, see Abernethy, Baker & Côté, 2005; Baker, Côté, & Abernethy, 2003a; 2003b; Baker, Côté, & Deakin, 2005; Berry, Abernethy, & Côté, 2008).

An alternative developmental model for the attainment of expertise in sport is the *Developmental Model of Sport Participation* (Baker et al., 2003a; 2003b; Côté, 1999; Côté & Hay, 2002). This model is broken into three general stages of participation; namely the sampling years (6 to 12 years of age), the specialising years (13 to 15 years of age) and the investment years (approximately > 16 years of age); with each stage being defined by a unique type of sporting participation. The sampling years are characterised by the acquisition of fundamental skills through a holistic sporting activity involvement; the specialising years see an increased focus on the deliberate practice in one or two sport(s); and the investment years are characterised through an increased volume of sport specific deliberate practice. Since the establishment of this model, there has been growing support toward its applicability for expertise acquisition in team sports (Berry et al., 2008; Bruce, Farrow, & Raynor, 2012a; Soberlak & Côté, 2003). Specifically, Bruce et al. (2012a) demonstrated the importance of a broad sporting involvement during the sampling and specialising years; noting that expert netball players invested a greater number of hours within sports external to netball during these years when compared to their non-expert counterparts. It was concluded that this diversity assisted with the acquisition of fundamental motor skills that

underpinned the sport specific skills needed to elicit an expert performance in netball. Although investigating the developmental pathway was not integral to this thesis, understanding the talent development process is important when determining the most appropriate age in which to attempt TID.

To allow the objective measurement of the key performance characteristics, it is critical to understand the multi-dimensional requisites of the sport in which a TID program is to be applied (Vaeyens et al., 2008). As demonstrated by Launder (2001) in the *Model of a Skilful Player*, a skilful performance in team sport is attributed to a range of physical, technical and tactical elements. However, despite some exceptions (for examples, see Gabbett, Georgieff, & Domrow, 2007; Gabbett, Jenkins, & Abernethy, 2011; Reilly, Williams, Nevill, & Franks, 2000; Vaeyens et al., 2006) this multi-dimensionality is not often accounted for in TID programs. Notably, logistical, financial and operational constraints have led to the use of physically biased performance tests as identifiers of prospective talent (MacNamara & Collins, 2011). Such mono-dimensional operationalisation is likely to result in talent wastage; diminishing the accuracy of TID strategies (Abbott, Button, Pepping, & Collins, 2005; 2013; Davids, Button, & Bennett, 2008; Phillips, Davids, Renshaw, & Portus, 2010; Pinder, Renshaw, & Davids, 2013). Moreover, the multi-dimensionality of many team sports often dictates that a disadvantageous performance quality may be compensated for by an advantageous performance in another; with this unequal performance weighting being referred to as a *compensation phenomenon* (Bartmus, Neumann, & de Marées, 1987; Tranckle & Cushion, 2006).

Currently, talented junior AF players are identified through the subjective observation of in-game performance (e.g. a talent recruiter observing the performance of players in game-play) (Burgess, Naughton, & Hopkins, 2012a). This method of

identification infers firstly that talent recruiters possess the expertise needed to subjectively forecast performance potential. However, subjective assessments may be largely unreliable, as differing perceptions of what constitutes a talented performance may lead to conflicting opinions, and thus, unsubstantiated identification (Meylan, Cronin, Oliver, & Hughes, 2010; Williams & Reilly, 2000). Secondly, subjective assessments infer that a talented performance in junior competitions is positively associated to that of a talented performance within elite senior competitions (Meylan et al., 2010). This is rarely the case in team sports, as increased contextual requirements (physical, technical and tactical) in senior competitions are likely to result in performance discrepancies compared with junior competitions (Bradley, Sheldon, Wooster, Olsen, & Krstrup, 2009; Burgess, Naughton, & Norton, 2012b).

Objective performance testing is currently used for TID in AF, and whilst providing a more reliable means of identification, the common performance tests reported are mono-dimensional (physically biased) (Keogh, 1999, Pyne, Gardener, Sheehan, & Hopkins, 2005; Veale, Pearce, Koehn, & Carlson, 2008). As AF is by nature combative, physicality is an important characteristic. However, basing identification and selection solely on isolated physical attributes such as maximal aerobic capacity (Veale, Pearce, & Carlson, 2010) and vertical jump height (Veale et al., 2008) can be misleading given the *compensation phenomenon* referred to above (Lidor, Côté, & Hackfort, 2009; Vaeyens et al., 2008; Woods, Raynor, Bruce, McDonald & Collier, 2015). Nevertheless, this mono-dimensionality can be expected as to date there are no representative tests designed to objectively measure technical and tactical skill specific to AF within the literature. In part, this may further increase the reliance placed upon subjective in-game observation as the primary means of TID in AF.

1.2 Thesis Aims and Research Questions

The current methods of TID in AF are a mixture of subjective practice (i.e. coach or talent scout perception) and objective mono-dimensional performance testing. The objective tests proposed in the literature for use in the TID process are physically biased, and do not measure the additional multi-dimensional (i.e. technical and tactical) elements that contribute to a successful performance (Lauder, 2001). Despite being proposed in junior soccer (Reilly et al., 2000; Vaeyens et al., 2006), rugby league (Gabbett et al., 2011) and volleyball (Gabbett et al., 2007), an objective multi-dimensional approach to TID in junior AF is yet to be investigated.

This thesis aims to develop a multi-dimensional objective approach to TID in AF by investigating a range of performance testing procedures. In doing so, it intends to enhance the accuracy of TID through the establishment of a multi-dimensional battery of performance tests. It is hypothesised that a multi-dimensional battery of objective performance tests will provide a more accurate means of TID when compared to performance measures used in isolation given the games multi-dimensionality. Thus, key physical, technical and tactical characteristics are measured within this thesis through the use of representative performance testing, and the determinants of a talented performance will be identified by addressing the following research questions:

1. Can the objective measurement of physical characteristics accurately identify talent in junior Australian football?
2. Can the objective measurement of technical skill be used to accurately identify talent in junior Australian football?
3. Can the objective measurement of decision-making skill accurately identify talent in junior Australian football?

4. Does the application of a multi-dimensional battery of objective performance tests in junior Australian football provide an accurate means of objective talent identification when compared with physical, technical and tactical performance measures used in isolation?

1.3 Thesis Overview

This thesis consists of seven chapters. Chapter Two reviews the key literature surrounding TID in team sport as well as providing a notational description about the main physical, technical and tactical requirements of AF. This is intended to guide the development of representative objective tests presented within the subsequent research chapters.

Chapters Three to Five document a series of experimental procedures that address the first three research questions. Chapter Six consolidates the findings from the previous chapters as a foundation for the development of a multi-dimensional battery of objective performance tests; addressing the fourth research question. A strong methodological feature of this research series is that it employs the same environment in which to recruit participants, thus providing a richer understanding of the multi-dimensional performance characteristics that may be indicative of talent identified and non-talent identified juniors.

Chapter Seven discusses the practical implications of this research to AF, whilst highlighting the main considerations for developing a multi-dimensional approach to TID in other team sports. Through the consolidation of the thesis findings, this last chapter also provides a platform to guide the direction of future research.

CHAPTER TWO: Review of the Literature

2.1 Chapter Overview

This chapter consists of three main sections. Firstly, it reviews and interprets the key literature related to the study of TID in team sport. Particular focus is directed toward the current limitations associated with traditional approaches to TID, namely their attempts at early identification not accounting for the development process, and their mono-dimensional design not accounting for the multi-dimensional requisites of many team sports.

The second section of this review describes the main physical, technical and tactical elements of AF in greater detail. This synthesises notational research that has been conducted in AF and is presented within the literature, however given the game's continual evolution, it also draws upon current reliable game-play data, sourced from commercial notational providers to quantify certain technical and tactical elements that are not yet detailed within the literature. Finally, the third section of this review will describe the conceptual framework underpinning the experimental procedures that will subsequently follow in Chapters Three through Six.

2.2 The Key Stages of Talent Identification and Development in Sport

As sporting expertise is so highly prized and difficult to attain, it is critical for National sporting bodies, federations and team administrators to uncover methods that enhance the efficiency of skill development in order to accelerate the acquisition of expertise (Abernethy, 2008). Reflective of this, many professional sporting organisations adopt acute science driven support systems to expose athletes to evidence-based practices that are hoped to aid their athletic preparation (e.g. strength and conditioning, skill acquisition and performance analysis techniques). In addition to these acute interventions, the perceived importance of exposing prospective juniors to longitudinal performance enhancing environments has led to the implementation of

long-term development programs (Durand-Bush & Salmela, 2001). This has resulted in the establishment of specialised developmental organisations such as Child and Youth Sport Schools in Eastern European countries, and National programs such as the UK High Performance Talent Program and ASPIRE in Qatar. However despite this developmental focus, many National sporting organisations continue to invest in the detection, identification, selection and confirmation of prospective juniors who are seen as capable of attaining excellence in senior competitions (Reilly et al., 2000; Vaeyens et al., 2008). Thus, talent detection, identification, selection and confirmation (in conjunction with development) play a crucial role in the attainment of sporting excellence (Figure 2) (Williams & Reilly, 2000).

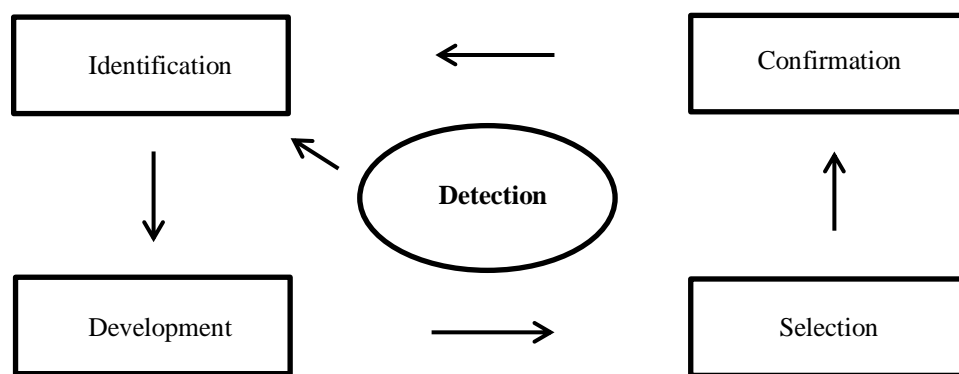


Figure 2. The key stages in the talent identification and development process

The detection of talent is typically defined as the discovery of performance potential within individuals who are not currently participating within specific sporting activities (Williams & Reilly, 2000). An example of this talent detection strategy in Australia is the Talent Search Program (Australian Sports Commission, 2008). This program attempts to test, and thus detect, a vast range of school aged children that possess certain gifts (predominantly physical) that may manifest into a talented performance within a pre-determined sport following the implementation of effective developmental strategies (Australian Sports Commission, 2008). However, these talent

detection programs may be better suited to mono-dimensional sports (i.e. swimming, cycling or rowing), where a talented performance is associated with a singular element (Pearson et al., 2006). Additionally, sports that have a rather shallow participation pool from which to ‘naturally’ develop talent may also benefit from these detection programs. Given the considerable resourceful and logistical considerations required for such programs, their effectiveness (for example, the number of gold medals won at Olympic games) is often financially determined, with these fiscal investments thought to be progressively increasing (Vaeyens et al., 2009). Notably, Hogan and Norton (2000) calculated that, for the Australian government, an Olympic gold medal was associated with a financial investment of approximately AUS\$37 million, and AUS\$8 million per medal in general.

The selection of talent encapsulates the process in which the most appropriate athlete, or group of athletes, are selected to perform a specific task (Williams & Reilly, 2000). Whilst this process has considerable merit for the attainment of excellence in elite senior sporting environments (i.e. selecting a relay team to win an Olympic gold medal), it has been subjected to criticism within junior sporting contexts (Tranckle & Cushion, 2006). Specifically, talent selection in junior sports may actually lead to ‘talent elimination’, where juniors who are continually not selected to compete drop-out or are discouraged to continue participation (Tranckle & Cushion, 2006). To overcome this talent elimination, an inclusive selection process should therefore be echoed within junior sporting environments.

Talent identification (TID) differs from detection and selection practices in that it is the recognition of considerable performance potential within a relatively homogenous sport specific population (Abernethy, 2008; Russell, 1989; Williams & Reilly, 2000). The importance of this identification process within the overall pursuit of

excellence cannot be underemphasised, as a comprehensive approach to TID would help optimise the financial, resourceful and logistical investments directed to development of prospective talent by allowing practitioners to focus upon a small sample of athletes. However, the vast majority of TID practices proposed within the literature appear to lack predictive capability, with their corresponding efficacy being questioned (Vaeyens et al., 2008); particularly within a team sporting context (Pearson et al., 2006). Demonstrating the poor efficacy of these traditional TID programs, Güllich, Thees and Bartz (2005) noted that out of 11,287 junior talent identified members of elite sporting schools, only 1.7% (79 individuals) subsequently obtained a medal in an international senior championship. Given these statistics, it is not surprising to note the criticism directed toward traditional TID programs (Abbott et al., 2005; Abbott & Collins, 2004; Helson et al., 2000; MacNamara, Button, & Collins, 2010a; 2010b; MacNamara & Collins, 2011; Musch & Grondin, 2001; Vaeyens et al., 2009).

In part, the poor efficacy of these traditional programs may stem from sporting organisations overlooking the importance of the talent confirmation process. This is the process whereby the detection, identification, development and selection processes are reviewed, ensuring the initially detected individuals have indeed fulfilled their proposed performance potential (Williams & Reilly, 2000). Despite its importance within the pursuit of excellence, this type of longitudinal analysis may be difficult to employ within a doctoral thesis given the imposed time constraints.

Continued research is required to guide a more evidence-based approach to TID in sport. To work towards this, the following sections of this review will synthesise the literature that has attempted to identify the determinants underlying a talented performance, and in doing so, highlight the limitations of such approaches.

2.3 Traditional Talent Identification Programs in Sport

Acknowledging the competitive and economic advantage effective TID programs have to offer National sporting bodies and elite teams, a wealth of research has attempted to uncover the characteristics distinguishing talent identified individuals from their non-talent identified peers (Table 1). Although these approaches have revealed some of the sport specific talent determinants, many of these traditional attempts have been limited through similar shortcomings. Notably, their cross-sectional design as a means of forecasting a talented performance in an adult/senior competition has discounted the myriad of developmental implications associated with the talent development process. This is problematic from a longitudinal predictive standpoint, as the characteristics that lead to a ‘talented’ performance in junior contexts may very well change throughout the development process (Vaeyens et al., 2006). Concurrently, these traditional programs have often been operationalised by the assessment of physically biased performance markers that may not be contextually representative or indicative of longitudinal performance, especially when measured in isolation (Davids et al., 2008; MacNamara & Collins, 2011; Pinder et al., 2013). In a team sporting environment, this mono-dimensionality is problematic for identifying talent, as the vast majority of team sports are multi-dimensional, requiring players to combine a range of physical, technical and tactical characteristics to successfully perform (Lauder, 2001).

Thus, in an effort to avoid these limitations and develop a scientifically robust multi-dimensional approach to TID in AF, the following sections of this review will discuss two main limitations often accompanying traditional TID programs; their (1) cross-sectional design in young populations not accounting for the development process, and (2) their reliance upon mono-dimensional performance tests to identify talent in multi-dimensional contexts.

Table 1. Examples of talent identification programs proposed in the literature

Reference	Country and sport	Methods and test items	Main results
Falk et al. (2004)	IL: Junior water polo	Physiological, technical, and tactical skill tests	Nationally identified juniors performed technical and tactical tests at a higher level acutely, and at a two-year follow up.
Gabbett et al. (2007)	AUS: Junior volleyball	Physiological, anthropometric, and technical skill tests	Measures of technical skill were the only significant determinants of talent identified and non-talent identified players; reflecting a TID accuracy of 89.5%.
Hoare (2000)	AUS: Male and female youth basketball	Anthropometric and physiological tests	41.3% and 38.3% of the variance in player standard was noted through anthropometric and physiological results in female and male players, respectively.
Keogh (1999)	AUS: Junior male AF	Anthropometric and physiological tests	A discriminate function analysis had a talent identification accuracy of 75.2%.
Keogh et al. (2003)	NZ: Youth female hockey	Anthropometric, physiological, and technical skill tests	Differences were noted between talent identified and non-talent identified in specific anthropometric, physiological, and technical measures.
Kevin et al. (2011)	UK: Junior rugby league	Anthropometric and physiological tests	Scores obtained through the testing battery corresponded with a talent prediction accuracy of 63.3%.
Mohamed et al. (2009)	EUR: Junior handball	Morphological and fitness testing	Elite players performed better on measures of strength, speed and cardiovascular endurance.
Nieuwenhuis et al. (2002)	SA: Youth female hockey	Anthropometric, physiological, technical, and tactical skill tests	Scores obtained through the testing battery corresponded with a prediction accuracy of 90.5%.

IL Israel; AUS Australia; NZ New Zealand; UK United Kingdom; EUR Europe; SA South Africa

2.3.1 Cross-sectional designs and early identification

Early identification can be described as the intention of identifying youngsters aged 6 to 15 years who possess specific characteristics thought to manifest into an expert performance in senior competitions following the initiation of a structured long-term athlete development program (Güllich & Emrich, 2006). Given this, early identification appears to be based upon the assumptions that:

1. Success in elite senior competitions is the result of long-term ‘linear’ development of a singular sporting element,
2. Success is monotonically proportionate to a specific type and volume of practice, and;
3. Early identification, and thus development, is indeed positively correlated with long-term success in elite senior competitions.

In part, these assumptions align with the domain-specific *Deliberate Practice Theory* (Ericsson et al., 1993). This theory proposes that the acquisition of expertise may be monotonically proportionate to the number of accumulated hours invested into deliberate skill rehearsal, often being termed the ‘10 year’ or ‘10,000 hour rule’ (Ford et al., 2009; Helson et al., 2000; 1998; Hodge & Deakin, 1998; Ward et al., 2007). Thus, the earlier the individual specialises through the initiation of domain specific deliberate practice, the more likely they may be to expedite the acquisition of expertise.

However, as athletes strive to attain excellence, it is not uncommon to observe positive skill transfers between sports of a similar nature (Bullock et al., 2009). Illustrating this, Berry et al. (2008) noted that the development of expert perceptual and decision-making skill in team invasion sports was likely due to the accumulated hours invested into non-sport specific invasion-type activities, rather than the early initiation

of sport specific skill rehearsal. Given this, it was concluded that the perceptual and decision-making skills developed through participation in team invasion sporting activities may positively enhance the acquisition of such skills within a specific team sporting context (Berry et al., 2008). This conclusion partly contradicts the *Deliberate Practice Theory*.

Additionally, the sport specific training onset age has been shown to be highly variable within athletes of the same sport despite each attaining excellence at the highest level (e.g. Olympic representatives) (Deakin & Cobley, 2003). Güllich (2007) observed the sport specific training onset age of Olympic athletes, noting that although some initiated sport specific training at a young age, the majority reflected a variable training onset age (Figure 3). A large proportion of Olympic athletes appeared to have initiated their sport specific training beyond the age range which traditional TID programs target, further demonstrating the potential inaccuracy and scientific misguidance of such programs. Through findings such as these, it is not surprising to note the wealth of literature contesting the application of the *Deliberate Practice Theory* and expertise attainment when viewed in isolation within the team sporting domain (for examples, see Abernethy et al., 2005; Baker, Cobley, & Fraser-Thomas, 2009; Baker et al., 2003a; 2003b; Baker et al., 2005; Berry et al., 2008; Williams & Ford, 2008). Thus, although potentially fitting within monotonic domains (i.e. music), the *Deliberate Practice Theory* may not correspond with the team sporting domain given the dynamic and often ‘non-linear’ development process (Davids & Baker, 2007).

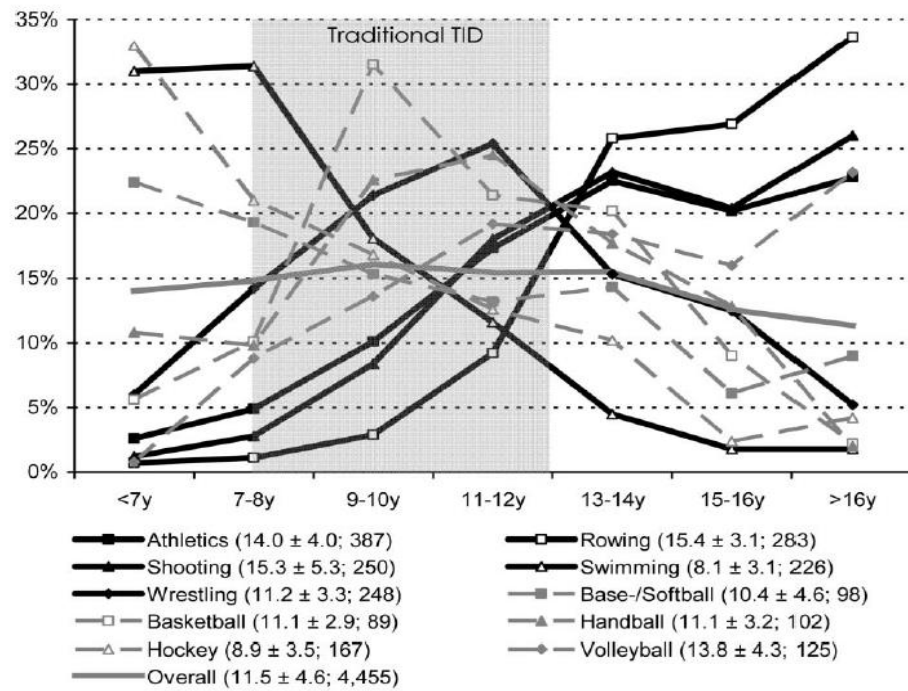


Figure 3. The age of main sport training onset for Olympic athletes (reproduced from Vaeyens et al. (2009) with permission from the Routledge Taylor & Francis Group)

2.3.1.1 The differentiated model of giftedness and talent

Gagné (1993) proposed that both genetic and environmental factors influence the talent development process. As illustrated in Figure 4, the *Differentiated Model of Giftedness and Talent* (DMGT) demonstrates a clear distinction between giftedness and talent; where ‘giftedness’ is defined as a natural ability placing an individual in the top 10% of four domains, whilst ‘talent’ is defined as the product of effective and systematic development. This gift-to-talent development process describes that intrapersonal, environmental and chance are three catalysts that could advantageously or disadvantageously influence the overall pursuit of excellence. Although potentially infinite, intrapersonal catalysts can be broadly classified into physical, mental and/or self-management factors inclusive of self-awareness or motivation (Gagné, 1993). Environmental catalysts can include location or cultural factors, interpersonal factors (e.g. parental and sibling influence), provisional factors (e.g. availability of services or

activities) or the occurrence of certain events (e.g. awards or accidents) (Gagné, 1993). The model's recognition of how 'chance' may be an influential component of the developmental process is unique, and although 'chance' slightly complicates an individual's potential development prediction, it is possible to minimise its potential negative impact. Specifically, certain developmental measures may allow for the avoidance of pre-empted detrimental risk factors (i.e. noting potential injury risk factors in certain sporting contexts) (Williams & Hodges, 2005).

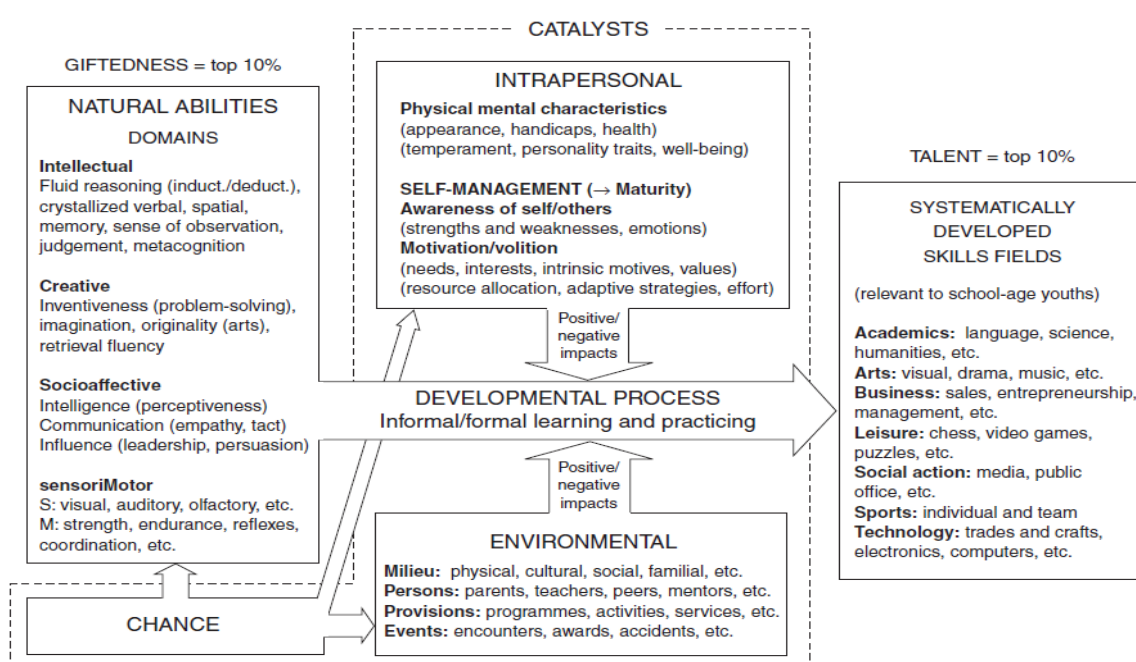


Figure 4. The *Differentiated Model of Giftedness and Talent* (reproduced from van Rossum and Gagné (2005) with permission from Prufrock Press Inc.)

Despite being initially proposed in the education domain, the DMGT provides a strong rationale for application within the sporting domain for two main reasons. Firstly, it acknowledges the dynamic way in which talent may be developed in sport, and secondly, it reflects the typical multi-dimensionality of sport (Tranckle & Cushion, 2006; Vaeyens et al., 2008). For example, the six components of the DMGT recognise the dynamic 'non-linear' processes in which a gift may be developed into a talent

through the interaction of various environmental and genetic catalysts. Additionally, recognising that gifts arise from four main domains, namely intellectual, creative, socioaffective and sensorimotor (Figure 4), links the multi-dimensional requirements of sport to this model, as sporting gifts often arise from domains other than the sensorimotor abilities (such as game-sense or decision-making). However, this multi-dimensionality may not become fully apparent until the completion of a contextually specific developmental training intervention (Güllich & Emrich, 2006). Thus, the following section will describe the *Developmental Model of Sport Participation* (Côté, 1999), and its efficacy for the acquisition of expertise in a team sporting context.

2.3.1.2 The developmental model of sport participation

Given the perceived advantage of a vast sporting diversity during the development of sporting excellence, a more fitting alternative developmental pathway to the *Deliberate Practice Theory* may be the *Developmental Model of Sport Participation* (Baker et al., 2003a; 2003b; Côté, 1999; Côté & Fraser-Thomas, 2007; Côté & Hay, 2002). This model consists of three participation stages, referred to as the sampling years (6 to 12 years of age), the specialising years (13 to 15 years of age) and the investment years (> 16 years of age). As the name implies, the sampling years are typified by participation in vast array of sporting activities; allowing the child the opportunity to develop a broad set of fundamental skills in an inherently enjoyable context. Following this stage, the specialising years feature a decreased involvement in extra-curricular activities and an increased focus toward the refinement of the specific skills needed to acquire expertise in one or two sport(s). The final stage, the investment years, is characterised by an increased focus on strategic and technical skill development within a specific sport (Côté, 1999). Typically this is the developmental

phase where seasonal sports evolve into year-long sports due to the implementation of an extensive pre-season training phase.

Since the establishment of this developmental model there has been an appreciation toward its applicability in the attainment of sporting excellence. Soberlak and Côté (2003) noted that a subset of expert ice hockey players had participated in up to six different sports within their sampling years; suggesting that this broad sporting diversification led to the acquisition of a range of fundamental skills that advantageously contributed toward the attainment of expertise. Similarly, Bruce et al. (2012a) recently noted that expert netball players had invested a greater number of hours within sports external to netball during their sampling and specialising years. Again, it was concluded that this diversity led to the acquisition of broad fundamental skills that underpinned the development of sport specific skills needed to elicit an expert performance in the game.

These combined results suggest that a diverse sporting involvement in the sampling and specialising years may contribute toward the acquisition of expertise in the sporting domain, granted the skills developed within these initial developmental years allows for a positive transfer in the investment years. Based upon this developmental model, it would appear conceptually misguided to attempt early identification through the use of cross-sectional research designs in team sports, as sporting specialisation may not occur until the ages of at least 16 years; limiting the accuracy of longitudinal performance predictions.

2.3.1.3 Maturational implications

Another problem associated with the utilisation of cross-sectional designs when attempting early identification is that such procedures do not acknowledge the myriad

of maturational variations that occur during the development process (Pearson et al., 2006). This in-turn may lead to a considerable identification bias when accompanied with non-representative, physically-oriented performance tests (Abbott et al., 2005; Abbott & Collins, 2002), and is likely to misinform the extrapolation of potential longitudinal performance trajectories (Gulbin et al., 2013; Vaeyens et al., 2006). Within males, peak maturational instability occurs during the ages of 13 to 16 years, with maturation variations diminishing following the age of 18 years (Malina, Bouchard, & Bar-Or, 2004a; Marshall & Tanner, 1986). The onset of maturation is known to influence physiological abilities inclusive of maximal aerobic and anaerobic capacity muscular strength and endurance (Bale, Mayhew, Piper, Ball, & Williams, 1993; Buchheit & Mendez-Villanueva, 2013; Gastin, Bennett, & Cook, 2013; Malina, Ribeiro, Aroso, & Cumming, 2007; Pearson et al., 2006). Thus, despite its common practice, the use of cross-sectional physiological testing to identify talent in adolescent or pre-adolescent populations is questionable given the lack of predictability associated with maturation (Pearson et al., 2006).

As demonstrated by Vaeyens et al. (2006), performance distinguishing characteristics in pubescent populations are likely to change based upon chronological age and maturity status. Regression analyses highlighted that running speed and technical skill appeared to be the strongest performance distinguishing characteristics in U13 and U14 soccer players, while cardiorespiratory endurance appeared to be the strongest talent discriminator in U15 and U16 soccer players (Vaeyens et al., 2006). Further, Abbott and Collins (2002) demonstrated the relative instability of certain physical and anthropometric performance markers when collected during periods of peak maturational variation. Specifically, measures of sprint time and standing height lacked test-retest reliability in Scottish children progressing through periods of

maturation. Combined, these findings demonstrate that traditional cross-sectional TID programs targeting identification between the ages of approximately 6 to 15 years are not likely to account for maturational variation; resulting in unstable performance discriminating characteristics. Consequently, talent misclassification may occur, as although early maturers may potentially demonstrate an acute performance advantage, it may not be longitudinally sustained once late maturers ‘catch up’ (Vaeyens et al., 2006). Hence, TID programs applied to such populations should account for this dynamic maturational development by allowing for a change in performance distinguishing characteristics throughout different stages of maturity (Pearson et al., 2006; Vaeyens et al., 2006).

Within certain team sports, this physical identification bias is often depicted through the birth date comparisons of talent identified and non-talent identified individuals (Barnsley, Thompson, & Legault, 1992). An over-representation of talent identified individuals born earlier in the selection year has been demonstrated in soccer (Helson, Van Winckel, & Williams, 2005; van de Honert, 2012), basketball (Delorme & Raspaud, 2009) and more recently, AF (Coutts, Kempton, & Vaeyens, 2014). This identification bias has been termed the relative age effect (RAE) (Barnsley et al., 1992) and is primarily reported within adolescent sporting populations (Jimenez & Pain, 2008). It is thought to be caused by a greater maturational and selection potential within individuals born earlier in the selection year (Figueiredo, Goncalves, Coelho, Silva, & Malina, 2009; Musch & Grondin, 2001; Wattie, Cobley, & Baker, 2008). Therefore, potentially superior physicality stemming from an earlier birthdate may be confused by talent recruiters as overall talent, resulting in the unwitting identification of relatively older juniors (Ashworth & Heyndels, 2007).

However, there is scarce evidence to suggest that individuals born earlier in the selection year will attain longitudinal sporting excellence when compared to their latter born counterparts (Figueiredo et al., 2009; Musch & Grondin, 2001). Rather, Ford and Williams (2011) noted a reverse RAE within award-winning elite senior athletes. It was concluded that individuals born later in the selection year may have to develop more pronounced technical and tactical skill characteristics to allow for the successful competition against their physically superior counterparts, maintaining these skills following the conclusion of maturation (e.g. approximately > 18 years of age). Nevertheless, if overlooked in junior contexts given unsuitable physically biased performance tests, technically and tactically talented juniors may be at a considerable developmental disadvantage. It is of note that within sports that place less reliance upon the use of physical performance tests to identify talent; a RAE is scarcely reported (Delorme & Raspaud, 2009).

Given these developmental considerations, 'current' cross-sectional TID programs should have an intended focus on 'mature-age' identification. Such an attentional shift away from these early 'snapshot' approaches is likely to allow for the influence of the natural developmental process to occur. Moreover, TID undertaken following the onset of sport specific training could allow for the development of the key performance characteristics that are more closely associated with a talented performance in senior contexts, and thus the acquisition of expertise (Abbott et al., 2005). Supportive of this suggestion, Güllich and Emrich (2013) noted that early talent identified Eastern German soccer players who were placed on accelerated developmental programs following early identification did not attain a higher level of sporting excellence in adult competitions when compared to their Western German counterparts who, conversely, were not exposed to early TID and development programs.

Although the evidence indicates that this proposed ‘mature-age’ approach to TID is supported by the literature, it is crucial that the performance measures intended to capture a talented performance allow for the multi-dimensionality of the team sport. However, with some exceptions (for examples, see Gabbett et al., 2011; Nieuwenhuis et al. 2002; Reilly et al., 2000; Vaeyens et al., 2006), multi-dimensionality is scarcely associated with TID programs that have been proposed within the literature.

2.3.2 Mono-dimensional performance measures

As illustrated in the *Model of a Skilful Player* (Lauder, 2001), a talented performance in team sport is the combination of a range of physical, technical and tactical elements (adaptation presented in Figure 5). This model provides sports scientists attempting to implement a multi-dimensional approach to TID with a conceptual framework to guide the measurement of physical, technical and tactical characteristics. However, this multi-dimensionality is scarcely accounted for when objectively identifying talent in team sporting contexts. Specifically, to maximise limited logistical, financial and operational resources, mechanistic and mono-dimensional measures have underpinned traditional TID programs. This mono-dimensional element is often physically biased, and although some sports require such physical characteristics to succeed, their measurement is usually conducted during inappropriate developmental periods (i.e. during phases of high maturational variability). Consequently, such TID programs often lack scientific rationale (Phillips et al., 2010). Despite their intentions, these mono-dimensional programs can be associated with talent wastage or talent de-identification, in which non-talent identified individuals are overlooked given disadvantageous superficial qualities that are presumed to be translatable with the attainment of sporting excellence in senior competitions (Abbott et al., 2005).

Pinder et al. (2013) aligns this talent de-identification with an inability to acknowledge the importance of representative test design in the construction and implementation of TID measures. Further, these reductionist tendencies are often confounded by the assumption that a skilful performance in one element of effective play is enough to forecast overall talent.

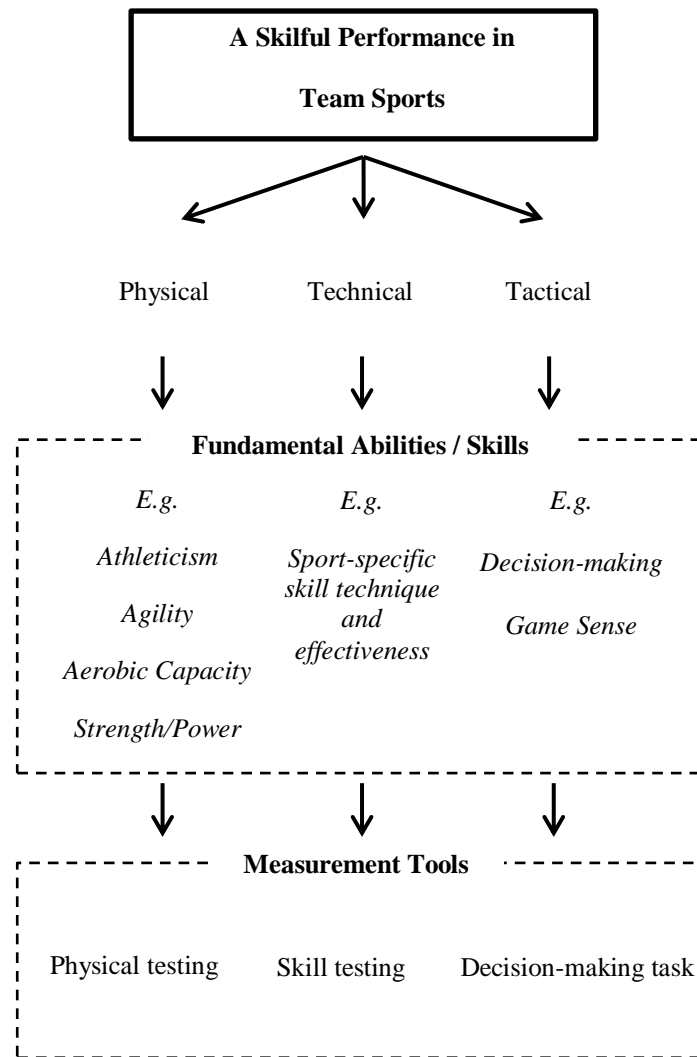


Figure 5. The *Model of a Skilful Player* in team sport as adapted from Launder (2001)

The weaknesses of these non-representative mono-dimensional tasks utilised within traditional TID programs are often further confounded by a researcher's innate interest in test decomposition (Pinder et al., 2013). Performances are typically broken into sub-phases for measurement control, and whilst this is partly necessary to enforce

the psychometric integrity of tests when implementing applied research, these sub-phases may lack ecological validity. For example, although the Yo-Yo intermittent recovery test (measure of maximal aerobic capacity) has been used to discriminate talent in junior AF (Veale et al., 2010), its singular administration as a means of TID is misleading given the games immense multi-dimensionality. As stated by Keogh (1999), although physical performance tests may be initially important for the identification of talent, their sole use may lack specificity by not accounting for a likely *compensation phenomenon* (Bartmus et al., 1987; Tranckle & Cushion, 2006).

Some researchers have strived toward the application of multi-dimensional performance batteries for TID, with their findings strongly encouraging an attentional shift. Reilly et al. (2000) measured the identification potential of a battery of anthropometric, physiological, psychological and sport specific technical skill tests within a junior soccer context. It was reported that a diverse set of performance characteristics stemming from the multi-dimensional elements of this test battery differentiated talent identified junior soccer players from their non-talent identified counterparts. Additionally, Nieuwenhuis et al. (2002) noted a classification accuracy of approximately 90% when applying a multi-dimensional battery of objective performance tests to a sample of talent identified and non-talent identified junior field hockey players. This classification accuracy is considerably superior to the 75.9% reported by Keogh (1999) and 63.3% reported by Kevin et al. (2011), both of which utilised a more mono-dimensional approach to TID in junior AF and rugby league.

Additionally, Vaeyens et al. (2006) demonstrated that a range of physiological abilities and technical skills were discriminative of talent at different levels of maturity in junior soccer players, drawing the suggestion that the measurement of a holistic profile is important when objectively identifying talent in team sport. Gabbett et al.

(2007) demonstrated that measures of technical skill were the only significant differences between talent identified and non-talent identified junior volleyball players despite the application of a multi-dimensional battery of objective performance tests. This suggests that certain measures may not be the key determinants of a talented performance, thus multi-dimensional designs should be implemented to gain a deeper and more sensitive insight into the constituents of talent. However despite the combined findings of this research, a multi-dimensional approach to TID is yet to be developed within AF.

Given this evidence, robust TID programs in team sport should strive to capture a holistic performance profile through the use of multi-dimensional representative tests that a) maintain a representative and feasible construct, and b) maintain an immediate, and potentially a long-term, performance translation. However, such operationalisation requires a profound understanding of the sport specific characteristics. As such, the following section of this review will apply the *Model of a Skilful Player* (Lauder, 2001) to AF and detail the key physical, technical and tactical requirements of game-play. Consequently, this section will draw upon key notational research conducted in AF, as well as utilising data acquired from commercial statistical providers to describe the current technical and tactical elements of game-play.

2.4 The Physical Requirements of Australian Football

A plethora of notational research directed toward the physical requirements of AF has led to a comprehensive understanding of the physical profiles of players at all developmental levels (e.g. Burgess et al., 2012b; Gray & Jenkins, 2010; Kempton, Sullivan, Bilsborough, Cordy, & Coutts, 2015; Veale & Pearce, 2009; Young & Pryor, 2007). This notational research describes the importance of certain anthropometric attributes for an advantageous performance in game-play. Specifically, Young and

Pryor (2007) noted that standing height was the only anthropometric attribute that differed between players who achieved success in aerial ball contests (e.g. when the ball is kicked to a pack of players) and those who did not. According to Keogh (1999) and Young et al. (2005), the average standing height of elite senior and junior Australian footballers is 189 ± 8 cm and 180.2 ± 7.2 cm, respectively. A larger body mass (presumably indicative of muscle mass and stature) may also be a highly advantageous anthropometric attribute given the collisional nature of the game (Gray & Jenkins, 2010), with the average body mass of elite senior and junior players ranging between 85 to 90 kg and 74 to 82 kg, respectively (Keogh, 1999; Pyne et al., 2005; Young et al., 2005; Young & Pryor, 2007).

Within a 120 minute game, it is not uncommon for elite AFL players to cover a total distance ranging between 9,000 to 17,000 m at an average speed ranging between 120 to 140 $\text{m} \cdot \text{min}^{-1}$ (Coutts, Quinn, Hocking, Castagna, & Rampinini, 2010; Wisbey, Montgomery, Pyne, & Rattray 2010). Consequently, several studies have highlighted the importance of maximal aerobic capacity in both elite senior and junior AF competitions (Keogh, 1999; Pyne et al., 2005; Young et al., 2005; Young & Pryor, 2007). Given logistical limitations associated with laboratory testing, maximal aerobic capacity is often estimated through the use of validated field tests such as the 20 m multistage fitness test (20 m MSFT) and the Yo-Yo intermittent recovery test (level 1) (Gray & Jenkins, 2010). Through this estimation, the average maximal aerobic ability of both junior and senior players ranges between 55 to 65 $\text{ml} \cdot \text{kg} \cdot \text{min}^{-1}$ (Keogh, 1999; Pyne et al., 2005; Young et al., 2005; Young & Pryor, 2007). Moreover, through the use of the Yo-Yo intermittent recovery test (level 1) Veale et al. (2010) noted that elite junior AF players (defined by selection onto an elite junior team) recorded a greater total distance in comparison to their sub-elite peers.

The speed at which the game is played within the AFL is thought to be increasing (Burgess et al., 2012b). Notably, Burgess et al. (2012b) recently compared the physical match activity profile of AFL players between the 2003 and 2009 seasons, highlighting that players in 2009 were performing a greater number of sprints when compared to the same competition in 2003. Thus, the ability to outrun an opposition player in an attempt to ‘create space’ or win ball possession is increasingly important (Gray & Jenkins, 2010). Highlighting the importance of sprint and accelerative ability in the game, Robertson, Woods and Gastin (2014) recently noted that 20 m sprint time was indicative of draft success (drafted versus non-drafted) in a homogenous sample of junior AF players. Wearable microtechnology (an accelerometer embedded within a global positioning system unit) has indicated that the maximal running speed of elite AFL players in game-play ranges between 8 to 9 m.s⁻¹ (28.8 to 32.4 km.hr⁻¹) (Coutts et al., 2010; Wisbey et al., 2010). Coupled with this maximal speed is the ability to rapidly accelerate to move away from an opponent or to initiate body contact (Gray & Jenkins, 2010).

It is not uncommon for players bump, tackle and ‘wrestle’ in an attempt to either maintain or obtain ball possession (Gray & Jenkins, 2010), indicating that lower and upper body strength and power are important abilities to successfully compete in the game. Within the AFL, it has been suggested that the average upper body strength (as measured using a three repetition maximum bench press) ranges from 95 to 100 kg (Young et al., 2005), with these average values being considerably higher than those reported in junior AF (approximately 63 kg) (Keogh, 1999). However, given the considerable ‘on-leg’ component of the game, lower body strength and power may be a more desirable ability (Gray & Jenkins, 2010). Lower body power may translate to a superior jump height, and when this ability is coupled with a superior standing height, a

player may achieve considerable success in aerial ball contests. The average stationary vertical jump height of elite junior AF players has been reported as being 55.2 ± 7.9 cm (Keogh, 1999), with this increasing to 62.8 ± 3.7 cm in senior AFL players (Young et al., 2005).

Thus, a range of physical characteristics appear important for the exhibition of a talented performance in AF, and it would appear necessary to include measures of physical performance when developing a TID program specific to the game. As demonstrated in Table 2, a range of physical and anthropometric measures have already been utilised for TID purposes in AF, although the physical characteristics which are most predictive of talent identified junior AF players are yet to be identified. Additionally, the age of these previous studies is an important consideration given the evolutionary speed of game-play (Burgess et al., 2012b) may actually underestimate the current physical requirements for game-play.

In accordance with the *Model of a Skilful Player*, physical characteristics are only one element of a skilful in-game performance in a team sporting context (Lauder, 2001). As such, the technical and tactical characteristics of game-play will be discussed in the following sections. This will assist with the construction of representative performance tests intended to measure such skills within the subsequent research series.

Table 2. Examples of talent identification studies in Australian football

Reference	Methods and test items	Main results and conclusions
Keogh (1999)	40 U18 players underwent anthropometric and physiological testing	<p>Talent identified players were considerably taller and stronger than non-identified players. In total, 8 players were incorrectly classified when using just these physical measures.</p> <p>Although somewhat important for initially identifying talent, the sole use of physical tests is likely to incur talent wastage. Author concluded that more representative (technical and tactical) tests are needed.</p>
Pyne et al. (2005)	Anthropometric and physiological data collected from 283 players over three years	<p>Linear sprint and maximal aerobic capacity differentiated draft outcome, but only 205 (72%) of players measured were drafted. Further, of these, only 166 (59%) made their AFL debut.</p> <p>Career progression has small associations with physiological testing scores. Mono-dimensional measures may initially guide TID but the considerable talent wastage noted suggests more holistic markers of performance (technical and tactical) are required.</p>
Veale et al. (2008)	54 players age 17-18 years of age underwent anthropometric and physiological testing	<p>Vertical jump height was the only test that significantly differed.</p> <p>Authors cited “skill demonstration” and “tactical competence” as important measures for future TID programs in junior AF.</p>

2.5 The Technical Requirements of Australian Football

Despite the range of technical skills performed by players, successful ball transfer (typically termed ‘disposal’) is paramount for an effective performance outcome in AF (Sullivan et al., 2014). It is performed via two modes: a ‘kick’, which is undertaken through either releasing the ball from the hand onto the foot or by kicking the ball off the ground; or a ‘handball’, which is performed by cradling the ball in one hand, and striking it with a fist created by the other hand. In the 2014 AFL season, kicks were the most common mode of ball disposal in game-play (57% kicks versus 43% handballs) (AFL Champion Data[®], Melbourne, Australia, 2014), but handballs were the more efficient mode of disposal (i.e. percentage of passes where possession was maintained; handball efficiency of 80% versus 60% kicking efficiency) (AFL Champion Data[®], Melbourne, Australia, 2014).

Given accuracy considerations, the drop punt is the most common kick performed by AF players (Ball, 2008). Initial notational research by Appleby and Dawson (2002) highlighted that three general kicking distances are often executed by AFL players in game-play; short (approximately 25 m), medium (approximately 35 m) and long (approximately 45 m). Increased kicking efficiency is known to improve a team’s scoring potential, as it increases the pressure placed upon an oppositions defensive structures (Ball, 2007; Forbes, 2003). Demonstrating the importance of proficient ball disposal in AF, Sullivan et al. (2014) recently noted that successful (winning) AFL teams were typically characterised by a higher number of positive skill involvements (specifically effective long kicks) when compared to their unsuccessful (losing) opposition. Moreover, within the 2014 AFL season the premiership winning team were recorded as having the highest number of kicks, and corresponding disposal efficiency (approximately 74%) in comparison to the remaining teams (AFL Champion

Data[®], Melbourne, Australia 2014). Interestingly, these particular findings are not delimited to AF, with other team invasion sports noting similar match activity profile trends. Specifically, both Gabbett (2014) and Rampinini et al. (2009) demonstrated that more successful rugby league and soccer teams (defined as being in the top four teams from a competition of eleven) were characterised by greater technical and tactical profiles and reduced high speed running performances when compared to the bottom four teams in the same competition. Thus, both recent literature and notational game statistics demonstrate the importance of proficient skill execution within AF and other team invasion sports.

Parrington et al. (2013) noted that in game-play, handball distances can be characterised as ‘short’ (< 6 m) or ‘long’ (> 6 m), with players typically being stationary and facing toward their target during disposal execution. Temporal constraints usually dictate that players have one to three seconds in which to handball when in game-play (Parrington et al., 2013). Players typically receive a handball at chest height and moving in the direction that the ball was handballed (Parrington et al., 2013). When executing both kicking and handballing disposals, it is not uncommon for players to utilise both dominant and non-dominant limbs; potentially being at a performance advantage if able to perform these bi-lateral disposals efficiently (Farrow, Pyne, & Gabbett, 2008).

Within team ball sports, the efficiency of technical skill may not only hinge upon the accuracy of disposal, but also upon the velocity at which the ball travels to its intended target (Robertson, Burnett, & Cochrane, 2014). Specifically, disposing the ball with high velocity and accuracy may prevent it from being intercepted by opposition players, especially when performing disposals over large distances. When quantifying technical skill using representative objective tests, ball velocity is typically measured through the use of a radar gun or high speed camera (Ali, Foskett, & Gant, 2008; Ali et

al., 2007; Gabbett & Georgieff, 2006; Russell, Benton, & Kingsley, 2010). This allows researchers the opportunity to investigate a potential ‘speed-accuracy trade-off’ (van den Tillaar & Ettema, 2006). For example, novice individuals often sacrifice the velocity of movement for the preservation of its corresponding accuracy, whilst experts are able to maintain both the speed and accuracy elements (Girgenrath, Bock, & Jüngling, 2004; van den Tillaar & Ettema, 2006).

Unlike soccer (Ali et al., 2008; 2007; Russell et al., 2010), rugby league (Gabbett et al., 2011) and volleyball (Gabbett & Georgieff, 2006) AF is yet to establish psychometric measures of technical skill for use in the TID process. This considerably limits the depth of current objective TID practices, and is a gap that requires attention when developing an objective multi-dimensional approach to TID in AF. Hence, the ball disposal considerations previously discussed in AF are important to consider when constructing representative tests capable of objectively measuring such technical skills. Specifically, Robertson et al. (2014) suggest that understanding the common distances in which disposals are typically performed, the target size and orientation, and the temporal constraints imposed upon players when disposing of the ball are all important considerations for the representative design of technical skill tests. Additionally, it is important to consider the procedural feasibility when constructing such tests, as an easily administered test could be more practically translatable, as coaches may be more inclined to apply them to current practices.

2.6 The Tactical Requirements of Australian Football

Decision-making, defined as a player’s skill to accurately select the correct choice from a range of alternatives under a variety of environmental contexts (Farrow & Raab, 2008), is an immensely valuable contributor to an expert performance in a team sporting context as highlighted by several authors (e.g. Berry et al., 2008; Buszard,

Farrow, & Kemp, 2013; Gabbett et al., 2007; Lorains, Ball, & MacMahon, 2013a; Lorains, MacMahon, & Ball, 2013b; Müller, Abernethy, & Farrow, 2006). This research has had an intended focus on the quantification of offensive decision-making (i.e. the decisions programmed when disposing the ball to a teammate) rather than the quantification of defensive decision-making (i.e. the decisions programmed when attempting to obtain the ball back from the opposition) through the use of video-based designs. This is likely due to the difficulty in objectively quantifying defensive decision-making skill. Specifically, defensive decision-making hinges upon an opposition's movement pattern; thus capturing or replicating these scenarios for usage in a video-based test may present construct difficulties. Alternatives to video-based perceptual tasks have been to utilise *in situ* tasks, in which actors perform a rehearsed passage of play designed to prompt a specific decision (Afonso, Garganta, McRobert, Williams, & Mesquita, 2014; Bruce, Farrow, Raynor, & Mann, 2012b). Although providing a deeper insight into the mechanisms underpinning the decision-making process when compared to video-based perceptual tasks (Afonso et al., 2014), the decision-making outcome (i.e. the product) has been shown to be similar between video-based and *in situ* tasks when quantifying decision-making skill (Bruce et al., 2012b).

Although coaches often employ structured game plans in team ball sports, the dynamic nature of game-play forces players to interpret opposition and teammate movement patterns when disposing the ball (Gréhaigne, Godbout & Bouthier, 2001). Thus from an offensive perspective, the ability for a player to identify the correct disposal option is an important contributor to its subsequent efficiency (Farrow, 2010). Lorains et al. (2013b) recently noted that elite AFL players typically have three or more offensive decisions to program at any given time prior to disposing of the ball.

Moreover, Parrington et al. (2013) defined decision-making difficulty as ‘high’ when AFL players had three or more disposal options; noting that in game-play this decision-making difficulty occurred approximately 26% of the time. Given these findings, it is appropriate to utilise scenarios that incorporate a range of potential disposal options (e.g. three or more) when developing a representative objective task of decision-making skill specific to AF.

Having discussed the main theoretical implications associated with the development of a multi-dimensional approach to TID in team sport and the physical, technical and tactical requirements of AF, the final section of this review will describe the conceptual framework underpinning the subsequent experimental procedures within this thesis.

2.7 Conceptual Underpinnings of the Thesis

The conceptual framework underpinning the following experimental procedures within this thesis is informed by the *Model of a Skilful Player* (Launder, 2001), the first stage of the *Expert Performance Approach* (Ericsson & Smith, 1991; Williams & Ericsson, 2005), and the *Developmental Model of Sport Participation* (Côté, 1999); being illustrated in Figure 6.

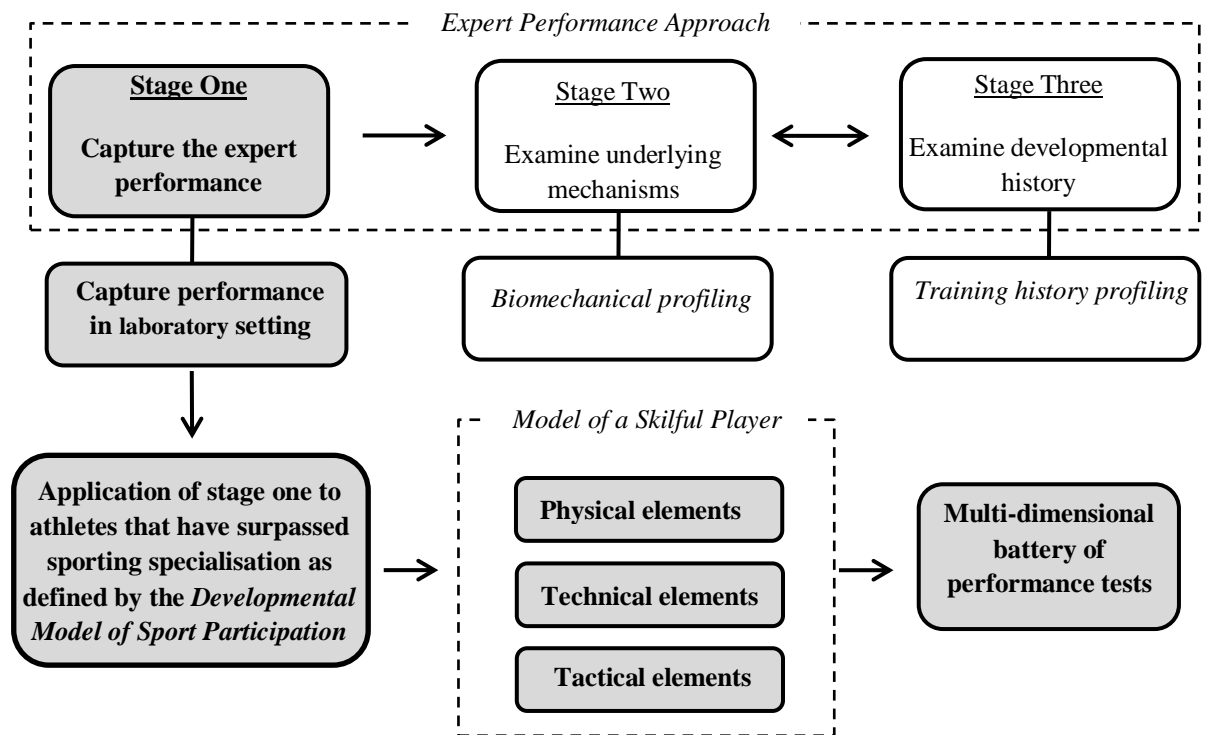


Figure 6. The theoretical overview and framework of the experimental procedures within this thesis

As demonstrated in the *Model of a Skilful Player* (Launder, 2001), a skilful performance in team sports is the resultant of physical (i.e. agility, athleticism or fitness), technical (i.e. skill outcome) and tactical (i.e. decision-making or game-sense) elements. To overcome the mono-dimensionality associated with traditional TID programs, a profound understanding of each element is required to allow the development of multi-dimensional performance tests (Vaeyens et al., 2008). Indeed, capturing each multi-dimensional constituent through the use of representative testing is reflective of the first stage of the *Expert Performance Approach* (Ericsson & Smith, 1991; Williams & Ericsson, 2005). In accordance with this first stage, the captured performance needs to be compared to that of a lesser talented counterpart in order to identify the contextual (sport specific) skills utilised by the expert performer (Ericsson & Smith, 1991). Once the expert performance has been captured and compared to that of less talented individuals, further analysis may begin to investigate the mechanisms

that mediate the skills leading to the talented performance. This subsequent analysis reflects stage two of the *Expert Performance Approach* (Ericsson & Smith, 1991). Examples of these mechanistic investigations include eye tracking (visual search), movement analysis (biomechanical profiling), data reduction techniques and verbal protocol analysis (McPherson & Thompson, 1989; Williams & Davids, 1998; Williams, Hodges, North, & Barton, 2006).

The third stage of the *Expert Performance Approach* requires scientists to retrospectively investigate the developmental histories of expert performers to identify the pertinent developmental milestones that have contributed to the acquisition of expertise (Ericsson & Smith, 1991). Importantly however, in accordance with the *Expert Performance Approach*, scientists must first establish what the determinants of an expert performance are to allow the subsequent mechanistic and developmental investigations. Hence, the latter stages of this approach (namely stage 2 and stage 3) lay outside the conceptual scope of this thesis.

The timing of when to attempt TID through the use of objective performance testing must also be considered to avoid the myriad of developmental implications. As demonstrated by the *Developmental Stages of Sports Participation* and the wealth of research supporting its application (for examples, see Berry et al., 2008; Bruce et al., 2012a; Soberlak & Côté, 2003) a diverse sporting participation during the ages of 6 to 15 years may be highly advantageous for the acquisition of expertise in senior sporting contexts. Thus, it would seem inappropriate to apply cross-sectional sport specific TID programs prior to the investment phase of development (e.g. < 16 years of age). Moreover, as synthesised within earlier sections of this review, traditional TID programs implement cross section designs during the ages of approximately 6 to 15 years of age (Vaeyens et al., 2009) despite peak maturational variability occurring

during 13 to 16 years of age (Buchheit & Mendez-Villanueva, 2013; Malina, 1994; Malina et al., 2004a; 2004b). To ensure that the captured performance is indeed reflective of potential talent rather than maturational status, it would be logical to attempt TID following times of peak maturational variability (e.g. > 16 years of age). Further, junior AF players are not eligible for drafting (i.e. selection into the AFL) until the age of 18 years; thus elite junior developmental programs are not often administered until approximately 16 to 17 years of age. Taking these implications into consideration, the most appropriate age at which to attempt TID in junior AF would be 17 to 18 years, as the performances captured are a close reflection of longitudinal performance in an elite senior competition (i.e. the AFL).

2.8 Summary of Literature Review

In summary, this chapter consisted of two main sections. Firstly, it reviewed and interpreted the key literature related to the study of TID and talent development in sport. Secondly, it synthesised notational research that had been conducted specific to AF game-play, whilst drawing upon key data sourced from a notational commercial provider to quantify certain technical and tactical elements not yet detailed within the literature.

Identifying individuals who possess the potential for success is a prioritised aspect of the sports science discipline. A comprehensive TID program may optimise the development of prospective talent by targeting a select athletic cohort. Although a wealth of research has uncovered some of the determinants to the TID process in team sports, these traditional programs lack predictive capability, with their corresponding efficacy often being questioned. Specifically, the cross-sectional design of traditional programs does not account for the development process in youth populations and their reliance on mono-dimensional designs to forecast playing prospects in multi-

dimensional contexts has potentially led to biased and unsubstantiated identification practices. Specifically TID in AF has also largely been driven by non-evidence-based practices, with subjective means often reigning supreme, whilst the supplementary objective testing is highly mono-dimensional despite the clear multi-dimensionality of game-play.

**CHAPTER THREE: Can the measurement of physical
characteristics accurately identify talent in junior
Australian football?**

3.1 Introduction

As demonstrated in the *Model of a Skilful Player* (Lauder, 2001), a skilful performance in team sports is attributable to a range of physical, technical and tactical elements. Thus, when attempting to identify talent in such sports it is important that each of these skills are measured; limiting a potential *compensation phenomenon* that may result in an identification bias (Vaeyens et al., 2008). However, the practical feasibility of measuring each multi-dimensional element may provide a challenge for talent recruiters given expertise, logistical and/or technical constraints. In such instances, measurements of physicality may provide an initial means of identifying potential talent when incorporated with additional technical and tactical performance measures (le Gall, Carling, Williams, & Reilly, 2010). It is important to consider that such physical testing should be completed within an athletic cohort that has likely surpassed maturation periods and sporting specialisation (e.g. 17-18 years of age) (Côté, 1999; Malina et al., 2004a; 2004b) to ensure that a captured performance is indeed reflective of potential. Additionally, the tests used to capture a physical performance need to be representative of the abilities utilised by players in game-play (MacNamara & Collins, 2011; Pinder et al., 2013; Vaeyens et al., 2008). Thus, to facilitate the latter consideration, a clear understanding of the sport specific physical requirements is critical.

Given the range of physical characteristics required to successfully play AF, a number of physical assessments have been used for TID purposes (Keogh, 1999; Pyne et al., 2005; Veale et al., 2008; 2010; Young & Pryor, 2007). Specifically, maximal aerobic capacity has been quantified using the 20 m MSFT (Keogh, 1999; Pyne et al., 2005), the Yo-Yo intermittent recovery (level 1) test (Veale et al., 2010) and a 3 km time trial (Veale et al., 2008). Linear speed and acceleration is typically measured via a

20 m sprint, consisting of 5 m and 10 m splits (Pyne et al., 2005; Veale et al., 2008; Young & Pryor, 2007). Measures of agility have been reported by Pyne et al. (2005), Young and Pryor (2007) and Veale et al. (2008) through the use of a pre-planned agility test referred to as the AFL agility test that consists of five changes of direction, whilst lower body power has been measured through the use of both stationary and dynamic vertical jump tests (Keogh, 1999; Pyne et al., 2005; Veale et al., 2008; Young & Pryor, 2007). Tests of muscular strength are scarcely reported within the literature given the difficulty encountered when developing representative tests of muscular strength specific to AF game-play (Keogh, 1999; Young et al. 2005).

Despite this extensive research, sports scientists are yet to identify if, and which, physical characteristics are predictive of talent within a relatively homogenous sample of junior AF players. This study aims to address the first research question of the thesis by investigating if the measurement of physical characteristics can be used to accurately identify talent in junior AF players. The subsequent findings hold important considerations for the establishment of a multi-dimensional battery of objective performance tests designed to assist with the TID process in AF. Given the combative and dynamic nature of game-play, it is hypothesised that certain physical characteristics will be predictive of talent identified juniors.

3.2 Methodology

3.2.1 Participants

From a total sample of 316 U18 WAFL players with a mean age of 17.9 ± 0.6 y, two groups; namely, talent identified ($n = 50$; 17.9 ± 0.5 y) and non-talent identified ($n = 50$; 17.8 ± 0.6 y) participated within this study. The talent identified sample consisted of 50 players who were invited to participate within the 2013 WAFL State U18 Academy squad, whilst the non-talent identified group consisted of 50 players randomly

chosen from the remaining cohort of 266 WAFL U18 players not selected in the Academy squad using the random number generation package in Excel (Microsoft Inc., Redmond, USA, 2010). As shown in Appendix A, the physical and anthropometric profiles of these randomly chosen non-talent identified players were compared to those of their remaining cohort to ensure they provided an accurate representation of the non-talent identified group, with no significant difference being noted across any of the performance measures that are described in the procedures ($P > 0.05$).

To ensure potential discrepancies in physical profiles were not indicative of an earlier birth month, and thus maturational potential (Carling, le Gall, Reilly, & Williams, 2009); RAE calculations for each group were completed. Chi-square analysis indicated that there were no signs of a RAE for either group (talent identified or non-talent identified) when birthdates were controlled for quartile distribution (Q1: Jan-Mar; Q2: Apr-Jun; Q3: Jul-Sept; Q4: Oct-Dec) (talent identified, $\chi^2_3 = 2.00$, $P > 0.05$; non-talent identified, $\chi^2_3 = 2.36$, $P > 0.05$) and half year distribution (H1: Jan-Jun; H2: Jul-Dec) (talent identified, $\chi^2_1 = 0.14$, $P > 0.05$; non-talent identified, $\chi^2_1 = 1.64$, $P > 0.05$). At the time of recruitment all players were injury free and participating in regular training sessions at their respective WAFL clubs. The Edith Cowan University Human Research Ethics Committee provided ethical approval with the West Australian Football Commission, all players and parents/guardians (if players were U18 years of age) providing written informed consent prior to testing (Appendix B, C, D).

3.2.2 Procedures

Given the age of the players used within this study was beyond the specialising years according the *Developmental Model of Sport Participation* (Côté, 1999), a cross-sectional observational research design was deemed suitable. Players completed a

battery of eight physical tests similar to those used within the AFL National Draft Combine; namely a 20 m sprint test, the AFL agility test, a stationary vertical jump test, a dynamic vertical jump dominant leg test, a dynamic vertical jump non-dominant leg test, the 20 m MSFT, and additionally, had their standing height and body mass recorded. All testing was completed on wooden flooring with the exception of the 20 m sprint and the AFL agility test which were completed on a synthetic running track. Testing took place at the end of the 2013 pre-season to ensure peak physiological fitness. A maximum of 50 players were tested at a time, with standing height and body mass being the first measurements recorded. Prior to the physical tests, a standardised warm up was completed by all players, consisting of light jogging, unilateral and bilateral countermovement jumps and dynamic stretches. The physical tests were completed in a circuit fashion and in the following order: 20 m sprint; AFL agility test; stationary vertical jump test; vertical jump dominant leg test, a dynamic vertical jump non-dominant leg test. However, players were randomly divided into five groups of approximately 10 players, and each group was assigned to one of the five testing stations, moving through each station in the above described fashion depending upon which station they were initially allocated. The 20 m MSFT was undertaken after all other testing was completed, with players being split into two equal groups to complete the test. For tests consisting of multiple trials, one minute was allocated between each trial, whilst two minutes was allocated between each testing station. Verbal encouragement was provided for each test requiring maximal effort.

3.2.2.1 Standing height

A stadiometer (Hart Sport, Queensland, Australia) was used to obtain standing height, with measurements being recorded to the nearest 0.1 cm. Players were required

to remove their footwear and were placed in the Frankfort Plane, and instructed to inhale as the measurement was taken.

3.2.2.2 Body mass

A set of calibrated digital scales (A & D Company Limited, Tokyo, Japan) were used to obtain body mass. Players were required to remove their footwear; with body mass being recorded to the nearest 0.1 kg. Training shorts and a singlet were permitted.

3.2.2.3 Stationary and dynamic vertical jump

The stationary and dynamic jump heights were obtained using a Vertec Jump Device (Swift Performance Equipment, Lismore, Australia). The maximum jump height for both the stationary and the dynamic jump was recorded as the difference between the standing reach height (obtained prior to completing both jumps) and the highest vane displaced whilst jumping. A stationary bilateral countermovement jump was used to obtain the players stationary vertical jump height, with the dynamic vertical jump being performed off the outside leg following a five metre straight line run-up. This was completed for both a dominant and non-dominant leg take-off, with leg dominance being defined as the player's preferred kicking leg. At the highest point of each jump, the inside hand was used to displace the vanes of the Vertec, with the highest vane displaced being recorded. For each jump (stationary/dynamic), three trials were completed by all players, and the maximum jump height (cm) was used as the criterion value for analysis.

3.2.2.4 Linear acceleration

Timing lights (Swift Performance Equipment, Lismore, Australia) were used to measure sprint times, with gates being placed at the start line, 5 m, 10 m and 20 m distances and 1.5 m wide. The 5 m and 10 m sprint times were obtained as splits from

the 20 m sprint. Players commenced the sprint in a stationary up-right position, placing their lead foot on the start line. They were cued “*do not decelerate until you reach the two cones*”, which were placed four metres past the 20 m finish line to ensure they did not decelerate. The players commenced the sprint when ready to eliminate a reaction time. Times were recorded to the nearest 0.01 s, with the fastest 5 m, 10 m and 20 m time of three trials being used as the criterion values for analysis.

3.2.2.5 The AFL agility test

The same AFL agility test as described by Young and Pryor (2007) was used, with this test requiring the players to manoeuvre as quickly as possible around five 1.1 m high poles; each with a circumference of 12 cm (Figure 7). If a pole was displaced during the test, the trial was abandoned and re-started after one minute. Players were instructed to not touch the ground with their hands when changing direction, with the trial being abandoned if this occurred. Timing lights (Swift Performance Equipment, Lismore, Australia) were placed 1.5 m apart and were positioned at the start and end of the test. The fastest time of three trials was used as the criterion value for analysis, with times being recorded to the nearest 0.01 s.

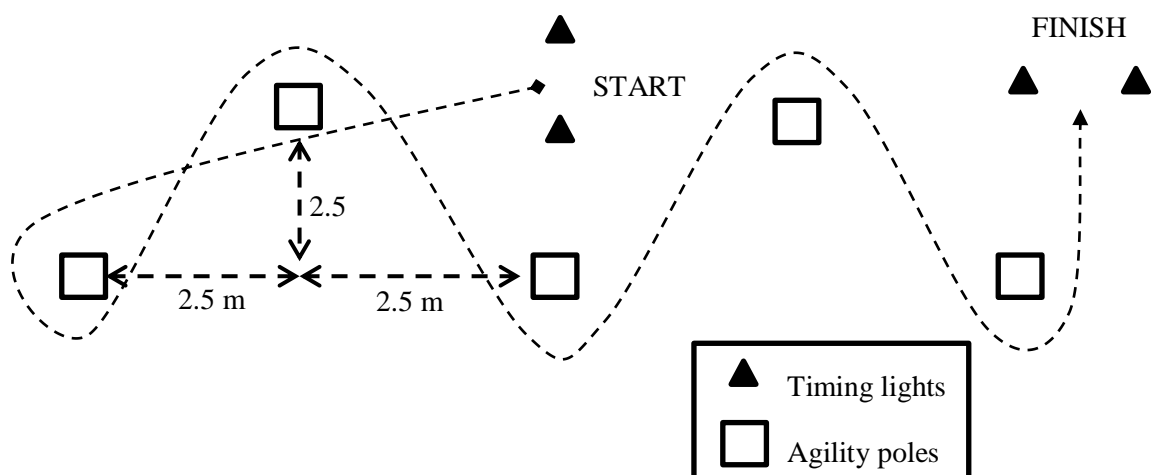


Figure 7. The AFL agility test

3.2.2.6 Maximal aerobic capacity

The 20 m MSFT was used to estimate the player's maximal aerobic capacity following the test protocols outlined by Ellis et al. (2000). Players were required to continually run back and forth along a 20 m distance, whilst keeping in time with a 'beep' emitted by a compact disc. The time between each beep (shuttle) gradually decreased as the test (or levels) progressed; requiring the players to incrementally increase their running speed. The test was concluded when player's either: (1) reached volitional exhaustion, or (2) were unable to keep time with the beeps on two consecutive occasions. The highest level and shuttle successfully obtained by each player was used as the criterion value for analysis.

3.2.3 Statistical analysis

Descriptive statistics, namely means and standard deviations (SD) were calculated for each physical and anthropometric criterion value. A multivariate analysis of variance (MANOVA) was used to test the main effect of 'status' (2 levels: talent identified, non-talent identified) on the physical abilities and anthropometric attributes. This analysis simultaneously tested the effect of status across all of the criterion variables while controlling for inflated Type-I error rates. If required, follow up one-way analysis of variance (ANOVA) was used to identify where statistical significance had occurred. The effect size of status on the physical abilities and anthropometric attributes was calculated using Cohen's d statistic; where an effect size of $d = 0.20$ was considered small, $d = 0.50$ moderate and $d > 0.80$ large (Cohen, 1988). All between group mean comparisons were done using the SPSS software (Version 19, SPSS Inc., Armonk, New York, 2010). The Type-I rate was set at $\alpha < 0.05$.

Logistic regression models were built to predict status using the physical abilities and anthropometric attributes as explanatory variables, with status coded as a

binary variable (1 = talent identified, 0 = non-talent identified). The logistic regression modelling and visualisation were done using the R statistical computing software version 2.15.1 (R Developmental Core Team, Vienna, Austria, 2012). The physical abilities and anthropometric attributes that significantly differed according to status were then used as the predictor variables, and were included in the construction of the full model. The most parsimonious model was found by reducing the full model using the ‘dredge’ function in the *Mumin* package (Burnham & Anderson, 2002). This function returns the best model using Akaike’s model weights (w_i) (Akaike, 1993). To ensure the strength of the best model, a null model was built and used as a comparator.

Additionally, the *pROC* package (Robin et al., 2011) was used to run a sensitivity analysis on the strongest combination model, and for separate models containing only single term predictors, to assess the potential of the predictive model to discriminate between talent identified and non-talent identified players. Bootstrapped receiver operator curves (ROC) were produced for each model(s), and the area under the curve (AUC) was calculated, with an AUC of 1 (100%) representing perfect discriminative power. The point on the curve at which the sum of the talent identified and non-talent identified score was maximised could be considered the value (e.g. the sum of the predictor values for a player) at which a ‘cut-off’ might be acceptable for identifying talented players. Here, the ROC was used to produce such cut-off indicators by using the total score for each player (arbitrary units; au), and for the individual predictors included in the final model.

3.3 Results

Using Pillai’s Trace (V), the MANOVA revealed a significant effect of status on the physical abilities and anthropometric attributes ($V = 0.60$, $F(12, 75.00) = 9.52$, $P < 0.01$). Separate univariate ANOVAs on each criterion value revealed a significant effect

of status on standing height, body mass, stationary vertical jump height, dynamic vertical jump height (dominant and non-dominant leg) and the 20 m MSFT (Table 3). These six predictor variables were then included in the full logistic regression model.

Table 3. The between group differences for each criterion variable (*Mean ± SD*)

Measurement	TI	Non-TI	<i>P</i>	<i>d</i>
Standing height (cm) *	185.8 ± 6.7	179.8 ± 5.3	< 0.01	0.75
Body mass (kg) *	81.3 ± 10.3	74.4 ± 7.9	0.01	0.67
Standing vertical jump (cm) *	62.3 ± 6.2	58.4 ± 4.5	0.03	0.53
Dynamic vertical jump dominant leg (cm) *	72.7 ± 5.7	66.0 ± 5.5	0.02	0.80
Dynamic vertical jump non-dominant leg (cm) *	80.0 ± 6.4	72.9 ± 5.1	< 0.01	0.97
20 m multistage fitness test (level.shuttle) *	12.7 ± 1.0	11.9 ± 0.9	< 0.01	0.59
Agility (s)	8.37 ± 0.27	8.47 ± 0.22	0.06	0.40
5 m sprint (s)	1.12 ± 0.05	1.10 ± 0.05	0.10	0.20
10 m sprint (s)	1.83 ± 0.06	1.84 ± 0.05	0.59	0.08
20 m sprint (s)	3.09 ± 0.10	3.12 ± 0.08	0.16	0.10

* Between group effect ($P < 0.05$); TI talent identified; *d* effect size

As shown in Table 4 and Figure 8a, it was the combination of standing height (SH), dynamic vertical jump non dominant leg (DJVNDL) and the 20 m MSFT that provided the best predictive capability ($w_i = 0.15$; AUC = 84.2%). For this full model, the ROC was maximised when the combined score of the physical and anthropometric predictors equalled 268.0 au (Figure 8a). Of the 50 talent identified players, 43 (86%) had a combined score ≥ 268.0 au whilst only 13 (26%) non-talent identified players had a combined score ≥ 268.0 au. Thus, the full model detected 86% of the true positives (talent identified players) and 74% of the true negatives (non-talent identified players).

Table 4. Model summary for the physical characteristics showing the ranking of each model based on the Akaike model weights

Predictors	<i>LL</i>	<i>df</i>	AICc	Δ AIC	w_i
~ SH + DVJNDL + 20 m MSFT	-46.13	4	100.70	0	0.15
~ SH + DVJNDL + BM + 20 m MSFT	-45.50	5	101.64	0.94	0.09
~ SH + DVJNDL + BM + SVJ	-45.50	5	101.65	0.95	0.09
~SH + DVJNDL + DVJDL + 20 m MSFT	-45.66	5	101.97	1.27	0.08
Null (~ 1)	-69.31	1	140.67	39.96	< 0.01

LL log likelihood; *df* degrees of freedom; AICc Akaike Information Criterion; Δ AIC delta AIC; w_i Akaike model weight

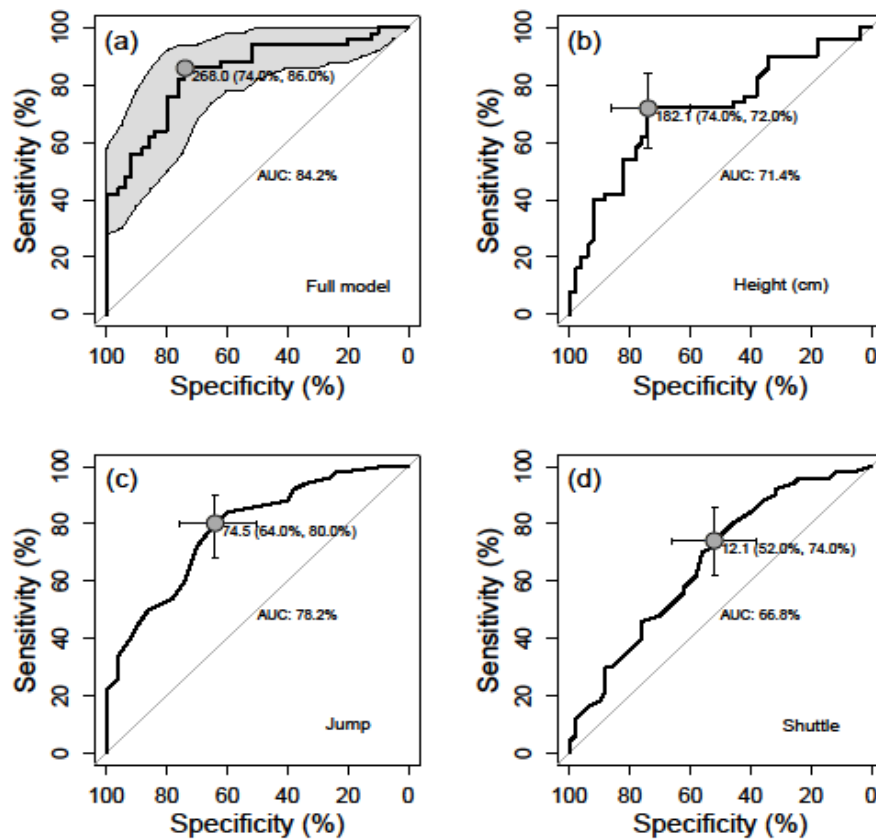


Figure 8. ROC plots for (a) the full logistic regression model (b) SH, (c) DVJNDL, and (d) the 20 m MSFT

The grey shaded area in (a) are the error bars representing the 95% confidence interval

The best single term predictor of status was the dynamic vertical jump non-dominant leg take off (AUC = 78.2%; Figure 8c), with a height of 74.5 cm being the value maximising the ROC, and thus deemed an acceptable cut-off for identifying talented players. The next strongest single term predictor was standing height (AUC = 71.4%, Figure 8b), with a standing height of 182.1 cm being the value maximising the ROC, thus reflecting an acceptable cut-off for identifying talented players, whilst finally the 20 m MSFT had an AUC of 66.8% (Figure 8d), with a score of 12.10 maximising the ROC; being an acceptable cut-off for identifying talent. Of the 13 non-talent identified players who had a combined score greater than 268.0, three players exceeded all three predictor variables. Specifically, these three players had a dynamic vertical jump non-dominant leg take off height > 74.5 cm, a standing height > 182.1 cm and scored > 12.10 on the 20 m MSFT, despite being within the non-talent identified sample, whilst the other misclassified non-talent identified players exceeded the cut-off on individual measurements only.

3.4 Discussion

This aim of this study was to investigate if the measurement of physical characteristics could be used to accurately identify talent in U18 AF players. Results indicated significant differences between the talent identified and non-talent identified players in measures of standing height, body mass, stationary vertical jump height, dynamic vertical jump height (both dominant and non-dominant leg take off), and the 20 m MSFT. However, the best predictive model retained only the combination of standing height, dynamic vertical jump height non-dominant leg take off and the 20 m MSFT as the strongest predictor of talent; with this model successfully classifying 86% and 74% of the talent identified and non-talent identified players, respectively.

The anthropometric differences noted within this study are similar to those reported by Keogh (1999) and thus collectively, the results suggest that taller and heavier bodies may be better suited for the requirements of AF at an U18 level. This may stem from the invasive nature in which the game is played; for example, taller players may have greater success in aerial ball contests (i.e. when the ball is kicked in the air to a pack of players) (Young & Pryor, 2007), when compared to their smaller counterparts. Moreover, the mean standing height of the talent identified sample appeared to be closer to that reported within the AFL (185.8 ± 6.7 cm versus 189 ± 8 cm, respectively) when compared to the non-talent identified sample (179.8 ± 5.3 cm versus 189 ± 8 cm, respectively) (Young et al., 2005). It is possible that the talent recruiters perceived taller players to be more competitive at an elite senior level if ultimately drafted into the AFL; warranting their inclusion within an elite talent development program.

The mean differences noted in the players stationary vertical jump height is in agreement with previous research (Keogh, 1999; McGee & Burkett, 2003; Young et al., 2005). Given this finding, the talent identified sample were also expected to have a greater dynamic vertical jump height when taking off both their dominant and non-dominant leg. It is of note that the mean height for the dynamic vertical jump dominant leg take off was lower than that of the dynamic vertical jump non-dominant leg in both samples; potentially being explained by the stabilisation role and corresponding movement pattern of the non-dominant leg during the kicking action (Lees, Asai, Anderson, Nunome, & Sterzing, 2010). However, further research is required to better understand this bilateral relationship in AF. When comparing the effect sizes of the vertical jumps with those of the linear sprints, an intriguing assumption can be drawn. Specifically, as the vertical jumps are presumably indicative of lower body power, it

seems rather counterintuitive for the linear sprints to have such negligible effect sizes when compared to the vertical jumps. An explanation for this may be that the vertical jumps require a higher level of gross motor coordination and control in addition to lower body power (Aouadi et al., 2012), particularly during the dynamic take off phase, when compared to the linear sprint. Indeed, the talent identified players may not necessarily be more powerful within their lower extremities in comparison to their non-talent identified counterparts, but rather possess a higher level of gross motor coordination and control; thus potentially obtaining a higher vertical jump height, both stationary and dynamically.

Despite using different tests to measure maximal aerobic capacity, the results of this study show agreement with Veale et al. (2010), who noted that talent identified junior AF players (U18) had a greater maximal aerobic capacity (as measured by the Yo-Yo intermittent recovery test) in comparison to their non-talent identified peers. Given the Yo-Yo intermittent recovery test and the 20 m MSFT are both continual incremental tests designed to assess maximal aerobic capacity and have both been shown to measure this attribute (Keogh, 1999; Veale et al., 2010); collectively, these results suggest that a greater aerobic capacity may be a desirable trait within U18 AF. Specifically, in game-play the average distance covered by U18 players ranges between 11,000 m to 15,000 m (Veale & Pearce, 2008). Thus, U18 players who are better equipped to manage these aerobic requirements may be more successful in game-play. Further, with recently implemented interchange limits imposed within the AFL (120 per team per game) in conjunction with a reduced player available for rotation during a game (four down to three players available for regular rotation off the bench), it is possible that highly aerobic players will be looked upon more favourably for selection within elite senior competitions; as such players may be exposed to large game times

with minimal aerobic decrement. Although this rule change is yet to be administered within elite U18 competitions, it is possible that talent recruiters forecasted the importance of this ability within elite senior competitions and by doing so, looked upon aerobically proficient U18 players more favourably. Additionally, when maximal aerobic capacity is coupled with a superior jump height and standing height, players may have a considerable influence on aerial contested possessions. Concurrently, a greater aerobic capacity may allow players to consistently ‘out-run’ their opponents, and although being speculative, when coupled with a potentially superior tactical awareness, a player may be able to place themselves in a greater number of field positions to obtain ball possession.

As no signs of a RAE were evident in either sample, the assumption that relatively older individuals may benefit from a superior physical developmental opportunity does not appear to fit within the current athletic cohort. This suggests that other factors may be contributing to the superior physicality shown by the talent identified U18 players within this study. Perhaps the superior physical profiles shown by the talent identified player’s stemmed from advantageous genetic factors or differences in training background (Côté, 1999; Gagné, 1993). For example, pre-adolescent athletes exposed to specific integrated neuromuscular training may show exponential physiological improvements well into late adolescence and young adulthood when compared to pre-adolescents not exposed to such training practices (Myer, Lloyd, Brent, & Faigenbaum, 2013).

A key practical consideration stemming from this study are the cut-off values deemed as acceptable for identifying talented U18 players based upon their physical and anthropometric profile. According to the AUC presented within Figure 8a, the combination of three physical measurements (standing height, stationary vertical jump

height and score obtained on the 20 m MSFT) provided the best prediction when compared to any one individual test, and thus, a combined score of greater than 268.0 au may be an acceptable cut-off value for initially identifying potential State U18 players within the WAFL.

3.5 Conclusion

Considerable differences were noted between the talent identified and non-talent identified players in measures of standing height, body mass, lower body power and maximal aerobic capacity. However, it was the combination of standing height, dynamic vertical jump height non-dominant leg take off and the 20 m MSFT test that provided the best identification of talent when using physical measures. In accordance with the *Model of a Skilful Player* (Lauder, 2001), it is important to note that the findings reported within this chapter do not fully encapsulate a talented performance in AF. Reflective of this, seven and 13 players within the talent identified and non-talent identified sample were misclassified, respectively. It is likely that either a disadvantageous or advantageous physical profile was accounted for in these individuals by a superior performance in another element of effective play (i.e. technical and/or tactical). Acknowledging the occurrence of a likely *compensation phenomenon*, it is crucial that research as described in the subsequent chapters is directed toward the objective measurement of technical and tactical skill to further guide the development of multi-dimensional performance tests specific to AF. Nevertheless, the current chapter provides a key element to the development of a multi-dimensional approach to TID by highlighting the key physical determinants of a talented performance in junior AF.

**CHAPTER FOUR: Can measurements of technical
skill be used to accurately identify talent in junior
Australian football?**

4.1 Introduction

Given the multi-dimensionality of team sport, the challenge for talent recruiters is to identify juniors who possess a balance of both skill and physiology (Farrow et al., 2008). As established within Chapter Three, specific physical characteristics; namely standing height, lower body power (as determined by a dynamic vertical jump test) and maximal aerobic capacity (as determined by the 20 m MSFT) are the main physical determinants of talent identified junior AF players. However, the technical skill determinants of a talented performance are currently unknown in junior AF; a gap which is necessary to fill when attempting to develop a comprehensive multi-dimensional approach to objective TID practices in the game.

Currently, a talented technical performance in AF is predominantly identified through subjective in-game evaluation (e.g. a talent recruiter's perceptions of a player's skill by observing them perform in game-play). However, subjectively assessing such skill characteristics whilst in game-play is considerably problematic. Notably, perceptual differences held by talent recruiters as to what actually constitutes technical skill may decrease the reliability of the identification process. Moreover, players who possess slightly 'unconventional' technique that might not be aesthetically pleasing, yet still effective, may not be credited as 'skilful', and subsequently may not be talent identified through subjective practice. However, subjective assessments of technical skill are to be expected, as to date, there is currently no evidence-based means of capturing a skilful technical performance in AF through the use of objective testing.

The difficulty encountered when designing technical skill tests representative of the characteristics of game-play is that the game's technical requirements are highly dynamic and often externally constrained. Technical skills inclusive of, but not limited to, kicking, handballing, marking and bouncing are routinely performed by players in

game contexts. However, despite the range of technical characteristics, successful ball disposal (via a kick or handball) is paramount for an effective performance outcome in team ball sports. Within AF, kicks are typically performed following the release of the ball from the hand, but the ball can also be kicked off the ground without hand contact. Given kicking accuracy and teammate marking (i.e. catching) considerations, the drop punt is the most common kick performed by players in game-play (Ball, 2008). Generally, kicks are classified into three distances; short (approximately 25 m), medium (approximately 35 m) or long (approximately 45 m) (Appleby & Dawson, 2002), with the increased efficiency of these kicks considerably improving a team's scoring potential (Ball 2007; Forbes, 2003), and likelihood of success (Sullivan et al., 2014). Although the target accuracy is a crucial element of an effective ball disposal, the velocity at which the ball travels to its target is also an important contributor. Specifically, to limit an opposition's interceptive potential, it may be advantageous for short and long field kicks to reach their intended target with a high velocity. Moreover, measuring ball velocity in conjunction with accuracy may allow the investigation into a speed-accuracy trade-off, where less talented individuals may sacrifice the velocity of movement for the preservation of its corresponding accuracy, whilst talented individuals may be able to maintain both elements (Girgenrath et al., 2004; van den Tillaar & Ettema, 2006). Thus, representative technical skill tests designed to assess ball disposal in AF should consider the inclusion of velocity measurements in conjunction with accuracy to allow for a more thorough analysis of the determinants of a talented technical performance.

Handballing is a highly unique technical skill specific to AF and is performed by cradling the ball in one hand and striking it with a fist created by the other hand. Rule constraints imposed during game-play dictate that a kicking distance of less than 15 m

cannot be credited with a mark (i.e. stoppage of play), thus it can be presumed that a handball would appear to be the primary mode of ball disposal over distances less than 15 m. Additionally, as described within Chapter Two, handballs are typically performed over short (< 6 m) or long (> 6 m) distances within one to three seconds of the ball being received (Parrington et al., 2013).

Understanding these basic in-game requirements can subsequently assist with the guidance of skill measurement through the construction of tests that are representative of the environmental constraints placed upon players in game-play; enhancing the ecological validity of the performance test (Ball & Horgan, 2013; Robertson et al., 2014). Further, the consultation with an expert coaching panel can provide clarity with regards to the temporal constraints often imposed upon players in game-play, and thus may be useful when designing representative test (Lorains et al., 2013a; 2013b).

This study aims to investigate whether objective measurements of technical skill could be used to accurately identify talent in U18 AF, thus addressing the second research question of this thesis. It is hypothesised that talent identified players will be more technically proficient than their non-talent identified counterparts based upon recent research conducted by Sullivan et al. (2014) who noted that successful AFL teams were characterised by a greater number of efficient skill involvements (specifically long kicks) when compared to their unsuccessful opposition. Thus to test this hypothesis, two tests measuring kicking and handballing skill will be used.

4.2 Methodology

4.2.1 Participants

From a total sample of 86 U18 WAFL players with a mean age of 17.6 ± 0.6 y, two groups; namely, talent identified ($n = 25$; 17.9 ± 0.5 y) and non-talent identified ($n = 25$; 17.3 ± 0.6 y) were recruited to participate in the current study. Players were classified as talent identified or non-talent identified using the same criteria as described within Chapter Three. As done within Chapter Three, chi-square analysis was undertaken to ensure that there was no RAE for either group when controlled for quartile distribution (talent identified, $\chi^2_3 = 2.12$, $P > 0.05$; non-talent identified, $\chi^2_3 = 2.89$, $P > 0.05$) and half year distribution (talent identified, $\chi^2_1 = 0.33$, $P > 0.05$; non-talent identified, $\chi^2_1 = 1.87$, $P > 0.05$). At the time of recruitment all players were injury free and participating in regular games and/or training sessions. The Edith Cowan University Human Research Ethics Committee provided ethical approval with all participants and parents/guardians (if participants were U18 years of age) providing written informed consent prior to testing.

4.2.2 Procedures

As was used within Chapter Three, a cross-sectional observational research design was employed here given the age of the participants was likely to have seen them surpass the specialising years according to the *Developmental Model of Sport Participation* (Côté, 1999). Participants completed a kicking and handballing test, herein referred to as the Australian Football Kicking (AFK) test and the Australian Football Handballing (AFHB) test. The talent identified and non-talent identified samples were tested on separate occasions, thus no more than 25 participants were tested at a time. The AFK test was completed on an outdoor football field, with the ambient temperature and wind speed recorded prior to testing to ensure similarities

between two testing sessions. A wind speed and temperature variation of less than 5 km.hr⁻¹ and 5°C, respectively, were deemed as being acceptable limits, with the two testing conditions being within these climatic zones. Due to the methodological design of the AFHB test, testing was completed in an indoor biomechanics laboratory. A standardised warm up was completed by all participants that consisted of light jogging and dynamic stretches, whilst a full practice trial of both tests on the dominant and non-dominant sides was completed in an attempt to minimise trial error. Testing took place at the end of the 2013 WAFL season to standardise the technical skill of participants. For both tests, ten seconds was allocated between each disposal (kick or handball). A Stalker-radar gun (Applied Concepts Inc., New York, USA) was used to measure the peak ball speed during the AFK test. Ball speed was not assessed in the AFHB test, as an expert panel of coaches ($n = 3$ state level coaches with a minimum of 10 years' experience) deemed this variable as a less critical assessment point for the handball in AF; noting that speed was not a key teaching point when coaching the handball. In accordance with this suggestion, ball speed was not included as a criterion variable for the AFHB test.

4.2.2.1 The AFK test

Before commencing the test, participants were required to nominate their dominant and non-dominant leg, with dominance being defined as their preferred kicking leg. One kick was completed at each distance (short, 20 m; medium, 30 m; long, 40 m) with the first three kicks being on their dominant leg. This influenced the side that they disposed the ball to; for example, if their dominant leg was their left leg, they would kick to the targets on the right side of their body. To begin the test, the participant was given possession of a football (AFL match standard) and stood on the start cone facing away from the targets (Figure 9). When cued by a whistle blown by the

scorer (designed to mimic that of an umpire), the participant ran to the turn cone, made a 180° turn (self-directed) and disposed the ball from behind the release line to a specified target player; positioned within a target circle. The target player was randomly assigned before each disposal by the scorer; however each target was only called once per side. The designated target player was required to call for the ball while remaining within the perimeter of the circle as the participant manoeuvred around the turning cone; whilst the remaining targets were stationary. The target player was instructed to “call for the ball as if you were in a game situation” to further optimise the tasks ecological construct. Once the three disposals on their dominant side (one at each distance) were completed, the participant was then instructed to use their non-dominant leg to dispose the ball to the target players on the opposite side. Participants were cued to “kick the ball to the target player as quickly and as accurately as possible” but if the ball was not disposed within three seconds of the trial commencing, they received a score of zero. This temporal constraint was implemented, as the expert coaching panel noted this as being similar to the time imposed upon players during game-play, and was supported by Parrington et al. (2013) who noted that the disposal time in AF was commonly between one to three seconds. To assess a participants kicking accuracy, two criterion variables were used; these being the participant’s total score on their dominant leg and their total score on their non-dominant leg. Additionally, two criterion variables were used to assess a participant’s ball speed; these being their average peak ball speed on each side. Accuracy was assessed through the use of the following scoring criteria; which was constructed with assistance from the expert panel of coaches:

- **3 points:** The ball reached the target player on the full and they did not have to leave the target circle to receive possession.
- **2 points:** The ball reached the target player on the full, however they were required to place one foot outside of the target circle to receive possession.
- **1 point:** The ball reached the target player on the full but they had to place both feet outside of the target circle to receive possession.
- **0 points:** The target player did not receive possession of the ball on the full.

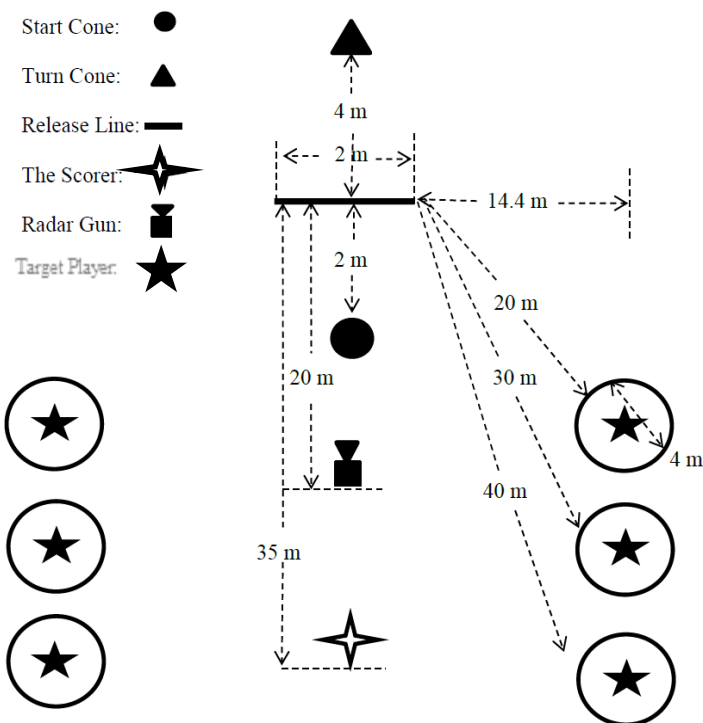


Figure 9. The AFK test utilised within the current study

4.2.2.2 Psychometric properties of the AFK test

To ensure the inter-rater reliability of the scoring criteria, two independent scorers assessed the same 10 trials, with the kappa statistic (κ) being used to assess the level of agreement between the scores given at each distance. Landis and Koch (1977) state the level of agreement for the kappa statistic as follows, < 0 less than chance agreement, 0.01-0.20 slight agreement, 0.21-0.40 fair agreement, 0.41-0.60 moderate

agreement, 0.61-0.80 substantial agreement, 0.81-0.99 almost perfect agreement. The strength of agreement at each distance is presented in Table 5.

To ensure the test-re-test reliability of the AFK test, eight randomly chosen talent identified players performed three kicks to each distance on the same trial. However, the targets were randomly allocated by the scorer to minimise any learning effect. This was undertaken separately from their main trial. The same test protocols were followed, with a two-way mixed single intra-class correlation coefficients (3, 1) indicating strong test-re-test correlations at each distance on both the dominant and non-dominant sides (Table 5).

Table 5. The test-retest and inter-rater reliability of the AFK test

Distance	Inter-rater reliability (κ)	Test-re-test reliability (ICC)
Short dominant	0.84	0.82
Short non-dominant	0.87	0.97
Medium dominant	0.78	0.95
Medium non-dominant	0.80	0.84
Long dominant	0.80	0.95
Long non-dominant	0.73	0.90
Range	0.73 – 0.87	0.82 – 0.97

4.2.2.3 The AFHB test

Following a similar protocol to the AFK test, participants were required to nominate their dominant and non-dominant hand prior to commencing the test, with hand dominance being defined as a participant's preferred hand for handballing. Following this, the participant was informed that the first nine handballs were to be on their dominant side. To begin the test, the participant was given possession of an AFL

match standard football and adopted a forward facing stance 8 m from the target. A distance of 8 m was chosen in accordance to the advice provided by the same expert panel of coaches as described within the AFK test design, and was also supported by the findings of Parrington et al. (2013). A 3 x 3 target grid was arranged, with each square being 50 cm wide and high for a total grid measurement of 150 x 150 cm. Each square was randomly numbered, ranging from one to nine (Figure 10).

When ready, the participant was required to handball once to each target, with the order being randomly chosen by a caller. Once the nine handballs on the dominant side had been completed, the participant was then required to use their non-dominant side. The participants were given one point if they successfully handballed the ball anywhere within the perimeter of the target number chosen; however ‘line-balls’ (e.g. handballs which hit the perimeter of the target, not within the target) were classified as a ‘miss’ and thus scored a zero. The participants were cued to “handball as quickly and as accurately as possible”, but if the handball was not completed within three seconds of the target being called, they were given a miss for that target. Three seconds was again used given the recommendations made by both the expert panel of coaches and the findings proposed by Parrington et al. (2013). To ensure the accuracy of the scores given, each trial was recorded through the use of a digital video camera (Sony, HDR-XR260VE) for later analysis. To assess a participant’s handballing accuracy, two criterion variables were used; these being the participant’s total score (maximum of nine) on each of their dominant and non-dominant side.

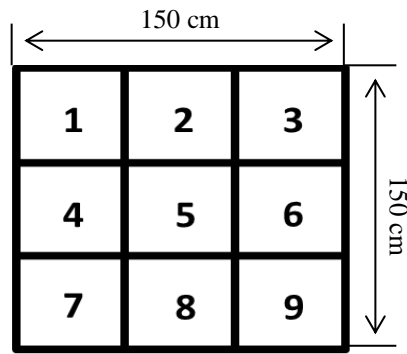


Figure 10. The handball grid as used within the AFHB test

4.2.3 Statistical analysis

Descriptive statistics, namely means and standard deviations (SD) were calculated for all test criterion variables; kicking accuracy and ball speed on both dominant and non-dominant sides and handballing accuracy on both dominant and non-dominant sides. A MANOVA was used to test the main effect of ‘status’ (2 levels: talent identified, non-talent identified) on the test criterion variables, with a one-way ANOVA being used to identify where significance had occurred if at all. The effect size of status on the test criterion variables was calculated using Cohen’s *d* statistic, with effect size strengths being described elsewhere (in Chapter Three). All between group mean comparisons were done using the SPSS software (Version 19, SPSS Inc., Armonk, New York, 2010), with the Type-I error rate being set at $\alpha < 0.05$.

Logistic regression models were built to predict status for both tests; using the test criteria as the explanatory variables, with status coded as a binary variable (1 = talent identified, 0 = non-talent identified). All modelling and visualisation were done using the statistical computing software R version 2.15.1 (R Developmental Core Team, Vienna, Austria, 2012). The test criterion variables that significantly differed according to status were used as the predictor variables and were included in the full models for both tests (as was done in Chapter Three). Following this, the most parsimonious model

was found for each test by reducing the full model using the ‘dredge’ function in the *Mumin* package (Burnham & Anderson, 2002). This function returns the best model using Akaike’s model weights (w_i) (Akaike, 1993). To ensure the strength of the best model, a null model was built and used as a comparator.

Additionally, the *pROC* package (Robin et al., 2011) was used to run a sensitivity analysis on the strongest combination model and for separate models containing only single term predictors, to assess the capability of the predictive model to discriminate between talent identified and non-talent identified players. Bootstrapped ROC’s were produced for each model, and the AUC was calculated, with an AUC of 1 (100%) representing perfect discriminant power (as was done within Chapter Three). The point on the curve at which the sum of the talent identified and non-talent identified score was maximised could be considered the value (e.g. the sum of the predictor values for a player) at which a ‘cut-off’ might be acceptable for selecting players. Here, the ROC was used to produce such cut-off indicators by using the total score for each player (au), and for the individual predictors included in the final model.

4.3 Results

The MANOVA revealed a significant effect of status on the technical variables ($V = 0.62$, $F(7, 42.00) = 9.930$, $P < 0.01$), with the follow-up analysis revealing a significant effect of ball speed and kicking accuracy for the AFK test and handballing accuracy for the AFHB test (Table 6). The full logistic regression models were built using the four predictor variables for the AFK test (dominant accuracy, non-dominant accuracy, dominant ball speed and non-dominant ball speed) for the AFK test and the two predictor variables (dominant and non-dominant accuracy) for the AFHB test.

Table 6. Between group differences for the skill test criterion variables (*Mean ± SD*)

AFK Test				
Measurement	TI	Non-TI	<i>P</i>	<i>d</i>
DomAcc (au)*	7.6 ± 1.3	5.5 ± 2.2	< 0.01	1.03
Non-DomAcc (au)*	5.4 ± 1.6	3.3 ± 2.7	< 0.01	0.86
DomBS (km.hr ⁻¹)*	62.1 ± 4.0	57.3 ± 4.2	< 0.01	1.01
Non-DomBS (km.hr ⁻¹)*	58.4 ± 4.9	52.7 ± 4.6	< 0.01	1.03
AFHB Test				
DomAcc (au)*	6.0 ± 1.2	3.7 ± 1.7	< 0.01	1.20
Non-DomAcc (au)*	5.4 ± 1.2	3.6 ± 0.9	< 0.01	1.00

* Between group effect ($P < 0.05$); DomAcc dominant accuracy; Non-DomAcc non-dominant accuracy;

DomBS dominant ball speed; Non-DomBS non-dominant ball speed; TI talent identified; *d* effect size

4.3.1 The AFK predictive model

For the full model, a combination of dominant accuracy, dominant ball speed, non-dominant accuracy and non-dominant ball speed, produced the best outcome ($w_i = 0.25$, AUC = 89.4%), as shown in Table 7 and Figure 11. The ROC, as shown in Figure 11, was maximised when the combined score of the AFK test variables equalled 127.3 au. Of the 25 talent identified players, 21 (84%) had a combined score ≥ 127.3 au, whilst only six (24%) non-talent identified players had a combined score ≥ 127.3 au. Thus, the full model successfully detected 84% (21) of the true positives (talent identified players) and 76% (19) of the true negatives (non-talent identified players).

Table 7. Model summary table for the AFK test showing the ranking of each model based on the Akaike model weights

AFK Test					
Predictors	<i>LL</i>	<i>df</i>	AICc	Δ AIC	w_i
~ DomAcc + DomBS + Non-DomAcc + Non-DomBS	-16.83	5.00	45.02	0.00	0.25
~ DomAcc + DomBS + Non-DomAcc	-18.09	4.00	45.06	0.04	0.24
~ DomAcc + Non-DomBS	-19.78	3.00	46.08	1.06	0.15
~ DomAcc + Non-DomAcc + Non-DomBS	-18.77	4.00	46.43	1.41	0.12
~ DomAcc + DomBS + Non-DomBS	-19.10	4.00	47.10	2.08	0.09
~ DomBS + Non-DomAcc	-20.40	3.00	47.33	2.31	0.08
Null (~ 1)	-34.66	1.00	71.40	26.38	< 0.01

LL log likelihood; *df* degrees of freedom; AICc Akaike Information Criterion; Δ AIC delta AIC; w_i Akaike model weight

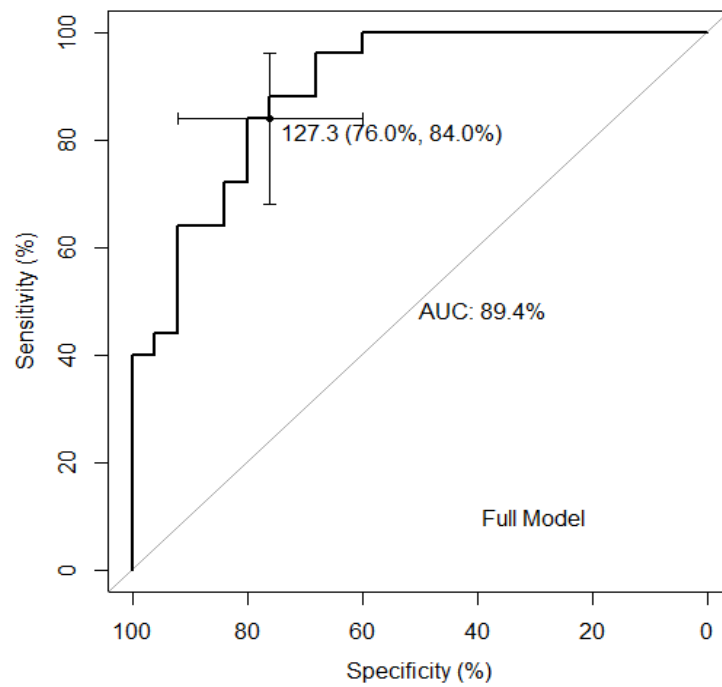


Figure 11. Bootstrapped ROC for the full logistic regression model for the AFK test

The best single term predictor of status for the AFK test was the dominant leg accuracy (AUC = 79.8%), with a score of 6.5 au being the value maximising the ROC (Figure 12a). This was followed by the non-dominant and dominant leg ball speed (AUC = 79.5%; AUC = 78.7%, respectively), with speeds of 50.7 km.hr⁻¹ (14.08 m.s⁻¹) and 61.0 km.hr⁻¹ (16.94 m.s⁻¹), respectively, maximising the ROC (Figure 12c and 12d). Finally, accuracy on the non-dominant leg was the weakest single term predictor of status (AUC = 74.5%), with a score of 3.5 au maximising the ROC (Figure 12b). Of the six non-talent identified players who had a combined score ≥ 127.3 au, one exceeded the cut-off value for each kicking variable, whilst the remaining five players exceeded the cut-off on only one kicking variable.

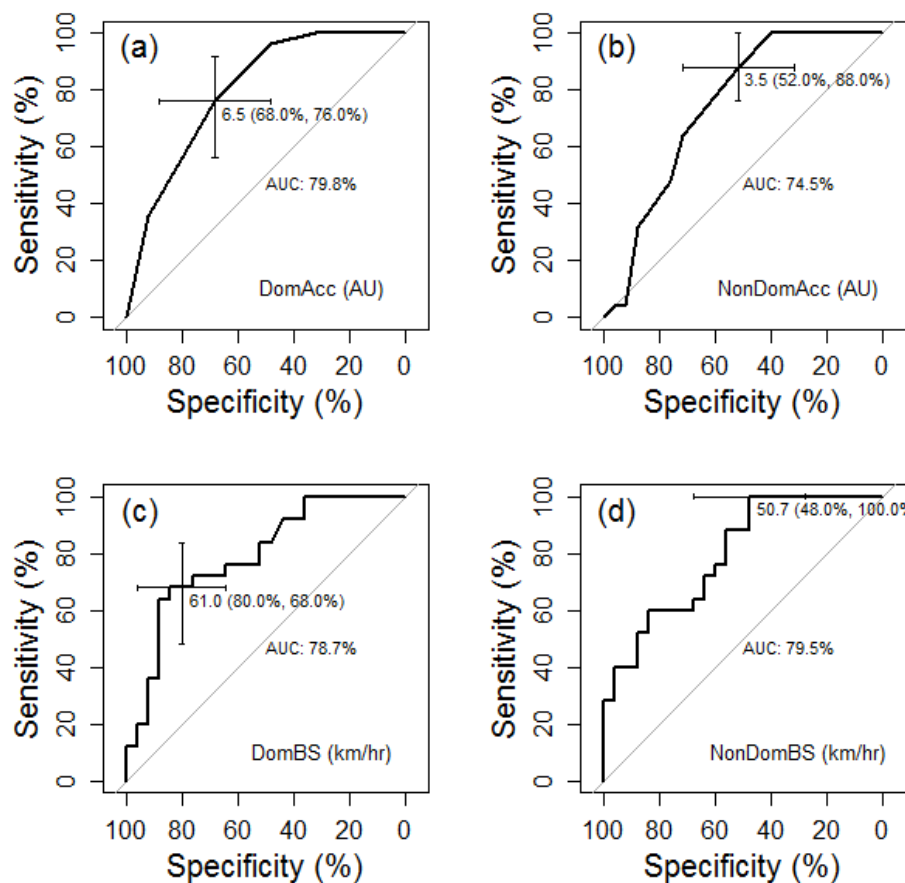


Figure 12. Bootstrapped ROC's for (a) dominant leg kicking accuracy, (b) non-dominant kicking leg accuracy, (c) dominant kicking leg ball speed, and (d) non-dominant kicking leg ball speed

4.3.2 The AFHB predictive model

The full model which included the combination of a players dominant and non-dominant handballing accuracy was the model that best predicted status ($w_1 = 0.80$, AUC = 88.4%), as shown in Figure 13 and Table 8. The ROC was maximised when a combined score (i.e. sum of dominant and non-dominant accuracy scores) equalled 8.5 au (Figure 13). Of the 25 talent identified players, 23 (92%) had a combined score ≥ 8.5 au, whilst only six (24%) non-talent identified players had a combined score ≥ 8.5 au. Thus, the model successfully detected 92% of the true positives (talent identified players) and 76% of the true negatives (non-talent identified players). Handballing accuracy on the dominant side was the best single term predictor of status (AUC = 85%), with a score of 5.5 au maximising the ROC (Figure 14a), whilst the handballing accuracy on the non-dominant side had an AUC of 78.2% and a maximised ROC score of 3.5 au (Figure 14b). Of the six non-talent identified players who had a combined score ≥ 8.5 au, three exceeded the cut-off value for each handballing variable, whilst the remaining three exceeded the cut-off on only one handballing variable.

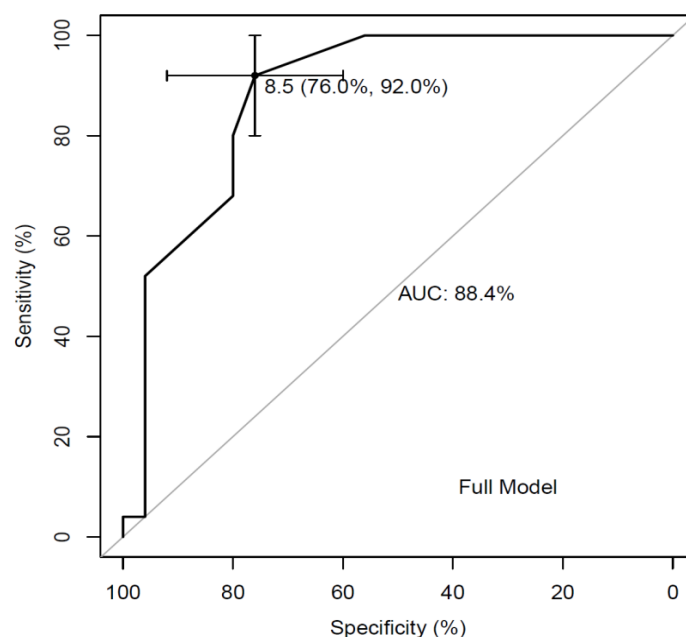


Figure 13. Bootstrapped ROC for the full logistic regression for the AFHB test

Table 8. Model summary table for the AFHB test showing the ranking of each model based on the Akaike model weights

AFHB test					
Predictors	<i>LL</i>	<i>df</i>	AICc	Δ AIC	w_i
~ DomAcc + Non-DomAcc	-21.26	3.00	49.05	0.00	0.80
~ DomAcc	-23.82	2.00	51.89	2.84	0.19
Null (~ 1)	-34.66	1.00	71.40	22.35	< 0.01

LL log likelihood; *df* degrees of freedom; AICc Akaike Information Criterion; Δ AIC delta AIC; w_i Akaike model weight

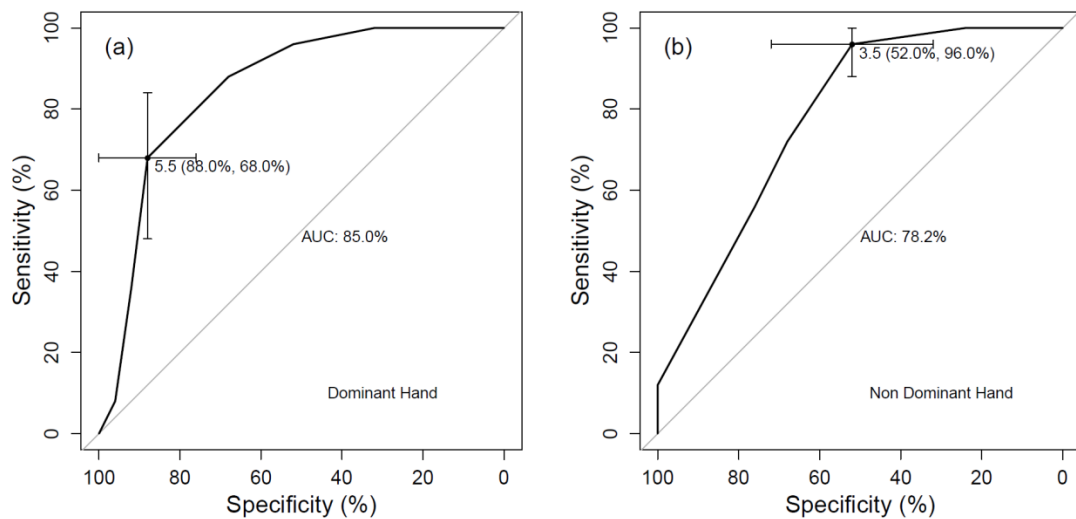


Figure 14. Bootstrapped ROC's for (a) dominant handballing accuracy, and (b) non-dominant handballing accuracy

4.4 Discussion

The aim of this study was to investigate if objective measurements of kicking and handballing skill could be used to accurately identify talent in junior AF; answering the second research question. Subsequently, the AFK test and the AFHB test were developed, and results supported the hypothesis that talent identified players would exhibit greater ball disposal skills in comparison to their non talent counterparts, with

both skill tests shown to be highly predictive of talent. Notably, it was the combination of all technical criterion variables for both tests that showed the greatest predictive value and thus classification potential. Consistent with the findings in other team invasion sports (Ali et al., 2007; Russell et al., 2010), the vast majority of the talent identified AF players possessed greater technical proficiency in comparison to their non-talent identified counterparts when kicking and handballing. These results support the construct of both tests when measuring kicking and handballing skill in AF and in doing so reinforce their usage in the TID process in AF.

Despite the originality of this research, the differences in technical skill noted between the two samples was to be expected based upon the findings of other research in team field and court ball sports (Ali et al., 2007; Farrow, 2010; Russell et al., 2010). Specifically, both Ali et al. (2007) and Russell et al. (2010) reported differences between talent identified and non-talent identified soccer players in measures of accuracy and speed for passing and in goal shooting tests specific to soccer. Moreover, Farrow (2010) noted that measures of passing skill discriminated talent in netball; explaining a considerable amount of variability between the open and developmental squads. Thus, although being different ball sports, the combined results suggest that talent identified players are more technically proficient (at least when kicking, and handballing in our case) when compared to their non-talent identified peers in certain team sports. It could be presumed that a higher calibre of technical skill when disposing the ball may lead to a greater potential for team success; as players are able to execute more intricate tactical strategies designed to overcome opposition defensive structures. For example, short kicks are often used by players to overcome an opposition's zone defence in AF. However, such a tactical strategy can be extensively damaging if players are unable to execute such proficient disposal.

For both the kicking and handballing tests, the criterion variables that significantly differed according to status were included as predictor variables within the full logistic regression models. According to the AUC's illustrated in both Figure 11 and Figure 13, it was the combination of each criterion variable that best predicted status. Thus, a score of greater than 127.3 au and 8.5 au for the AFK and AFHB tests, respectively, may be seen as acceptable cut-off values when utilising these tests for TID purposes within the WAFL. Of particular interest were the low discriminating scores for the accuracy variables on the non-dominant side for both tests. This may suggest that both groups lack proficiency when executing disposals on their non-dominant side. From this finding, it could be inferred that the talent identified players were better able to supplement this inefficiency on their non-dominant side with a superior performance on their dominant side. Additionally, due the multi-dimensional nature of AF, the talent identified players may have possessed other attributes (for example, refer to Chapter Three) that outweighed an apparent technical inefficiency.

4.5 Conclusion

Considerable differences were noted between the talent identified and non-talent identified players in all measures of technical skill. It was however, the combination of kicking accuracy and ball speed (off both the dominant and non-dominant sides) and handballing accuracy (off both dominant and non-dominant sides) that were the greatest determinants of talent for both tests. Given these findings, it can be concluded that both the AFK and AFHB tests are valuable for TID purposes in AF. Their representative design allows the accurate identification of high and low skilled players with regards to ball disposal; holding strong rationale for their inclusion within a multi-dimensional battery of performance tests designed to enhance the accuracy of objective TID.

When the results of the current research are analysed in conjunction to those reported within Chapter Three, it is clear that talent identified U18 players possess a unique blend of physical and technical characteristics when compared to their non-talent identified peers. These combined findings further argue against the use of traditional approaches to TID, and support the development of a multi-dimensional approach to TID. However, prior to establishing a battery of multi-dimensional performance tests to enhance the accuracy of objective TID in AF, the remaining element of effective play as outlined in the *Model of a Skilful Player* (Lauder, 2001), namely decision-making skill, needs to be investigated.

CHAPTER FIVE: Can the measurement of decision-making skill accurately identify talent in junior Australian football?

5.1 Introduction

As discussed throughout this thesis, capturing a talented performance in team sports through the use of objective performance testing is challenging, as it requires the consideration of a range of multi-dimensional elements (Falk et al., 2004; Farrow, 2010; Farrow & Raab, 2008). Thus, Chapters Three and Four investigated the use of objective physical and technical testing for use in the TID process in junior AF. However, to date, it is unknown if talent identified junior AF players possess superior decision-making skill despite its suggested importance for success in team ball sports (Berry et al., 2008; Farrow, 2010; Farrow & Raab, 2008; Gréhaigne et al., 2001). Consequently, it is not surprising to note that there is currently no means of objectively capturing such a skill within AF, as similar to the assessment of technical skill; decision-making skill has traditionally been evaluated through subjective in-game evaluation. As previously discussed within this thesis, such a subjective means is both psychometrically and representatively limited. Hence, an objective procedure may provide a more robust means of skill quantification.

Decision-making skill is highly critical to possess in order to succeed within AF, as skilled decision-makers are likely to compensate for physical and/or technical skill deficiencies with a superior contextual decision-making performance (Abbott & Collins, 2004; Farrow & Raab, 2008). Additionally, it is suggested that when junior players are playing at a higher level, their 'survival' in the team may rely on their tactical skill rather than their physical and/or technical skill level (Farrow & Raab, 2008). Somewhat substantiating this, Sullivan et al. (2014) noted that successful AFL teams were characterised by a reduced physical exertion in game-play when compared to their unsuccessful (e.g. losing) opposition; postulating that superior tactical and technical skill execution could be attributed to this occurrence.

Simulating the game-based constraints when constructing a task designed to capture decision-making skill is complex in team sports. Notably, the spatial, temporal and visual constraints typically imposed upon players whilst in game-play can provide considerable ecological difficulties when designing representative tests. However, these constraints can be partially limited through the use of video-based experimental procedures that allow the provision of environmental similarities to ensure players view the same scenarios under the same contextual constraints. Nevertheless, a video-based decision-making task needs to be contextually underpinned, with the chosen scenarios needing to provide a situation enabling the identification of a possible outcome (e.g. option generation) before the decision (i.e. response) is programed (Mascarenhas, Collins, & Mortimer, 2005; Raab & Johnson, 2007). When exploring the expert-near-expert paradigm with regards to decision-making skill, Farrow and Raab (2008) suggest that the scenarios utilised within a task should reflect game structures that are commonly encountered by players in game-play (i.e. passing the ball from defence into attack).

It has been reported that decision-making skill is a process whereby experts use superior visual search and option-generation strategies when compared to their lesser skilled counterparts (Hepler & Feltz, 2012; Raab & Johnson, 2007; Savelsbergh, Haans, Kooijman, & van Kampen, 2010; Ward, Ericsson, & Williams, 2013). However, the specifics of this process have not yet been applied to AF. A better understanding of this decision-making process will allow coaches to design and deliver more effective training interventions to maximise components of a players' tactical development, and could assist with the TID process (Savelsbergh et al., 2010). Nevertheless, in accordance with the theoretical framework utilised within this thesis, namely the first stage of the *Expert Performance Approach* (Ericsson & Smith, 1991), it must first be

established if decision-making skill is indeed a key determinant of talent within junior AF. Subsequent findings may therefore lead to the examination into the mechanisms that underpin a superior decision-making performance within junior AF.

Although *in situ* tasks may allow for a deeper mechanistic perspective as to the decision-making process (Afonso et al., 2014), there is evidence to suggest the accuracy of the product (i.e. the decision outcome) does not differ between video-based and *in situ* tasks (Bruce et al., 2014b). Therefore, this study provides an initial investigation into the decision-making skill of junior AF players, and intentionally focuses on the product rather than the process leading to the decision made; whereby the product (in this case decision-making skill) is captured and compared between two groups through the use of a video-based decision-making task.

The aim of the study is to investigate if the application of an objective decision-making task can be used to identify talent in junior AF. The outcome of this study will contribute the last remaining element toward the development of a multi-dimensional approach of TID in AF, and in doing so, answer the third research question. It is hypothesised that talent identified junior AF players will possess superior decision-making skill in comparison to their non-talent identified counterparts.

5.2 Methodology

5.2.1 Participants

From an initial sample of 85 U18 WAFL players with a mean age of 17.8 ± 0.8 y, two groups; namely, talent identified ($n = 25$; 17.8 ± 0.5 y) and non-talent identified ($n = 25$; 17.3 ± 0.6 y) were selected. The same classification that was used in Chapter Three has been applied here. As was done in Chapters Three and Four, relative age calculations were completed to ensure a birthdate effect was not influential upon

decision-making skill. Chi-square analyses did not indicate a RAE for both groups when controlled for quartile distribution (talent identified, $\chi^2_3 = 2.66$, $P > 0.05$; non-talent identified, $\chi^2_3 = 2.89$, $P > 0.05$) and half year distribution (talent identified, $\chi^2_3 = 0.33$, $P > 0.05$; non-talent identified, $\chi^2_3 = 1.87$, $P > 0.05$). At the time of recruitment all players were injury free and participating in regular training sessions and games. The Edith Cowan University Human Research Ethics Committee provided ethical approval with all players and parents/guardians (if participants were U18 years of age) providing informed consent prior to testing.

5.2.2 Procedures

To test the study hypothesis, a cross-sectional observational research design was used in this Chapter. Prior to objectively measuring decision-making skill however, a representative video-based performance task was constructed. Each video clip included within this task was sourced from aerial AFL game-day footage that was filmed from an elevated camera set-up behind the goals, with this footage being obtained with permission from one AFL club. These clips were from an offensive perspective (i.e. the team was in possession of the ball at the decision-making moment) and were inclusive of ball movements into attack (inside 50 m plays), passages of play from defence (including kick-ins) and passages of play through the midfield. This clip assortment was intentionally imposed to limit a potential bias in playing position and corresponding scenarios utilised.

A total of 18 AFL games from the 2012 season were viewed, with clips being initially included in the task if the player in possession of the ball had a minimum of three and maximum of five teammates available to kick or handball the ball to. This minimum and maximum was used in an attempt to control the number of possible

decisions participants potentially had to make to help facilitate a more concise reflection of decision-making skill, and was based upon the findings of Lorains et al. (2013b) and Parrington et al. (2013). This inclusion criterion initially identified 52 possible clips, each of which being edited using Adobe Premiere Elements version 9 (Adobe Systems Incorporated, Australia) to provide a lead time of approximately 15 s prior to the critical decision-making moment. This lead time was intended to optimise the player's contextual understanding of the clip, and has been utilised within other video-based decision-making studies (e.g. Berry et al., 2008; Lorains et al., 2013a; 2013b).

These clips were then independently reviewed by three highly experienced state level coaches; each with a minimum of 10 years' coaching at senior state and/or AFL level. Moreover, these coaches had not coached either the talent identified or non-talent identified participants reported within this study to help limit a potential coaching bias influencing a participant's decision-making choice. Each coach was independently asked to nominate who the player in possession of the ball should pass to. Only clips where all three coaches agreed upon the passing option were included in the final version of the task; with this secondary inclusion criterion resulting in 26 applicable clips.

Players were tested in groups of no more than five players at a time with the players seated four metres from a 140 cm flat screen television and separated from one another by approximately 50 cm. Two invigilators were present at the time of testing to ensure players' choices were indeed their own. Prior to starting the main trial, the players viewed five warm up clips to familiarise themselves with the task requirements. Each player was provided with an A4 sized booklet that consisted of a coloured screenshot of each decision-making trial, with an example of this screenshot being presented in Figure 15. For the ease of the participants, a red circle was placed around

the player with the ball on each screen shot. These screenshots were separated by a blank page to ensure the players could not view the next decision-making trial prior to witnessing it on screen. Upon presentation of the decision-making trial, the clip was frozen for three seconds and the players were cued on screen to “turn the page and circle your choice on the screenshot provided”. Consequently, the players were required to circle their preferred passing option (ranging from three to five possible passing options). Following the three seconds, the screen was occluded and the players were cued to “turn your page in readiness for the next clip”. Three seconds was used as the temporal constraint in accordance with the consultation provided by the expert panel of coaches, and is supported by the procedures performed in other studies (e.g. Lorains et al., 2013b). Following a similar protocol to Lorains et al. (2013a; 2013b), a dichotomous scoring system was employed, with ‘1’ being given to correct choices and ‘0’ to incorrect choices. The total score out of a possible of 26 was the criterion variable utilised to quantify decision-making accuracy.



Figure 15. An example of a critical decision-making moment used within the decision-making task

5.2.2.1 Psychometric properties

The test-retest reliability of the video decision-making task was assessed with ten randomly chosen talent identified players completing the entire task on two separate occasions separated by five days. The clips were presented in the same order on each occasion, however no feedback was provided to these players between or post trials in an attempt to control any external factors which may have influenced their decisions. The same test protocols as described above were followed on each occasion, with two-way mixed single ICC's (3, 1) indicating a range of 0.88 to 0.99.

5.2.3 Statistical analysis

Descriptive statistics, namely means and standard deviations (SD) were obtained for both groups, with a box plot being built to detail between group differences. The main effect of 'status' (2 levels: talent identified, non-talent identified) was assessed using a one-way ANOVA for the task criterion variable (total score) using SPSS software (Version 19, SPSS Inc., Armonk, New York, 2010), with the Type-I error rate set at $\alpha < 0.05$. The effect size of status was calculated using Cohen's d statistic, with effect size strengths being described elsewhere (refer to Chapter Three).

To examine the potential of the task to classify players correctly, a bootstrapped ROC was produced and the AUC was calculated, with an AUC of 1 (100%) representing perfect discriminant power (Robin et al., 2011). The point on the curve at which the talent identified and non-talent identified score was maximised was considered the value at which a 'cut-off' might be acceptable for identifying talented players, with this method of discrimination being previously described within Chapters Three and Four. All modelling and visualisation was undertaken using the statistical computing software R version 2.15.1 (R Developmental Core Team, Vienna, Austria, 2012).

5.3 Results

A mean difference in the total score obtained by the talent identified and non-talent identified groups was evident. A significant between group difference was evident for the main effect of status on the decision-making task ($F(1, 48) = 43.01, P < 0.01; d = 1.36$) with the mean score for the talent identified group being 18 ± 1.8 (69%) compared to only 12 ± 2.5 (46%) for the non-talent identified group.

According to the AUC presented in Figure 16, the ROC was maximised with a score of 15.5/26 with 23 of the talent identified players (92%) having a score greater than 15.5, whilst only six of the non-talent identified players (24%) scored greater than 15.5. Consequently, the ROC classified 92% of the true positives (talent identified players) and 76% of the true negatives (non-talent identified players).

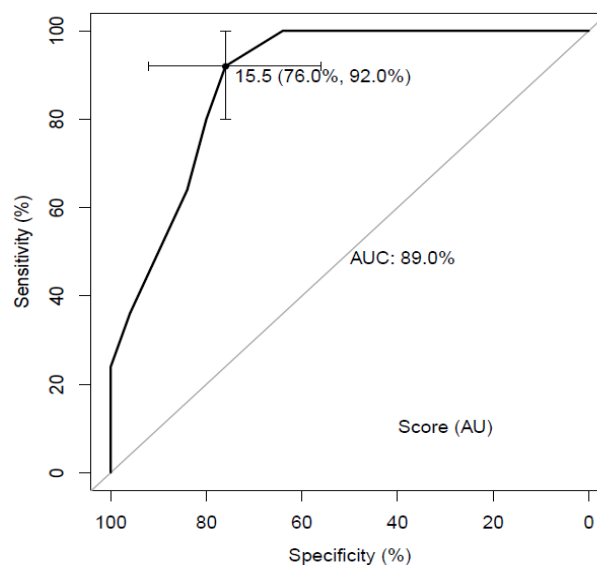


Figure 16. ROC plot indicating the point on the curve reflecting the greatest discrimination between the talent identified and non-talent identified players

5.4 Discussion

The aim of this study was to investigate if the application of an objective decision-making task could be used to identify talent in junior AF. It was hypothesised

that talent identified players would possess superior decision-making skill, and the current results supported this hypothesis, indicating that the talent identified players were indeed more accurate than their non-talent identified counterparts when making game-based decisions on the video task. Evidently, the majority of the talent identified players possessed greater decision-making skill than the non-talent identified group; highlighting the importance of objectively assessing decision-making skill when attempting to identify talent in the game. Unlike many studies that have previously been reported in the literature (e.g. Berry et al., 2008; Lorains et al., 2013a; 2013b; Raab & Johnson, 2007; Ward et al., 2013) this study design had an intended focus on the product of decision-making rather than the processes preceding it. Thus, the methodology and results presented here provide a highly feasible objective means for identifying decision-making skill in AF.

The greater decision-making skill shown by the talent identified players may stem from a variety of reasons, and in accordance with the second stage of the *Expert Performance Approach* (Ericsson & Smith, 1991) it would be of interest to further examine the now pertinent question of why this difference between the groups exists. Whilst there are many possible factors that would need to be investigated, it was of interest to note that of the 25 talent identified players, 16 had been a part of the WAFL State Academy squad at an U16 level and had thus been a part of an elite talent development program for at least two years. Each of these 16 talent identified players were successfully classified according the sensitivity analysis undertaken. This is in contrast to the non-talent identified sample where none had previously represented the WAFL State Academy at an U16 level. The prolonged superior training environment that the majority of the talent identified group had been exposed to may have led to greater training of these decision-making skills, and thus the better outcomes that were

observed. Specifically, the training drills employed by the expert development coaches within the State Academy may have been more game-specific and environmentally open. Such drill designs are likely to enhance both physiological responses and the cognitive information loading (Farrow et al., 2008); thus developing a player's perceptual skills (inclusive of decision-making) in a range of contexts. Additionally, such drills may have also led to a superior option-generation strategy and eye movement, allowing the talent identified players to filter irrelevant visual cues and isolate the correct decision more consistently (Raab & Johnson, 2007; Vaeyens, Lenoir, Williams, Mazyn, & Philippaerts, 2007; Ward et al., 2013). However at this stage, these developmental history and mechanistic explanations are merely speculated, warranting further investigation.

To limit any potential field position bias, the video decision-making task was intentionally designed to consist of a random assortment of clips that included ball movements into attack, passages of play from defence and passages of play through the midfield. Thus, it was not expected to note potential signs of positional variation in decision-making skill. However despite this, the two best decision-makers within the talent identified sample and three of the six misclassified non-talent identified sample were midfield (e.g. nomadic) type players. This finding is similar to those reported by Bruce et al. (2012a), who reported that in netball, midfielders may be better equipped to transfer their decision-making skills across court positions. Although different sports, these combined results suggest that within team invasion sports (both field and court based) the reduced spatial restrictions placed upon midfielders when compared to key position players may lead to a greater contextual understanding of both attacking and defending passages of play. In addition to the positional requirements leading to the development of decision-making skill, it is possible that the midfielders used within this

study (both talent identified and non-talent identified) had experience playing as either defenders and/or attackers and as such had a more efficient encoding and retrieval process in comparison to the key position players (Bruce et al., 2012a).

Although offensive decision-making is an important skill to succeed in the game (Berry et al., 2008), the dynamic and invasive nature in which it is played often requires players to compete to obtain ball possession from their opposition (Johnson et al., 2012). As such, in addition to making offensive decisions, players are often required to make defensive decisions (i.e. choosing a defensive manoeuvre to either stop the opposition or win ball possession back; commonly referred to as ‘chopping out’). Given the task reported within this study only evaluated offensive decision-making skill, it would be worthwhile for future research to incorporate decision-making scenarios that consist of both offensive and defensive clips. However, as discussed within Chapter Two of this thesis, the investigation of defensive decision-making skill using game-based video scenarios is complex, as defensive decision-making is likely to hinge upon an opposition’s movement pattern. Thus, capturing these scenarios in game-play may present construct difficulties, and was hence avoided here.

5.5 Conclusion

This study demonstrates the importance of objectively measuring decision-making skill when identifying talent in AF. Results indicated that through the use of an offensive video decision-making test, 92% and 76% of the talent identified and non-talent identified players respectively were correctly classified. Thus, the methodology reported within this study may provide a representative objective means in which to measure a skill that is traditionally subjectively measured within AF.

The results of this study contribute the remaining element of a skilful performance as outlined by Launder (2001), allowing the development of an objective multi-dimensional battery of performance tests for use in the TID process in AF. Consolidating the findings of Chapters Three, Four and Five, talent identified players clearly possess a unique range of physical, technical and tactical characteristics in comparison to their non-talent identified counterparts. As was to be expected, when each measure was used in isolation a certain level of misclassification was evident; likely due to a compensatory phenomenon (Bartmus et al., 1987; Tranckle & Cushion, 2006). It is hypothesised that a multi-dimensional objective battery of multi-dimensional performance tests could increase the identification accuracy by measuring each the physical, technical and tactical determinants of a talented performance in conjunction with one another. Thus, Chapter Six will test this hypothesis by investigating the TID accuracy of a multi-dimensional battery of objective performance tests in junior AF.

**CHAPTER SIX: The application of a multi-
dimensional battery of objective performance tests for
TID in junior Australian football**

6.1 Introduction

Acknowledging the competitive and economic advantage effective TID programs have to offer National sporting bodies and elite teams, a plethora of research has attempted to uncover the key sport specific determinants of a talented performance (for examples, see Hoare, 2000; Keogh, 1999; Kevin et al., 2011; Mohamed et al., 2009; Nieuwenhuis et al., 2002). Although revealing some of the characteristics of talented performers, many of these attempts have been limited in their identification potential. Specifically, they have been operationalised by the assessment of physically biased performance tests that are not representative of all the characteristics required for a successful performance in team sporting contexts (Davids et al., 2008; Pinder et al., 2013). Thus, despite their intentions, these mono-dimensional attempts may result in talent being overlooked if athletes do not possess the physical characteristics presumed to translate to a talented long-term performance (Abbott et al., 2005).

Nevertheless, some researchers have attempted to account for the multi-dimensionality of team sports when objectively identifying talent; with their findings supporting the implementation of such holistic testing batteries. Notably, Reilly et al. (2000) established a battery of multi-dimensional objective performance tests inclusive of anthropometric, physiological, psychological and technical skill tests for TID purposes in junior soccer. It was reported that talent identified players outperformed their non-talent identified counterparts in a range of multi-dimensional performance tests; namely agility and sprint time, motivational status and anticipatory skill. The diverse talent determining skills reported by Reilly et al. (2000) demonstrates the importance of implementing a multi-dimensional design when attempting TID in team sporting contexts. Additionally, Nieuwenhuis et al. (2002) reported a TID accuracy of approximately 90% when applying a battery of multi-dimensional objective tests in

junior field hockey. This accuracy should be viewed against the 75.9% reported by Keogh (1999) who applied a more mono-dimensional approach to TID in junior AF. In both studies, a discriminant function analysis was used to identify the combination of performance characteristics that provided the best discrimination between talent identified and non-talent identified players. It is important to note the different sports utilised when viewing this accuracy comparison. However, given that both are field based and invasive by nature, the comparison is warranted, and again reinforces the need for multi-dimensional designs when using objective performance tests to identify talented performers.

Despite these earlier studies, a multi-dimensional battery of objective performance tests has yet to be applied in AF. To fill this remaining gap and attempt to enhance the accuracy of TID practices in AF, the current research series has investigated the underlying determinants of a talented performance by objectively capturing key physical, technical and tactical characteristics of talent identified junior AF players. Through the consolidation of these findings, this final study aims to investigate the TID accuracy of a multi-dimensional battery of objective performance tests specific to junior AF; thus addressing the fourth research question of this thesis. It is hypothesised that a) the talent identified players will perform each test at a higher standard than the non-talent identified players, and b) this battery of tests will demonstrate an increased accuracy when compared to performance measures used in isolation given its multi-dimensional construction.

6.2 Methodology

6.2.1 Participants

From a total sample of 379 U18 players with a means age of 17.5 ± 0.4 y registered with the WAFL for the 2014 season, two groups; namely talent identified ($n = 42$; 17.6 ± 0.4 y) and non-talent identified ($n = 42$; 17.4 ± 0.5 y) participated in this study. The definition of talent identified and non-talent identified was as previously stated in Chapter Three, however this study used athletes from the 2014 cohort whereas the previous studies in this thesis had used the 2013 cohort. The non-talent identified sample consisted of 42 players randomly selected using the random number generation package in Excel (Microsoft Inc., Redmond, USA, 2010) from the remaining cohort of 337 WAFL U18 players who were not selected in the 2014 State Academy squad. A sample size of 42 for each group were used as external constraints dictated that only 42 players were eligible on the State U18 Academy in the 2014 WAFL season.

As has been done within previous studies, RAE calculations were completed to ensure that neither group possessed a performance advantage by a relatively earlier birth month. Subsequently, chi-square analysis indicated that there was no RAE within either group when controlled for birth distribution quartile (talent identified, $\chi^2_3 = 7.66$, $P > 0.05$; non-talent identified, $\chi^2_3 = 1.81$, $P > 0.05$) or half year (talent identified, $\chi^2_1 = 2.45$, $P > 0.05$; non-talent identified, $\chi^2_1 = 0.24$, $P > 0.05$); with the distribution cut-offs used being described in Chapter Three. At the time of recruitment all players were injury free and participating in regular training sessions. The Edith Cowan University Human Research Ethics Committee provided ethical approval with all players and parents and/or guardians (if a player was U18 years of age) providing written informed consent prior to testing.

6.2.2 Procedures

As been done previously, a cross-sectional research design was used within this study, with all participants completing the battery of multi-dimensional objective performance tests listed in Table 9. The selection of these tests was informed by the findings of the previous studies within this thesis. Consequently, the protocols, environmental conditions and criterion variables for each performance test were as described within their relevant chapters. Testing took place at the end of the 2014 WAFL pre-season training phase in an attempt to standardise the physical, technical and tactical characteristics of players. Standing height was the first measurement recorded, following this players were randomly divided into groups of approximately 12 players and then each group was assigned to one of the four testing stations (1: the dynamic vertical jump non-dominant leg; 2: the AFK test; 3: the AFHB test; 4: the video decision-making task); being rotated to the next station following test completion. The 20 m MSFT was undertaken following the completion of all other testing.

Table 9. The multi-dimensional battery of objective performance tests based on the finding from previous studies

Element	Performance determinant	Performance test	Test criterion(s)
Physical	Standing height	Standing height	Height (cm)
	Lower body power	Dynamic vertical jump	Height (cm)
	Aerobic capacity	20 m MSFT	Level.Shuttle
Technical	Kicking	AFK Test	DomAcc
			Non-DomAcc
			DomBS (km.hr ⁻¹)
			Non-DomBS (km.hr ⁻¹)
	Handballing	AFHB Test	DomAccHB
			Non-DomAccHB
Tactical	Decision-making	Video decision-making task	Number of correct decisions

6.2.3 Statistical analysis

Descriptive statistics, namely means and standard deviations (SD) were obtained for both groups. To test the first hypothesis, a MANOVA was used to test the main effect of status (2 levels: talent identified, non-talent identified) on the criterion variables, with follow up univariate analysis (one-way ANOVA) being used to identify which, if any specific criterion variable(s) differed significantly according to the main effect. The effect of status on each criterion variable was calculated using Cohen's *d* statistic (Cohen, 1988) with the effect size strengths being described previously (in Chapter Three). All between group comparisons were undertaken using the SPSS software (Version 19, SPSS Inc., Armonk, New York, 2010) and the Type-I error rate was set at $\alpha < 0.05$.

To examine the classification accuracy of the full battery of tests, the *pROC* package was used to run a sensitivity versus specificity analysis (Robin et al., 2011) using the R statistical computing software version 2.15.1 (R Developmental Core Team, Vienna, Austria, 2012). A bootstrapped ROC was produced and an AUC was calculated, with an AUC of 1 (100%) representing perfect classification accuracy. As previously described, the point on the curve at which the sum of each the talent identified and non-talent identified scores was maximised was considered the value at which a ‘cut-off’ could be used to effectively classify talent identified and non-talent identified players; thus the point in which the false positive (miss-classification) rate was minimised. The ROC was used to produce such an indicator by summing each physical, technical and tactical test criterion variable (Table 9).

Thus, to test the second hypothesis and demonstrate the increased TID accuracy of the multi-dimensional test battery in comparison to performance measures used in isolation, a tabulated comparison of the AUC’s reported in each research study in this thesis was produced, with the highest AUC demonstrating the most accurate player classification (talent identified, non-talent identified).

A model set table was built to identify the best single term model(s) for predicting the talent identified players, thus identifying which of the ten single term predictors provided the best predictive potential. The models were ranked using AICc and the relative support for each model in the set was assessed using Akaike model weights (w_i) (Akaike, 1993) and delta AIC (ΔAIC). The models were built using the ‘glm’ function in the *MASS* package (Venables & Ripley, 2002) and the model selection table was built using the ‘model.sel’ function in the *MuMin* package (Burnham & Anderson, 2002). To ensure the strength of the best model, a null model was built and used as a comparator.

6.3 Results

Using Pillai's Trace (V), the MANOVA revealed a significant effect of status on the criterion variables ($V = 0.74$; $F(10, 73.00) = 20.61$; $P < 0.01$). Follow up univariate analysis revealed a significant effect of status for each criterion variable, with handballing accuracy on the dominant side, decision-making score and dynamic vertical jump non-dominant leg height having the greatest effect sizes (d) (Table 10).

Table 10. Between group differences for each test criterion ($Mean \pm SD$)

Test criterion	TI	Non-TI	P	d
Standing height (cm) *	185.5 ± 6.9	182.1 ± 6.8	0.03	0.48
Dynamic vertical jump height non-dominant leg (cm) *	77.5 ± 6.5	69.2 ± 6.7	< 0.01	1.06
20 m MSFT (level.shuttle) *	12.08 ± 1.01	12.02 ± 0.9	0.04	0.35
DomAcc – AFK test *	7.2 ± 1.9	5.3 ± 1.8	< 0.01	0.97
NonDomAcc – AFK test *	5.1 ± 2.1	3.5 ± 2.3	< 0.01	0.89
DomBS (km/hr^{-1}) – AFK test *	62.1 ± 6.3	58.9 ± 4.9	0.02	0.54
NonDomBS (km/hr^{-1}) – AFK test *	55.9 ± 5.2	51.6 ± 5.4	< 0.01	0.75
DomAccHB – AFHB test *	6.0 ± 1.2	5.1 ± 1.4	< 0.01	0.67
NonDomAccHB – AFHB test *	5.2 ± 1.2	3.1 ± 1.4	< 0.01	1.22
DMScore (/26) *	17.0 ± 2.2	14.0 ± 2.4	< 0.01	1.11

* Between group effect ($P < 0.05$); TI talent identified, d effect size

As illustrated in Figure 17, the ROC was maximised with a summated score of 412.4 au (AUC = 95.4%). Of the 42 talent identified players, 40 (95%) had a combined score ≥ 412.4 au, whilst only six (14%) non-talent identified players had a combined score ≥ 412.4 au. Thus, a score of 412.4 au successfully classified 95% (40) of the true positives (talent identified players) and 86% of the true negatives (non-talent identified players).

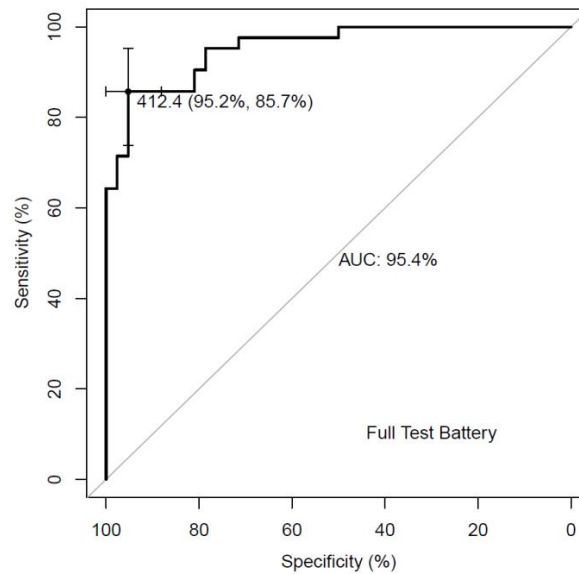


Figure 17. ROC plot indicating the point of greatest discrimination between the talent identified and non-talent identified players using the summation of each test criterion

Table 11 compares the AUC's reported for each test in Chapters Three, Four and Five with that reported here. Through this comparison, it is apparent that the AUC currently presented is more comprehensive than what has been previously reported; demonstrating the greater classification accuracy of the multi-dimensional test battery in comparison to isolated performance measures.

Table 11. A comparison of the AUC's reported in each research chapter

Chapter	Element	AUC
Chapter Three	Physical	84.2%
Chapter Four	Technical	
	<i>AFK test</i>	89.4%
	<i>AFHB test</i>	88.4%
Chapter Five	Tactical	89.0%
Chapter Six	Multi-dimensional test battery	95.4%

Of all the ten tests that were included in the multi-dimensional test battery, the best single predictor of status in this study was a player's handballing accuracy on their

non-dominant side ($\Delta AIC = 0.00$, $w_i = 0.792$); followed by a player's handballing accuracy on their dominant side (Table 12). Dynamic jump height on the non-dominant leg was the next best predictor; followed by decision-making skill.

Table 12. Model summary ranking each single term predictor based upon the Akaike model weights

Single Term Predictors	<i>LL</i>	<i>df</i>	AICc	ΔAIC	w_i
Non-DomAccHB	- 40.049	2	84.2	0.00	0.79
DomAccHB	- 41.813	2	87.8	3.53	0.14
DVJND foot	- 42.695	2	89.5	5.29	0.06
DMScore	- 43.930	2	92.0	7.76	0.02
Non-DomAcc	- 48.292	2	100.7	16.49	< 0.01
DomAcc	- 49.970	2	104.1	19.84	< 0.01
Non-DomBS	- 51.833	2	107.8	23.57	< 0.01
DomBS	- 55.051	2	114.3	30.01	< 0.01
Standing Height	- 55.570	2	115.3	31.04	< 0.01
20 m MSFT	- 56.883	2	117.9	33.67	< 0.01
Null (~1)	-58.224	1	118.5	34.25	< 0.01

LL log likelihood; *df* degrees of freedom; AICc Akaike Information Criterion; ΔAIC delta AIC; w_i Akaike weight

6.4 Discussion

The aim of this study was to investigate the accuracy of a multi-dimensional battery of objective performance tests to identify talent in junior AF. Results supported both the hypotheses tested in this study, with a total combined score of 412.4 au correctly classifying 95% (40/42) and 86% (36/42) of the talent identified and non-talent identified participants respectively, which produced the highest AUC reported in

this thesis (95.4%). Thus, when compared to the previous studies presented here, the current study reflected the strongest classification accuracy for both the talent identified and non-talent identified samples.

Additionally, when comparing the classification accuracy currently reported with TID approaches in AF already proposed within the literature, a clear difference is evident. Specifically, although the TID approach utilised by Keogh (1999) showed some identification potential, it was mono-dimensional and physically biased; only classifying 22 of the 29 talent identified players (75.9%) correctly. It is possible that this classification accuracy in Keogh's (1999) study could have been improved using a multi-dimensional test design as the additional seven players may have displayed higher levels of skill in other non-physical elements of the game. When compared to the classification accuracy shown in this chapter, it is apparent that although these traditional mono-dimensional approaches may provide an initial indicator of talent, they may lack identification accuracy when compared to objective multi-dimensional performance batteries. These findings suggest a change in practice is indeed warranted for objective TID in team sport to enhance the accuracy of identification.

Despite the increased classification accuracy when using the multi-dimensional test battery compared to the outcomes of the isolated performance tests in previous chapters, some misclassification was still evident, with two of the talent identified players failing to reach the classification cut-off score. However, this misclassification may be explained by the unique positional requirements of the game. Although not scoring above the combined multi-dimensional cut-off, both players scored very highly when compared to their talent identified peers (two standard deviations above the sample mean) in the individual measures of either standing height or decision-making skill. This demonstrates that a remarkable performance in an individual element (e.g.

physical, technical or tactical) may be viewed favourably by coaches despite a less pronounced holistic profile in some cases.

Further investigation of these two players indicated that the considerably taller player was a ruckman (a player who competes to win possession in an aerial ball contest), whilst the highly skilled decision-maker was predominantly a midfield type player. Although providing somewhat contradictory evidence to that proposed by Kempton and Coutts (2015) who did not report player profile differences when controlled for position in rugby league, the positional requirements of AF are unique, and thus in some cases, certain positions may require a specific type, or profile, of player, as suggested by Pyne, Gardener, Sheehan and Hopkins (2006). Moreover, as indicated within Chapter Five, a midfield player may possess superior contextual decision-making skill given their nomadic positional requirements. Evidently, despite some previous findings, positional profile variations may, in some cases, contribute to the identification of players in team sports. Nonetheless, it is important to note the strong classification accuracy shown in this study firmly supports the acquisition of a range of performance characteristics regardless of playing position in U18 AF.

In addition to the two misclassified talent identified players, six non-talent identified players were also misclassified with each possessing profiles that should have, according to the current multi-dimensional test battery, led to their inclusion in the talent identified group. Financial constraints dictated that only 42 places were available in this elite junior program in the 2014 season, and as such, these six misclassified players may be somewhat 'unlucky' to have not been identified. With this being said, it is also possible that despite their seemingly positive multi-dimensional profiles, there could indeed have been 'other' factors that were not inherently captured resulting in their non-identification. For example, this battery of multi-dimensional performance

tests did not include measures of game-sense, psychological orientation or sociological status; each of which may contribute toward a skilful performance. Zuber, Zibung and Conzelmann (2015) recently noted that intrapersonal psychological factors (such as intrinsic motivation and/or mental resilience) may influence the talent development process, which may in turn influence the TID process. Within AF, it is not uncommon for talent recruiters at the highest level to interview prospective talented players to ensure their ethos matches that of the team or academy in which they are intended to be identified onto. A potential ethos mismatch or disadvantageous psychological orientation could limit a player's developmental potential, resulting in them being unfavourably perceived by talent recruiters. Thus, although the current test battery has provided a high level of classification accuracy when identifying junior football players, it may be worthwhile for future TID research in AF to incorporate a multi-disciplinary approach through the inclusion of psychological markers in conjunction with the performance tests reported throughout this research series.

6.5 Conclusion

This study aimed to answer the fourth research question and examine the classification accuracy of a multi-dimensional battery of objective performance tests in AF. When compared to previous chapters in this thesis, and the more traditional approaches to TID reported in the literature, the classification of talent noted through the use of multi-dimensional test battery reported here was more accurate. Specifically, the vast majority of the talent identified players had a set of characteristics that were more pronounced than their non-talent identified counterparts. These results suggest a shift away from the traditional mono-dimensional TID approaches is indeed warranted.

Nevertheless, this multi-dimensional framework does require ongoing development given that some misclassification was still evident. Additional measures of

game-sense and psychological orientation may provide a more multi-disciplinary insight into an individual's performance potential when measured in conjunction with the tests reported throughout this thesis.

CHAPTER SEVEN: General Thesis Summary and Conclusions

7.1 General Summary

Traditional TID programs in team sports have been operationalised by the assessment of a limited number of physically biased performance tests that are not necessarily representative of the requirements of game-play (Abbott et al., 2005; MacNamara & Collins, 2011; Pinder et al., 2013). Moreover, they are often administered prior to the age of the sport specific training onset (Côté 1999; Güllich et al., 2005; Vaeyens et al., 2009), and during times of peak maturational variation (Malina, 1994; Malina et al., 2004b; Vaeyens et al., 2008). As such, they do not account for the dynamic nature in which talent is developed from its initial gifted state (Gagné, 1993; Gulbin et al., 2013). Given these limitations, the predictability of traditional TID programs is questionable (Güllich, 2007), especially within a multi-dimensional team sporting context.

Despite its importance for the attainment of excellence within the game, current TID methods in AF do not appear to be evidence-based. Notably, the subjectivity commonly employed may lead to conflicting opinions between talent recruiters due to perceptual differences in what constitutes a talented performance, and thus, result in unsubstantiated identification (Meylan et al., 2010; Williams & Reilly, 2000). Additionally, although providing a somewhat more reliable insight into performance, the objective performance testing that is currently used in the TID process is mono-dimensional (physically biased) (Keogh, 1999, Pyne et al., 2005; Veale et al., 2008). Physicality is an important characteristic of AF game-play, but basing identification and selection on isolated physical attributes is misleading given that a skilful performance can be attributed to a combination of multi-dimensional performance elements (Lauder, 2001). However, this objective mono-dimensionality to TID in AF can be partly expected given the scarcity of representative tests designed to objectively

measure technical and tactical skill, which may increase the reliance placed upon in-game observation as the primary means of TID in AF. Thus, despite being proposed in other team sports (e.g. Reilly et al., 2000; Vaeyens et al., 2006), a multi-dimensional approach to TID had yet to be developed in AF.

This thesis aimed to develop a multi-dimensional approach to TID in AF to assist with the identification of talent by establishing objective physical, technical and tactical testing procedures. This led to the investigation of the key physical, technical and tactical determinants of a talented performance through the use of representative tests.

Given the invasive nature of the game, a range of physical characteristics are utilised by players in game-play (Gray & Jenkins, 2010). Therefore, it was hypothesised that talent identified players who had been selected in the State U18 Academy would indeed possess superior physical profiles when compared to their non-talent identified counterparts. In accordance with the *Model of a Skilful Player* (Lauder, 2001) and the first stage of the *Expert Performance Approach* (Ericsson & Smith, 1991), the first research study investigated whether the objective measurement of physicality could accurately identify talent in U18 AF. Although a range of physical characteristics were shown to significantly differ between the talent identified and non-talent identified junior players, it was the combination of standing height, dynamic vertical jump height (non-dominant leg take off) and maximal aerobic capacity that together provided the most accurate classification of talent. These physical measures were therefore deemed as key contributors to the development of a multi-dimensional battery of objective performance tests intended to improve objective identification practices in the game.

Despite the range of technical skills utilised by players in game-play, the two modes of ball transfer; namely kicking and handballing skill, are the key technical determinants of a successful team performance in AF (Ball, 2008; Parrington et al., 2013; Sullivan et al., 2014). However, it was currently unknown if such technical skills were predictive of talent given the paucity of objective tests intended to reliably capture such skills. Thus, Chapter Four addressed the second research question and investigated whether objective measures of kicking and handballing skill could be used to accurately identify talent in U18 AF. To answer this question, the AFK test and the AFHB test were subsequently utilised. Results indicated that the talent identified players performed both tests with a greater level of proficiency when compared to their non-talent identified counterparts in all measures of ball disposal. Skilful ball disposal may allow players to perform more intricate game plans, and in doing so, assist with a team's scoring potential. Moreover, kicks executed with high accuracy and velocity, particularly over long distances, may limit an opposition's ability to intercept the ball. Thus, such players may be looked upon more favourably by talent recruiters. Both the AFK and AFHB tests are important objective measures for the identification of talent in junior AF, and important contributors to the development of a multi-dimensional battery of objective performance tests specific to AF.

In accordance with the *Model of a Skilful Player* (Lauder, 2001), Chapter Five investigated whether the objective measurement of tactical decision-making skill could accurately identify talent in U18 AF. To address the third research question and capture a skilful decision-making performance in an objective manner, a decision-making test needed to be established; sufficing the first stage of the *Expert Performance Approach* (Ericsson & Smith, 1991). Through its development and subsequent application, it was noted that the majority of the talent identified players were superior decision-makers in

comparison to their non-talent identified counterparts. This finding demonstrated the importance of measuring decision-making skill when identifying talent in junior AF. Moreover, the methodology proposed within Chapter Five provides an objective framework which coaches can apply when measuring a skill that is traditionally subjectively assessed.

Summarising the findings from Chapters Three, Four and Five, a specific set of physical, technical and tactical characteristics were considered the determinants of a talented performance in junior AF (Figure 18); highlighting the importance of objectively measuring multi-dimensional performance characteristics in a team sporting context. Importantly, these findings contributed to the development of the multi-dimensional battery of objective performance tests that were presented within Chapter Six.

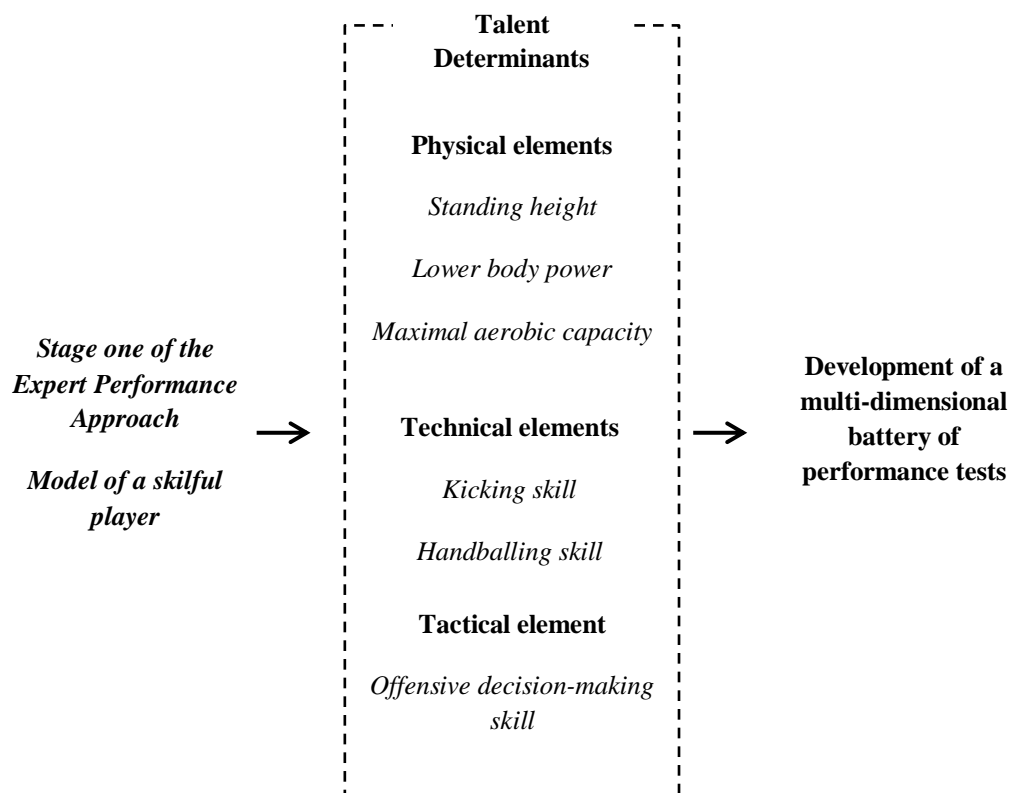


Figure 18. The physical, technical and tactical elements contributing to the development of a multi-dimensional battery of performance tests

Chapter Six investigated if the application of a multi-dimensional battery of objective performance tests provided an accurate means of TID in junior AF when compared with physical, technical and tactical performance measures used in isolation. The results indicated that the talent identified players, on average, outperformed their non-talent identified peers in each objective test. As shown in Figure 19, the multi-dimensional test battery demonstrated the most accurate classification of talent when compared to that shown within the previous research chapters.

It is of note that out of the 40 correctly classified talent identified players, 10 were subsequently drafted into the AFL in 2014. Despite being only 25% of the correctly classified sample, this statistic cannot be underestimated given the limitations imposed upon the AFL Draft. Additionally, as none of the non-talent identified players were drafted into the AFL, the importance of participation in the State Academy for optimising draft outcome is apparent; further demonstrating the need for robust TID procedures prior to State Academy participation. Indeed, continued prospective analyses are required before the longitudinal predictive capability of this multi-dimensional battery of objective performance tests can be comprehensively understood. Nevertheless, the findings displayed throughout this research series hold important implications for both coaches and sports scientists charged with TID responsibilities in junior AF and in other team sporting contexts. As such, the following sections will discuss these implications in greater detail.

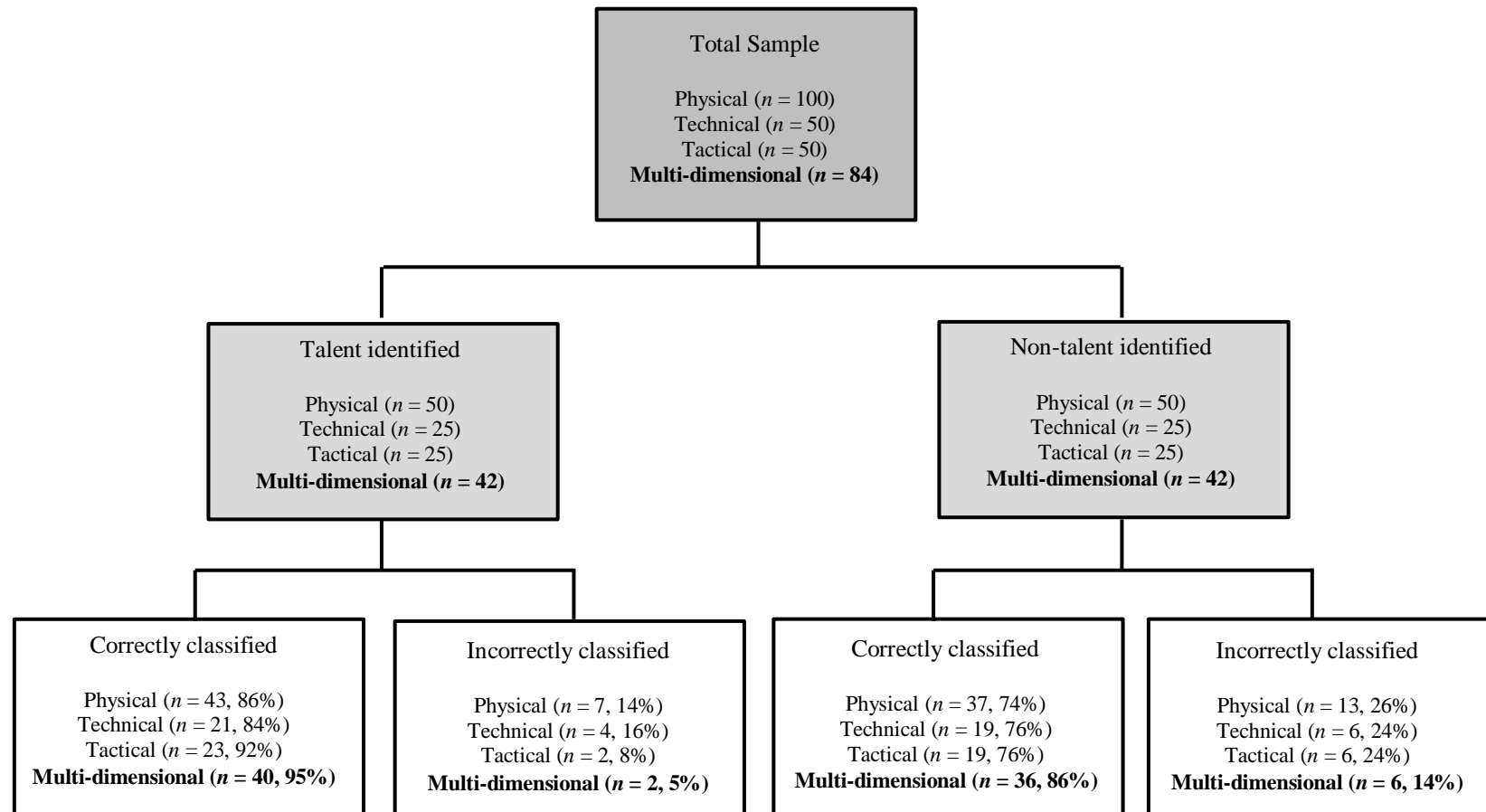


Figure 19. The classification of talent identified and non-talent identified players using the cut-off score established in Chapter Six for the multi-dimensional test battery

7.2 Practical Implications for Talent Identification in Australian Football

As discussed throughout this thesis, current TID practices in AF do not appear to be evidence-based. The two most notable limitations of such practices are that they are either objectively mono-dimensional or subjective. These somewhat inappropriate identification methods have led to signs of talent misclassification and wastage (Keogh, 1999; Pyne et al., 2005). Thus, the objective multi-dimensional approach to TID constructed throughout this thesis provides a robust means for the identification of a talented performance within a junior context.

As demonstrated by Launder in the *Model of a Skilful Player* (Launder, 2001), a skilful performance in team sport is attributable to a range of multi-dimensional performance characteristics. Given this performance diversity, it is not uncommon to observe an unequal performance weighting; for example, a slight disadvantageous physical attribute may be outweighed through a superior technical and/or tactical performance (i.e. the *compensation phenomenon*) (Tranckle & Cushion, 2006). Yet despite this, the current objective means of TID in AF has primarily been physically biased, which although being an important characteristic for game-play, physical performance cannot be used to solely drive objective identification and selection given the aforementioned multi-dimensionality of game-play. Therefore, the multi-dimensional objective performance tests provided throughout this research series allow talent recruiters the opportunity to reliably measure technical and tactical skills that may have been traditionally assessed through the use of subjective in-game evaluation. Specifically, the inclusion of the technical skill tests presented in Chapter Four and the video-based decision-making task presented in Chapter Five allow talent recruiters the opportunity to objectively capture these pertinent performance characteristics when attempting to identify talent. Additionally, an important aspect of the performance tests

utilised throughout this thesis is their feasible application and interpretation. This is highly advantageous for coaches, as it allows the opportunity to apply scientifically robust objective testing with ease, and interpret the results to guide the corresponding identification process.

The test battery presented within Chapter Six allows for the occurrence of a *compensation phenomenon* given its multi-dimensional nature; considerably limiting the potential for a mono-dimensional objective identification bias. The objectivity of such a performance battery may lead to a certain level of identification accountability; removing a talent recruiters 'perception' as a potentially biasing element to the identification process. For example, non-talent identified players may be provided with objective justification as to their non-identification through the analysis of their multi-dimensional performance score. However, this multi-dimensional objective approach to TID does not completely discount the value of an expert talent recruiter's ability to identify talent subjectively; rather it suggests that expert subjectivity may supplement the objectivity provided by multi-dimensional performance tests.

7.3 Knowledge Transfer – Implications for Talent Identification in Team Sports

It is likely that much of the talent misclassification associated with TID in team sport stems from a scarcity of research to guide the scientific translation of a multi-dimensional approach (for exceptions, see Vaeyens et al., 2008; 2006; Weissensteiner, Abernethy, & Farrow, 2009). Therefore, this thesis may provide a transferrable framework for TID programs in other team invasion sports by highlighting three main considerations for the development of a multi-dimensional approach. Namely, TID programs should: 1) understand the sport specific requirements to optimise the design of the representative multi-dimensional objective performance tests, 2) understand the developmental considerations associated with the gift-to-talent developmental process,

and 3) interpret performance scores resulting from the application of a multi-dimensional battery of performance tests.

7.3.1 Understanding the sport specific requirements to optimise the design of objective performance testing

Although Launder (2001) has demonstrated that a skilful performance in team sports is often the result of physical, technical and tactical elements, these elements are sport specific. Thus, the initial consideration in the development of a multi-dimensional approach to TID is to understand the sport specific physical, technical and tactical requisites of game-play. This contextual understanding was discussed within Chapter Two; drawing upon both notational literature specific to AF, and commercially available notational statistics to detail the physical, technical and tactical requirements of AF game-play. If unsure as to the multi-dimensional requirements, notational analyses of game-play could be conducted; thus identifying at least some of the physical, technical and/or tactical elements that are likely to result in a talented performance.

As well as being sport specific, these requirements may also be gender specific. For example, despite potentially sharing similar fundamental elements, the specific determinants of a talented performance may differ between male and female competitions due to a number of factors; namely competition tactics, game structures, and physiological differences to name but a few (Baumgart, Hoppe, & Freiwald, 2014; Sekulic, Spasic, Mirkov, Cavar, & Sattler, 2013). Understanding how these gender differences may influence the exhibition of a talented performance is important when developing a multi-dimensional approach to TID, as a TID program in male competitions may not always be transferrable to female competitions.

In accordance with the first stage of the *Expert Performance Approach* (Ericsson & Smith, 1991; Williams & Ericsson, 2005), once the multi-dimensional requirements have been noted, sports scientists need to consider the use of tests to reliably capture key performance determinants. Importantly, these tests need to be representative of the environmental situations in which such skills are performed in game-play (Pinder et al., 2013). For example, the temporal and spatial constraints imposed upon basketball players when shooting in a match environment should be considered when developing representative tests intended to objectively capture this technical performance quality.

If unsure as to the constraints imposed on players whilst in game-play, the utilisation of an expert panel of coaches as used by Bruce et al. (2012a) may provide clarity. An example of this can also be noted within Chapters Four and Five, in which the technical and tactical tests were developed through consultation with an expert panel of coaches; ensuring that their construction was ecologically valid, as well as feasible to administer in a practical setting.

7.3.2 Understanding developmental considerations associated with the gift-to-talent development process

It is imperative to understand the dynamic gift-to-talent developmental process to optimise the timing of a TID program (Vaeyens et al., 2008). As was done within this thesis, theoretical, scientific, and practical considerations each need to be considered when attempting to develop a robust TID program. Demonstrated within the *Developmental Model of Sport Participation* (Côté, 1999), it is likely that the sport specific training onset age will not occur until approximately 16 years in team sports. This is an important consideration, as many of the sport specific skill determinants transferring to a talented performance in senior competitions may not become apparent until the implementation of structured skill rehearsal (Güllich & Emrich, 2006; Vaeyens

et al., 2009). Thus, attempting to implement a TID program prior to the age of the sport specific training onset may indeed misinform predicted performance trajectories.

Additionally, it is imperative to consider the maturational implications that may be associated with the timing of TID programs in junior populations. Peak maturational variability in males occurs during the ages of 13 to 16 years (Malina, 1994), and begins to diminish following the age of 17 years (Marshall & Tanner, 1986). When implementing a cross-sectional design within periods of maturational instability, it is important to understand that performance may be more indicative of the current maturational status rather than the long-term performance potential (Malina et al., 2004a; 2004b; Malina & Koziel, 2014).

Irrespective of these theoretical and scientific implications, the application of TID may indeed hinge upon the structures that are already in-place in the sporting organisation. For example, some National sporting organisations may still wish to accelerate the development of certain juniors by identifying them onto elite junior talent development programs at young ages (e.g. U14). In these cases, sports scientists need to be aware of the previously discussed developmental implications, and astutely nominate the tests that are most appropriate to identify talent. For example, the utilisation of physical performance tests to identify talent within juniors progressing through maturation may lead to an identification bias. Maturation is known to influence physiological abilities inclusive of maximal aerobic and anaerobic capacity, and muscular strength and endurance (Bale et al., 1993; Gastin et al., 2013; Malina et al., 2007; Pearson et al., 2006). Coupled with this, in team sporting contexts the physical performance requisites that result in a talented performance within these younger age groupings may not transfer to those needed within older age groupings (Vaeyens et al., 2006). Notably, Vaeyens et al. (2006) demonstrated that the talent discriminators within

U13 and U14 soccer players were linear speed and soccer-specific technical skill execution, whilst in players aged U15 to U16, maximal aerobic capacity was shown to have the strongest discriminatory potential. This led to the conclusion that the determinants of a talented performance are likely to change as the individuals progresses through periods of maturation. Thus, if the sports organisational structure dictates that TID is required within a particularly young population, it is recommended that highly sport specific representative tests be predominately utilised to drive TID; thus enhancing the accuracy of identification by limiting the potential influence of physical maturation. Following the variable maturational periods (i.e. > 16 years), physical measures may be re-introduced in the TID program, as these measures might then provide an accurate translation to the longitudinal physical characteristics needed to succeed in senior elite competitions.

However, if still compelled to incorporate physical performance tests in the identification of talent between the ages of 13 to 16 years, measures of biological maturation should be considered. This measurement may provide a deeper insight into the physiological performance potential of young athletes during periods of maturation. Thus, a poor physical performance may be due to a developing maturity, which might not warrant immediate exclusion from being talent identified. An example of a non-invasive means in which biological maturation can be examined is through the analysis of anatomical assessments to provide an estimated peak height velocity (PHV) (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). It is important to note that this biological maturity measure was not included within this thesis as PHV has been shown to be considerably unreliable at estimating biological maturation following the age of approximately 16 years (Malina & Koziel, 2014; Mirwald et al., 2002). Hence, it may

only be a feasible inclusion when attempting TID in younger (e.g. between the ages of 13 to 16 years) populations.

7.3.3 Interpreting performance scores resulting from the application of a multi-dimensional battery of performance tests

Once the objective sport specific multi-dimensional performance tests have been established within a suitable population, sports scientists must attempt to interpret the subsequent results to ultimately identify talented performers. As was done in Chapter Six, a combined threshold value could be effectively used to classify talent. Specifically, the combined score obtained through the application of the multi-dimensional battery of performance tests may allow for the establishment of a player ranking system. The pre-determined number of places available on an elite talent development program (due to financial and resourceful constraints) could be objectively filled by the highest ranking players. This ranking process would immediately remove coach subjectivity as a potential biasing factor in the identification of talented performers, and ensure the most multi-dimensionally talented individuals are identified. Player ranking systems have been developed in AF, with Heasman, Dawson, Berry and Stewart (2008) ranking player performances using game-based technical indicators; noting that it provided a valid objective means in which to guide team selection strategies when compared to subjective coach selections used in isolation.

It is however important to highlight a potential limitation associated with this ranking system, namely the occurrence of the same score for multiple players. For example, if there are only 20 places eligible on an elite talent development program, yet players ranked 18 to 22 obtain the same multi-dimensional performance score, it would be difficult to nominate which players should fill these remaining two places. In this instance, expert subjectivity could be drawn upon, or multi-disciplinary measures (i.e.

psychological evaluation) could be used to provide insights into a players potential. Through such additional multi-disciplinary assessments it may become apparent that, although possessing the same multi-dimensional performance score, certain players may possess a superior longitudinal developmental potential, and are thus deemed more suitable for inclusion on an elite junior talent development program.

7.4 Limitations

While providing a strong scientific basis to both TID programs in AF and other team sports, this thesis was not without limitations and thus there are areas for refinement. In an attempt to design representative tests that mimic game-play in AF, it is inevitable that there would be some methodological limitations associated with their construction. Moreover, the inclusion of additional multi-disciplinary markers of longitudinal performance may have clarified certain findings noted in this thesis. Hence, two major limitations of this research series have been identified:

1. Continued development of performance test representativeness

Although the predominant focus of this thesis was to utilise representative tests to investigate the determinants of a talented performance in junior AF, there are some limitations that were encountered. Although the construction of the AFK test was done in consultation with an expert coaching panel, some aspects may be strengthened to further enhance its representativeness. In game-play it is not uncommon to witness player's dispose of the ball to both stationary and dynamic targets (Appleby & Dawson, 2002; Parrington et al., 2013). However, the AFK test used within Chapter Four only assessed kicking accuracy directed toward a stationary target. Whilst the research team involved in the construction of this task felt it was necessary to use stationary targets to enhance the psychometric properties of the test, the inclusion of a dynamic target may further strengthen the representativeness of this test, as players are required to complete

both types of kicks that they may encounter in game-play (i.e. to stationary and dynamic targets). Although the outcome of the kick (i.e. accuracy / speed) was the primary criterion for the AFK test, future modifications may include ball flight characteristics within the scoring criteria. This may provide an additional insight into the differences between the two player standard levels with regards to technical skill execution. This continued ecological development may also be applied to the AFHB test used in the same chapter.

Additionally, although clearly differentiating performance between talent identified and non-talent identified players, the ecological validity of the decision-making task could be further enhanced. Specifically, the decision-making task utilised in this thesis consisted of clips captured from an elevated aerial perspective. Although this perspective is common methodology (Berry et al., 2008; Lorains et al. 2013a; 2013b), future research may seek to incorporate clips from a ground level or immersed perspective to potentially enhance the viewing fidelity of the players. Moreover, it would have been intriguing to have included a measure of defensive decision-making skill, as players are often required to make defensive decisions in game-play (i.e. choosing a defensive manoeuvre to either stop the opposition or win ball possession back; commonly referred to as ‘chopping out’). However, isolating such defensive scenarios in game-play for use in a video-based task is difficult given the environmental constraints (i.e. such a decision hinges upon opposition movement patterns). It is possible to control these defensive scenarios through the use of *in situ* tasks that require actors to perform a specific movement that is designed to prompt a decision (as used by Afonso et al., 2014; Bruce et al., 2012b). However, such an approach may detract from the representativeness of the task given the pre-planned movement component. Additionally, the decision-making outcome (i.e. the product) appears to be similar

between video-based and *in situ* tasks when quantifying offensive decision-making skill (Bruce et al., 2014b), and thus the later task design did not appear to be necessary in the context of this thesis.

2. The inclusion of multi-disciplinary performance markers

The six non-talent identified players who were misclassified within Chapter Six led to the suggestion that these players may have possessed attributes from ‘other’ disciplines that were not inherently investigated within this thesis. Given this, incorporating additional objective multi-disciplinary markers (e.g. psychological status, such as motivation and resilience) may provide a more concise explanation for these results. This leaves an enticing platform for the continued development of TID programs in other team sports.

7.5 Conclusions

This thesis has developed a multi-dimensional objective approach to TID in AF. Chapters Three through Five investigated the key sport specific determinants of a talented performance through the use of representative objective performance tests. The methodologies proposed within this thesis may therefore provide coaches with objective means by which to feasibly identify talent.

Given the findings of Chapter Three, it was concluded that the key physical determinants of talent in U18 AF were measures of standing height, lower body power and maximal aerobic ability. This finding suggested that due to the invasive nature in which the game is played, physicality is an important determinant of a talented performance, and thus key measures to consider when developing a multi-dimensional battery of objective performance tests.

In addition to these physical characteristics, Chapter Four demonstrated the predictive capability of two objective measures of kicking and handballing skill; namely the AFK test and AFHB test. When compared to the non-talent identified sample, the talent identified players were considerably more skilful in measurements of kicking accuracy and ball speed on both their dominant and non-dominant sides, and handballing accuracy on both their dominant and non-dominant sides. Thus, it was concluded that players who possess superior ball disposal skills are more likely to be talent identified, as they may be able to perform more intricate tactical game plans requiring a high level of technical skill to execute. Moreover, a greater number of effective long kicks (i.e. kicks that incur an advantageous outcome for the team currently in possession of the ball) is likely to be indicative of a successful match outcome (i.e. winning) in the AFL (Sullivan et al., 2014), and is hence a desirable technical skill.

The contribution that effective decision-making skill has toward an expert performance in team sport is understood within the literature (Berry et al., 2008; Bruce et al., 2012a; Lorains et al., 2013b). However, its importance within the TID process in junior AF was currently unknown. Chapter Five aimed to fill this remaining gap by investigating whether the objective measurement of decision-making skill could accurately identify talent in U18 AF. Through the application of a video-based task, it was concluded that talent identified players were more accurate offensive decision-makers in comparison to their non-talent identified peers, and was thus deemed an important skill to objectively quantify when identifying talent.

Consolidating the results of Chapters Three, Four and Five, a range of physical, technical and tactical characteristics contribute to a talented performance in junior AF (Figure 18). Importantly, the combined findings of these chapters led to the

development of a multi-dimensional objective battery of performance tests for use in the identification of talent in junior AF. Through its application in Chapter Six, valuable conclusions and practical implications were drawn. Specifically, the vast majority of the talent identified players had a combined set of superior performance qualities when compared to their non-talent identified counterparts. Additionally, the classification accuracy evident through its application was highly robust, reflecting an accuracy of approximately 95%. In comparison to the classification accuracy reported in Chapters Three, Four and Five, this finding strongly suggests a shift away from the use of isolated performance markers in the identification of talented junior team sporting athletes.

This thesis strived to make a significant contribution to the scholarly knowledge base with regards to the study of TID in AF. Specifically, it has provided a scientific basis for the development of multi-dimensional performance tests, and in doing so enhances the accuracy of TID strategies in AF. Three main considerations have been recommended when applying a similar TID methodology in other team sports. Firstly, a thorough understanding of the sporting requirements is needed to optimise the design of the objective performance tests. Secondly, consideration must be directed toward the gift-to-talent developmental process when attempting cross-sectional TID designs; and thirdly, effective interpretation must accompany the multi-dimensional performance scores resulting from the application of an objective battery of performance tests.

7.6 Future Research Directions

This research series has attempted to provide grounding toward the development of multi-dimensional objective performance tests to improve the accuracy of TID in junior AF. However, the continued development of these measures provides an exciting prospect for the continued study of talent identification in team sports. Specifically:

1. There is a clear need for longitudinal research to complement the cross-sectional studies of TID offered here, as the prospective performance potential of the talent identified players is still unknown. Although appearing to be a limitation of the current research series, the inclusion of such longitudinal research within a doctoral project was not feasible given the time constraints. However, it is envisaged that the longitudinal predictability of the testing battery proposed within Chapter Six will be examined in the future, which would immensely strengthen the construct of the measures included within it. Specifically, a longitudinal study following the results of Chapter Six would determine whether the talent identified participants continued in their proposed performance trajectory (e.g. determined by the number of games played at the highest possible level). Unquestionably, this longitudinal investigation would be of considerable value for TID research in AF and other team sports.

2. Given the tests utilised throughout this thesis were explicitly outcome driven, isolating the mechanisms that mediated their exhibition would make for appealing future research, and hold important talent development implications. Indeed, such continued investigations would reflect stages Two and Three of the *Expert Performance Approach* (Ericsson & Williams, 1991; Williams & Ericsson, 2005). These continued investigations may shift some of the training and performance identification focus away from the outcome measure (i.e. time, accuracy or speed) and address the key issues associated with the quality of task, or skill, execution. In turn, this may enhance the performance outcome and additionally provide a deeper insight into a juniors prospective developmental potential.

3. Future cross-sectional research may look to incorporate a larger distribution in age-groupings (i.e. U18 and adult) to investigate potential transitions of skill. Whilst being predominantly investigated from a physical and tactical perspective in other team sporting contexts (for examples, see Bruce et al., 2012b; Falk et al., 2004; Gonaus & Müller, 2012; Vaeyens et al., 2006), research is yet to comprehensively investigate the transitions of technical skill between developmental levels in AF. This thesis only utilised one age-grouping in a cross-sectional design, and hence the investigation into the skill transition was not possible. Further, although research has investigated the influence of biological maturation on physical performance qualities (for examples, see Buchheit & Mendez-Villanueva, 2013; Gastin et al., 2013; Malina et al., 2004a; 2004b), research is yet to investigate how technical and tactical performance qualities are influenced by biological maturation. These continued investigations may hold important considerations for talent development programs, and corresponding training interventions in younger age-groupings.
4. With regards to the multi-disciplinary addition to the objective performance tests proposed here, there may be scope for future research to include psychological measurements into the identification of talent. The inclusion of such a tool to the already comprehensive measures proposed within this thesis may provide an insight into the longitudinal development of athletes by examining their self-confidence, motivation, mental toughness, general coping skill, and overall commitment to attain excellence at the highest possible level.

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Appendix A

The physical and anthropometric profiles of the randomly chosen non-talent identified players in comparison to the remaining non-talent identified sample in Chapter Three

Measurement	Chosen non TI sample (<i>n</i> = 50)	Remaining non TI sample (<i>n</i> = 216)
Standing height (cm)	179.8 ± 5.3	180 ± 7.1
Body mass (kg)	74.4 ± 7.9	75.0 ± 9.3
Standing vertical jump (cm)	58.4 ± 4.5	60.3 ± 6.1
Dynamic vertical jump dominant leg (cm)	66.0 ± 5.5	68 ± 8.1
Dynamic vertical jump non-dominant leg (cm)	72.9 ± 5.1	71.6 ± 8.4
20 m multistage fitness test (level.shuttle)	11.9 ± 0.9	11.10 ± 1.2
Agility (s)	8.47 ± 0.22	8.44 ± 0.30
5 m sprint (s)	1.10 ± 0.05	1.10 ± 0.01
10 m sprint (s)	1.84 ± 0.05	1.82 ± 0.03
20 m sprint (s)	3.12 ± 0.08	3.11 ± 0.03
<i>Note:</i> No significant differences were noted between either sample; TI talent identified		

Appendix B

Participant Information Sheet

“The physical, technical and tactical characteristics of U18 AF players”

This research is supported by Edith Cowan University (ECU) (School of Exercise and Health Sciences), the Western Australian Football Commission. This research is being undertaken as part of the requirements of a PhD at ECU and has been approved by the Human Research Ethics Committee.

Contact details and affiliations of researchers

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PhD candidate and chief investigator

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Faculty of Computing, Health and Science

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Phone: (08) 6304 2726 or z.mcdonald@ecu.edu.au

You are invited to participate in the following research. Participation within this research is voluntary and once involved; you are free to withdraw without prejudice at any time. If you wish to participate within this research, please sign the Informed Consent Form provided by the chief investigator.

Aim of Research: To identify the physical, technical and tactical determinants talent identified and non-talent identified U18 players.

Participant Recruitment: You were selected to participate in this research, as you are either a member of your State Academy U18 squad or a member of a Western Australian Football League (WAFL) U18 team. If you are not a member of your State U18 squad, you have been randomly selected from the nine WAFL U18 clubs.

Participant Requirements: You will be required to undertake a battery of AF specific tasks that will be split into three measurable components; these being physical, technical and tactical. The physical tests will be as used within the Australian Football League (AFL) National Draft Combine. These physical tests are annually implemented by the WAFL and as a current WAFL U18 player, you may have already participated in these tests over previous seasons. In addition to the physical tests, you will be required to complete two novel technical skill tests designed to capture kicking and handballing skill, and a tactical perceptual video decision-making task; both being created by the chief investigator. The decision-making task will consist of approximately 26 video

clips, with these clips being obtained from the 2012 AFL season from a behind the goals perspective. This will take approximately 20 minutes to complete; being completed at your corresponding WAFL training facilities. The associated risks with participating in this research are minimal and highly unlikely; however the physical tests may induce some local muscular fatigue and some potential muscle soreness. In the unlikely event of an injury, the supervision team will have the adequate first aid training to assist with the acute injury recovery strategy.

All data obtained as part of this research will be retained for five years and stored in a locked filing cabinet in the office of the chief investigator at ECU. All records containing personally identifiable data will remain strictly confidential and no information leading to the identification of participants will be released. The research team named above will access to your testing results, as well as potential research assistants who may be used for data entry. Data obtained for this research will potentially be published in scientific journals and (or) presented at conferences. If this is the case, your data will be de-identified, with no personal information being published or presented. You will be provided with a copy of the results if you require. By participating in this research you will be assisting to improve the identification of talented U18 AF players. If you have any questions or concerns regarding participation within this research, please contact the chief investigator using the above contact details, or contact a Research Ethics Officer using the below details:

Research Ethics Officer

Edith Cowan University

270 Joondalup Drive

JOONDALUP WA 6027

Phone: (08) 6304 2170 Email: research.ethics@ecu.edu.au

Appendix C

Consent Form

“The physical, technical and tactical characteristics of U18 AF players”

This research is supported by Edith Cowan University (School of Exercise and Health Sciences)

Chief Investigator:

Mr Carl Woods

PhD candidate

School of Exercise and Health Sciences, Edith Cowan University, Western Australia,
Joondalup

Ph: (08) 6304 3821 or c.woods@ecu.edu.au

Supervisors:

Assoc. Prof. Annette Raynor, Dr. Lyndell Bruce, Mr Zane McDonald

This is to certify that I _____ hereby agree (give permission for my child) to participate in this scientific investigation entitled *“the development of an objective multi-dimensional approach to talent identification in junior Australian football”* under the supervision of _____. The investigation, its procedures and my (child’s) role in the investigation has been defined and fully explained to me by _____ and I understand the explanation. A full outline of the investigations procedures and description of any risks and discomforts has been provided to me and discussed in detail. I give permission for my (child’s) testing results to be distributed to my coach and (or) club if they wish to review the results:

☐ Yes

☐ No

- I have received information about this scientific research project.
- I understand the purpose and aim of the research project and my involvement in it.
- I understand that I am free to withdraw consent and discontinue participation in this study at any time without prejudice.
- I understand that all information provided and data collected will be treated as strictly confidential. I agree that research data gathered for the study may be published provided no name or other identifying information is used.
- I understand that the data files will be stored on a USB securely locked and stored away in a filing cabinet in the office of the chief investigator (Carl Woods). The supervisors of this research (Assoc. Prof. Annette Raynor, Dr. Lyndell Bruce and Mr Zane McDonald) will be allowed access of the data if required.

Signature of participant: _____

Date: _____

Signature of parent or guardian for minors (under 18 years of age):

Date: _____

I, the undersigned, was present when the research and its procedures were explained to the participant(s) in detail and to the best of my knowledge, believe it was clearly understood.

Signature of chief investigator: _____

Date: _____

Appendix D

Letter of Approval

“The physical, technical and tactical characteristics of U18 AF players”

This research is supported by Edith Cowan University (School of Exercise and Health Sciences)

Chief Investigator:

Mr Carl Woods

PhD candidate

School of Exercise and Health Sciences, Edith Cowan University, Western Australia,
Joondalup

Ph: (08) 6304 3821 or c.woods@ecu.edu.au

Supervisors:

Assoc. Prof. Annette Raynor, Dr. Lyndell Bruce, Mr Zane McDonald

I _____, a representative on behalf of _____
_____, hereby give permission for Mr Carl Woods (chief investigator) to undertake the research entitled “*the development of an objective multi-dimensional approach to talent identification in junior Australian football*”, which will involve the recruitment and participation of our corresponding players. I have been made aware of the procedures involved and allow future publications resulting from the aforementioned study.

Signature of Association Representative: _____

Date: _____

Signature of Chief Investigator: _____

Date: _____