Benchmarking kicking skills across the talent pathway in Australian football

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ABSTRACT

In Australian football, effective kicking is a critical technical skill to maintain ball possession and more importantly, score. Despite the importance of kicking in Australian football, for talent identification purposes, no assessment of technical match play kicking performance has been developed with sufficient validity. This thesis used notational analysis of match play kicking actions to guide the development of a valid and reliable Australian football field-based kicking assessment and an Australian football small-sided game kicking assessment. These two new field-based assessments contribute to the current array of technical skill assessments to help provide a more sequential skill Performance Assessment Model.

The first study (Bonney, Berry, Ball, & Larkin, 2019; Chapter three of this thesis) reviewed current Australian football technical skill assessments using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement as a guideline. A structured framework for practitioners was developed to consider when assessing, or developing, assessments of technical game based skill. The study proposed a 5-Level Performance Assessment Model for athlete assessment. The model applied match play notational analysis to separate technical game skill on a continuum comprising of Level-1 (i.e., laboratory test), Level-2 (i.e., static field-based test), Level-3 (i.e., dynamic field-based test), Level-4 (i.e., small-sided game field-based test) and Level-5 (i.e., match play). These levels incorporated a step-wise progression of performance demands to more closely represent match-play conditions. The proposed model was suggested to provide researchers and practitioners with a better understanding of the potential technical performance demands and key outcomes associated with each level of the performance model.

Study two (Bonney, Berry, Ball, & Larkin, 2020; Chapter four of this thesis) developed a valid and reliable Australian football kicking proficiency assessment comparative to match play kicking performance. Youth male Australian football players (n = 251) from different stages within the Australian football talent pathway were assessed for kicking proficiency and physical performance outcomes. The developed Australian football field-based – dynamic kicking assessment considered particular constraints of match play kicking demands such as the distance of the kick; the speed and running direction of the player kicking the ball; the speed and direction of the player

receiving the ball and the type of kick being executed. Content, logical and construct validity and test re-test reliability were assessed. Findings suggested the kicking assessment could distinguish across and between the under 14, under 16 and under 18 age groups (U14; U16; U18) and club, sub-elite and elite skill groups. Kicking proficiency increased from U14 to U18 and as skill level increased from novice to elite. The timeframe between U14 and U16 had the greatest increase in kicking motor pattern development and was identified as a potential key period where kicking skill acquisition may be most impressionable; however, further research was recommended to support this. The developed Australian football field-based – dynamic kicking assessment was the first Australian football specific kicking assessment to consider and apply match play kicking constraints to make a more representative, valid and reliable assessment. Furthermore, this dynamic field-based assessment provides an example of a Level-3 assessment from the Performance Assessment Model where kicking proficiency can be evaluated from a more representative performance environment.

The fourth level, of the Performance Assessment Model, required the implementation of a field-based small-sided game assessment. With numerous small-sided game conditions available and limited small-sided game research conducted in Australian football, it was important to investigate how different player number conditions may influence skill involvements and physical responses in Australian football players. Study three (Bonney, Berry, Ball, & Larkin, 2020; Chapter five of this thesis) contributed to this gap in the literature by investigating the effect of four different small-sided game player number conditions (5v5, 5v6, 6v6, 7v7), played in the same 50m zone, on the technical (kicking) and physical (distance travelled total and per minute, maximum velocity and percentage of high intensity running) performance outcomes in 22 sub-elite youth Australian football players. Player number configurations were chosen in consultation with elite U18 Australian football coaches and by considering match play starting configurations (i.e., 6v6 in the forward 50m zone) and then manipulating player numbers around this. Particular constraints were applied to the small-sided game to ensure the focus was on kicking (i.e., after each handball a kick must be performed). The results demonstrated when more technical events are required under more pressure situations (i.e., physical and time) the 5v6 condition appeared to be most appropriate. However, when the focus was on kicking to a contested possession balanced player numbers would appear optimal. Alternatively, when the small-sided game focus was on increasing physical demands lower player density conditions appeared more suitable. These findings were considered with an expert panel of coaches, retired elite players, sub-elite junior players and sport scientists. It was decided the technical and physical performance outcomes in the 5v6 small-sided game were the most appropriate to investigate further in study four.

Study four (Bonney, Berry, Ball, & Larkin, 2020; Chapter six of this thesis) developed a valid and reliable 5v6 Australian football small-sided game kicking proficiency assessment. Youth male Australian football players (n = 145) from different stages within the Australian football talent pathway were assessed for technical and physical performance outcomes. Logical validity was determined from player, coach and skill acquisition expert opinion. Construct validity was determined by conducting a one-way analysis of variance to compare between age and skill groups and within an age group. Test re-test and inter-rater reliability were also assessed. Findings suggested the Australian football small-sided kicking assessment was a valid and reliable Australian football kicking proficiency assessment tool, providing an appropriate technical assessment for Level-4 on the Performance Assessment Model. The assessment considered and applied match play kicking constraints to make a more representative assessment of match play demands. The Australian football small-sided kicking assessment was 97% successful in identifying players as either novice or sub-elite. These findings may provide worthwhile information to coaches regarding kicking performance along the Australian Football League pathway, to profile player strengths whilst identifying specific areas of improvement.

With the results of study four suggesting the 5v6 Australian football field-based small-sided game was a valid and reliable assessment tool, it was important to investigate the extent to which the small-sided game compared to match play performance. The final study (Bonney, Ball, Berry, & Larkin, 2020; Chapter seven of this thesis) investigated sixteen youth Australian football players to see if the technical and physical match performance outcomes could be replicated in a 5v6 small-sided game. Players were assessed in the small-sided game and then two days later were assessed during match play. Both the testing session and match play analysis occurred at the same ground. The results suggested kicking proficiency, the number of kicks executed, meters travelled per minute and percentage of high intensity running were all higher in the small-sided game than during match play. During match play, players had less time affordance to execute a kick and achieved higher maximum running velocities than during the small-sided game. These findings provided further insights to Australian football youth coaches about the technical and physical performance outcomes of the 5v6 Australian football small-sided game kicking assessment and the technical and physical performance outcomes of match play in youth Australian football players. Understanding these responses could enable Australian football youth coaches to apply more representative training programmes.

Overall, results suggest the 5-Level Performance Assessment Model could provide sport coaches with greater clarification of the benefits and limitations of the technical assessment tasks they are using. When players are assessed from a holistic approach the tracking of player development and the display of player strengths and limitations may become more meaningful to coaches and recruiters. Furthermore, the results of studies two, three, four and five provide coaches with alternative options for technical Australian football kicking assessment and training methods. The results from studies two and four indicate that kicking proficiency improves from U13 to U16 and then appears to stabilize; however, as skill level increases so too does kicking proficiency. The greatest percentage of improvement was between U14 and U16 suggesting this may be a key developmental period where kicking skill is more susceptible to development. These results may assist coaches in developing specific technical skill programmes for particular age groups.

SIGNED DECLARATION

"I, Nathan Bonney declare that the PhD thesis with Publication entitled 'Benchmarking kicking skills across the talent pathway in Australian Football' is no more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work".

"I have conducted my research in alignment with the Australian Code for the Responsible Conduct of Research and Victoria University's Higher Degree by Research Policy and Procedures".

"All research procedures reported in the thesis were approved by the Victoria University Human Research Ethics Committee HRE16-064."

Signature: [redacted] **Date:** 29/7/2020

Nathan Todd Bonney

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LIST OF PUBLICATIONS AND PRESENTATIONS

Peer-Reviewed Journal Publications

Bonney, N., Berry, J., Ball, K., & Larkin, P. (2019). Australian football skill-based assessments: a proposed model for future research. *Frontiers in Psychology*, *10*, 429.

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Bonney, N., Ball, K., Berry, J., & Larkin, P. (2020). Effects of manipulating player numbers on technical and physical performances participating in an Australian Football Small-Sided Game. *Journal of Sports Sciences*, 1-7.

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Conference Presentations

Bonney, N., Berry, J., Ball, K., Larkin, P. (2018). *Benchmarking kicking skills across the Australian Football talent pathway*. Presented at the Australasian Skill Acquisition Network Conference, Sydney, Australia.

Bonney, N., Berry, J., Ball, K., Larkin, P. (2019). *Small-sided games: The creation, implementation and application to sport*. Presented at the World Congress on Science and Football Conference, Melbourne, Australia.

Conference Posters

Bonney, N., Berry, J., Ball, K., Larkin, P. (2018). *Benchmarking kicking skills across the talent pathway in Australian Football: The development of a kicking test to assess Australian Football kicking proficiency.* Poster presented at the 2018 Australian Strength and Conditioning Association International Conference, Sydney, Australia.

Bonney, N., Berry, J., Ball, K., Larkin, P. (2019). *The development of a kicking test to assess Australian Football kicking proficiency.* Poster presented at the 2019 World Congress on Science and Football Conference, Melbourne, Australia.

PART A:

DETAILS OF INCLUDED PAPERS: THESIS BY PUBLICATION

Please list details of each Paper included in the thesis submission. Copies of published Papers and submitted and/or final draft Paper manuscripts should also be included in the thesis submission

Item/ Chapter No.	**Paper Title**	**Publication Status** (e.g. published, accepted for publication, to be revised and resubmitted, currently under review, unsubmitted but proposed to be submitted)	**Publication Title and Details** (e.g. date published, impact factor etc.)
1/3	Australian football skill-based assessments: a proposed model for future research.	Published	Bonney, N., Berry, J., Ball, K., & Larkin, P. (2019). Australian football skill-based assessments: a proposed model for future research. Frontiers in psychology, 10, 429. Impact factor 2.129
2/4	The development of a field-based kicking assessment to evaluate Australian Football kicking proficiency.	Published	Bonney, N., Berry, J., Ball, K., & Larkin, P. (2020). The development of a field-based kicking assessment to evaluate Australian Football kicking proficiency. Research Quarterly for Exercise and Sport, 91(1), 73-82. Impact factor 2.032
3/5	Effects of manipulating player numbers on technical and physical performances participating in an Australian Football Small-Sided Game.	Published	Bonney, N., Ball, K., Berry, J., & Larkin, P. (2020). Effects of manipulating player numbers on technical and physical performances participating in an Australian Football Small-Sided Game. Journal of Sports Sciences. Impact factor 2.811
4/6	Validity and reliability of an Australian football small- sided game to assess kicking proficiency.	Published	Bonney, N., Berry, J., Ball, K., & Larkin, P. (2020). Validity and reliability of an Australian football small-sided game to assess kicking proficiency. Journal of Sports Sciences, 38(1), 79-85. Impact factor 2.811
5/7	Can match play kicking and physical performance outcomes be replicated in an Australian Football small-sided game?	Published	Bonney, N., Berry, J., Ball, K., & Larkin, P. (2020). Can match play kicking and physical performance outcomes be replicated in an Australian Football small-sided game? Science and Medicine in Football. Impact factor NA

Declaration by [candidate name]: **Signature:** [redacted] **Date:** 23/6/2020

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GLOSSARY AND ABBREVIATED TERMINOLOGY

%HIR	Percentage of High Intensity Running
AF	Australian Football
AFFB-DKA	Australian Football Field-Based Dynamic Kicking Assessment
AFL	Australian Football League
ANOVA	Analysis of Variance
CI	Confidence Interval
CV	Coefficient of Variation
EPA	Expert Performance Approach
ES	Effect Size
ICC	Intra-class Correlation Coefficient
PAM	Performance Assessment Model
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RAE	Relative Age Effect
TI	Talent Identification
TID	Talent Identification and Development
U18	Under 18
VFA	Victorian Football Association
RAE	Relative Age Effect
RLD	Representative Learning Design
SAQ	Speed, Agility and Quickness
SD	Standard Deviation
SEM	Standard Error of Measurement
SSG	Small-sided game

CHAPTER ONE – Introduction

1.1 Background

Australian football is an example of a team sport based upon many interconnected performance components (i.e., technical, tactical, physical, psychological). As age and relative skill level increases (i.e., club level to national level) so too does the performance demands of these components (Burgess, Naughton, & Norton, 2012b). The ability to identify these elements may expedite the talent identification and development process and create a larger talent pool. This improvement from within the system can potentially save teams and organizations finances, staffing and resources (Falk, Lidor, Lander, & Lang, 2004). Previous research has used physiological capacities, such as aerobic capacity, speed and power to distinguish between team selection and non-selection, career progression and playing performance (Veale, Pearce, & Carlson, 2010b; Young & Pryor, 2007). Whilst physiological capabilities are important in the game of Australian football, ball possession and kicking skill proficiency (Robertson, Back, & Bartlett, 2015a) have been shown to be greater influences on match outcomes. Accordingly, technical assessments have been recommended to be added to testing batteries in an attempt to further improve future success prediction (Robertson, Woods, & Gastin, 2015b).

Talent selection in Australian football has been typically biased towards players who are able to perform at a high level across a range of physiological tests and therefore able to fulfil a range of positions (Veale, Pearce, Koehn, & Carlson, 2008). Currently there are numerous objective measures for assessing physiological capabilities at the Australian Football League Combine. The Australian Football League Combine occurs over four days in October each year and involves identified players displaying their physiological, psychological and selected Australian football skills to team recruiters. These attributes are tested in isolation of each other with no two or more attributes being combined in the one assessment. In contrast, match play performance requires a player to combine their technical, tactical, physiological and psychological attributes when performing a skill therefore, current assessments are inherently limited.

1.2 Theoretical framework

The goal of practice is to acquire skills that lead to improved performance in competition (Davids, Araujo, Correia, & Vilar, 2013a). However, when testing or practice sessions are not representative of match play conditions, an athlete will modify their movement patterns in response to the environment they are performing within (Araujo, Davids, & Hristovski, 2006). For example, when an athlete faces a bowling machine their timing and technique is modified when compared to facing a bowler in match play (Pinder, Renshaw, & Davids, 2009; Renshaw, Oldham, Davids, & Golds, 2007). To increase the likelihood of the testing or practice session to be representative of the competitive environment, researchers have suggested the use of a 'representative learning design' as a theoretical framework (Pinder, Davids, Renshaw, & Araujo, 2011). This framework suggests testing and practice sessions should be representative of match play conditions including the technical and tactical execution of skills and the conditions, actions and perceptual stimuli present during the competitive environment (Araujo et al., 2006; Davids et al., 2013a; Pinder et al., 2011). This style of practice has been adopted by international hockey coaches when preparing their athletes for field goal shooting (Slade, 2015). The coaches replicated scenarios from match play and found it enabled the players to successfully integrate their technical, tactical, perceptual and decision making skill rehearsal.

Although Australian football is played in an open environment, where expert performers are able to adapt to their changing environment to perform consistently (Araujo & Davids, 2011), the Australian Football League currently assesses technical skill in a static environment (i.e., kicking efficiency test). This setting eliminates the ability of the athlete to demonstrate their competence in anticipation, problem solving and attention, which consequently affects their ability to execute their skill proficiently (Falk et al., 2004; Hoare & Warr, 2000; Lidor, Cote, & Hackfort, 2009). In 2009, a search on 'Australian Football' in PubMed returned 193 articles of which only 5% were dedicated to skill acquisition/decision making (Gray & Jenkins, 2010). Currently a significant gap exists between current testing procedures and match play. A new representative skill test is warranted where behaviour emulates competition and this void can be abridged. Previous research has highlighted the need for this by suggesting an objective assessment tool, which measures technical and tactical competence, would not only assist in the development of benchmarking skill performance but enhance the selection process and improve prediction of future success (Hoare & Warr, 2000; Robertson et al., 2015b).

1.3 Research aims

The primary purpose of this research is to 1) explore the current technical kicking assessments used throughout the Australian Football League participation pathway and examine how representative they are of match play; 2) use this information to guide the development of a valid and reliable Australian football field-based kicking assessment; and 3) use this information to guide the development of a valid and reliable Australian football small-sided game kicking assessment. These assessments aim to bridge the gap between current static kicking skill assessments and the dynamic nature of kicking in Australian football match play. Each assessment will be a step-wise progression of the demands placed upon the player by closely referencing what occurs during match play (necessitating more of the components to be displayed at the one time). For example, the introduction of a new dynamic field-based kicking proficiency assessment requires the technical, physical and to some degree the tactical components to be performed together. In comparison, the new small-sided game kicking proficiency assessment requires all four performance components, the technical, tactical, physical and psychological, to be interacting together under a similar performance demand to match play.

1.4 Objectives

- Use current notational analysis on match play kicking actions to guide the development of two new kicking assessments;
- Develop a valid and reliable match referenced dynamic field-based kicking assessment to assess Australian football player kicking proficiency;
- Investigate four different small-sided games (i.e., 5v5, 5v6, 6v6, 7v7) to identify the technical and physical differences. These results would then be considered with an expert panel of coaches, retired elite players, sub-elite junior players and sport scientists to select the most appropriate number condition to guide the development of the Australian football field-based small-sided game assessment;
- Develop a valid and reliable match referenced field-based small-sided game to assess Australian football player kicking proficiency; and
- Determine if the technical and physical performance characteristics of the Australian football field-based small-sided game are comparable to match play.

1.5 Chapter Organisation

This thesis is submitted as a thesis by publication.

Chapter three (Bonney, Berry, Ball, & Larkin, 2019) was published in Frontiers in Psychology;

Chapter four (Bonney, Berry, Ball, & Larkin, 2020) was published in Research Quarterly for Exercise and Sport;

Chapter five (Bonney, Berry, Ball, & Larkin, 2020) was published in Journal of Sports Sciences;

Chapter six (Bonney, Berry, Ball, & Larkin, 2020) was published in Journal of Sports Sciences and

Chapter seven (Bonney, Ball, Berry, & Larkin, 2020) was published in Science and Medicine in Football.

Chapter one introduces the background, specific aims and objectives for the research conducted in this dissertation.

Chapter two provides an overview of skill assessment in team sport, with a particular focus on the sport of Australian football. Specifically, this Chapter provides a critical analysis of how talent is currently being identified and the factors potentially influencing the effectiveness of these assessments. Furthermore, this Chapter explores the key components a skill assessment should consider to guide the development of a more representative and objective kicking assessment such as those discussed within research Chapters four and six.

Chapter three (Bonney, Berry, Ball, & Larkin, 2019) explores current talent identification assessments, with a particular focus on Australian football. It proposes a 5-Level Performance Assessment Model for athlete assessment. The proposed model separates skill assessments on a continuum from Level-1 (i.e., laboratory test) to Level-5 (i.e., match-play) incorporating a step-wise progression of performance demands more closely representing match play conditions. The proposed model provides a better understanding of the potential performance demands and key outcomes associated with each level of the performance model and provides the foundation for Chapters four, five, six and seven.

Chapter four (Bonney, Berry, Ball, & Larkin, 2020b) establishes a valid and reliable Australian football kicking proficiency assessment comparative to match play kicking performance. The developed Australian football field-based – dynamic kicking assessment considered particular constraints of match play kicking demands such as kick type, distance of kick, speed and movement of the player kicking the ball and speed and movement of the player receiving the ball. This assessment contained a more integrated approach of match play components (i.e., technical, tactical, physical) than the current static assessments and required a higher performance demand (e.g., kicking the ball whilst running) to be more representative of match play.

Chapter five (Bonney, Ball, Berry, & Larkin, P, 2020) investigated the effect of four different small-sided game player number constraints (5v5, 5v6, 6v6, 7v7) on the technical (kicking) and physical (distance travelled total and per minute, maximum velocity and percentage of high intensity running) performance outcomes. Results demonstrated when more technical events are required under more pressure situations (i.e., physical and time) the 5v6 constraint appears to be most appropriate. However, when the focus is on kicking to a contested possession balanced player numbers would appear optimal. Alternatively, when the small-sided game focus is on increasing physiological demands (i.e., meters travelled per minute) lower player density constraints appear more suitable. Results of this Chapter were discussed with an expert panel of coaches, retired players, sub-elite junior players and sport scientists to inform the small-sided game player number configuration for Chapter six.

Chapter six (Bonney, Berry, Ball, & Larkin, 2020c) investigated if an Australian football small-sided game could be an appropriate method for assessing the skill of kicking in Australian football. To answer this question, a 5v6 Australian football field-based small-sided game kicking proficiency assessment was developed and validated. This Chapter investigated how the Australian football small-sided kicking assessment can differentiate between age (i.e., U13; U14; U16; U18) and skill groups (i.e., novice and sub-elite). The assessment contained a more integrated approach of match play components (i.e., technical, tactical, physiological, psychological) than Chapter four and provided an example of a Level-4 skill assessment from Chapter three. Outcomes from this Chapter may provide worthwhile information to coaches regarding player kicking performance during competition (rather than specific details on how they will perform the skill), information on kicking performance along the Australian Football League pathway and greater insights on player strengths whilst identifying specific areas of improvement.

Chapter seven (Bonney, Berry, Ball, & Larkin, 2020a) investigated if the technical and physical performance outcomes between the 5v6 Australian football small-sided game and match play are comparable. The technical variables assessed were kicking proficiency, number of kicks executed and time pressure before disposal (i.e., under 2 seconds, 2-4 seconds, over 4 seconds). The physical variables assessed were distance travelled total and per minute, maximum velocity and percentage of high intensity running. The results suggest kicking proficiency, the number of kicks executed, meters travelled per minute and percentage of high intensity running were all higher in the small-sided game than during match play. During match play, players have less time affordance to dispose of the ball and achieve higher running velocities than during the small-sided game. This Chapter provided critical information to coaches regarding the interpretation and application of the Chapter six results. Understanding these responses could enable Australian football youth coaches to apply a more effective periodised skill acquisition training programme.

Chapter eight provides an overview of Chapters three to seven and discusses the practical implications of this thesis. This Chapter involves a general summary and conclusion of the experimental studies and provides recommendations for future research based upon the findings in this thesis.

CHAPTER TWO – Literature Review

2.1 Australian football

Australian Football is an invasion style game where the objective is to score more points than the opposition. The Victorian Football Association began in 1877 and in 1896 evolved into the Victorian Football League until 1990 where the competition expanded into a national league called the Australian Football League (Booth, 1997). It has now grown to be one of the most participated sports in Australia (approximately 685,732 participants) and has expanded to over 30 countries worldwide (*AusPlay national tracking survey*, 2016; Booth, 1997).

The game is played on a grass oval between 135 meters and 185 meters in length and 110 meters and 155 meters in width (*Laws of Australian Football*, 2015). The duration of the match is eighty minutes, divided into four equal quarters of twenty minutes of actual playing time (this does not include stoppages in play). A quarter of match play will involve a variety of different phases. Contested play is the most common (occurring 25% of the time) with offense (18%), defense (18%) and umpire stoppages (18%) following (Rennie, Watsford, Spurrs, Kelly, & Pine, 2018). There is a six-minute interval between the first and second and third and fourth quarter whilst the half time interval (between the second and third quarter) has a duration of twenty minutes. A team must have a minimum of fourteen players and maximum of eighteen players on the ground at any one time with a maximum of four interchange players (*Laws of Australian Football*, 2015). The ball used is of a symmetrical oval shape between 720-730 millimeters in circumference and 545-555 millimeters transverse circumference and inflated to a pressure between 62 and 76 kilopascals (kPa) (*Laws of Australian Football*, 2015).

In Australian football there are two ways of moving the ball around the ground: handballing (i.e., holding the ball in one hand and hitting the football with a clenched fist of the other hand) and kicking (i.e., making contact with the ball with any part of the player's leg below the knee). There are four goal posts situated at either end of the ground 6.4 meters apart allowing for three scoring zones: a middle and two outside zones (Figure 1). A goal (six points) is awarded when the football is kicked and passes completely over the goal line, between the two middle posts of the middle zone, by a player of the attacking team without being touched by the opposition. If the ball touches a goal post, crosses the behind line of either of the two outside zones, or is touched by the opposition one point is awarded (*Laws of Australian Football*, 2015).

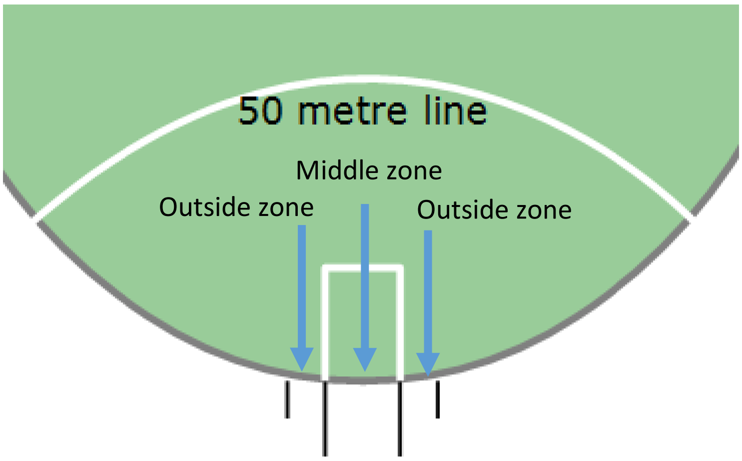

Figure 1. Schematic of the forward third of an Australian football ground with the indicated goal scoring zones

As the game evolved into a more professional league so too did the speed at which the game was played. In 1961 players moved the ball at 3.38 meters per second (m/s) whilst in 1997 they moved the ball at 6.58m/s (Norton, Craig, & Olds, 1999). As the game progressed, strategies used to move the ball around the field also evolved (Woods, Robertson, & Collier, 2017b). Accordingly, the anthropometrics of the players changed to effectively perform these new requirements. Selected players were not only taller but heavier (Booth, 1997; Norton et al., 1999). With the help of more sophisticated training programmes, players were able to increase their muscle mass whilst decreasing their adipose tissue. This increase in muscle mass, particularly within the lower limbs, may assist players in applying a greater force through their kicking action and onto the ball, causing the ball to go through the air at a much faster speed (Peacock, Ball, & Taylor, 2017).

The increase in ball movement instigated players to not only adapt their aerobic capacity but also their anaerobic capacity. Australian football players run approximately 13,000 meters per game with over 3000 meters being performed at high intensity (above 14.4km h^{-1}) (Coutts, Quinn, Hocking, Castagna, & Rampinini, 2010). When covering these distances players are performing more than 150 high intensity movements per game, which equates to 4-6% of total movements, for a duration of less than six seconds (Dawson, Hopkinson, Appleby, Stewart, & Roberts, 2004). Furthermore, more than half of all sprints performed by the players involved at least one change of direction mostly between 0-90 degrees (Dawson et al., 2004). Delaney, Thornton, Burgess, Dascombe, and Duthie (2017) investigated running intensities of 40 elite Australian football players over 30 games and discovered the midfield players peaked at 223 meters a minute (m/min^{-1}) for a one minute effort. The authors noted how midfield and mobile forward players covered more relative distance than tall backs and how midfield players covered more distance at relative high-speed than the other two positions. When comparing this data to elite under-18 (U18) players, researchers have found the U18 players cover less total distance (approximately 11,500m) and performed fewer 'working' efforts (Burgess et al., 2012b; Veale, Pearce, & Carlson, 2007) highlighting the unique physiological differences between the U18 and elite Australian football ability groups.

When comparing Australian football higher and lower skilled players it was revealed higher skilled players had more involvements with the football per minute (0.26 compared to 0.12 disposal per minute), covered less distance per involvement with the ball (Johnston, Watsford, Pine, Spurrs, Murphy, & Pruyn, 2012) and spent more time on the field (7.2%) than lower skilled players (Johnston, Watsford, Austin, Pine, & Spurrs, 2016). Conversely, Johnston et al. (2016) investigated physical demands, match event and match performance data from 19 players over two Australian Football League (AFL) seasons. They found higher skilled players covered more total distance (9.6%) and spent more time running at high-speed per minute (11.9%) than lower skilled players. Overall, these data not only establish the importance of a player's physical attributes but also their technical attributes. With the increase in the speed of the ball and the increase in higher speed running there is a necessity for players to be able to make accurate and timely decisions whilst effectively passing the ball in order to maintain possession.

2.2 Australian football kicking

In Australian football, there are two methods to pass the ball and score – kicking and handballing (Kempton, Sullivan, Bilsborough, Cordy, & Coutts, 2015; Sullivan, Bilsborough, Cianciosi, Hocking, Cordy, & Coutts, 2014b). Although handballing is an effective method to pass the ball (Parrington, Ball, & MacMahon, 2013), in elite junior Australian football kicking is used more frequently (Woods, Veale, Fransen, Robertson, & Collier, 2018) and is the only method by which a goal can be scored. Obtaining greater clarity around kicking requirements can assist coaches by informing training requirements, designing team strategies and assessing player performance. For example, the drop punt is the most commonly used kick in Australian football with higher skilled players having more kicks and disposals per minute than lesser skilled players (Johnston et al., 2012). These game insights can also be used to indicate the likelihood of a match outcome. Teams who accurately kick the ball (Sullivan, Bilsborough, Cianciosi, Hocking, Cordy, & Coutts, 2014a), execute more kicks and convert goals greater than 4.2% than their opposition (Robertson et al., 2015a) are more likely to win the match. Considering the only way to score a goal is from a kick, goal kicking is another important consideration. The set shot goal-kick in Australian football occurs, on average, 23 times during a game with player's averaging only 55% accuracy (Anderson, Breed, Spittle, & Larkin, 2018). Furthermore, as the kicking distance extends beyond 50m kicking accuracy declines from 97% (0-15m) to 36% (beyond 50m) with players 2.6 times more accurate when the set shot was less than 30°. These results provide important information for players to consider when executing a kick into the forward 50m arc. Ideally, the ball would be kicked to a teammate close to goal, directly in front, as when the distance and/or angle of the kick increases the accuracy of the kick decreases.

When kicking the ball in from a behind, short kicks under 25m have been shown to have a higher success rate (93%) than long kicks over 50m (29%) at retaining possession of the ball. Short kicks reduce the amount of time the ball spends in the air thereby reducing the opportunity for opponents to intercept the ball (Appleby & Dawson, 2002). The ability to proficiently kick the ball in a game situation (i.e., pass to the intended target or score) is a critical factor in Australian football. A coach's perception of player performance is largely influenced by the number of disposals they have had and their effectiveness to pass the ball and maintain possession (Sullivan et al., 2014b). When comparing experienced and less experienced players in Australian football, the experienced players had more skill involvements during the second and fourth quarters (in peak 3-minute block) and performed technically and physically better following peak periods of match play than their counterparts (Black, Gabbett, Naughton, & McLean, 2016). A possible reason for this may be the shorter break duration at quarter and three quarter time, with lesser skilled players having more residual fatigue in their bodies following these breaks (Abbiss & Laursen, 2007). This research highlights how important skill proficiency is when not only in a fresh state but also, if not more importantly, in a fatigued state.

Biomechanical assessment of the Australian football drop punt kick has revealed different movement patterns are associated with the preferred and non-preferred leg. When kicking with the preferred leg players use their pelvis, knee and shank more; however, when kicking with the non-preferred leg players rely more on their hips and thighs (Ball, 2011). When assessing kicking performance these mechanics are important considerations as accurate kickers have greater hip flexion in both limbs and greater knee flexion in the support limb throughout the kicking movement (Dichiera, Webster, Kuilboer, Morris, Bach, & Feller, 2006). Furthermore, when kicking for maximal distance a higher foot velocity and greater ankle motion rigidity (due to greater plantar flexion) was found when compared to kicking for accuracy (Peacock et al., 2017). Similar to Dichiera and colleagues (2006), Blair, Duthie, Robertson, and Ball (2017) noted goal accuracy increased when players had greater support leg and kick leg knee flexion; however, footspeed and shank angular velocities had individual differences. Interestingly, when a player is in a short-term fatigued state their range of motion at their pelvis and kicking thigh increased although their foot speed was maintained (Coventry, Ball, Parrington, Aughey, & McKenna, 2015). This guided the authors to conclude when players are kicking for maximal distance they are able to make kinematic adaptations in an attempt to maintain their foot speed.

Considering the importance of kicking in Australian football, it is surprising there is currently very little research conducted on the application of using kicking performance as an assessment tool for talent identification (Cripps, Hopper, & Joyce, 2015; Woods, Raynor, Bruce, & McDonald, 2015c). In an attempt to assess kicking skill performance of elite youth Australian football players, the Australian Football League included two skill tests to the Australian Football League Draft Combine (i.e., large scale standardised testing for Australian football talent identified youth athletes). The tests include a goal kicking test and a kicking efficiency test. Representative validity (discussed in section 2.10); however, is a major concern with both of these tests. The most representative skill test at the Australian Football League Combine is the set-shot goal kicking test. A set-shot is a closed skill performed during a stop in play as a result of a mark or free-kick penalty. To the author’s knowledge no research has been conducted on this test to validate its use and without established validity it is unclear whether the test measures what it claims to (Larkin, Mesagno, Berry, & Spittle, 2014). The kicking efficiency test involves a player running towards a feeder who receives the ball and delivers it to one of six randomly assigned stationary targets (Cripps et al., 2015). Kicking performance is subjectively assessed on a scale from 0 to 5 (5 being the highest score) for each kick. Cripps et al. (2015) investigated the test on 121 semi elite U16 male players and found the inter-rater reliability to be high; however, the test could only differentiate between dominant and non-dominant kicking leg accuracy across varying distances. The authors concluded more research was required to determine if the test can distinguish between higher and lesser skilled players and if kicking ability changes with age (Cripps et al., 2015). Woods et al. (2015c) also assessed the kicking efficiency test on 50 U18 male players (25 state representatives and 25 non state representatives) and found when kicking accuracy and ball speed were combined playing status was able to be predicted. A limitation of the current kicking test is the assessment is conducted in isolation and does not assess the range of in-game kicking constraints typically performed within the performance environment. As a result, kicking ability is not assessed under match referenced conditions and consequently alternative actions and performances may be performed by the players (Araujo et al., 2006). A new match-referenced kicking skill test appears warranted as the main purpose of a performance test is to demonstrate how the test relates to the competitive environment (Vilar, Araujo, Davids, & Renshaw, 2012). Once a valid and reliable kicking test has been constructed it may be possible to create kicking skill benchmarks from performances on these tests, assisting in the identification of talent and the tracking of player development.

2.3 Talent identification in team sport

Talent is a multi-dimensional concept and requires the effective and efficient organization of an individual's technical, tactical, physiological and psychological competencies to be applied concurrently to meet the requirements of both the environment and the sporting situation (Johnston, Wattie, Schorer, & Baker, 2018; Vaeyens, Gullich, Warr, & Philippaerts, 2009). Talent identification programmes endeavor to discover this 'talent' in individuals with the greatest potential to respond to a training intervention and reach the highest level in sport (Abbott & Collins, 2004; Hoare & Warr, 2000). The ability to identify talented players in team sports is not only a financially rewarding business but a key component of future winning teams and long term success (Gee, Marshall, & King, 2010; Larkin & Reeves, 2018).

In an attempt to identify this talent, researchers analysed physiological capabilities and discovered players who can perform above level 14 on the multistage fitness test and sprint 20-meters in under three seconds were more likely to be drafted (Robertson et al., 2015b). Other researchers have found leg power, high-intensity intermittent running ability (Young, Newton, Doyle, Chapman, Cormack, Stewart, & Dawson, 2005) and repeated sprint ability were able to differentiate between selected and non-selected players to play the first match of the season (Le Rossignol, Gabbett, Comerford, & Stanton, 2014). Although physical testing does provide an insight into the physiological requirements of potential draftees and players selected for the first competition game of the season, it does not identify how proficient (i.e., the level of competency when executing a specific skill) a player is with the ball.

In comparison to physiological competencies, sport specific skill proficiency has been shown to be a more sensitive predictor of successful teams (Kempton, Sirotic, & Coutts, 2017). When comparing winning to losing a game it was discovered winning quarters consisted of more skill involvements (i.e., kicking and handballing) and higher skill efficiency whilst quarters lost involved more physical requirements (Sullivan et al., 2014a). This highlights the importance of skill involvements and skill proficiency, in comparison to physical activity profiles, to team success. The use of technical skill testing to predict performance has been effective in team and individual sports such as handball (Lidor, Falk, Arnon, Cohen, Segal, & Lander, 2005), soccer (Ali, Foskett, & Gant, 2008) and rugby (Gabbett, Jenkins, & Abernethy, 2011a). It has been suggested a player's proficiency in skill execution can potentially influence playing performance and therefore team performance to a larger extent. For example, Kempton et al. (2017) examined the differences in physical and technical performance profiles between successful and less-successful rugby teams. They found successful teams gained more territory in attack, had more possessions and committed fewer errors than less-successful teams. In conclusion, the authors noted proficiency in technical performance components were better able to differentiate between successful and less-successful teams than physical outputs (Kempton et al., 2017). Considering how critical technical and physical performances are to talent identification, it is important to understand how maturation may impact these performance outcomes.

2.4 Maturation in team sport talent assessment

Maturation is an important factor to be considered when trying to identify talent. When identifying athletes below the age of 15, differences as small as one-year in stages of puberty can have a significant effect upon an athlete. Early maturers have more developed physical attributes such as height and weight which are related to a player's strength, power and speed (Russell, Le Rossignol, & Sparrow, 1998; Sheppard, McNamara, Osborne, Andrews, Oliveira Borges, Walshe, & Chapman, 2012). As such, these players appear more competent than their peers and consequently more likely to attract the attention of talent recruiters (Cobley, Baker, Wattie, & McKenna, 2009; Figueiredo, Coelho, Cumming, & Malina, 2010). Coutts, Kempton, and Vaeyens (2014) investigated 806 players drafted to play elite Australian football. They found drafted players were more likely to be born in the first quartile and first half of the year, had advanced physical and psychological maturity and had exposure to higher level coaching. This was supported in a study of 66 10-14-year-old Spanish talent identified soccer players where it was shown 72% were born in the first semester with faster sprint times over 30m (Gravina, Gil, Ruiz, Zubero, Gil, & Irazusta, 2008).

The term relative age effect (RAE) is used to describe a selection bias dependent upon the time of year the athlete is born (Andronikos, Elumaro, Westbury, & Martindale, 2016). The relative age effect appears to be most pronounced between the ages of 15-18 at representative level (Cobley et al., 2009). Haycraft, Kovalchik, Pyne, Larkin, and Robertson (2018) examined the influence of relative age effect across the Australian Football League talent pathway. They found a relative age effect was present at the state U16 level and is maintained at State and National level combines. In a soccer study following 55 14-year-old soccer players, for eight years, the authors highlighted how 60.1% of the players who made it to the elite level were late maturers whilst only 11.8% were early maturers (38.1% were normal maturers) (Ostojic, Castagna, Calleja-Gonzalez, Jukic, Idrizovic, & Stojanovic, 2014). To try and assess when stabilization in activities, such as repeated sprint ability, might occur Spencer, Pyne, Santisteban, and Mujika (2011) studied 119 U11-U18 soccer players. They discovered it was not until 18-years of age where stabilization occurred and trying to identify players with the potential to continue developing on factors such as these are unpredictable. Collectively these studies would imply early maturers are being selected based more upon physical statue rather than skill proficiency. Furthermore, once all athletes have gone through maturation, it is more so the late matures who are more likely to reach the elite level. This is largely due to once they have caught up to the early maturers physical statue, their years of playing against bigger and stronger competition have enabled them to develop superior skills (technically, tactically, physiologically and psychologically) to become higher skilled players (Pearson, Naughton, & Torode, 2006).

It is important that selection does not discriminate against late-maturing players who may develop their abilities later. A suggestion to avoid this is for coaches to apply a more skilled based selection criterion (i.e. movement accuracy/skill proficiency) and look towards long term athlete development than short term success (Cobley et al., 2009). Figueiredo et al. (2010) noted how soccer-specific skills performed by players 11-14-years old were less affected by maturation than physiological attributes. Similar findings have also been reported in handball (Matthys, Vaeyens, Coelho, Lenoir, & Philippaerts, 2012) and basketball with sport-specific skill appearing to be independent of pubertal status (Silva, Carvalho, Goncalves, Figueiredo, Elferink-Gemser, Philippaerts, & Malina, 2010). Other key performance components, such as game intelligence, and psychosocial attributes (Williams & Reilly, 2000) in combination with physical performance and growth measures could also be assessed. These assessments could then be used to highlight and nurture player strengths whilst improving player weaknesses rather than excluding players (Pearson et al., 2006).

2.5 Fatigue and pressure situations

Successful athletes not only display a high proficiency of technical skill and decision making ability but they can display these traits under both a fatigued state and under pressure situations (Kitsantas & Zimmerman, 2002; Royal, Farrow, Mujika, Halson, Pyne, & Abernethy, 2006). Fatigue; however, is an element often neglected by skill tests. There are many opinions on how to explain fatigue such as a decline in muscle force (Komi & Tesch, 1979), an increase in metabolic accumulation (Hargreaves, McKenna, Jenkins, Warmington, Li, Snow, & Febbraio, 1998), energy substrate depletion (Balsom, Gaitanos, Soderlund, & Ekblom, 1999), alterations of neuromuscular propagation, excitation-contraction coupling failure and modifications of the intrinsic capability of force production (Millet & Lepers, 2004) or a sensation we feel originating from a difference in our homeostatic control systems (St Clair Gibson, Baden, Lambert, Lambert, Harley, Hampson, Russell, & Noakes, 2003). These opinions can be further examined according to the time period where the activity took place. For example, fatigue following an intense period of exercise appears to be related to disturbances in muscle ion homeostasis whilst the initial constraint in generating maximal force post half time may be due to a lower muscle temperature; with the fatigue experienced towards the end of the game being due to low levels of glycogen (Mohr, Krustrup, & Bangsbo, 2005). Environmental conditions can also play a role in the fatigue experienced by the athlete with hot and humid conditions leading to a greater chance of dehydration occurring (Mohr et al., 2005).

Due to the varying definitions of the word 'fatigue' researchers have suggested each definition has its own place in the literature dependent upon the context in which the term is being used (Abbiss & Laursen, 2007). For the purpose of this thesis, 'fatigue' will be defined as a generic term including physical exertion and psychological arousal to a level impacting physical, cognitive or technical performance to some degree (Aaronson, Teel, Cassmeyer, Neuberger, Pallikkathayil, Pierce, Press, Williams, & Wingate, 1999; Abbiss & Laursen, 2007). During the game of Australian football, fatigue can lead to many detriments in playing performance. Kicking performance may decline due to alterations in the neuromuscular systems and force generation capacity, which may alter the mechanics of the kicking performance (Kellis, Katis, & Vrabas, 2006). Furthermore, it can impact the speed at which information is taken in, processed and a response is initiated thereby impeding a player's ability to effectively select the correct passing option and execute the skill proficiently. Finally, moderately high fatigue can impair performances requiring strength, endurance and rapid movements (Lidor et al., 2009) such as those displayed in Australian football marking, tackling, running and kicking. In a soccer study of 15 academy players it was noted how shots taken after exercise were 25% less accurate than those taken before exercise and passes in the last 15-minutes were 7.8% slower than in the first 15-minutes (Russell, Benton, & Kingsley, 2011). Although this study was analyzing 15 18-year-olds without opposition (thereby decreasing its representativeness) other researchers have found similar results with a decline in passing accuracy and performance following high intensity activity (Rampinini, Impellizzeri, Castagna, Azzalin, Ferrari Bravo, & Wisloff, 2008). Lorist, Kernell, Meijman, and Zijdewind (2002) studied 16 healthy adults (21-44 years old) and noted how cognitive performance was significantly affected by motor fatigue. When performing in a single-task condition, participant results were relatively stable; however, during the fatiguing dual task condition subjects reacted more slowly and made more incorrect decisions.

The type of activities players participate in will have a large impact upon their performance. Activities such as tackling and collisions have been shown to significantly impact the number of repeated high intensity efforts performed (Gabbett, 2013). In a study of 24 elite Australian football players it was shown less experienced players were more likely to cover less high-speed distances during the period following the most intense passage of play in comparison to experienced players (Black et al., 2016). Furthermore, these less experienced players had fewer involvements during high-intensity periods of the match as well as during the periods subsequent to the most intense periods of play. Joseph, Woods, and Joyce (2017) investigated the relationship between aerobic capacity and kicking performance in Australian football. They noted players who had a higher yo-yo intermittent recovery two score had higher kicking speeds and better accuracy scores than players with lower aerobic conditioning. This research is important as it demonstrates as fatigue increases technical and tactical abilities deteriorate and this regression is more prominent in less experienced players than experienced players.

Many sport skills are performed in a fatigued state. Research; however, has suggested match related fatigue has a greater effect on a players ability to get involved with the ball than it does on a player’s skill proficiency (Rampinini, Impellizzeri, Castagna, Coutts, & Wisloff, 2009). The intensity of the fatigue is an important factor to consider within this context. In a study of 20 college students it was found soccer passing performance was better following moderate muscle fatigue in comparison to rest or high levels of fatigue. This test; however, was completed in a static environment where players had to dribble the ball within a certain area and pass the ball to a stationary box with no involvement from ‘live’ opponents (Lyons, Al-Nakeeb, & Nevill, 2006). The level of the athlete may also be an important consideration. In water polo it was shown elite athletes are more resilient to physiological stresses occurring during competition and as such are better able to maintain their technical accuracy. These elite water polo players made 18% better decisions with high fatigue than with low fatigue with shooting accuracy and velocity being unaffected (Royal et al., 2006). Shooting technique; however, did decrease by 43% between pre-test and high-fatigue suggesting elite athletes are able to self-regulate in order to optimize their performance (i.e., they decreased their proficiency on non-essential technique to ensure accuracy and speed was maintained) (Kitsantas & Zimmerman, 2002; Royal et al., 2006). As current Australian football talent identification skill tests do not cater for fatigue, it is suggested a new skill test is created involving a level of fatigue appropriate for the age and ability level of the athlete.

2.6 Skill acquisition in team sport

Team sport talent identification programmes rely heavily upon physiological capabilities. Although it is important to have a high level of physiological ability in order to be effective in team sport, it is equally if not more important to have a high level of skill proficiency. Skill proficiency has been shown to have a higher level of reliability in comparison to physical skill when attempting to identify talent. For example, in a study of junior volleyball players it was found particular skill test results of game proficiency (subjective coach evaluation of passing and serving) were the only variables to discriminate between selected and non-selected players in comparison to physiological or anthropometric results (Gabbett, Georgieff, & Domrow, 2007a). A similar result was found in rugby players. When investigating first grade rugby players Gabbett, Kelly, and Pezet (2007b) found selection was based more upon playing experience and skill proficiency of players than their physiological capacities (Gabbett et al., 2007b). The authors did; however, note a high level of physical fitness did contribute to effective playing ability in these selected players. Cupples and O'Connor (2011) investigated performance indicators in elite youth rugby from a coach's perspective. They discovered cognitive ability to be the greatest influence of playing position in elite youth rugby league players, followed closely by game skills and finally to a lesser extent physiological indicators. It was further discussed how the development of a skills test, simulating game specific conditions, will improve the coach's knowledge of player strengths and weaknesses, whilst providing performance criteria for the monitoring of improvements throughout the season or longer (Cupples & O'Connor, 2011; Gabbett, 2002).

The amount of time each player participates in practice has been shown to discriminate between skill levels. Ward, Hodges, Starkes, and Williams (2007) investigated the contribution of domain-specific and non-domain specific activities to the development of soccer expertise in nine to 18 year-olds. Players who spent more time in decision making activities, such as those designed to improve performance (i.e., time spent in tactical and strategic decision making activities), were more likely to become elite players than those participating in activities designed for general education or exposure (Ericsson, 2008; Ward et al., 2007). Interestingly, 40.9% of elite players played the game in order to improve their skill in comparison to sub-elite players whose main reason to play the game was for enjoyment (Ward et al., 2007). This therefore demonstrates the importance of skill with respect to playing stature. In another study looking at the skill and physiological demands of open and closed training drills, in elite junior Australian football players, it was highlighted how open skills were more physically and cognitively demanding than closed drills (Farrow, Pyne, & Gabbett, 2008). Considering Australian football requires a high level of physical ability in combination with technical skill and decision making ability the application of open skill assessments in Australian football is most appropriate. Well-designed open skill assessments not only provide a suitable amount of skill affordances but are more contextually relevant to the game setting (Farrow et al., 2008).

During match play higher skilled players are able to perform effectively in unpredictable environments with very little preparation time (Ericsson, 2008; Williams & Ford, 2008). In tennis, skilled players are able to anticipate an opponent's tennis stroke faster than non-skilled players by applying more effective visual search behaviours (Williams, Ward, Knowles, & Smeeton, 2002). The skilled players also use prior knowledge and experience to direct their gaze to the central body areas (i.e., head-shoulder, trunk-hip) whereas the less skilled players focused more on the deterministic cues from the racket and ball regions (Williams et al., 2002). This information suggests coaches should allocate more time to the development of learning ecosystems. These ecosystems may involve players being exposed to tasks where players learn to detect information from affordances (possibilities for actions) in the environment using a variety of modalities such as haptic, visual and auditory sensory systems (Woods, McKeown, Rothwell, Araujo, Robertson, & Davids, 2020). Training for superior performances requires a careful implementation of deliberate practice (training focused on improving a particular task) which is individualised to the skill level of the players to ensure skill adaptation is transferred into representative performance (Ericsson, 2008). When implementing a deliberate practice environment, it needs to provide specific feedback to the athlete, provide an environment where problem-solving situations occur and time for the athlete to evaluate and refine their responses (Ericsson, 2008). Furthermore, game intelligence should also be taught through teaching anticipation and decision making as this style of coaching has been shown to lead to more skilled performances during match play (Ward et al., 2007). In order for training to transfer across into match play, training should be random with task difficulty high to simulate the match play environment. Although this may lead to a decrease in performance during training it will lead to a greater retention and transfer of skill to match play due to higher levels of cognitive effort being required (Rendell, Masters, Farrow, & Morris, 2011). It is important to note; however, a higher level of cognitive effort will only occur if the task being performed is deemed demanding (Rendell et al., 2011; Roca & Williams, 2016). The ability to not only identify the most appropriate tasks to implement but also if there are any optimal times to apply these interventions are areas requiring further investigation (Farrow, Reid, Buszard, & Kovalchik, 2017). Such research would advance current understandings of how to effectively design representative assessments and would assist in the development of a more holistic approach to track potential improvements in performance (Farrow et al., 2017).

2.7 Decision making in team sport

When athletes move, they do so with purpose. They carefully consider the information available in their environment, establishing their options and likely outcomes, before progressing (Araujo, Davids, & Hristovski, 2006). Elite team sport players are therefore expert decision makers with the ability to read the play and make timely and accurate decisions (Berry, Abernethy, & Cote, 2008). Furthermore, these attributes can take up to 13 years / 4000 hours of invasion-type activity and sport specific practice to obtain (Baker & Cote, 2003; Berry et al., 2008). In knowing this, sport practitioners have used decision making assessments to identify talent.

In an attempt to assess decision making ability in Australian football players, video-based decision making tasks have been examined (Lorains, Ball, & MacMahon, 2013; Woods, Raynor, Bruce, & McDonald, 2016). When investigating 85 male Australian football players, across three skill levels (elite, sub-elite and novice), it was found elite players have superior decision making accuracy compared to sub-elite and novice players (Lorains et al., 2013). Furthermore, it was suggested elite players use superior processing efficiency to perform more accurately when the speed of the video is increased from .75 speed to 2.0 speed. Similar results were also found when investigating the decision making ability of U18 Australian football players. Results indicated a video-based decision making task could correctly classify 92% of talent-identified players and 72% of the non-identified players, with the talent-identified players making more accurate game-based decisions compared to non-talent-identified players (Woods et al., 2016). More recently, 360 degree virtual reality footage has been used as an alternative off-field decision making assessment tool to match broadcast; however, more research is needed to clarify its application to Australian football players (Kittel, Larkin, Elsworthy, Lindsay, & Spittle, 2020; Kittel, Larkin, Elsworthy, & Spittle, 2019).

When trying to decipher how a player makes a decision it is crucial to examine the environmental and task constraints present, as these two components have an integral effect on the decision making process. A model used by practitioners to enhance decision making ability is the constraints-led approach. This approach is an ecological model, centred on the relationships that emerge from interactions of players and their performance environment (Renshaw, Araujo, Button, Chow, Davids, & Moy, 2016). It requires the practitioner to identify and modify interacting constraints to facilitate the emergence of perception-action couplings (Renshaw et al., 2016). Decisions, therefore, are made and improved through a player's knowledge of a performance environment which is gained from acting and perceiving (Renshaw, Chow, Davids, & Hammond, 2010). To replicate match play decision making, it is critical the same constraints are present otherwise movement patterns may alter and the decision making process will adjust in order to adapt to the different stimulus (Araujo et al., 2006). To enhance decision making ability players use specific stimuli from the environment to inform their movement decision. In cricket, less skilled players spent more time fixating on distal cues, such as the ball hand area, whilst skilled players fixated on more proximal predictive cues such as the bowling arm, trunk-hips and predicted ball-release area (McRobert, Ward, Eccles, & Williams, 2011). Interestingly, both groups improved when more contextual information was available. In addition, players may also use cues such as postural movements of opponents and task specific structures or patterns to make accurate decisions (Roca & Williams, 2016). This research suggests how practice needs to be representative of the actual task and the context constraints in order to elicit enhanced player decision making (McRobert et al., 2011).

Search strategy has been suggested to differentiate between skilled and lesser skilled players. Roca, Ford, McRobert, and Williams (2011) found skilled soccer players were able to search the environment more effectively and efficiently than lesser skilled players. Although they search the entire situation they are more focused on informative locations assisting them in making more accurate decisions in a timelier manner (Roca et al., 2011). The ability to successfully achieve this in a quick and unconscious manner is trainable; however, it takes time to build (Roca et al., 2011). An interesting observation was made in the Berry and Abernethy (2009) paper outlining how elite Australian football players felt much of the current training environment is not effective enough at developing perceptual and decision-making skill to a level where it meets the demands of match play. It is important the training environment is representative of the demands of the game as lesser-skilled players do not attempt particular maneuvers when they lack the knowledge or ability, in a certain context, to proficiently perform the skill (French & Thomas, 1987).

To enhance player decision making, researchers have suggested several different training methods. For example, to improve a player's decision making and pattern recognition abilities, participation in pre-expertise activities (such as an U14 Australian football player competing in basketball) may be advantageous to their progression and provide an alternative method for obtaining the required 'practice' hours (Baker & Cote, 2003; Berry & Abernethy, 2009; Berry et al., 2008; Bruce, Farrow, Raynor, & Mann, 2012). Lorains et al. (2013) investigated 13 Australian football players and discovered the more games the players participated in, the more accurate their decisions became, indicating with more match specific practice decision making can be improved. Similar results were found in another study investigating 15 17-year old and 14 11-year old male ranked tennis players (Farrow & Reid, 2012). The authors investigated situational probability in regards to anticipatory skill between the two age groups and found the older athletes were able to pick up on the service pattern much sooner than their younger counterparts (Farrow & Reid, 2012). It was suggested the reason for this was because the younger athletes were not trained to pick up on such anticipatory factors and it was not until more games were played and more attention to this area was allocated before their anticipatory skills started to improve (Farrow & Reid, 2012). In an attempt to improve decision making qualities in 16 elite female soccer players, it was found players who used match play video-based perceptual training for four weeks improved their game awareness and decision making ability (Gabbett, Carius, & Mulvey, 2008). It is therefore critical recruiters and sport coaches understand identification of talented athletes will be limited in value unless information regarding the proficiency of skills of the game are considered with the ability to read the game and anticipate an opponent's intention (Reilly, Williams, Nevill, & Franks, 2000). Accordingly, the current skill assessments utilised within the Australian Football League combine should be reviewed with more match specific skill assessments implemented (e.g., requiring players to make decisions and perform skills under representative conditions).

2.8 Talent identification in Australian football

In an attempt to more accurately identify and assess individual talent the Australian Football League introduced a draft combine. This combine occurs annually with potential draftees invited to complete a testing battery of standardised technical (e.g., handball test), physical (e.g., 20-meter sprint test), psychological (e.g., personality test) and medical tests (e.g., eye test) conducted over a four-day period. These measures are then combined with talent recruiter subjective opinions to help identify playing status (i.e., elite or sub-elite) (Woods, Raynor, Bruce, McDonald, & Collier, 2015b) and select players (Robertson et al., 2015b). When the relationship between the coach and recruiter is a conflict-based relationship these assessments become critical as they provide key information upon which decisions are rationalised (Toohey, MacMahon, Weissensteiner, Thomson, Auld, Beaton, Burke, & Woolcock, 2018). Interestingly, the authors noted when a close relationship exists between the recruiter and head coach a more intuitive process occurs to select the desired players (Toohey et al., 2018). The analysis of skill effectiveness has also been successful in identifying first round draft picks in comparison to second and fourth round picks. First round draft picks had more kicks, effective disposals, contested possessions and contested marks than athletes selected later in the draft selection (Woods, Veale, Collier, & Robertson, 2016d). Furthermore, drafted players were able to deliver the ball more times within the attacking 50-meter (50m) zone than non-drafted players (Woods, Joyce, & Robertson, 2015a).

Although the technical assessments used can potentially predict talent it must be considered that these assessments (i.e., the Australian Football League kicking efficiency test) are predominantly performed in a closed setting, separating the skill from the demands of match performance. Consequently, these assessments may lack the identification of key components such as decision making, game tempo adjustment and tactical awareness (Burgess & Naughton, 2010). Furthermore, there is an inadequate number of assessment opportunities for participants, there is a lack of skill pressure being applied to the task and subjective opinion is used to assess match performance (Burgess et al., 2012b). Due to the scarcity of representative validity within these assessments it is plausible to suggest the results obtained may not accurately identify all talented players and players may produce results different from match play. As such, talent identification models need to provide opportunities for athletes to develop these underlining skills and have these skills monitored throughout their involvement in the programme as well as adjusting training loads accordingly (Abbott, Button, Pepping, & Collins, 2005; Abbott & Collins, 2004; Burgess & Naughton, 2010).

One of the major barriers to talent identification and development is not in identifying current talent but rather in identifying what factors will restrict the development of talent over time (Abbott & Collins, 2004) as players have not always continued with their development as age increases (Gullich, 2014). Ideally, talent identification and development programmes would be interrelated as effective identification may be aided by effective development and vice-versa. For example, identifying a player’s ability for future success following an intervention programme rather than assessing their future potential off their current playing abilities, which can be manipulated by maturation (Meylan, Cronin, Oliver, & Hughes, 2010). Talent identification assessments should be dynamic in nature and consider the effect of physical and psychological maturity, relative age effect, objective measures of game sense and technical proficiency (Burgess & Naughton, 2010). They should endeavor to develop talent rather than exclude. This can be achieved through intervention programmes having less focus on performance outcomes and more emphasis on structured practice and performance standards for talent identified players, irrespective of their chronological age (Davids, Lees, & Burwitz, 2000). In reflection of a talent identification study conducted on 15 19-year-old female soccer players, it was suggested an objective assessment measuring game sense (tactical and technical awareness) is needed as many players are strong athletically but lacked general game sense (Hoare & Warr, 2000). The authors continued to suggest a 2-3-month trial period is needed to not underestimate late developers. These recommendations were further supported in another soccer study looking at 105 youth soccer players (Kannekens, Elferink-Gemser, & Visscher, 2011). In this study it was determined positioning and decision making were the tactical skills best predicting adult performance.

When contemplating talent identification in Australian football, it is apparent more sport specific research is required to obtain clarity on the interconnecting components. Reviews have highlighted the high level of variability in the elements separating higher and lesser skilled players (Robinson, Baker, Wattie, & Schorer, 2018). A possible suggestion to achieving greater continuity is to have studies based on sound theoretical principles and valid research designs (Bergkamp, Niessen, den Hartigh, Frencken, & Meijer, 2018). New assessments should consider the interacting constraints, movement behaviours, contain adequate environmental variables and ensure the functional coupling between perception and action processes (Pinder et al., 2011). Additionally, they should challenge athletes to make accurate and timely decisions whilst executing the skill under some level of fatigue (Dawson et al., 2004; González-Víllora, Serra-Olivares, Pastor-Vicedo, & Teoldo da Costa, 2015). It is therefore evident a significant gap exists within the Australian Football League talent assessment procedures.

2.9 Ecological dynamics for performance assessment

Ecological dynamics is a framework researchers use to understand and explain sport performance (Seifert, Araujo, Komar, & Davids, 2017). This framework is based on human behaviour and motor learning understandings to underpin the learning design in the performance context (Davids, Renshaw, Pinder, Araujo, & Vilar, 2012; Seifert et al., 2017). There are three main components of ecological dynamics. The first is viewing players and teams as a complex adaptive system, the second involves cognition and behaviour being considered together and the third component relates to how behaviours are organised based upon the information available (Seifert et al., 2017). In comparison to other methodologies (e.g., perceptual-cognitive training), ecological dynamics requires all parts of the system (brain, body and environment) to be dynamically integrated (Renshaw, Davids, Araujo, Lucas, Roberts, Newcombe, & Franks, 2018). Alternative methodologies assume perceptual and cognitive systems and brain processes can be trained in isolation from the informational constraints of competitive performance environments (Renshaw et al., 2018). Although training these systems and processes in isolation can be an efficient use of time and money, current research suggests there is little evidence to support their effectiveness (Harris, Wilson, & Vine, 2018). Accordingly, sport scientists have suggested the use of the ecological dynamics framework to improve the analysis of data collected and to gain greater insights into competitive performance behaviours so training can be more meaningful to the performance environment (Browne, Sweeting, Davids, & Robertson, 2019; Travassos, Davids, Araujo, & Esteves, 2013).

Ecological dynamics is an important consideration in the assessment of performance and the development of practice sessions (e.g., small-sided games) as player skill acquisition and tactical behaviours are constrained by player task constraints (Silva, Garganta, Santos, & Teoldo, 2014). During competition players are constantly changing their behaviours based upon the constraints imposed by other players and the environment (Araujo et al., 2006). For example, when executing a kick in Australian football, players need to consider the movement and speed of their teammates, the movement and speed of the opposition, who they will kick the ball to, the type of kick to be executed, the amount of force to be applied to the ball and the amount of time they have to execute the kick. The ecological dynamics framework is therefore an important consideration when developing performance assessments and practice sessions to ensuring players are afforded enough information to achieve the goal of the task (Araujo et al., 2006).

When designing performance assessments, the opportunity players are afforded to perform actions should be based from a specific performance context (Araujo et al., 2006; Woods, McKeown, Shuttleworth, Davids, & Robertson, 2019). Factors to be considered in the performance context should include the interactions between players and teams, notational analysis of game performance and time motion (Travassos et al., 2013). When attempting to assess player performance the assessment should ensure the same intentions, information and behaviours are available and performed (Davids et al., 2012). Additionally, these assessments should create a context where the decision making behaviour is largely anticipatory based on the availability of information from the player’s actions and their environment (Araujo et al., 2006). These performance contexts can then be used to assess a player’s ability to recognise affordances for action and execute their skill (Davids et al., 2012).

Current Australian football methods of technical match play assessment are largely focused on recording frequency of actions and patterns of player’s movements (Travassos et al., 2013). These approaches are too centered around discrete actions, considered in isolation from the game context and do not consider the interpersonal interactions between players and teams (Travassos et al., 2013). Match play constraint interactions are an important consideration as they can influence technical skill proficiency. For example, an Australian football players kicking proficiency average may be 54%; however, when the player kicks the ball in under two seconds and over 40m the proficiency may decline to 47% (Browne et al., 2019). As such, when constraints are viewed from a more integrated manner greater insights into player behaviour performance can be found (e.g., kicking performance of players). The use of the ecological dynamics framework, to understand these interacting constraints, may also assist in the identification of key events which can be replicated in training and performance assessments (Couceiro, Dias, Araujo, & Davids, 2016). Therefore, to achieve a greater understanding of how a player may perform under match like conditions a more representative performance assessment, where more constraints can be applied to the one task (e.g., time, distance and pressure), may be more appropriate.

2.10 Representative design for performance assessment

The main aim of a performance evaluation assessment is to demonstrate how the assessment relates to the competitive environment (Davids et al., 2013a). To increase the likelihood of the assessment session to be representative of the competitive environment, researchers have suggested the use of a 'representative learning design' as a theoretical framework. This framework suggests testing and practice sessions should be reflective of match play conditions including the technical and tactical execution of skills (Corbett, Bartlett, O'Connor, Back, Torres-Ronda, & Robertson, 2018) and the environmental conditions, actions and perceptual stimuli present during the competitive environment (Araujo et al., 2006; Araujo, Davids, & Passos, 2007; Davids et al., 2013a; Davids, Renshaw, & Glazier, 2005; Pinder et al., 2011; Vilar et al., 2012).

Team sport athletes are well rehearsed with intended movement patterns. These movements; however, cannot be entirely planned and acted upon due to the unpredictable environmental elements and constraints (i.e., opposition movement) (Chow, Davids, Hristovski, Araujo, & Passos, 2011). Therefore, movements and decisions are largely anticipatory in nature based upon key information from their actions and the external environment (Araujo et al., 2006). When assessing the anticipatory visual cues for 25 tennis players (13 skilled and 12 novice) it was found skilled players were more accurate with live and video displays (but not with point-light displays) than novices (Shim, Carlton, Chow, & Chae, 2005). This research highlights the importance of visual perception (i.e., opposition movement) in the assessment task and how this can effect skill execution.

A player's ability to effectively move is dependent upon the environment, perceptual stimulus, goal of the task and/or constraints present (Pinder et al., 2009). If alternative movement patterns are implemented, dissimilar outcomes may occur leading to an ineffective assessment of the skill. Static assessments lack functionality and do not successfully represent the constraints of the performance environment (Pinder et al., 2009). In a study analyzing the practice and free-throw performance of male Division 1 basketballers, it was shown practice free-throw percentage (74.5%) was higher than game percentage (69.2%) (Kozar, Vaughn, Lord, & Whitfield, 1995). Free-throw shooting is typically practiced in a block modality, whereas in a game a free-throw is typically taken twice in succession. However, when only the first two practice free-throws were accounted for the percentage decreased to 69.8% which is comparable to match play performance (Kozar et al., 1995). In another study of seven team coaches in the Federation of International Hockey 2011 Champions Trophy tournament (field hockey) it was identified six of the coaches used more match representative designs when constructing their field goal shooting practice (Slade, 2015). The coaches found by moving away from the closed skill drilling sessions, into a more match representative task design, players were able to improve their tactical understanding, decision making and likely player patterns when attempting field goal shooting (Slade, 2015).

The development and implementation of a skill assessment should be carefully considered. Renshaw et al. (2007) investigated the differences in cricket batting actions when facing a human bowler in comparison to a bowling machine. Four 21-year old premier league cricket participants demonstrated how changing from a human bowler to a bowling machine instigated a re-organization of the coordination and timing of the forward defensive shot (Renshaw et al., 2007). Similar results were also found in a follow up cricket study looking at 12 15-year-olds. In this study, the authors identified a change in movement pattern occurred when batters faced a real bowler compared to a bowling machine (Pinder et al., 2009). When facing a bowling machine participants modified their peak height of backswing, drive initiation of the downward swing, front foot initiation and front foot placement (Pinder et al., 2009). Careful consideration therefore needs to be applied to designing assessments for athletes to complete. Assessments should be dynamic and consider the perceptual information being presented to ensure the movement patterns performed are representative of those experienced during match play (Pinder et al., 2011). It is suggested tennis coaches who use less prescriptive coaching and more variable and random practices, with an emphasis placed upon intrinsic feedback from an earlier age, appear to help their athletes become more robust under stressful situations (Reid, Crespo, Lay, & Berry, 2007). It could be argued these more random situations more closely resemble the dynamic nature of sport allowing the athlete to practice under match like conditions thereby facilitating a more effective transfer of skill into match play (with the same concept being applicable to skill assessment sessions) (Farrow, 2010).

Australian football is played in an open environment. Within this setting expert players are constantly adapting to their changing environment to perform consistently (Araujo & Davids, 2011). Current Australian football skill assessments are conducted in a static environment. These environments are not effective in assessing skill proficiency as they simulate behaviours different to that performed in match play (Pinder et al., 2011). Furthermore, these settings eliminate the ability of the athlete to demonstrate their competence in anticipation, problem solving and attention, which consequently affects their ability to execute their skill proficiently (Falk et al., 2004; Lidor et al., 2009). Skill assessments should create opportunities for players to trial moving in a variety of different patterns. This would demonstrate the player’s ability to overcome constraints during match play in order to achieve the intended performance outcome (Davids et al., 2013a). Active opponents are integral to this concept as they assist in the environment being more dynamic and challenging for the players to perform within (Vilar et al., 2012). A significant gap therefore exists between current static assessment procedures and the dynamic nature of match play. A new representative skill assessment, where behaviour emulates competition (e.g., small-sided games), may assist in abridging this void.

2.11 Small-sided game play in team sport

Skill proficiency is a critical component of game performance to measure. To assess how proficient a player can execute their skill, researchers have recommended skill proficiency to be combined with tactical awareness and perceptual-cognitive skills when being assessed (Oslin, Mitchell, & Griffin, 1998). Perceptual-cognitive skills for sport, such as decision making, anticipation and pattern recognition are important skill attributes for players to possess and may not only be conducive for developing appropriate game-reading skills but also enhancing the talent identification process (Hoare & Warr, 2000; Ward & Williams, 2003). It has been established expert players have better perceptive and cognitive skills in comparison to novice players (Roca et al., 2011). Their anticipation and decision making processes are faster and more accurate due to their ability to identify opposition team pattern structures and opposition player position and movements more rapidly (Poplu, Ripoll, Mavromatis, & Baratgin, 2008). Other than video-based decision making testing (which lacks physical application, is resource and time intensive and has no set standardised assessment criteria) there are currently no known perceptual-cognitive skill assessments discussed in the literature or practically used within Australian football to rate player performance and potentially identify talented athletes.

Invasion type activities have been shown to assist in the development of perceptual and decision making expertise in team sports (Berry et al., 2008). As such, sport coaches of rugby (Gabbett, 2006), soccer (Bennett, Novak, Pluss, Stevens, Coutts, & Fransen, 2018; Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011) and Australian football (Davies, Young, Farrow, & Bahnert, 2013) have implemented small-sided games as part of their training regimen. This style of training involves modifying or manipulating task constraints (e.g., playing area) to develop skills (e.g., decision making), fitness (Cronin, Harrison, Lloyd, & Spittle, 2017) and talent identification (Bennett et al., 2018) from an integrated approach. Small-sided game play has been shown to more closely simulate competition than general skill drills as they require the athlete to move and perform their skills in a manner replicating match play (Davids et al., 2013a; Loader, Montgomery, Williams, Lorenzen, & Kemp, 2012; Young & Rogers, 2014).

Match play is unstable, dynamic and unpredictable. There is a strong need for coaches to develop drills where the components of match play are more interconnected whilst replicating the most intense performance demands of competition without a decrease in running performance (Johnston, Gabbett, & Jenkins, 2015). Traditional training methods have a tendency to isolate the key components of technical, tactical, physiological and psychological competencies, thereby making practice more predictable and achievable (Davids et al., 2013a). Although this traditional process appears successful at training the transfer effect to match play is poor (Slade, 2015). Small-sided games demand a greater cognitive effort (Lee, Swinnen, & Serrien, 1994) which is associated with greater decision making capabilities, skill execution (Turner & Martinek, 1999) and tactical awareness (Chatzopoulos, Drakou, Kotzamanidou, & Tsorbatzoudis, 2006). In addition, small-sided games challenge the athlete to make timely decisions whilst proficiently disposing of the ball in a simulated match environment (Davids et al., 2013a; Young & Rogers, 2014). Gabbett (2009) investigated the application of using small-sided games for improving skill and physical fitness in team sport athletes. The author concluded small-sided games were effective in developing technical expertise and suggested small-sided games may also be beneficial for developing perceptual expertise. In addition, small-sided games have the ability to challenge a player's agility, speed, aerobic conditioning and power (Bujalance-Moreno, Latorre-Roman, & Garcia-Pinillos, 2018). Small-sided games can be manipulated in a variety of ways to achieve the desired outcome. For example, coaches will vary environmental conditions such as the playing area, practice objectives and rules of play to ensure players are performing enough skill executions (Davids et al., 2013a). Timmerman, Farrow, and Savelsbergh (2017) investigated the influence of manipulating player numbers and area per player on match performance in 10-14-year old hockey players. The authors found by decreasing player numbers there were more opportunities for players to be involved with skill executions (e.g., passing) and be involved in more "high pressure" moments (i.e., more physical or time pressure on the player when performing their skill).

Assessments of playing performance can be accurately assessed within match play situations. When a representative environment allows an athlete to display their tactical understanding and their ability to make timely and accurate decisions, combined with their ability to proficiently execute game related skills, players can be accurately identified as either higher skilled or lesser skilled (Piggott, Muller, Chivers, Cripps, & Hoyne, 2018). Bennett et al. (2018) investigated the use of small-sided games in identifying youth soccer player skill proficiency. They found higher skilled players had more total skill involvements and their skill proficiency was higher than lesser skilled players. In another soccer study investigating if small-sided games could be used to identify talented pre-pubertal soccer players, it was noted higher skilled players were more successful during the small-sided games, covered more distance, played at higher speeds than the lesser skilled players and were the same players rated highly by coaches (Fenner, Iga, & Unnithan, 2016). Although these were soccer studies, Johnston et al. (2016) found similar results in Australian football match play with the higher skilled players being involved more with the football per minute than the lesser skilled players.

Considering the extensive research conducted on small-sided games only four studies have been conducted within Australian football. Two of these studies (Davies et al., 2013; Young & Rogers, 2014) analysed the effect small-sided game play had on agility demands and development. Fleay, Joyce, Banyard, and Woods (2018) investigated the effect of field dimension on technical and physical performance; however, this only involved three 60-second periods over three blocked weeks (i.e., week 1 "small" small-sided game, week 2 "large small-sided game" and week 3 "medium"). Their research indicated "small" and "medium" sized small-sided games generated more turnovers and ineffective tackles with "large" small-sided games generating greater absolute distance, relative distance and maximum velocity. Interestingly, all three articles only used handballing in their study excluding the critical skill of kicking. In the fourth study, Piggott et al. (2018) investigated if small-sided games can discriminate perceptual-cognitive-motor capability and predict disposal efficiency in match performance of skilled Australian football players. The participants played three small-sided games for three minutes with each disposal from only the attacking players scored for decision making and motor skill execution. Both scores were combined to make a total score. The authors found the higher skilled players were able to make better decisions and obtain a higher total score than the lesser skilled players. Furthermore, only the higher skilled players total scores were successful in predicting disposal proficiency in match performance (Piggott et al., 2018).

Other research in Australian football has investigated the developmental histories of expert level Australian football players and reported the importance of game exposure in the development process (Berry et al., 2008). It is important for players to develop their ability to impact match play as player and team impact scores have been shown to not only have a significant correlation with winning but also as a valid method of assessing game performance (Heasman, Dawson, Berry, & Stewart, 2008). Interestingly, the main indicator correlating with the derived team impact score was effective long kicks (Heasman et al., 2008) with previous research finding similar results (Stewart, Mitchell, & Stavros, 2007). It is important therefore, this type of kick is accurately assessed within any future Australian football kicking assessment. A further finding in this study was impact score comparisons should only be made with positional zones (Heasman et al., 2008). Although an important factor to consider, it would also be worthwhile to assess these scores within a match simulated small-sided game environment where all players will be playing in the same zone. A fair and comparable assessment between athletes can then be made based upon the same constraints. By introducing constraints (e.g., two consecutive touches per possession) the small-sided game can more accurately replicate match play (Almeida, Ferreira, & Volossovitch, 2012). Furthermore, the constraints applied can encourage players to explore solutions to problems (Cronin et al., 2017) highlighting a players strengths and areas of improvement.

The size of the small-sided game perimeter is varied in the literature. In soccer, areas such as 12x20m and 46x48m have been used (Coutts, Rampinini, Marcora, Castagna, & Impellizzeri, 2009) whilst in Australian football playing areas such as 30x20m, 45x30m, 23.2x20m, 30x40m and 40x50m have all been used to compare the physical and technical demands of small-sided games in elite Australian football (Davies et al., 2013; Fleay et al., 2018). Davies et al. (2013) demonstrated how a reduction in players resulted in increased amounts of variability seen during training combined with small increases in total agility maneuvers. In another Australian football study Fleay et al. (2018) found "large" small-sided games generated fewer technical errors and tackles, more bounces and a greater physical activity profile in comparison to "small" and "medium" dimensions. An earlier futsal study found similar results (Duarte, Batalha, Folgado, & Sampaio, 2009). The authors noted when there was a decrease in the number of players from 4v4 to 2v2, with a pitch size of 20x20m, player intensity increased and more frequent tactical actions occurred. It was hypothesised this was due to more surface area being available per player (Duarte et al., 2009). In contrast to these two studies, a rugby league study analyzing the effect of field size on the physiological and skill demands of players involved in small-sided games noted no significant skill involvement differences when using a 10mx40m playing area versus a 40mx70m playing areas (Gabbett, Abernethy, & Jenkins, 2012a). Increases in meters travelled and distances covered at moderate, high and very high intensities were; however, noted in games played on the larger field size, with senior elite players recording higher amounts than junior elite players. The authors suggest the difference in small-sided game field size in rugby league may have a greater impact on physical output than volume or quality of skill executions (Gabbett et al., 2012a).

The duration of each bout is an important consideration when discussing small-sided games. Research has shown in a 3v3 soccer contest, bout duration did not have an effect on the number of technical actions performed per minute or proficiency (Fanchini, Azzalin, Castagna, Schena, McCall, & Impellizzeri, 2011). However, as duration increased from two to six minutes there was a decrease in exercise intensity (Fanchini et al., 2011). When trying to emulate match play intensity in soccer, 4-minute bouts are suggested as the best choice. In an elite 4v4 soccer game, going for four minutes in duration (with three minutes passive recovery), it was shown small-sided game intensity was comparable to generic aerobic interval training (Impellizzeri, Marcora, Castagna, Reilly, Sassi, Iaia, & Rampinini, 2006). When compared to match play, small-sided games have been shown to be greater in total distance covered per minute, total number of duels and lost ball possessions (Dellal, Owen, Wong, Krustrup, van Exsel, & Mallo, 2012). Furthermore, fewer ball touches (i.e., 1 or 2) increased the difficulty for players to perform technical actions. The authors continued to suggest if one or more of the physical, tactical, technical components can be developed simultaneously rather than in isolation, coaches would have the opportunity to maximize their contact time with players and increase efficiency of their training sessions (Dellal et al., 2012).

Small-sided games do; however, contain limitations. When compared to speed, agility and quickness training, small-sided game training may produce inferior physical conditioning (Polman, Bloomfield, & Edwards, 2009). For example, speed, agility and quickness training improved 5m and 15m times, concentric strength and reactive strength in comparison to small-sided games (Polman et al., 2009). Small-sided games have nonetheless been shown to improve agility performance by enhancing the speed of decision making rather than movement speed in a 4v4 Australian football situation (without tackling) on a 20x23m field and a 2v2 situation in a 15m x 15m field (Young & Rogers, 2014). More research; however, is required to provide greater clarity on the use of small-sided games for the long term development of technical skill, tactical proficiency and physical capacity of team sport players (Hill-Haas et al., 2011).

Overall, these studies indicate by changing the pitch area, the amount of players participating and rules by which the players are abiding by, the intensity of the game can be modified. For example, a smaller number of players (lower player density) can produce higher external and internal loads (Randers, Orntoft, Hagman, Nielsen, & Krustrup, 2018). Furthermore, when fewer player numbers are used with a large pitch size players work at a higher exercise intensity (Hill-Haas et al., 2011). Age and skill specific standards have also been suggested in an attempt to ensure player adaptation and improvement are occurring from training (Gabbett et al., 2012a). Considering small-sided games are the closest representation of match play conditions from a physiological, tactical and technical perspective and player performance should be analysed from within a simulated, competitive environment it appears small-sided game testing is the best solution (other than actual match play) for assessing competition skill performance. If proven to be valid and reliable, this assessment modality could then be used to identify talent and develop age appropriate performance benchmarks (Davids et al., 2013a; Piggott et al., 2018).

2.12 Conclusion

As the focus on the elite Australian Football League competition becomes greater so too does the demand for success. Clubs are more heavily scrutinised for their draft selections and as such are taking more interest in the younger levels of competition in an attempt to identify and monitor talent. Although the skill of kicking is critical to team success, in Australian football it has been poorly tested and measured (if at all). The addition of two new valid Australian football kicking assessments may assist in filling this gap. These new assessments would reference match play kicking actions in an attempt to be more representative of the dynamic interaction of the environment, task and individual (Newell, 1986). They could then be used to assist in talent identification and the tracking of player development progress along the Australian Football League talent pathway.

CHAPTER THREE – Study I

‘Australian Football Skill-based Assessments: A proposed model for future research’

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I declare that the publication above meets the requirements to be included in the thesis as outlined in the HDR Policy and related Procedures – policy.vu.edu.au.

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3. CO-AUTHOR(S) DECLARATION

In the case of the above publication, the following authors contributed to the work as follows:

The undersigned certify that:

1. They meet criteria for authorship in that they have participated in the conception, execution or interpretation of at least that part of the publication in their field of expertise;

2. They take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;

3. There are no other authors of the publication according to these criteria;

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'Australian Football Skill-based Assessments: A proposed model for future research'

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3.1 Abstract

Identifying sporting talent remains a difficult task due to the complex nature of sport. Technical skill assessments are used throughout the talent pathway to monitor athletes in an attempt to more effectively predict future performance. These assessments; however, largely focus on the isolated execution of key skills devoid of any game context. When assessments are representative of match-play and applied in a setting where all four components of competition (i.e., technical, tactical, physiological and psychological) are assessed within an integrated approach, prediction of talent is more likely to be successful. This article explores the current talent identification technical skill assessments, with a particular focus on Australian Football, and proposes a 5-level Performance Assessment Model for athlete assessment. The model separates technical game skill on a continuum from Level-1 (i.e., laboratory analysis) to Level-5 (i.e., match-play). These levels, using the assumptions of the expert performance model and representative learning design theory, incorporate a step-wise progression of performance demands to more closely represent match-play conditions. The proposed model will provide researchers and practitioners with a structured framework to consider when assessing, or developing, new assessments of technical game-based skill.

3.2 Introduction

Talent is a multi-dimensional concept and requires the effective and efficient organization of an individual's technical, tactical, physiological and psychological competencies to be applied in a method that meets the requirements of both the environment and the sporting situation (Abbott et al., 2005; Vaeyens, Lenoir, Williams, & Philippaerts, 2008). Talent identification programmes endeavour to discover this 'talent' in individuals with the greatest potential to respond to a training intervention and reach the highest level in their chosen sport (Abbott & Collins, 2004; Hoare & Warr, 2000). The ability to identify talented players in team sports is not only a financially rewarding business but a key component of future winning teams and long term success (Gee et al., 2010; Larkin & Reeves, 2018).

Identifying sporting talent remains a complex task due to the evolving nature of sport and the limited number of athletes selected to play at the elite level (Honer & Votteler, 2016; Simonton, 1999). Australian Football (AF) talent scouts consider a variety of subjective measures (such as the technical, tactical, physiological and psychological components) to inform their decisions. These opinions are then combined with objective isolated skill data (e.g., the AF kicking efficiency test) in an attempt to more effectively predict future performance. Ericsson and Smith (1991) created the expert performance approach (EPA) which entailed three stages. The first involves observation of performance in situ to identify key components that can be reproduced and assessed in the laboratory. The second stage examines these performances within field-based assessments (i.e., AF kicking efficiency test) in an attempt to understand the factors that contribute to expert performance. The final stage involves efforts to detail the adaptive learning and explicit acquisition processes relevant to the development of expertise, with potential implications for practice and instruction.

The term representative learning design has more recently been discussed in the literature (Krause, Farrow, Buszard, Pinder, & Reid, 2019) and should be considered within the second and third stage of the EPA. Representative learning design (RLD) is a framework that assesses how closely information provided in a task is representative of the specific performance context (Krause et al., 2019). To increase how representative a task is there needs to be functional coupling between perception and action processes, an adequate amount of informational characteristics from within the competitive environment, and consider the interrelating constraints on movement characteristics (Pinder et al., 2011; Pinder, Headrick, & Oudejans, 2015). For an assessment to replicate competition it must have functionality (i.e., the degree to which a player can use the same informational sources present during competition) and action fidelity (i.e., the degree to which a player's movements replicate competition) (Pinder et al., 2011; Stoffregen, Bardy, Smart, & Pagulayan, 2003). Krause, Farrow, Reid, Buszard, and Pinder (2018) used the RLD framework to develop an assessment tool to assess and enhance tennis practice sessions to maximise the potential for skill development to transfer into match-play (Krause et al., 2019). The authors found when comparing practice sessions to match play of junior tennis players, practice tasks are not representative of the shot and movement characteristics typical of match play. Overall, this study highlights the importance of the first stage in the EPA model, the identification of key components, in combination with the RLD framework when designing and assessing tasks.

Talent identification programmes have generated a series of discussions regarding their value, with some authors questioning their use and predictability during athlete development (Honer & Votteler, 2016; Pankhurst, Collins, & Macnamara, 2013); where others have used these programmes with success (Hoare & Warr, 2000). Whilst these debates are warranted, talent identification programmes are well ingrained in elite sport and should aim to identify promising athletes from a multidisciplinary approach rather than a reductionist approach. Where tasks are reductionist in approach, they are performed in a controlled environment where unidimensional components (i.e., speed) are assessed in isolation from the performance context, and may not have enough representation to enhance learning in specific sports (Davids, Araujo, Vilar, Renshaw, & Pinder, 2013c).

The challenge for talent identification and development (TID) programmes is not in identifying current talent, but rather in classifying what factors will restrict the development of talent over time. Whilst there are numerous papers identifying current differences in higher and lesser skilled AF players (Veale et al., 2010b; Woods, Cripps, Hopper, & Joyce, 2017a), there are only limited attempts at identifying factors underpinning development across the AF pathway (Farrow et al., 2017; Gastin, Tangalos, Torres, & Robertson, 2017). Further, team sport talent identification programmes, focused on isolated skill development independent of the game environment, may lack the identification of key components such as decision making, game tempo adjustment and tactical awareness (Burgess & Naughton, 2010). This is supported by Hoare and Warr (2000) who suggested objective assessments that measure tactical and technical awareness are needed as many players are strong athletically but lack these crucial components.

The aim of this paper is to review current Australian Football technical skill assessments, whilst considering the expert performance model and representative learning design theory, to develop a structured framework for practitioners to consider when assessing, or developing, new assessments of technical game based skill. This article applies these foundation concepts to exploring AF skill assessment. A 5-level Performance Assessment Model (PAM) is proposed, attempting to order skill assessments along the performance continuum.

3.3 Method

The PAM model was developed from an extensive search of the AF literature using the Preferred Reporting Reviews and Meta-Analyses (PRISMA) statement as a guideline (Moher, Liberati, Tetzlaff, Altman, & Group, 2009). Studies were included in the final review if they contained the following: 1. AF kicking proficiency test; 2. AF kicking test assessment; 3. AF kicking proficiency. The search strategy commenced with electronic database searches in SPORTDiscus, PubMed and Google Scholar. Further studies were then examined from secondary sources such as the reference list of articles found from the initial search (Robertson, Burnett, & Cochrane, 2014). Search terms were limited to *Australian Football, Australian Football League, kicking, small-sided game, skill assessment and skill test.* In total, 282 relevant studies were returned with 19 studies examining the technical skill of the AF drop-punt kick. Ten studies examined the drop-punt from a biomechanical perspective, seven investigated the technical skill from either a performance perspective, for talent identification purposes, or for the classification of playing position. Only two papers investigated the reliability and validity of the current AF kicking test (see Table 1).

Table 1. Australian Football kicking test and proficiency investigation paper

Author(s)	Year	Participants	Investigation
AF kicking test investigations			
*Cripps et al.	2015	121 Sub-elite AFL Players	Inter-rater reliability and validity of AFL kicking and handball tests
*Woods et al.	2015	25 elite U18 AF players and 25 non-state AF players	The use of skill tests to predict status in junior AF
AF kicking proficiency investigations			
*Cripps et al.	2017	282 U16 AF State Academy	The biological maturity, anthropometric, physical and technical assessment of talent identified AF players
*Gastin et al.	2017	156 amateur 10-15 year-olds	Age related differences in maturity, physical fitness, match running performance and skill execution proficiency
Heasman et al.	2008	22 AFL games	Development and validation of a player impact ranking system in AF
Joseph et al.	2017	24 elite U18 AF players	The relationship between repeated kicking performance and maximal aerobic capacity
Tangalos et al.	2015	156 amateur 10-15 year-olds	The relationship between fitness, skill and player performance
*Woods et al.	2016	42 talented and 42 non-talent identified U18 AF players	The application of a multi-dimensional assessment approach to talent identification in AF
*Woods et al.	2018	211 U18 state representatives	Classification of playing position in elite junior AF using technical skill indicators

* Studies that included both kicking and handballing

3.4 Discussion

5-Level Performance Assessment Model

During match-play all four components of performance (i.e., technical, tactical, physical and psychological) are required to work in unison whilst the highest demand of intensity/pressure is being placed upon them. The 5-level PAM provides a progression of skill assessment from a performance demand perspective and how representative the assessment is to measure technical skills. At the base of the model is the notational analysis, which is the foundation stone for the PAM. Notational analysis identifies key skills and actions performed within the competitive environment. It is a technique for observing performance and recording the frequencies of these events. As such, in the PAM model, key in-game skills would be notionally analysed and assessed using the appropriate level on the PAM. Accordingly, the 5-Level PAM proposes match-play is the ultimate level of assessment and resides at the highest point of the performance continuum at Level-5 (see Figure 1).

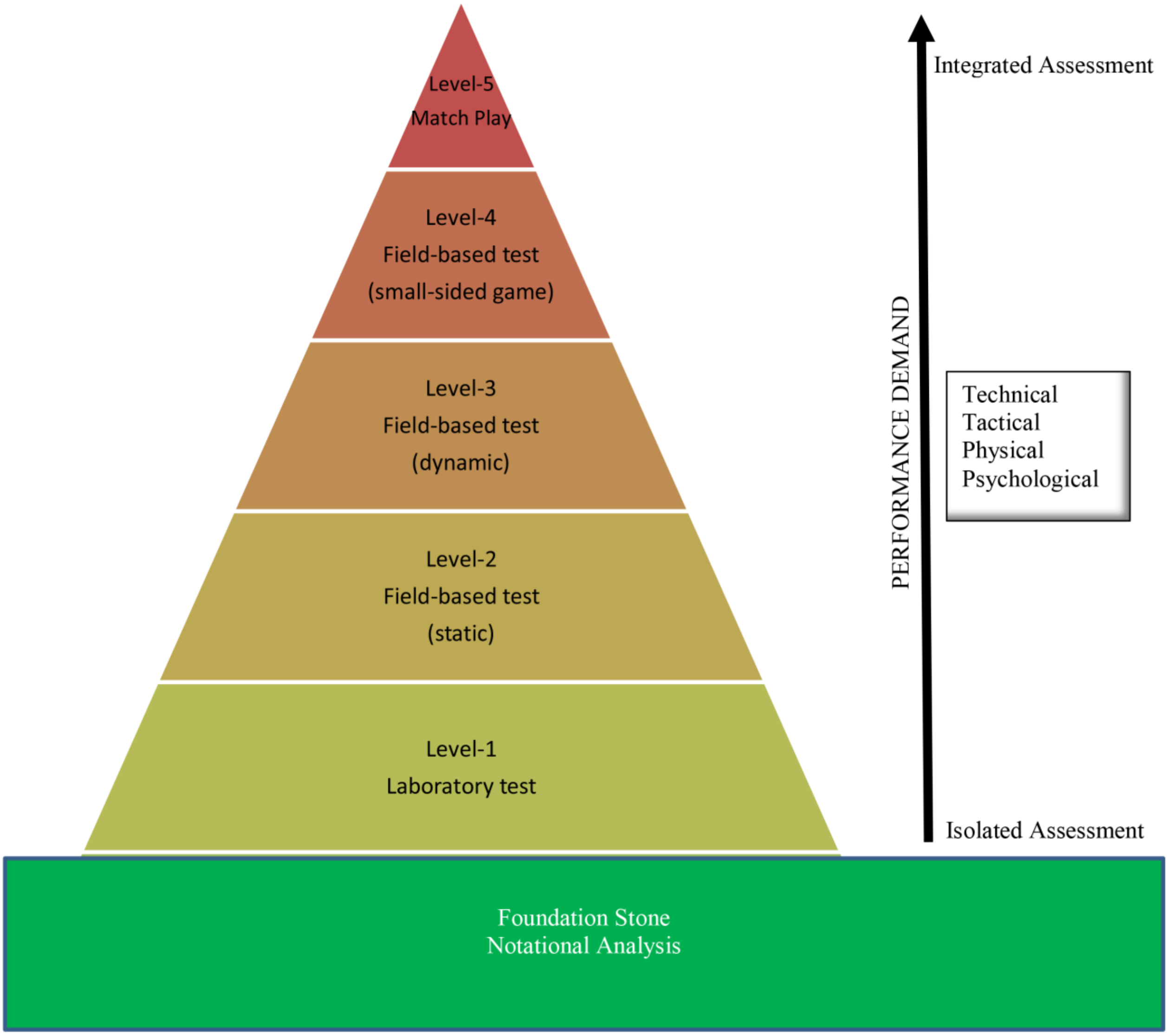

Figure 1. The 5-Level Performance Assessment Model for team-sports.

Foundation Stone: Notational Analysis

This stone is an application of the first stage of the EPA by identifying key components from match-play to be assessed. Notational analysis from actual game performance is needed to determine the key skill-based outcomes such as technical performance skills. For example, this level may identify ball possession duration, kick distance or locomotion whilst kicking the ball. Without this level of analysis, assessment selection would remain largely subjective and potentially inaccurate.

In AF, notational analysis identified two critical skills to pass and score - handballing and kicking (Kempton et al., 2015; Sullivan et al., 2014a). Although handballing is an effective method to pass the ball (Parrington et al., 2013), in elite junior AF kicking is used more frequently (Woods et al., 2018) and is the only method by which a goal can be scored. The ability to proficiently kick the ball in a game situation (i.e., pass to the intended target or score) is a critical factor, with the drop punt the most commonly used kick in AF (Ball, 2008). Robertson, Back and Bartlett (2015a) highlighted the importance of kicking in one AFL team over a 2-year period. Winning teams had more kicks and were able to use the ball more efficiently to both pass the ball and to score. This study revealed teams who had more kicks and greater goal conversion (>4.2%) than their opposition won on 49 of 54 occasions (Robertson et al., 2015a). Although kicking is a very specific skill in AF and has been associated with team success, from a talent identification perspective it has been poorly tested and measured in comparison to other AF performance variables (e.g., speed without the ball) (Woods et al., 2015c).

The distance a kick travels is another important consideration. Long kicks (i.e., > 40 meters) have been associated with a team's impact score (Heasman et al., 2008) as they create more opportunities for the kicker to score, pass and are harder to defend (Ball, 2008). However, they are generally delivered to a contest (i.e., where several players for each team compete for the ball) where retaining possession becomes more difficult (Appleby & Dawson, 2002). In comparison, Appleby and Dawson (2002) noted short kicks (i.e., < 40 meters) are commonly delivered to teammates who have moved away from their opponent and are by themselves. This reduces the amount of time the ball spends in the air, reducing the opportunity for opponents to intercept the ball and increasing a team's effectiveness at retaining possession of the ball (Appleby & Dawson, 2002).

The analysis of skill effectiveness has been used to differentiate between first round and later round draft picks. Findings have shown players drafted from U18 level to elite AF in the first and second rounds had more kicks, effective disposals, contested possessions and contested marks in the U18 National Championships than athletes selected later in the draft (Woods et al., 2016d). Furthermore, drafted players from the Championships, were able to deliver the ball more times within the attacking 50m zone than non-drafted players (Woods et al., 2015a). Unfortunately, this study did not specify whether these kicks were effective or not, but as this criterion influenced being drafted it is reasonable to assume they were effective. Finally, delivering the ball inside the 50m zone was deemed more influential to talent scouts than rebound 50's (a player removing the ball from their defensive 50m zone) as these kicks result in scoring opportunities (Woods et al., 2015a). Notational analysis; therefore, is the foundation for any research investigating key aspects of a performance environment. By using this process key performance skills which warrant further investigation can be identified.

Level-1: Laboratory Test

Laboratory based assessments are performed under well controlled environments and provide highly accurate outcomes (Henriksson, Vescovi, Fjellman-Wiklund, & Gilenstam, 2016). Using the RLD framework, this level would have low representation and therefore is positioned the furthest away from in-game performance. Traditionally, researchers have used laboratory-based tasks in an attempt to reliably capture an aspect of performance which inadvertently separates perception from action (Farrow et al., 2017). In AF, these tests have been largely used to assess, speed and anthropometrics (Pyne, Gardner, Sheehan, & Hopkins, 2005; Veale et al., 2008) and to a lesser extent, tactical capabilities (decision making abilities) (Breed, Mills, & Spittle, 2018) and technical characteristics (biomechanical assessments to analyse key components of the moving body segments to produce a skill) (Dichiera et al., 2006).

Level-1 assessments, such as maximal oxygen uptake (VO_2 max) (Lorenzen, Williams, Turk, Meehan, & Cicioni Kolsky, 2009), are an important consideration in AF. On average, AFL players are covering just under 13,000 meters per game with over 3000 meters being performed at high intensity (between 4.17 and 10.00 $m.s^{-1}$) (Aughey, 2010; Coutts et al., 2010). Additionally, this level would be appropriate for identifying particular biomechanical movement patterns, such as the effect lower limb joint angles have on kicking accuracy (Dichiera et al., 2006). Whilst these assessments do provide valuable feedback for coaches and participants (e.g., they can provide appropriate intervention strategies) they do contain certain limitations. Laboratory assessments do not ascertain how proficient a player is with their skill execution under match conditions and they may not consider a player changing their kinematic movements to compensate for any deficiencies they may have when executing a skill (Coventry et al., 2015; Royal et al., 2006).

Level-2: Field-based Test (Static)

Level-2 on the performance continuum explores skill execution through field-based testing within a static environment (i.e., AF kicking efficiency test). Although this level is more representative than laboratory tests, it largely focuses on the isolated technical element of key skills required in AF (i.e., the technical ability to kick the ball with limited presence of the physiological, tactical and psychological demands of AF). As such, this test would remain a low rating for representativeness, positioned one level higher on the continuum. Biomechanical researchers have used this level to obtain a more natural assessment of kicking actions. For example, Ball (2008) assessed the isolated technical elements of distance kicking of 28 AFL players on the ground where players trained and played. It was noted greater foot speeds and shank angular velocities, with an increase in last step length, were required to deliver the ball further (Ball, 2008). In a small study investigating the goal-kicking accuracy in two junior AF players, using an inertial measurement system, it was noted the participants had individual differences with goal kicking accuracy suggesting goal kicking assessment in junior athletes require an individual-based analysis (Blair et al., 2017).

In an attempt to more accurately identify and assess talent the Australian Football League (AFL) introduced a draft combine. This combine occurs annually with potential draftees invited to complete a testing battery of standardised technical (e.g., kicking efficiency test), physical (e.g., 2km time trial), psychological (e.g., personality test) and medical tests (e.g., eye test) conducted over a four-day period. These measures are then combined with talent scouts subjective opinions of in-game performance to help classify, identify and select players (Burgess, Naughton, & Hopkins, 2012a). While there are six physical tests, measuring speed (20m sprint), change of direction (agility test), running endurance (Yo-Yo test & 2km time trial), and power (standing vertical jump, running vertical jump), currently, there are only two technical skill tests used in the AFL Draft Combine: a goal kicking test and a kicking efficiency test.

The goal kicking test involves players having five shots at goal (i.e., two set shots, two snap shots and one on the run) within a 70 second period. The kicking efficiency test involves players taking six kicks from a designated distance (i.e., two at 20m, two at 30m and two at 40m) to a pre-determined location in a random order. Whilst there has been extensive use of the tests at the AFL Draft Combine, there has been minimal research conducted on the use of these AF technical skill assessments. Cripps and colleagues (2015) indicated the kicking efficiency test is appropriate for assessing kicking in a static environment (i.e., a setting where the skill is performed in an isolated manner, absent of opposition in a relatively predictable environment), whilst also being able to provide feedback to developing athletes regarding dominant and non-dominant disposals over a range of distances. Despite these findings, Cripps et al. (2015) concluded more research is required to determine if the test can also distinguish between higher and lower skilled players and whether kicking ability changes with age. In contrast Woods et al. (2015c) assessed 50 U18 male players (25 state representatives and 25 non state representatives) and found when kicking accuracy and ball speed were combined, playing status was able to be predicted.

Skill assessment is an important consideration and when combined with physiological competencies, the ability to predict future individual success was increased (Tangalos, Robertson, Spittle, & Gastin, 2015). The use of technical skill testing to predict performance has been effective in team and individual sports such as handball (Lidor et al., 2005), soccer (Ali et al., 2008) and rugby (Gabbett et al., 2011a). It has been suggested a player's proficiency in skill execution can potentially influence playing performance and therefore team performance to a larger extent (Gabbett & Ryan, 2009; Gabbett, Jenkins, & Abernethy, 2011b). This not only highlights the importance of skill in regard to game influence and draft selection, but also emphasizes the importance of further skill development and how it may contribute to match performance (through maintaining possession and effectively delivering the ball) and player development.

Whilst the technical and physiological tests do provide some valuable information (such as the potential to identify skill strengths and weaknesses), they are predominantly performed in a relatively closed setting, separating the skill from the demands of match performance. Research on the kicking efficiency test indicates no significant correlation between coaches' perceptions of skill and kicking test scores ($r = -0.13$, $P = 0.75$). Construct validity for the test was shown to be poor; however, the kicking test did demonstrate partial content validity and a strong inter-rater reliability score (ICC = 0.96, $P < 0.01$) (Cripps et al., 2015).

Overall, Level-2 assessments are more practical to implement (as they are easier to set up and conduct than laboratory tests), making them not only appropriate at the elite level but also at the sub-elite level. Although Level-2 is accurate at identifying specific body segment skill movements, these movement patterns are done in isolation of game performance demands. This approach has been suggested as one reason as to why talent identification (TID) programmes are not effective (Pinder, Renshaw, & Davids, 2013; Unnithan, White, Georgiou, Iga, & Drust, 2012) and why future research should move forward from this approach and include more multidimensional aspects of performance (Pearson et al., 2006). Although this approach would be more complex to develop than univariate assessment, they are more dynamic and may better capture the nuances of talent and how it evolves across development (Johnston et al., 2018). An additional level is therefore required where the skill is executed in a more representative assessment.

Level-3: Field-based test (dynamic)

Field-based dynamic tests are a further progression along the representation and stability of the environment whilst remaining structured. Where Level-2 tests are pre-planned, Level-3 tests are more open and match-like. They require a minimum of three match-specific components to be integrated at the one time (e.g., technical, tactical and physiological) and demand a higher level of performance intensity than field-based static tests thereby making them a medium representation of match-play and positioned one level higher than the previous two levels. In ecological dynamics, it has been discussed how the continuous performer-environment interaction is critical to making effective decisions and organizing their actions during performance (Brunswick, 1956; Gisbon, 1979; Travassos, Araujo, Davids, Vilar, Esteves, & Correia, 2012).

The process of perception-action coupling occurs throughout Level-3 to facilitate behaviour based on the visual information available in the performance environment. Within team sport match-play, successful actions of athletes will vary due to the unpredictable environmental elements and constraints (e.g., opposition movement). Therefore, movements are largely anticipatory in nature based upon key information from their actions and the external environment (Araujo et al., 2006). When assessing the anticipatory visual cues of 25 tennis players (13 skilled and 12 novice) it was found skilled players were more accurate with live and video displays (but not with point-light displays) than novices (Shim et al., 2005). This highlights the importance of information presented to be representative of the performance environment as stimuli presence or absence may shape player behaviour (Greenwood, Davids, & Renshaw, 2016).

For example, the use of bowling machines in cricket practise have enabled players to rehearse their physical actions to be trained; however, their use is limited due to the lack of perceptual stimulus displayed. When there is a lack of perceptual stimulus (i.e., bowlers arm, hand, hip, trunk movement) players re-organize their coordination and timing, leading to movement patterns which are not representative of match-play (i.e., peak height of back swing was higher and drive initiation of the downswing occurred earlier and lasted longer when batting against a machine) (Renshaw et al., 2007). Although these studies would suggest human opposition is the preferred option, it is important to be mindful that humans may be more inconsistent, not as fast and may not be able to produce as much volume thereby limiting the amount of quality practice a player has. Careful consideration therefore needs to be applied to designing tests for athletes to complete as there appears to be a continuum as to how representative a test can be.

To the author's knowledge, there have been no published articles exploring the use of field-based dynamic tests (i.e., Level-3) for the purpose of talent identification in AF. This is an important consideration as in a review of TID in male soccer is was discussed how the combination of a player's technical and tactical skills in combination with their anthropometric and physiological characteristics is a complex relationship requiring careful attention (Sarmento, Anguera, Pereira, & Araujo, 2018). This relationship should be considered according to the age, maturational status and specific playing position of each player to avoid discriminating against younger or late-maturing players and the effect these may have on performance capabilities (Sarmento et al., 2018). Tangalos et al. (2015) investigated the relationships between indices of fitness and skill on player performance in 10-15 year old amateur AF players. The authors found when skill (coach rating) and fitness (20m shuttle test) were combined, there is a good correlation with the number of disposals an athlete will achieve as well as the number of effective disposals (Tangalos et al., 2015). As the main purpose of a performance test is to demonstrate how that test relates to the competitive environment (Tangalos et al., 2015), researchers need to understand the dynamics of AF and the technical elements. To achieve this, the notational analysis gathered at the Foundation Stone could be used to identify performance specific movement patterns, skill executions and physical demands allowing critical skills to be identified within the context they are performed. For example, identifying how a player obtains the ball, what movement patterns they perform with the ball and how they deliver the ball could then be applied to a dynamic skill test, enabling key factors such as skill executions and movement patterns to be combined together.

The ability to identify the physical and informational constraints from the environment and use opportunities for actions to achieve performance goals (Davids et al., 2013c) is a critical skill that talent scouts are looking for in recruits (Woods et al., 2015a). As such, Level-3 may assist talent scouts in identifying players who are able to do this. In sports like track and field, cricket and gymnastics, athletes use perceptual variables to regulate their approach to performing the task (i.e., in cricket athletes use the umpire as a way of ascertaining depth perception and to regulate their gait during run up) (Greenwood, Davids, & Renshaw, 2012). Elite coaches are also aware of the importance of task constraints in learning design and use nonlinear pedagogy to design training around the individual athlete constraints (i.e., their physical, physiological, cognitive and emotional characteristics) to allow the athlete to solve the performance problem (Greenwood et al., 2012).

Overall, Level-3 contains a more integrated approach of match-play components and a higher requirement from the performance demands (i.e., pressure) than Level-2. The skill execution is assessed with an outcome focus (i.e., kick effectiveness) rather than a performance focus (i.e., the mechanics of the kicking action). When investigating the kinematic effects of a short term fatigue protocol on drop-punt kicking, it was concluded players are able to make kinematic adaptations in order to maintain foot speed while punting for maximal distance (Coventry et al., 2015). Therefore, a player at this level may be effective in their delivery of the ball; however, their mechanics may alter from the preferred technique. This assessment result could potentially be used as a way of determining a player's ability to execute a skill under particular constraints. A limitation of Level-3 is the absence of opposition and the ability to assess how proficient a player is with their skill execution in a more open and dynamic playing environment. Therefore, a fourth level is required where this can be addressed.

Level-4: Field-based test (Small-Sided Game)

Level-4 is the implementation of field-based small-sided games, where all four components of performance are assessed at the one time. This integrated approach of the components enables this test to be high in representation and therefore positioned one level below match-play assessment. Field-hockey coaches have noted that whilst technique is important, so too was practising in a tactical context where match-play is simulated, as the latter improved players tactical understanding, decision making ability and their understanding of player patterns (Slade, 2015). The absence of live opponents in the current AF skill tests may alter the perceptual cues available to the performer and consequently the performer may use alternative, non-match like movement patterns, leading to an unreliable evaluation of that particular skill performance (Roca & Williams, 2016). In AF there is not one typical stimulus that a player is going to react to (i.e., the umpire blowing their whistle) but a continuous flow of stimuli from the environment that needs to be perceived and responded to (Davids et al., 2005). It has been discussed that a flaw in sports science research is the inability to accurately sample the perceptual variables of performance environments in which skilled athletes operate (Dicks, Davids, & Button, 2009).

When contemplating talent identification in AF, it is apparent more sport specific research is required to obtain clarity on the interconnecting components. Reviews such as the one conducted by Robinson et al. (2018) have highlighted the high level of variability in the elements separating higher and lesser skilled players. A possible suggestion to achieving greater continuity is to have studies based on sound theoretical principles and valid research designs (Bergkamp et al., 2018). New assessments should consider the interacting constraints, movement behaviours, contain adequate environmental variables and ensure the functional coupling between perception and action processes (Pinder et al., 2011). Additionally, they should challenge athletes to make accurate and timely decisions whilst executing the skill under some level of fatigue (Dawson et al., 2004). It is therefore evident a significant gap exists within the AFL talent assessment procedures.

Small-sided games are modified games played on reduced ground areas, often using adapted rules and involve smaller number of players than traditional games (Hill-Haas et al., 2011). The use of small-sided games (SSGs) at Level-4 could be appropriate as they replicate movement constraints (i.e., pressure when kicking the ball, locomotor patterns), information variables from the specific environment and the functional coupling between perception and action processes from competition. Furthermore, the goals in the assessment context (i.e., kicking proficiency) are based on comparable information (i.e., decision making) to the performance environment (Loader et al., 2012; Pinder et al., 2011). When a representative environment allows athletes to display their tactical understanding and their ability to make timely and accurate decisions, combined with their ability to proficiently execute game related skills, players can be identified as either higher skilled or lesser skilled (Davids, Araujo, Correia, & Vilar, 2013b; Oslin et al., 1998).

Match-play occurs within an unstable, dynamic and unpredictable environment. Traditional assessment methods (such as those discussed at Level-1 and Level-2), have a tendency to isolate the key components of technical, tactical, physiological and psychological competencies, thereby making the movement patterns more predictable and consequently limiting their application to match-play. There is a strong need for coaches to develop activities where these components are more interconnected whilst replicating the most intense contact demands of competition without a decrease in running performance (Johnston et al., 2015). The use of SSGs and practice matches as a way of developing skill and selecting team members is a well-established concept that most, if not all, sports utilize (Gabbett, 2009; Hoare & Warr, 2000). Team sport coaches of rugby (Gabbett, Jenkins, & Abernethy, 2012b), soccer (Hill-Haas et al., 2011) and AF (Davies et al., 2013) have implemented small-sided games as part of their training regimen in an attempt to develop decision making (O'Connor, Larkin, & Williams, 2017), skill execution (Klusemann, Pyne, Foster, & Drinkwater, 2012) and tactical awareness skills (Chatzopoulos et al., 2006). This style of training creates an environment where the interaction between players are constantly changing in a dynamic manner thereby creating opportunities to challenge the athlete to make timely decisions whilst efficiently disposing of the ball in a simulated match environment (Davids et al., 2013a).

The size of the small-sided game perimeter has varied within the literature due to the focus being on specific fitness qualities rather than talent assessment. In AF, playing areas such as 30x20m, 45x30m, 23.2x20m, 30x20m have all been used to compare the agility demands of SSGs (Davies et al., 2013). These SSGs involved elite AF players competing in a small-sided handballing game where the reduction in players resulted in small increases in total agility maneuvers (a maximum or near-maximum change of direction or deceleration to influence a contest). Although the only skill performed was handballing, an earlier soccer study using different constraints found similar results (Duarte et al., 2009). Duarte and colleagues (2009) reported when there was a decrease in the number of soccer players from 4v4 to 2v2, with a pitch size of 20x20m, player intensity increased and more frequent tactical actions occurred. It was hypothesised this was due to more surface area being available per player. In contrast to these two studies, a rugby league study analysing the effect of field size on the physiological and skill demands of players involved in SSGs, noted no significant skill involvement differences when using a 10x40m playing area versus a 40x70m playing area. Increases in distances covered at moderate, high and very high intensities however were noted in games played on the larger field size with senior elite players recording higher amounts than junior elite players (Gabbett et al., 2012a). When using SSGs as a way of assessing talent it is important the perimeter applied allows the skills in AF to occur naturally (i.e., kicking and handballing). It is therefore suggested the surface area per player should be representative of the surface area each player has during match-play.

The duration of each bout is an important consideration when discussing SSGs. Research has shown in a 3v3 soccer contest, bout duration did not have an effect on the number of technical actions performed per minute or proficiency (Fanchini et al., 2011). The authors did however note, as duration increased from two to six minutes there was a decrease in exercise intensity. Sampaio and Macas (2012) have suggested as players become more skilled they run less as their movement patterns are more intentional due to a greater tactical awareness of the game. When trying to emulate match-play intensity, 4-minute bouts are suggested as the best choice. In an elite 4v4 soccer game, of four minutes in duration (with three minutes passive recovery), it was shown SSG intensity was comparable to generic aerobic interval training with the total distance covered per minute, total number of duels and lost ball possessions all being greater in the SSG than actual game play (Impellizzeri et al., 2006). Furthermore, manipulating the constraint of fewer ball touches (i.e., 1 or 2) increased the difficulty for players to perform technical actions making it more specific to match demands (Dellal et al., 2012).

Small-sided game play allows players more opportunities to gain possession of the ball to display their skill proficiency as well as more opportunities to apply game strategy and tactical maneuvers in an easily manipulated and convenient setting. This form of assessment replicates match-play conditions from an integrated physiological, tactical and technical perspective. Considering player performance should be analysed from within a simulated, competitive environment it appears SSG assessment is the best solution (other than actual match-play at Level-5) for assessing competition skill performance (Davids et al., 2013a). To effectively develop a small-sided game assessment, researchers could examine the notational analysis of match-play dynamics from the foundation stone. They could then apply these findings by modifying the SSG variables such as pitch area, the number of players participating, the rules by which the players are abiding by and the intensity at which the game is played. For example, a smaller number of players combined with a large pitch size will make players work at a higher exercise intensity (Hill-Haas et al., 2011).

Overall, Level 4 provides a more open playing environment along the continuum where the rules replicate match-play. The skill assessment will more closely resemble match-play, assessing a player's ability to not only obtain possession of the ball but deliver the ball under match like demands (i.e., pressure). This analysis could then be used in assessing player talent selection, player development tracking, the effectiveness of intervention programmes and potentially how a player will perform during match-play. A limitation of Level-4 might be the reluctance of the coach to implement the game with contact (thereby reducing the representativeness of the assessment).

Level-5: Match-play

Match-play assessment resides at the highest point in the model, as this ultimately highlights a player’s ability to perform within the sport. When recruiters were interviewed as what they perceived as important for U13 soccer performance they identified the technical (i.e., first touch), tactical (i.e., decision making) and the psychological attributes (i.e., trainability) as being highly important, with other attributes such as physiological, anthropometrical and sociological being less important suggesting recruiters apply a holistic multidisciplinary approach to talent selection (Larkin & O'Connor, 2017). This finding was supported in another soccer study interviewing eight Danish national team coaches (Christensen, 2009). Within this study it was highlighted how coaches regarded game intelligence (i.e., tactical awareness), peak competences (i.e., technical skill), willingness to learn, work ethic and dedication as the most important qualities when selecting talented players. These studies highlight how match-play performance is a key component in the talent identification process in comparison to objective skill assessments.

It is common practice for AF coaches to select teams based off competition performance; however, the effectiveness of this method has had limited investigation in the literature. Black et al. (2016) identified how higher skilled players perform greater physical and technical performances following peak periods of match-play in comparison to lesser skilled players. When coaches subjectively rated player match performance, Johnston and colleagues (2012) found the higher skilled players had more kicks and disposals per minute, covered less distance and performed fewer high-speed efforts than lesser skilled players. This finding was supported in another AF study where skill performance, in comparison to physical activity, was found to be more important to a coaches perception of performance (Sullivan et al., 2014b). In contrast to these two studies, Johnston et al. (2016) investigated the relationship between movement demands, match events and match performance in AFL players. They noted how higher skilled players had higher match durations, covered greater total distance and spent more time running at high speeds per minute than lesser skilled players.

Combined, this research supports how match-play could be used as an integrated assessment. Unfortunately, there are limited opportunities for a player to be selected to play at the highest level and once selected there may be limited chances for the player to display their capabilities. For example, external variables such as weather, opposition tactics and flow of play may impact the amount of possessions a player has. Therefore, in an attempt to identify talent, an array of tests along the continuum may be required to more effectively assess specific components of performance. As such, it should be acknowledged a limitation of the current model is it does not consider other factors influencing talent detection and development (e.g., social, coaching, physical, physiological and psychological) (Pazo Haro, Saenz-Lopez Bunuel, & Fradua Uriondo, 2012; Williams & Reilly, 2000). Therefore, the assessment of technical skill ability is just one piece of the talent identification conundrum.

3.5 Conclusion

There are many factors to consider when implementing a technical skill assessment. The prediction of talent is more likely to be successful when tests are more representative of match-play and assessed within an integrated approach. The EPA model, which contains three stages – identification of key components, the assessment of these components and the acquisition of these components, has been combined with the RLD framework to review current Australian Football technical skill assessments and develop a structured framework for practitioners to consider when assessing, or developing, new assessments of technical game-based skills.

A 5-level Performance Assessment Model has been proposed that explores the skill assessment continuum. As the tests apply the notational analysis and move from Level-1 (laboratory analysis) to Level-5 (match-play assessment) there is a step-wise progression in the performance demands and integration of the four components to more closely represent match-play conditions (representative design). For example, Level-1 can provide a detailed isolated analysis of the kicking action in a controlled and stable environment, the kicking action is pre-determined with no opposition pressure. Level-2 is also an isolated analysis, with no opposition pressure and delivering the ball to a pre-determined location. This level assesses the technical component of the kick in a field-based setting with the focus on skill proficiency. Level-3 is a more dynamic field-based assessment, involving the combination of several match-specific components at the one time (e.g., technical, physical, psychological). The constraints are more open (e.g., the ball needs to be passed to a moving teammate); however, there are no opposition present. Level-4 looks at integrating all of the components under similar performance demands in a field-based small-sided game. Normal game rules apply, and opponents are present, which allows for a greater assessment of match-play skill execution than technical competency. Match-play resides at Level-5 as this is the ultimate level of skill assessment, highlighting a player's ability to perform in the sport. For example, a player's ability to proficiently dispose of the ball under scoreboard pressure or opposition tactics (e.g., playing area pressure). Assessments from these tests could be used in conjunction with each other to profile players, track player development and display player strengths whilst identifying specific areas of improvement along the AF talent pathway.

3.6 References

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CHAPTER FOUR – Study II

‘The development of a field-based kicking assessment to evaluate Australian Football kicking proficiency’

Following on from the development of the 5-level performance assessment model, it was evident current Australian football kicking assessment procedures were not entirely representative of competitive match-play environments. As such, the findings of Chapter three suggested the need for the development of two new skill assessments: a field-based dynamic kicking assessment (i.e., Level-3) and a small-sided game kicking assessment (i.e., Level-4). The development of each assessment will enable a greater understanding of Australian football kicking skills along the Performance Assessment Model continuum. As such, Chapter four develops a valid and reliable field-based kicking assessment to evaluate Australian football kicking proficiency.

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DECLARATION OF CO-AUTHORSHIP AND CO-CONTRIBUTION: PAPERS INCORPORATED IN THESIS

This declaration is to be completed for each conjointly authored publication and placed at the beginning of the thesis chapter in which the publication appears.

1. PUBLICATION DETAILS (to be completed by the candidate)

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Name(s) of Co-Author(s)	Contribution (%)	Nature of Contribution	Signature	Date
Jason Berry	15	Conceptual idea	[redacted]	21 July 2020
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CHAPTER FIVE – Study III

‘Effects of manipulating player numbers on technical and physical performances participating in an Australian Football Small-Sided Game’

Level four of the 5-Level Performance Assessment Model (Chapter three) required the development of a technical skill field-based small-sided game assessment. To develop an understanding of player number conditions on the technical and physical performances of players in an Australian football small-sided game, Chapter five was required. The aim of Chapter five was to determine the appropriate number of Australian football players, from the four conditions investigated, to use in the small-sided game assessment of kicking performance.

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CHAPTER SIX – Study IV

‘Validity and reliability of an Australian Football small-sided game to assess kicking proficiency’

Level four of the 5-Level Performance Assessment Model (Chapter three) required the development of a technical skill field-based small-sided game assessment. After consulting the findings of Chapter five with an expert panel of coaches, players and sport scientists, it was decided the 5v6 player number configuration was the most appropriate to investigate further in Chapter six. The aim of Chapter six was to develop a valid and reliable Australian football small-sided game to assess kicking proficiency.

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‘Validity and reliability of an Australian Football small-sided game to assess kicking proficiency’

This Chapter is presented in pre-publication format of a recent publication titled:

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6.1 Abstract

In Australian Football (AF), small-sided games (SSGs) have been used extensively as an alternative training method for technical and physical adaptations. Considering their application to AF, it is surprising a valid and reliable SSG kicking assessment remains absent. Therefore, the aim of this study was to develop a valid and reliable 5v6 Australian Football Field-Based Small-Sided Game (AFFB-SSG) kicking proficiency assessment. Youth male AF players (*n* = 145) from different stages within the AF talent pathway were recruited. Validity (i.e., logical and construct) and reliability (i.e., test re-test) were assessed. Kicking proficiency increased from U13 to U16 and as skill level increased from novice to sub-elite. Between the ages of U16 and U18 kicking proficiency appears to stabilize. The AFFB-SSG was 97% successful in identifying players as either novice or sub-elite. The physical attributes (i.e., odometer, m/min^{-1} and %HIR) all increased from U14 to U18 and as skill progressed from novice to sub-elite. Collectively, these findings suggest the AFFB-SSG is a valid and reliable AF kicking proficiency assessment tool and may provide worthwhile information to coaches regarding kicking performance along the AFL pathway, to profile player strengths whilst identifying specific areas of improvement.

6.2 Introduction

Talent identification (TI) programmes aim to identify and select youth athletes with the potential to become an elite senior athlete (Williams & Reilly, 2000). In an attempt to more accurately identify and discriminate between players (i.e., novice and sub elite), researchers in Australian Football (AF) have investigated key performance characteristics including anthropometrics (e.g., height) (Keogh, 1999), physiological capacity (e.g., aerobic endurance) (Veale et al., 2010b), technical competency (e.g., kicking accuracy) (Woods et al., 2015c) and perceptual-cognitive skill (e.g., decision making) (Woods et al., 2016b). Whilst these assessments do provide specific feedback (e.g., dominant and non-dominant leg kicking accuracy, aerobic capacity), they are performed in isolation (e.g., no opposition) and therefore remain distant from what occurs during match play (Bonney et al., 2019).

In an attempt to more accurately predict talented AF players, researchers have implemented multidimensional assessment designs, which incorporate a range of assessments including anthropometrics, motor competence, physical and skill abilities (Tribolet et al., 2018). Tribolet et al. (2018) found significant age-related differences for anthropometry, fitness and coach skill ratings. Furthermore, they noted their multi-dimensional approach was 90.9% accurate at identifying selected U15 players and 90% accurate at identifying the deselected U15 players. Woods and colleagues (2016c) also investigated whether a multi-dimensional assessment could discriminate between talent identified and non-talent identified U18 players. They assessed physical, technical and perceptual-cognitive performances and found their assessment could correctly classify 95% of the talent identified players and 86% of the non-talent identified players. Although these designs were more successful at identifying talented AF athletes than single assessment approaches, they do not consider how these characteristics are interconnected or replicate the performance demands of the game (e.g., performing a kick under pressure).

One method that may be used to assess athlete performance in an environment that resembles the demands of match play is small-sided games. Small-sided games have been used extensively in sport training due to their ability to replicate modified versions of match play (Davids et al., 2013a). As a method of assessment, small-sided games can potentially create opportunities for athletes to gain possession of the ball and display their skill proficiency, as well as apply game strategy and tactical maneuvers in an easily manipulated and convenient setting (Hill-Haas et al., 2011).

In AF, small-sided games have predominantly been used to understand the implications on physical performance. For example, published small-sided game research has been limited to comparing the effects of traditional and small-sided game training on athletes physical performance (Young & Rogers, 2014). More recently, Fleay et al. (2018) investigated how manipulating field dimensions during small-sided games impacts the technical and physical profiles of Australian footballers. The authors found a reduction in playing space led to a greater amount of turnovers, ineffective handballs and tackles whilst a 'large' small-sided game resulted in greater total, relative and high-speed running distances and maximum velocities.

Recent AF performance analysis investigations have suggested greater ball possession and kicking skill proficiency relative to the opposition have been shown to have greater influences on match outcomes (Robertson et al., 2015a). Considering the importance of kicking in AF, research has largely focused on biomechanical analysis (Blair, Duthie, Robertson, Hopkins, & Ball, 2018; Peacock et al., 2017) with limited research conducted on the assessment of match play kicking proficiency (Anderson et al., 2018; Gastin et al., 2017; Robertson et al., 2015a). Woods and colleagues (2015c) assessed 50 U18 male athletes (25 state representatives and 25 non state representatives) using the Australian Football Kicking Test. The test involves players running towards a feeder and receiving a ball, turning and executing a kick to one of six randomly assigned stationary targets (Cripps et al., 2015). Kicking performance is subjectively assessed on a scale from 0-5 (5 being the highest) for each kick. It was found when kicking accuracy and ball speed were combined playing status was able to be predicted (Woods et al., 2015c). In another study, Cripps et al. (2015) investigated 121 sub-elite U16 male AF players and although they found the inter-rater reliability to be high, the test could only differentiate between dominant and non-dominant kicking leg accuracy. A limitation of the current AF kicking test, is the assessment is conducted in isolation and does not assess the range of kicks typically performed within the performance environment (e.g., performing a kick under physical pressure). As a result, kicking ability is not assessed under match referenced conditions and consequently players may perform alternative actions and performances (Araujo et al., 2006).

Australian football is played within an unpredictable environment where athletes adapt to situations in an attempt to best deliver the ball. This suggests a variety of interconnected factors are involved when attempting to successfully perform a domain-specific skill during match play. Although the design and implementation of small-sided games in AF training is varied, largely depending upon the goal of the training session

(Hill-Haas et al., 2011), they are a progression along the Performance Assessment Model suggested by Bonney et al. (2019). Accordingly, an AF small-sided game may be an appropriate method for assessing AF skill proficiency, in particular, kicking. Therefore, the aim of this study was to 1) develop an Australian football small-sided game kicking assessment in consultation with players and coaches; 2) assess the logical, content and construct validity of the assessment to see if it can differentiate between age groups (i.e., U13; U14; U16; U18) and skill groups (i.e., novice and sub-elite); 3) assess the test re-test reliability of the assessment; and 4) assess the inter-rater reliability of the assessment.

6.3 Method

6.3.1 Participants

Youth male Australian football players (*n* = 145) from different stages within the AF talent pathway were recruited. The players were recruited from a local club (novice; U13: *n* = 22; U14: *n* = 26; U16: *n* = 22; U18: *n* = 11); state junior representatives (sub-elite; U16: *n* = 22; U18: *n* = 42).

6.3.2 Test Development

When developing new assessments, validity is an important consideration as it ensures the test measures what it claims to measure (Thomas et al., 2011). The 50m arc area was selected as notational analysis from six U18 sub-elite level matches (Mantle, 2017) and 19 AFL matches (Back, 2015) identified this was a common area where attackers, defenders and midfield players participated within. Furthermore, during match play, critical actions occur within this zone such as kicking for goal, delivering the ball inside 50m and rebounding the ball outside the 50m zone.

To assess the content validity of the test, a pilot study was conducted to obtain feedback (i.e., verbal and notational analysis) from an expert panel on the design, functionality and assessment process of the 5v6 small-sided game. Two of these experts are co-authors of this study with initials reported in parenthesis. This panel included a current elite U18 representative squad coach (*n* = 1); recently retired elite AFL players (*n* = 2); current sub-elite U15 AF players (*n* = 11); current sub-elite U18 AF players (*n* = 26); skill acquisition experts (*n* = 2, PL); a biomechanist (*n* = 1, KB); and a senior sport scientist working within an AFL club (*n* = 1). Feedback was obtained from the panel and slight modifications to the procedure of the test were applied. For example, it was suggested to include a 5m zone outside the 50m area to further challenge kicking proficiency.

The Australian football small-sided kicking assessment involved 4x3min quarters with 60 seconds recovery between the 1st and 2nd and 3rd and 4th quarters and 90 seconds between the 2nd and 3rd quarters in an attempt to replicate match play break durations (i.e., in AFL match play there is a longer break at half time in comparison to quarter time and three quarter time).

6.3.3 Data Analysis

Video footage from the three cameras were stacked (i.e., having the three camera angles showing on the one screen side-by-side) and coded using SportsCode 10.3.25. Each kick was scored according to how accurate the kick was executed. The same scoring criteria was used as previously published by Bonney et al. (2020b). Kicking proficiency percentage was calculated as total scored achieved / maximum possible score for kicks taken * 100.

Logical validity gathered from the Likert scale questionnaire is presented in the form of descriptive statistics and was assessed by a cross-section of sub-elite U18 players (n = 30), elite U18 representative squad coaches (n = 3), and skill acquisition experts (n = 2). One skill acquisition expert (PL) was also involved in the development of the test. The mean and standard deviation for each topic section were calculated from the 5-point Likert scale (i.e., 1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree) (Boone & Boone, 2012). Mean results were classified using previously published descriptors by Bonney et al. (2020b) strongly disagree (1-1.9), disagree (2-2.9), agree (3-3.9), strongly agree (4-4.9). Likert scale questions were provided to two senior sport scientists and one elite U18 representative coach for feedback prior to use. The questionnaire had 11 questions pertaining to player assessment, game simulation and test suitability in comparison to match play (e.g., the time the player had to dispose of the ball was similar to that performed during match play at your level). To ensure reliability of the questionnaire, sub-elite U18 players (n = 10) and an elite U18 representative coach (n = 1) were given the same questionnaire on two separate occasions, one week apart. Their results were assessed using Cronbach's alpha with a score of 0.96, indicating excellent reliability (Altman, 1991).

To determine construct validity, a One-Way ANOVA was used to compare between groups (e.g., U13; U14; U16; U18) (independent variable) and kicking proficiency score (dependent variable), and within group comparisons assessing skill (e.g., U18 novice and U18 sub-elite) (independent variable) and the kicking proficiency score (dependent variable). Significance for data sets were set at $p < 0.05$. A multinomial logistic regression was used to determine if kicking proficiency percentage could accurately classify age (i.e., U13; U14; U16; U18) and skill groups (i.e., novice; sub-elite) of players.

The Catapult Sprint 5.1.7 software was used to download the GPS data. Individual player odometer, meters travelled per minute (m/min^{-1}) and percentage of high intensity running (%HIR) were recorded as measures of central tendency. Effect sizes (ES) for ANOVAs were reported as partial eta squared (η_p^2) (Olejnik & Algina, 2003) and post hoc effect sizes were calculated using Cohen's *d* with 95% confidence intervals (CI) (Cohen, 1988). All other calculations were made using the statistical package SPSS Statistics (SPSS Version 25.0).

The stability of the test performances were determined by test re-test reliability using the two-way mixed-effects intra-class correlation coefficient (ICC) model (with absolute agreement) with 95% confidence limits (Koo & Li, 2016), the coefficient of variation (CV) and the standard error of measurement (SEM) (Hopkins et al., 2009). The ICC classifications used were >0.90 excellent, 0.75 and 0.90 good, 0.50 and 0.75 moderate and <0.50 poor (Koo & Li, 2016). Inter-rater reliability was examined with two trained independent assessors analysing 80% (116 players, 1138 kicks) of the kicks using the scoring procedure outlined by Bonney et al. (2020b). The kappa (k) correlation was interpreted as follow: poor (<0.20), fair (≤0.20-0.40), moderate (≤0.40-0.60), good (≤0.60-0.80) and very good (≤0.80-1.00) (Altman, 1991).

On both test occasions, standardised procedures and instructions were followed. The stability of individual responses was determined by one sub-section of sub-elite U18 participants (*n* =15) completing the protocol on two occasions, seven days apart, as long retest intervals can result in large variations due to factors such as participant behaviour or circadian variations (Robertson et al., 2014).

6.3.4 Procedures

Each small-sided game was completed on an outdoor regulation AF oval as outlined in Figure 1. Cones were placed on the field 5m from the 50m line to mark the “5m zone”. Six spare AF regulation footballs were placed behind the goal posts in an attempt to maximise game time after a score. The Australian football small-sided kicking assessment consisted of a 5v6 variation (with one player designated as a floater who is always on the attacking team). The first kick of each quarter was performed from the attacking team inside the goal square (this was rotated each quarter). The attacking team then needed to complete a minimum of two kicks before attempting to kicking the ball into the 5m zone. When kicking the ball outside the 50m arc within 5m (5m zone) only attacking players, leading for the ball, are allowed. If the lead is not successful players must return to within the 50m zone. If the pass is unsuccessful within this zone (i.e., the ball is dropped) the opposition obtain possession. If successful, the attacking team must complete another two kicks before a goal is attempted. If there is an intercept, the new attacking team must follow the same process of taking the ball out of the area before returning into the 50m zone to have an attempt at goal.

If the ball goes over the boundary line the opposition was awarded a free kick and to ensure the focus was on kicking, after every handball a kick needed to be executed. Goal posts were used; however, after a score (point or goal) the opposition had to play the ball immediately. Regulation AF rules were imposed for each small-sided game (including tackling), with an umpire.

To increase the stabilization of performance data, the protocol for testing included a requirement for familiarization. Players participated in a practice session of approximately five minutes before the testing session began to allow players time to familiarize themselves with the test, as recommended by Currell and Jeukendrup (2008). A five-minute break then occurred before the test commenced. All testing sessions were conducted at the player’s training ground in conditions deemed acceptable by the lead researcher.

All players were allocated numbered bibs for the Australian football small-sided kicking assessment and a GPS unit (Catapult, Minimax S5) to wear. During the assessment, three cameras were positioned on the field to capture the test performance. One camera was positioned five meters behind the goal posts (i.e., to capture shots at goal) and the other two cameras were positioned on opposite sides of the playing area approximately two meters outside the boundary line (i.e., to capture test footage in that specific side of the field).

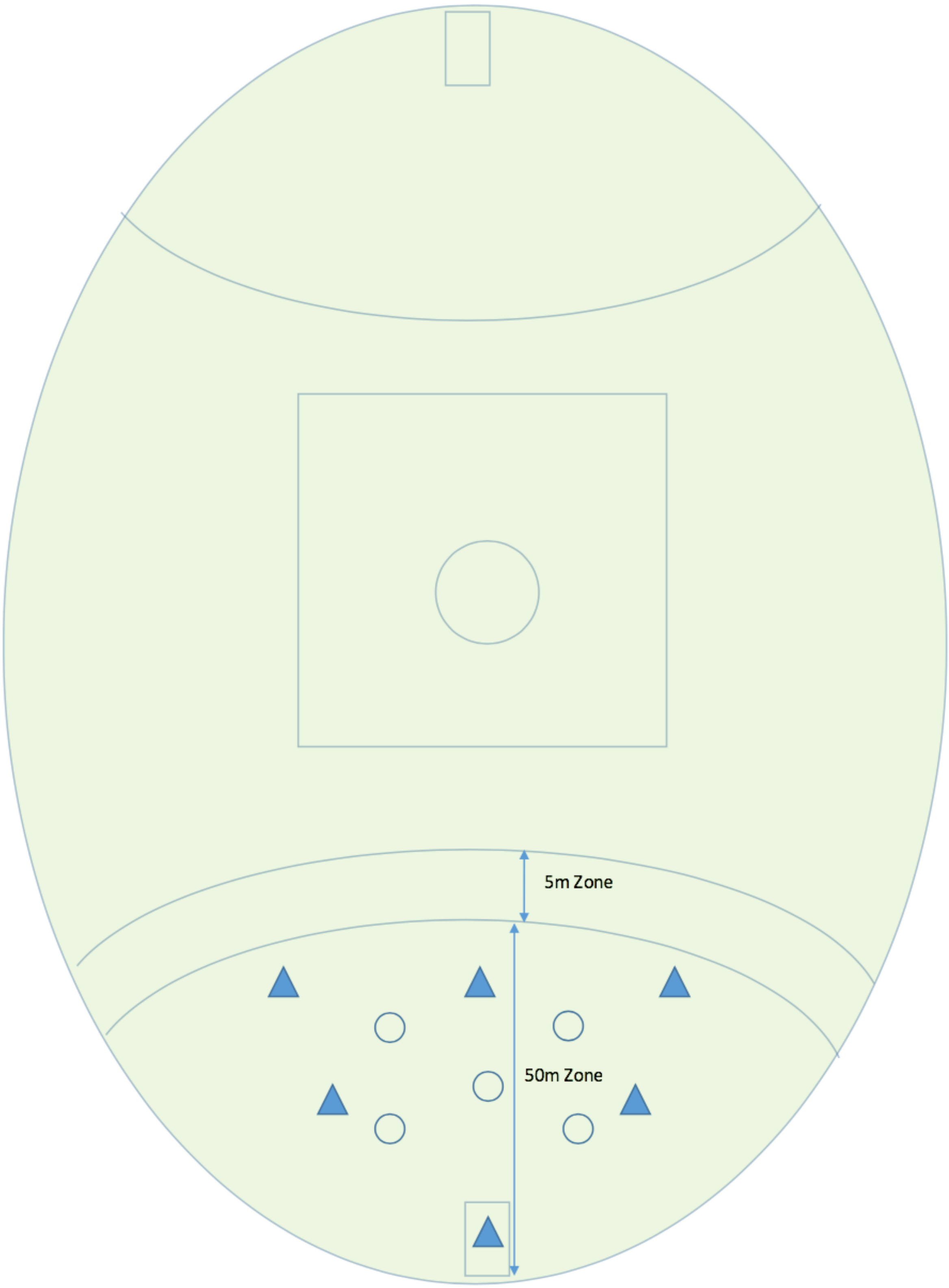

Figure 1. Schematic of the 5v6 AFFB-SSG set up

6.4 Results

6.4.1 Logical Validity

Logical validity was supported through both players and coaches strongly agreeing the test can assess kicking efficiency and assesses player decision making abilities similar to match play (mean ± SD; players 4.2 ± 0.69; coaches 4.47 ± 0.62). Further, players and coaches agreed the test simulated kicking patterns and playing intensity similar to match play (mean ± SD; players 3.78 ± 0.74; coaches 3.41 ± 1.13). The players strongly agreed, and coaches agreed, the test was suitable for the age and ability level of the group whilst also having potential to be used as a selection tool (mean ± SD; players 4.02 ± 0.77; coaches 3.80 ± 0.98).

6.4.2 Construct Validity

A one-way between subject ANOVA was conducted to compare the effect of age on kicking efficiency at the U13, U14, U16 and U18 age groups. There was a significant effect of age on kicking proficiency at the $p<.05$ level [$F(3, 162) = 17.582$, $p < 0.001$, $\eta_p^2 = .308$]. Post hoc comparisons using the Tukey HSD and the Cohen's *d* test indicated the mean score for the U14 group was significantly different with a very large ES to the U16 group (*d* = 1.4, p < 0.001) and a significant large ES to the U18 group (*d* = 1.5, p < 0.001). There was not a significant difference between the U13 and U14 age groups (*d* = 0.4, p = .540) and the U16 and U18 age groups (*d* = -0.06, p = .960). While this study was not longitudinal in nature, analysis of the kicking performance across age groups shows an increasing trend from U13 to U16. On average, there was a 4.99% kicking proficiency difference between the U13's and U14's, 13.54% from U14's to U16's and -0.65% from U16's to U18's. A multinomial regression analysis was conducted, using kicking proficiency percentage as a predictor of age group. This analysis identified the Australian football small-sided kicking assessment could correctly identify 87.1% of players as either U13, U14, U16 or U18.

A one-way between subject ANOVA was conducted to compare the effect of skill on kicking efficiency between U18 novice and U18 sub-elite players. There was a significant effect of skill on kicking proficiency at the $p<.05$ level [$F(2, 30) = 11.457$, $p < 0.001$, $\eta_p^2 = .495$]. Post hoc comparisons using the Tukey HSD and the Cohen's *d* test indicated the mean score for the novice group was significantly different with a very large ES to the sub-elite group (*d* = 1.9, p < 0.001). A multinomial regression analysis was conducted, using kicking proficiency percentage as a predictor of skill group. This analysis identified the Australian football small-sided kicking assessment could correctly identify 97.0% of players as either novice or sub-elite.

A one-way between subject ANOVA was conducted to compare the effect of age on odometer, m/min^{-1} and %HIR between U13, U14, U16 and U18 players. There was a significant effect of age on distance covered [$F(3, 130) = 47.229$, $p < 0.001$, $\eta_p^2 = .522$], m/min^{-1} [$F(3, 130) = 48.155$, $p < 0.001$, $\eta_p^2 = .526$] and %HIR [$F(3, 130) = 45.482$, $p < 0.001$, $\eta_p^2 = .512$] at the $p < 0.05$ level. Post hoc comparisons using the Tukey HSD indicated as age increased so too did the distance covered by the players, the amount of ground covered per minute and the intensity at which the players participated.

A one-way between subject ANOVA was conducted to compare the effect of skill on odometer, m/min^{-1} and %HIR between novice and sub-elite players. There was a significant effect of age on distance covered [$F(1, 37) = 9.364$, $p = .004$, $\eta_p^2 = .202$], m/min^{-1} [$F(3, 37) = 14.883$, $p < 0.001$, $\eta_p^2 = .287$] and %HIR [$F(1, 37) = 16.607$, $p < 0.001$, $\eta_p^2 = .310$] at the $p < 0.05$ level. Post hoc comparisons using the Tukey HSD indicated as skill level increased so too did the distance covered by the players, the amount of ground covered per minute and the intensity at which the players participated (Table 1).

6.4.3 Reliability

For the reliability of the test, the ICC ± 95% CL, CV ± 95% CL and the SEM indicated good reliability between the test re-test assessment (ICC = 0.82 ± 0.45 - 0.94, CV = 14.80, SEM = 3.43). The kappa (k) correlation was classified as very good (k = 0.88).

Table 1. Age and skill level mean (95% CI), SD and SEM for kicking proficiency percentage, odometer, meters travelled per minute and percentage of high intensity running

Age

	U13			U14			U16			U18		
	Mean (95% CI)	**SD**	**SEM**	**Mean (95% CI)**	**SD**	**SEM**	**Mean (95% CI)**	**SD**	**SEM**	**Mean (95% CI)**	**SD**	**SEM**
Technical												
Kicking Proficiency	44.23 (36.2-52.3)	18.1	5.3	49.22 (46.36-52.08)	9.1	3.9	62.76 (57.64-67.89)a	11.6	4.9	62.11 (57.49-66.72)a	6.9	2.9
Physical												
Odometer	395.4 (374-417)a	43.9	18.1	312.6 (299-326)b	40.4	16.9	383.5 (368-399)	35.6	14.8	420 (408-433)ab	47.5	20.5
Meters travelled per minute	131.8 (124-139)a	14.6	6.0	105.4 (101-110)b	13	5.5	127.8 (123-133)	11.9	4.9	140.9 (137-145)ab	15.3	6.8
Percentage of high intensity running	71.2 (67-75)a	8.0	3.3	56.1 (53-59)b	9	3.8	69.2 (66.8-71.7)	5.5	7.7	73.8 (72-76)a	6.5	3.0

Skill

	Novice			Sub-elite		
	Mean (95% CI)	**SD**	**SEM**	**Mean (95% CI)**	**SD**	**SEM**
Technical						
Kicking Proficiency	46.64 (42.1-51.2)*	6.8	2.9	66.75 (57.72-75.78)*	13.5	5.7
Physical						
Odometer	381.1 (347-415)*	48.2	20.5	432.0 (414-449)*	44.4	18.9
Meters travelled per minute	127.0 (115-138)*	16.1	6.8	147.1 (141.8-152.4)*	13.4	5.7
Percentage of high intensity running	68.0 (63-73)*	7.1	3.0	76.7 (74.6-78.8)*	5.3	2.2

CI = Confidence Interval; SD = Standard Deviation; SEM = Standard Error of Measurement

Letter indices denote a significant difference $p < .05$ level; a vs. U14; b vs U16.

* Denote a significant difference between novice and sub-elite

6.5 Discussion

The aim of the study was to develop a valid and reliable Australian football small-sided game kicking proficiency assessment which can differentiate between age (i.e., U13; U14; U16; U18) and skill groups (i.e., novice and sub-elite). Validity (logical and construct) and reliability (test re-test) suggested the Australian football small-sided kicking assessment can successfully distinguish between age groups and skill groups. Kicking proficiency increased from U13 to U16 and as skill level increased from novice to sub-elite. The physical attributes (i.e., odometer, m/min^{-1} and percentage of %HIR) all increased from U14 to U18 and as skill progressed from novice to sub-elite. The reliability of the Australian football small-sided kicking assessment, as assessed by test-re-test, was classified as good. Overall, this study is the first AF investigation attempting to validate the use of a 5v6 small-sided game to assess the kicking proficiency of players.

Logical validity was supported by players and coaches agreeing the Australian football small-sided kicking assessment can assess player performance and simulates playing actions and demands similar to match play. The players and coaches moderately supported the Australian football small-sided kicking assessment as a tool for selecting future teams. For the establishment of construct validity, the test should differentiate between known performance levels (Thomas et al., 2011). To date, no AF small-sided game or kicking test has reported the construct validity of the assessment prior to its implementation. Therefore, without assessment of construct validity prior to the implementation of a new kicking test, it may be unclear whether performance differences are a result of skill differences or an unreliable test (Larkin et al., 2014). The results of this study demonstrate the Australian football small-sided kicking assessment was successful in distinguishing between players across age groups (i.e., U13; U14; U16 and U18) and across skill levels within the same age group (i.e., U18 novice and U18 sub-elite) along the AFL talent pathway.

The Australian football small-sided kicking assessment was successful in distinguishing a significant kicking proficiency difference between the age groups of U14 and U16 and U14 and U18 and whilst there was an increase from the U13 to U14 age group, it was not significant. There is limited empirical evidence to compare the results the Australian football small-sided kicking assessment to other similar AF small-sided games or match play performance within these age groups. When comparing the U13 and U14 kicking proficiency to those previously reported by Gastin et al. (2017) the current study found similar results with disposal efficiency increasing as age increased. It is important to note; however, the Gastin et al. (2017) study reported both kicking and handballing in their disposal efficiency percentage.

An interesting finding from the current study was the stabilization in kicking proficiency between the U16 and U18 age group. This may suggest once selected into a team all players at that particular age and skill level may have the same technical capacity; however, when comparing between higher and lower skill groups a difference in proficiency may be seen. The results of the current study found small-sided games were able to differentiate between novice and sub-elite athletes which is similar to those previously reported. Bennett et al. (2018) found higher skilled players had significantly greater number of attempted and completed passes, touches and total skill involvements compared to lower skilled players in youth soccer small-sided games. Furthermore, they found total skill proficiency was greater in higher skilled players than lesser skilled players which is a similar finding to this study.

The largest difference in kicking proficiency occurred between the U14 and U16 age group, which is consistent with previous findings on AF kicking proficiency (Bonney et al., 2020b); however, further research is recommended to explore whether there is a key developmental period where kicking skill is more susceptible to development or simply due to maturation (i.e., early maturation). For example, Malina, Ribeiro, Aroso, and Cumming (2007) found when the stage of puberty, aerobic resistance and height are combined they can explain 29% of the variance for soccer skill, highlighting the inter-relationship of growth, maturity and functional characteristics of youth soccer players. In comparison, researchers have investigated the effect of physical parameters and maturity on skill performance of 12-13 year-old basketball players (Silva et al., 2010) and adolescent handball players (Matthys et al., 2012) and found maturity had no effect on sport-specific skills.

During the Australian football small-sided kicking assessment a higher physical performance (odometer, m/min^{-1} and percentage of %HIR) output was noted as age (i.e., U14 to U18) and skill (i.e., novice to sub-elite) increased. The m/min^{-1} was greater in this study when compared to those previously reported in youth (U10-U15) match play (Gastin et al., 2017). A possible reason for this may be the amount of area the players had to participate within. For example, Gastin et al. (2017) assessed player skill execution and physical performance through match play where players had larger areas to perform within and may have to wait for the ball to return from another area before moving again. In comparison, the Australian football small-sided kicking assessment restricted players to the 50m zone, affording players with more opportunities to be involved with the ball and subsequently covering more distance per minute.

When interpreting the findings of this study, some limitations should be considered. Firstly, this study is a cross-section design and to further clarify if the Australian football small-sided kicking assessment is a suitable assessment tool for all age groups more players, from more age groups, should be assessed through longitudinal research designs. Such designs could track athlete performance over the key developmental age periods in an attempt to identify the impact of age on athlete skill development. This may also assist with the development of more standardised scores to help coaches become more specific with their planning for development of players (i.e., kicking proficiency). Finally, the ICC 95% confidence interval results indicate the reliability to be between 0.45 (poor) and 0.94 (excellent). Accordingly, results from this study should be viewed with caution until more data has been collected and can confirm the findings of this study.

The demand for an ecological valid assessment of skill in AF, that closely represents game demands, has been requested in the literature (Tribolet et al., 2018). Overall, these results suggest the Australian football small-sided kicking assessment could be included as part of a multidimensional assessment battery. This may provide worthwhile information to coaches regarding kicking performance along the AFL pathway, to profile player strengths whilst identifying specific areas of improvement. This test does not require a large amount of equipment or time to complete and can assess 11 players at the one time, thereby making it appropriate for large scale testing days. Furthermore, the development of the Australian football small-sided kicking assessment supports Level-4 on the Performance Assessment Model suggested by Bonney et al. (2019) to help coaches provide more objective feedback to players regarding their kicking skill performance.

6.6 Conclusion

These data contribute significantly to the Australian football talent identification research as they provide an indicator of player kicking performance during an AF small-sided game. This study was the first to examine the applicability of an AF 5v6 small-sided game as a valid and reliable assessment tool. The results suggest as age and skill level (novice to sub-elite) increase so too does the kicking proficiency, odometer, m/min^{-1} and percentage of time spent running at high speeds. However, between the ages of U16 and U18 kicking proficiency appears to stabilize. Finally, the Australian football small-sided kicking assessment was 97% successful in identifying players as either novice or sub-elite. Collectively these findings support the use of the Australian football small-sided kicking assessment as a skill assessment tool for talent identification purposes.

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CHAPTER SEVEN – Study V

'Can match play kicking and physical performance outcomes be replicated in an Australian Football small-sided game?'

With the results of Chapter six suggesting the 5v6 Australian football field-based small-sided game was a valid and reliable assessment tool, it was important to investigate the extent to which the small-sided game compared to match play performance. These findings provided necessary insights to Australian football youth coaches about the technical and physical performance outcomes of the 5v6 Australian football small-sided game kicking assessment and the technical and physical performance outcomes of match play in youth Australian football players. Accordingly, Chapter seven investigated whether the technical and physical match performance outcomes could be replicated in a 5v6 Australian football small-sided game.

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DECLARATION OF CO-AUTHORSHIP AND CO-CONTRIBUTION: PAPERS INCORPORATED IN THESIS

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2. CANDIDATE DECLARATION

I declare that the publication above meets the requirements to be included in the thesis as outlined in the HDR Policy and related Procedures – policy.vu.edu.au.

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Date

3. CO-AUTHOR(S) DECLARATION

In the case of the above publication, the following authors contributed to the work as follows:

The undersigned certify that:

1. They meet criteria for authorship in that they have participated in the conception, execution or interpretation of at least that part of the publication in their field of expertise;

2. They take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;

3. There are no other authors of the publication according to these criteria;

4. Potential conflicts of interest have been disclosed to a) granting bodies, b) the editor or publisher of journals or other publications, and c) the head of the responsible academic unit; and

5. The original data will be held for at least five years from the date indicated below and is stored at the following **location(s)**:

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Name(s) of Co-Author(s)	Contribution (%)	Nature of Contribution	Signature	Date
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Paul Larkin	15	Data Collection, reviewer, edits.		21/7/2020

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CHAPTER EIGHT –Thesis Overview and Conclusions

8.1 Overview

When contemplating talent identification in Australian football, it is apparent more sport specific research is required to obtain clarity on the interconnecting components. Researchers have used multidimensional assessment designs (e.g., isolated assessments of technical, physical and psychological capabilities) to identify talent (Tribolet, Bennett, Watsford, & Fransen, 2018; Woods, Raynor, Bruce, McDonald, & Robertson, 2016b). Although these designs are more successful than single assessments, they do not consider how these components are interconnected or replicate the performance demands of the game. The Australian football small-sided game assessment, developed in this thesis, combined all the performance components into the one assessment. This assessment was 97% successful in identifying talented youth players and is suggested to be a more time efficient and ecologically valid way to identify talented players. Reviews of talent assessment; however, have highlighted the high level of variability in the elements separating higher and lesser skilled players (Robinson, Baker, Wattie, & Schorer, 2018). Although, variability should be carefully considered as variability can be “good” (functional) and “bad” (dysfunctional) (Woods, McKeown, Rothwell, Araujo, Robertson, & Davids, 2020b). A possible suggestion to achieving greater continuity is to have studies based on sound theoretical principles and valid research designs (Bergkamp, Niessen, den Hartigh, Frencken, & Meijer, 2018).

Current research suggests sports training and assessment environments should be guided by an ecological dynamics framework (Davids, Araujo, Vilar, Renshaw, & Pinder, 2013b; Woods, McKeown, O'Sullivan, Robertson, & Davids, 2020a; Woods et al., 2020b). This framework may be used to guide the design of new assessments by practitioners developing assessments centered around the athlete-environment interaction (Woods et al., 2020a). These assessments should consider the interacting constraints, movement behaviours, contain adequate environmental variables and ensure the functional coupling between perception and action processes (Pinder, Davids, Renshaw, & Araujo, 2011). They should consider the effect of physical and psychological maturity and relative age effect (Burgess & Naughton, 2010) whilst challenging players to make accurate and timely decisions whilst executing the skill under some level of fatigue (Dawson, Hopkinson, Appleby, Stewart, & Roberts, 2004; González-Víllora, Serra-Olivares, Pastor-Vicedo, & Teoldo da Costa, 2015).

The ability to proficiently kick the ball under match performance demands (e.g., evading opponents and kicking the ball to a teammate) is a critical factor in Australian football. A coach's perception of player performance is largely influenced by the number of disposals they have had and their effectiveness to pass the ball and maintain possession (Sullivan, Bilsborough, Cianciosi, Hocking, Cordy, & Coutts, 2014b). Considering the importance of kicking in Australian football, it is surprising there is currently very little research conducted on the application of using kicking performance as an assessment tool for talent identification (Cripps, Hopper, & Joyce, 2015; Woods, Raynor, Bruce, & McDonald, 2015c). In an attempt to assess kicking skill performance of elite youth Australian football players, the Australian Football League included two skill tests to the Australian Football League draft combine; however, the ecological validity of both tests is a major concern.

This thesis has attempted to provide greater clarity on skill assessments through the suggestion of a 5-Level Performance Assessment Model. The model applies match play notational analysis to separate technical game skill on a continuum comprising of Level-1 (i.e., laboratory test), Level-2 (i.e., static field-based test), Level-3 (i.e., dynamic field-based test), Level-4 (i.e., small-sided game field-based test) and Level-5 (i.e., match play). The proposed model provides coaches with a better understanding of the potential performance demands and key outcomes associated with each level. The 5-Level Performance Assessment Model provides sport coaches with greater clarification of the benefits and limitations of the technical assessment tasks they are using. When players are assessed from a holistic approach (i.e., applying each level of the Performance Assessment Model to profile players) the tracking of player development and the display of player strengths and limitations may become more meaningful to coaches and recruiters.

In an attempt to fill the void between Level-2 and Level-5, on the 5-Level Performance Assessment Model, this thesis has developed the first two valid and reliable Australian football kicking skill assessments: a dynamic kicking assessment (an example of a Level-3 test) and a small-sided game (an example of a Level-4 test). These assessments used notational analysis to consider match play kicking demands and apply a more integrated approach of match play components. Interestingly, the results for these two assessment found both the dynamic kicking assessment (68.3% successful) and the small-sided game (97%) were successful at identifying player skill levels. These results may suggest as assessments move further along the continuum, integrating more components of match play, they are also more successful at identifying talent. Further, these results may provide coaches with worthwhile information regarding player kicking performance during competition rather than specific details on how they will perform the skill. As such, Level-3 and Level-4 assessments provide greater insights into match play kicking proficiency thereby improving current talent identification programmes.

Finally, the results of this thesis indicate an improvement in kicking proficiency occurs from U13 to U16 and then appears to stabilize; however, as skill level increases so too does kicking proficiency. An interesting finding was how Australian football kicking ability appears to be most impressionable between the age groups of U14 to U16. These results may assist coaches in developing specific technical skill programmes for particular age groups. Accordingly, these assessments are recommended to be included in future Australian football draft combines. Other results found in this thesis highlight the need for coaches and practitioners to understand player physical and technical responses to particular constraints and player number conditions applied to the task. These results suggest particular constraints and player number conditions may produce specific technical and physical player behaviours. For example, when looking to assess general match play kicking proficiency the 5v6 variation may be most relevant; however, when looking to assess the ability of a player to proficiently kick the ball to a contest the 6v6 variation may be more suitable.

8.2 Practical implications for talent identification in Australian Football

8.2.1 5-Level Performance Assessment Model

In an attempt to better conceptualize Australian football technical skill assessments, whilst considering the expert performance model (Ericsson & Smith, 1991) and representative learning design theory (Pinder et al., 2011), a structured framework for sport practitioners was developed. This framework was called the 5-Level Performance Assessment Model (discussed in Chapter three) which attempted to order skill assessments along a performance continuum to assist practitioners when assessing or developing new tasks of technical game based skill. As the tests apply the notational analysis and move from Level-1 (laboratory analysis) to Level-5 (match-play assessment) there is a step-wise progression in the performance demands and integration of the four components to more closely represent match play conditions. For example, Level-1 can provide a detailed isolated analysis of the kicking action, Level-2 also provides an isolated analysis; however, the player is on the sporting field and delivering the ball to a pre-determined location. Level-3 is a more dynamic field assessment involving the combination of several performance components at the one time, whilst Level-4 integrates all of the components under similar performance demands as match play in a small-sided game. Match play resides at Level-5 as this is the ultimate level of skill assessment, highlighting a player's ability to perform in the competitive game environment.

When applying this framework to alternative sports, coaches should first consider the outcomes they are trying to identify. For example, Level-1 assessments would be appropriate when investigating specific biomechanical movement patterns; Level-2 assessments would be appropriate when investigating a player's specific body segment movements under limited performance demands on the playing surface; Level-3 assessments could be used when investigating a particular skill outcome under an integrated approach of the match play components; Level-4 would be appropriate when assessing a player's ability to perform under a particular tactical playing constraint against opposition; and Level-5 is appropriate when assessing a player's ability to perform during competition.

8.2.2 Talent assessment in Australian Football

The current assessment methods used in Australian football talent identification and development are largely isolated from the demands of match play. The addition of the 5-Level Performance Assessment Model provides coaches with a model to guide skill assessment whilst highlighting how these results relate to skill execution and match play performance. Although laboratory assessments (Veale et al., 2008) and static field-based assessments (Cripps et al., 2015) currently exist, prior to this doctoral research, no dynamic field-based assessment or small-sided game assessment had been developed for Australian football.

When considering skill assessment and to a larger extent talent identification and development in Australian football, it is imperative to understand the importance of match play notational analysis and the role it has in outlining the key characteristics of match play to be assessed. Whilst the individual isolated characteristics assessed by Woods et al. (2016c) and Tribolet et al. (2018) are important components of successful match play, it is the combined application of these characteristics and how they relate to match play that should drive talent identification. A suggested way of achieving this is through designing tasks so they are representative of match play (Pinder et al., 2011). When an assessment has more functional coupling between perception and action processes and more informational characteristics from within the competitive environment a more representative task of match play will result (Pinder et al., 2011; Pinder et al., 2015). When tasks are not representative of match play, skill execution and movement characteristics differ to match play actions (Krause et al., 2019). As such, when attempting to identify talented players in Australian football, assessments should be more dynamic and consider how representative they are of match play. Accordingly, the integrated assessment approach of the Australian football field-based – dynamic kicking assessment and the 5v6 Australian football small-sided game provide a robust means for talent identification and development of junior Australian football players within the Australian Football League participation pathway.

In particular, this doctoral investigation provides coaches with alternative methods to assessing kicking performance dependent on skill context or player ability. The analysis of these assessments could be applied to player talent selection, identifying player kicking limitations, player development tracking, analysing the effectiveness of an intervention programme and identifying how a player will perform during match play. The two objective assessments are easily administered with the results of the assessment easy to interpret and apply to talent identification and development programmes in Australian football. Such analysis could also be used to confirm talent scout opinion and provide an objective measure to a subjective opinion.

These two new assessments may additionally help coaches in identifying players who are not as physically mature; however, possess superior technical skills and who through time may develop into elite players. Researchers have noted how talent identified players are predominantly early maturers (Haycraft et al., 2018) with late maturing players more likely to experience adult success (Ostojic et al., 2014). As such, Cobley et al. (2009) have suggested for coaches to integrate more skill-based criteria in talent selection with less dependence on physical attributes. The results provided within this thesis provide examples where talent can be objectively assessed from skill proficiency rather than physical attributes. Furthermore, they can be used as a guideline to assess kicking proficiency along the Australian Football League talent pathway, where individualised football programmes can be applied based upon the results obtained. For example, creating specific kicking intervention groups based upon kicking proficiency results, as opposed to generic programmes with a ‘one size fits all’ approach.

8.2.3 Task constraints applied to assessment protocols

The results of Chapters five and seven highlight the importance of considering task constraints when developing a skill assessment task. Each task constraint a coach applies will entail a specific technical and physical player performance response (Corbett et al., 2018). In this thesis, it was found technical proficiency and disposals were highest during imbalanced player numbers (i.e., 5v6) whilst ball delivery to a contested possession (i.e., kicking to leading or covered players) was highest during balanced player numbers (e.g., 6v6). Furthermore, when sub-elite youth players are participating on a fixed pitch size, the amount of meters covered, average meters travelled per minute, average maximum velocity and percentage of high intensity running all increased when the number of players decreased and hence the relative pitch size increased. Overall, these findings are consistent with previous research (Randers et al., 2018; Timmerman et al., 2017) and provide Australian football coaches with a greater understanding of the impact player number variations, on fixed sized areas, have on the technical and physical performance outcomes of players in a 5v6 small-sided game.

The interaction of constraints need to be carefully considered as their interaction can impact the skill performance outcome and proficiency score achieved. For example, Browne et al. (2019) compared the variations in constraint interaction upon kicking outcomes in Australian football and found when all constraints are considered a more complete understanding of the context of the kick can be developed. This informed understanding could then be used to compare the design of training to match play demands. The results of this thesis suggest a 5v6 small-sided game variation will afford players with more opportunities to kick the ball, more time when kicking the ball, run more meters per minute and spend more time performing high intensity running than during match play. In comparison, match play pressures players to kick the ball within a shorter time period and affords players more opportunities to achieve higher average maximum running velocities.

The results from Chapters five and seven may assist future researchers and coaches in their development of kicking skill assessments and the design of skill interventions. These findings support previous research in soccer (Randers et al., 2018) and highlight how particular constraints may produce distinct technical and physical responses from players. Furthermore, the results could enable an Australian football youth coach to apply a more effective periodised skill acquisition training programme. For example, in the pre-season the focus could be on the physical attributes and quantity of skill executions whilst during the competition season the focus could be on skill execution under time and physical pressure. The results from these Chapters; however, should be carefully considered as not all responses were found to be comparable to match play performances. This is a common outcome in Australian football when comparing the technical and physical responses of training drills to match play (Ireland et al., 2019) and indicates alternative constraints may need to be investigated in order to achieve more match specific performance outcomes.

8.3 Implications for talent identification in team sports

Chapter three provides a framework for skill assessment in other sports. During match play all four components of performance (i.e., technical, tactical, physical and psychological) are required to work in unison whilst the highest demand of intensity/pressure is being placed upon the player. The 5-Level Performance Assessment Model provides a progression of skill assessment from a performance demand perspective to how representative the assessment is when measuring skill. This provides researchers and coaches of other sports with a well-defined model when considering skill assessments for a particular performance outcome. For example, when analyzing netball match play passing preparedness, a coach may select a small-sided game variation and observe how proficient a player executes their skills under more representative conditions of match play. The results obtained can then be used in conjunction with other assessments to help determine the selected team.

The foundation stone of the 5-Level Performance Assessment Model is notational analysis. Team sports can use this foundation stone to identify and record the frequencies of the key skills and actions unique to their competitive environment. Once identified, coaches can use this information, as part of a multidisciplinary approach, in assessing talent during match play and whilst at training. In soccer, recruiters assess components such as the technical, tactical and psychological in combination with other attributes (e.g., physiological, anthropometrical and sociological) during match play and training to identify and select players (Larkin & O'Connor, 2017). Once team sports have identified the key skills and actions involved in their sport, more representative skill assessments can be developed. Furthermore, recruiters may be able to combine this objective data to their subjective opinion to provide a more detailed talent selection report.

The assessments outlined within this doctoral investigation can be used as a valid method for monitoring skill performance under different constraints. For example, in Australian football the average kicking proficiency, before considering the effect of constraints, is 54% (Browne et al., 2019). When considering constraints such as kicking distance, time before disposal and the type of pressure applied to the kicker, kicking proficiency fluctuates between 14.6% and 87% (Browne et al., 2019), highlighting the need for kicking proficiency to be monitored under different constraints. Once a skill assessment has been conducted, individualised programmes can be developed and improvements can be tracked in an attempt to improve match play proficiency along the talent pathway. For the example above, an Australian football intervention programme may consist of kicks being executed in under 2-seconds whilst being chased from behind or players executing kicks over 40 meters from a ground-ball pick-up (Ireland et al., 2019).

The current assessment methods used in talent identification and development are largely isolated from the demands of match play. Whilst physical characteristics have been extensively researched in regard to talent identification and development, technical characteristics have had limited investigation. These physical characteristics for talent identification have been shown to only demonstrate small associations with team selection (Keogh, 1999) whilst multi-dimensional assessments, involving isolated assessments, have had higher levels of success. Tribolet et al. (2018) found their assessment battery could identify 90.9% and 90% of U15 selected and deselected players and Woods et al. (2016b) found their battery could correctly classify 95% and 86% of the talent identified and non-identified athletes. However, the Australian football small-sided game kicking assessment was successful in identifying 97% of talent identified players within the one integrated task. A possible reason for this increase in accuracy may have been the higher level of representativeness the assessment was to match play. Accordingly, team sports may be able to use this information as a guide when deciding upon future talent assessments. This thesis provides evidence a more integrated assessment of match play demands may provide greater accuracy to talent identification and when combined with other assessments (e.g., talent scout opinion) a more objective and detailed analysis can be made for talent selection.

8.4 Limitations

The main focus of this thesis was to design two Australian football kicking assessments, representative of match play demands, to investigate the determinants of a talented kicking performance in junior Australian football. While the results of this thesis provide scientific rigor to the assessment of Australian football kicking and to a larger extent talent identification and development in Australian football and other sports, it is not without limitations and requirements for improvement. Firstly, the results are limited to youth male Australian football players and they cannot be assumed to be transferrable to elite senior Australian football players or female Australian football players. For example, senior Australian Football League players perform at higher physical intensities (Burgess et al., 2012b) and have greater athletic movement skills than elite U18 male players (Woods, McKeown, Haff, & Robertson, 2016a).

When comparing male and female athletes, females have different maturational, anthropometrics, physiological and psychological differences (Sarmento et al., 2018). Specifically, females have less testosterone than males (thereby limiting their strength and power capacities) and play with modified numbers during Australian football match play (Baumgart, Hoppe, & Freiwald, 2014; Sekulic, Spasic, Mirkov, Cavar, & Sattler, 2013). These differences may impact the skill execution of the players and provide alternative results. Accordingly, further research is recommended to investigate the specific development of the drop-punt kick in female players along the Australian football talent pathway.

The relatively large sample size used in this thesis provides the basis for performance kicking benchmarks; however, greater numbers across a larger cross-section of players would be beneficial. Obtaining larger participant numbers across more age and skill groups could provide greater insights into the technical and physical demands of the constraints investigated and provide greater clarity on the development of kicking skill acquisition. Standardised benchmarks could then be developed and applied along the Australian Football League participation pathway with greater conviction. These benchmarks could then be used as a guide for tracking kicking development of players and assessing the effectiveness of intervention training programmes.

Although the competition games analysed did provide some insights into match play kicking proficiency a greater amount of matches, across the Australian Football League participation pathway, are required to obtain a more thorough analysis of how the 5v6 small-sided game correlates to match play kicking. Match activity profiles can be affected through weather, opposition strategy, ground size, travel, opposition ladder position and physical capabilities (Rampinini et al., 2007; Robertson & Joyce, 2018; Sullivan et al., 2014a). Although the conditions for match play assessment were favorable and the games assessed were conducted at the team's home ground, it is important for coaches and recruiters to understand this limitation when interpreting the results. By analyzing a greater amount of competitive matches, it may be possible to understand whether the Australian football small-sided game kicking assessment is sensitive enough to identify how a change in the assessment score may impact the kicking proficiency during match play. In addition, it would be interesting to see if the results varied when investigating novice and skilled players within each age group to identify if any performance variations existed. For example, Chapters four and six identified how there was a difference in kicking proficiency during the Australian football field-based – dynamic kicking assessment and the Australian football small-sided game kicking assessment; however, further research is required to identify if differences may occur during match play. Finally, performance assessments were only analysed if data for players were available for both the small-sided game and match play. Therefore, it is plausible to assume the data presented may not be indicative of team performances rather only individual player performances.

Success in Australian football is reliant upon all isolated characteristics combining during match play to display player strengths whilst compensating for player weaknesses. Although this thesis considered the integrated characteristics of the technical, tactical, physical and psychological demands of match play, the assessments did not always comprise of match play intensity and demands (i.e., the Australian football field-based – dynamic kicking assessment consisted of no physical pressure). Therefore, in an attempt to identify talent, an array of tests along the continuum may be required to more effectively assess specific components of performance. As such, it should be acknowledged a limitation of the Australian football field-based – dynamic kicking assessment and the Australian football small-sided game kicking assessment is they do not consider other factors influencing talent detection and development (e.g., social, coaching) (Serra-Olivares, Pastor-Vicedo, Gonzalez-Villora, & Teoldo da Costa, 2016; Williams & Reilly, 2000). The addition of assessing these isolated characteristics, such as the psychological component, may provide greater insights into talent development; however, the assessment of these characteristics was not within the scope of this thesis as the focus was on the specific integrated requirements of match play kicking. Accordingly, the assessment of technical skill ability is just one piece of the talent identification conundrum and it would be interesting to further examine the Australian football field-based – dynamic kicking assessment and the Australian football small-sided game kicking assessment within a multi-dimensional fitness battery such as those previously investigated (Tribolet et al., 2018; Woods et al., 2016c).

Global positional systems (GPS) were used to identify physical measurements throughout this thesis. These results provided further insights and comparisons of the physical demands required within the Australian football field-based – dynamic kicking assessment, the small-sided game number variations and the Australian football small-sided game kicking assessment. The use of GPS technology; however, is known to underestimate distance, speed measures during straight line running, multi-directional changes and variable movement patterns in field team sports (Duffield, Reid, Baker, & Spratford, 2010; Vickery, Dascombe, Baker, Higham, Spratford, & Duffield, 2014). As such, caution is needed in the analysis of the GPS data collected.

Finally, biological maturation of players was not collected. The effect of maturation on kicking skill development in Australian football has not been investigated and should be carefully considered as performance outcomes during maturation may be indicative of maturational status rather than the long-term performance potential (Malina et al., 2004a; 2004b; Malina & Koziel, 2014). Although research has identified maturation can influence physiological abilities such as aerobic capacity and muscular strength (Bale et al., 1993; Gastin et al., 2013; Malina et al., 2007; Pearson et al., 2006) other researchers have found skill to be independent of pubertal status (Matthys et al., 2012; Silva et al., 2010). Nevertheless, obtaining player biological maturation may have provided further insights into key time frames where kicking skill acquisition may be most predisposed to adaptation.

8.5 Future research directions

This thesis has attempted to extend the literature in regard to the development of two new kicking performance assessments. It has attempted to fill the void between the current static Australian football field-based assessments and match play. However, it would be inept to think the void has been filled. Adaptations of these assessments should be explored in an attempt to not only design assessments more representative, with stronger correlations to match play, but to also use the knowledge gained from this thesis to explore new ways of assessing the integrated technical, tactical, physiological and psychological variables. This should be done in an attempt to more objectively and accurately identify, develop and monitor talent in Australian football and other team sports.

In comparison to the current isolated and static assessments used in the Australian Football League Draft Combine, discussed in Chapter three, the Australian football field-based – dynamic kicking assessment and the Australian football small-sided game kicking assessments were a stepwise progression in their representativeness of the dynamic nature of Australian football match play. Furthermore, these assessments provide greater insights into match play performance (i.e., a player's kicking proficiency) rather than isolated technique analysis and provide a more objective assessment of kicking proficiency to enhance the accuracy of talent identification and development in junior Australian football players. However, the game of Australian football is constantly evolving (Woods et al., 2017b) and accordingly so should these assessments. As such, every effort was made to ensure the Australian football field-based – dynamic kicking assessment and the Australian football small-sided game kicking assessment were based off notational analysis. In order to maintain an attractive sport to watch, annually each year the Australian Football League review the rules of Australian football and at times implement new rules (i.e., the interchange rule). In response to these changes Australian football coaches evolve their game style and strategy (Woods et al., 2017b) to maximize their team's chance of winning. To ensure the current assessments remain representative of match play and are delivering valid and reliable results, there is a need to continually monitor the Australian football field-based – dynamic kicking assessment and the Australian football small-sided game kicking assessments. Therefore, the continued refinement of these performance assessments, in line with contemporary game strategies provides scope for future research.

Several multi-dimensional batteries have been suggested in the literature (Tribolet et al., 2018; Woods et al., 2016c); however, no objective dynamic kicking or small-sided game assessment was included. Accordingly, it would be interesting to see the Australian football field-based – dynamic kicking assessment and/or the Australian football small-sided game kicking assessment added to a multi-dimensional testing battery. The addition of a more dynamic assessment to a multi-dimensional assessment battery may provide further insights to coaches and recruiters regarding a player's overall ability to apply their isolated characteristics in a more integrated manner. Such detail would not only identify player specific strengths and limitations but also their ability to compensate for their weaknesses during match play. Coaches and recruiters could then use this information to make more informed decisions about a players developmental plan.

There is a need for longitudinal research to be conducted on the two dynamic skill assessments discussed in Chapters four and six. Whilst these Chapters provided insights into kicking skill acquisition across age and skill groups, it remains unknown how individual players progress in these assessments as they move through the Australian Football League participation pathway. Although not feasible due to time constraints within this thesis, a longitudinal study following Australian football players from U13 through to their senior playing years, utilizing the assessments outlined in Chapters four and six, would be insightful. Such information would be of considerable value to talent identification and development research in team sports and specifically to Australian football coaches and recruiters. Specifically, these results may be used to support subjective talent scout opinion, to develop greater understandings of player match play kicking competency and to enable appropriate developmental programmes to be implemented.

An interesting finding during this doctoral investigation was how kicking proficiency increases from U13 to U16 and then appears to stabilize between the U16 and U18 age groups. The improvement in kicking proficiency from U13 to U16 may indicate a key developmental period where kicking motor pattern sequencing may be developing at the greatest rate and most susceptible to improvement. The stabilization found in kicking proficiency between the U16 and U18 age groups may indicate a timeframe where kicking motor pattern sequencing is starting to consolidate and technique modification is more challenging. If future research confirms these findings, they present critical information for sport practitioners to consider. Key timeframes in player lifespans should be carefully considered for primary objectives to be taught. For example, between the ages of 13-years and 16-years training time and resources should be primarily placed into developing sport specific skills. Then, 17-years onwards, the primary focus may turn to game strategy and physical development.

The research conducted within this thesis was limited to junior male players along the Australian Football League participation pathway. Future research is required to investigate how these results compare to senior players at novice, sub-elite and elite levels and to female Australian football players. Research on kicking proficiency assessments within these groups may provide valuable information in helping to establish additional benchmarks and identify kicking characteristics from these assessments (i.e., kicking proficiency, number of kicks, physical intensity). This may assist coaches and recruiters by identifying players of all ability levels and genders who may have the potential to make the elite level in the future, rather than identifying players who display early superior qualities (primarily due to maturation) and fail to continue in their development.

Greater research on how the technical and tactical performances are influenced by biological maturation, over a longitudinal study, may provide further insights on Australian football kicking skill acquisition. When identifying athletes below the age of fifteen, differences as small as one-year in stages of puberty can have a significant effect upon an athlete. Early maturers have more developed physical attributes such as height and weight which are related to a player's strength, power and speed (Russell et al., 1998; Sheppard et al., 2012). As such, these players appear more competent than their peers and consequently more likely to attract the attention of talent recruiters (Cobley et al., 2009; Figueiredo et al., 2010). Whilst maturation has been discussed for physical attributes and mentioned for technical qualities, more research on the effects of maturation on technical and tactical performances are required. Figueiredo et al. (2010) noted how soccer-specific skills performed by players 11-14-years old were less affected by maturation than physiological attributes. Similar findings have also been reported in handball (Matthys et al., 2012) and basketball with sport-specific skill appearing to be independent of pubertal status (Silva et al., 2010). As such, additional research on the effects of maturation on Australian football kicking development could provide further insights into talent development programmes and interventions in younger age groupings so development can be more efficient and effective along the talent pathway.

Further research should also be conducted into the comparisons between small-sided game assessments and match play. Chapter six investigated how a 5v6 small-sided game was a valid and reliable measure of talent; however, Chapter seven highlighted how the Australian football small-sided game kicking assessment did not demonstrate a strong correlation to match play performances. Therefore, further research should explore this concept to identify if it is possible to create a representative small-sided game assessment where variables are more closely correlated to match play demands (i.e., pressure). Coaches and recruiters may then use this information to assess a player's capacity to perform under particular match play demands (i.e., kicking to leading player).

Additional investigations into why players execute poor deliveries of the ball may provide greater insights into the development of players for team sports. For example, a robust five-point kicking scoring assessment has been used in Chapters four, five, six and seven; however, this assessment did not include a criterion for reasons other than kicking outcome (e.g., why a kick was rated low). Reasons for a low kicking score may include decision making ability (Woods et al., 2016b), pressure (e.g., physical, time) (Ireland et al., 2019; Parrington et al., 2013), the timing of the muscle coordination (Peacock & Ball, 2018), not enough strength or speed to deliver the kick (Peacock & Ba, 2017). It is hypothesised a combination of the above would most likely influence the outcome; however, further investigations are required to confirm this. Coaches may then use this information to develop more specific intervention programmes thereby enhancing match play skill execution proficiency.

Finally, with more time and investment being placed into talent identification within team sports, there is scope to extend this research. The methods discussed throughout this thesis are applicable to other team sport pathways. These methods could assist in skill assessments becoming more representative of match play actions and therefore more indicative of match play performances. Furthermore, they could provide a more robust and objective method of identifying talent and assisting coaches with more meaningful intervention programmes.

8.6 Conclusions

The first aim of this doctoral investigation was successfully achieved by developing greater clarity around Australian football kicking skill assessment. A 5-Level Performance Assessment Model was suggested where skill assessments were positioned on a continuum according to how representative they were to match play. As the tests apply the notational analysis and move from Level-1 (laboratory analysis) to Level-5 (match-play assessment) there is a step-wise progression in the performance demands and integration of the four components to more closely represent match-play conditions. Additionally, this model provided sport coaches with greater clarification on the advantages and limitations of using each technical assessment along the continuum. It was suggested assessments from these tests could be used in conjunction with each other to profile players, track player development and display player strengths whilst identifying specific areas of improvement along the Australian football talent pathway.

The second aim was successfully achieved through the development of a valid and reliable Australian football field-based - dynamic kicking assessment. This dynamic field-based assessment was suggested as a viable option to fill the void of Level-3 on the Performance Assessment Model. The developed Australian football field-based – dynamic kicking assessment was successful in distinguishing across and between age (i.e., U14; U16; U18) and skill groups (i.e., novice; sub-elite; elite). Furthermore, the timeframe between U14 and U16 was identified as a key period where kicking skill acquisition may be most impressionable. The developed Australian football field-based – dynamic kicking assessment was the first Australian football specific kicking assessment to consider and apply match play kicking constraints to make a more representative, valid and reliable assessment.

The final aim of this doctoral investigation was successfully achieved through the development of a valid and reliable Australian football field-based small-sided game.

This small-sided game assessment was suggested as a viable option to fill the void of Level-4 on the Performance Assessment Model. Before developing the small-sided game an initial investigation occurred using four different playing number conditions to determine the influence of playing numbers on kicking and physical performances of sub-elite youth players. Overall, the results demonstrated when more technical events were required, under more pressure situations (i.e., physical and time), the 5v6 constraint appeared to be most appropriate. However, when the focus is on kicking to a contested possession balanced player numbers would appear optimal.

The aim of Chapter six was to develop a valid and reliable Australian football small-sided game kicking proficiency assessment that could differentiate between age groups (i.e., U14; U16; U18) and within skill groups (i.e., novice and sub-elite). The developed small-sided game considered and applied match play kicking constraints to make a more representative assessment. The Australian football small-sided game kicking assessment was successful in distinguishing kicking proficiency between the age groups of U14 and U16 and U14 and U18 and whilst there was an increase from the U13 to U14 age group it was not significant. An interesting finding was stabilization occurring in kicking proficiency scores between the U16 and U18 age groups. Similar to Chapter four findings, the largest improvement occurred between the U14 and U16 age group with the reliability of the small-sided game as an assessment tool assessed as “good”.

Finally, Chapter seven investigated if the technical and physical match performance outcomes can be replicated in a 5v6 small-sided game. The technical variables assessed were kicking proficiency, number of kicks executed and time pressure before disposal (i.e., under 2s, 2-4s, over 4s). The physical variables assessed were meters travelled total and per minute, maximum velocity and percentage of high intensity running. The results of this Chapter suggest kicking proficiency, the number of kicks executed, meters travelled per minute and percentage of high intensity running were all higher in the small-sided game than during match play. During match play, players have less time affordance to dispose of the ball and achieve higher running velocities than during the small-sided game. Understanding these responses could enable Australian football youth coaches to apply a more individualised kicking intervention programme to players and develop an effective periodised skill acquisition training programme throughout the training year.

Overall, this doctoral investigation developed a more practical and objective Australian football kicking assessment protocol. Coaches and recruiters may use this information to help guide the identification and development of talent across the Australian Football League participation pathway. A specific focus of the investigation was the design and implementation of two new valid and reliable kicking assessments, based off notational analysis, with each increasing in their representativeness of match play. These results suggest when designing multi-dimensional assessment batteries an isolated assessment may deliver more precise information regarding technique; however, more integrated assessments (i.e., the Australian football small-sided game kicking assessment) provide more accurate assessments of match play kicking ability. For coaches, these results provide critical insights on age and skill level kicking development and provide a time efficient option to talent assessment in Australian football. Finally, previous research has found Australian football disposal proficiency (i.e., both kicking and handballing) increases between the U10 and U15 age groups (Gastin et al., 2017); however, no studies have investigated the key timeframes for only kicking proficiency or identified the development from U13 to U18. A novel finding from this doctoral investigation was how Australian football kicking ability appears to continue in development, up to the age group of U16, and then plateaus. The largest improvement was found between the age groups of U14 to U16, indicating a possible timeframe where kicking acquisition may be more susceptible to development. Applying the findings of this thesis may provide coaches with a more sequential and time efficient method of talent identification and kicking development along the Australian football talent pathway.

8.7 References

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