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A profile of game style, physical, technical and tactical skills, and the pathways that underpin expertise in Australian youth soccer players

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A profile of game style, physical, technical and tactical skills, and the pathways that underpin expertise in Australian youth soccer players

This thesis is submitted for the degree of

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THESIS SUMMARY

The attainment of expertise has been the focus of research in many domains including music, chess and sport. This research has progressed with many theories detailing the best way to develop expertise and nurture talent in sport. Soccer is a multifaceted sport which requires a number of physical, technical and tactical skills to be successful, making it difficult to achieve expertise. Although Australia's performance on the international stage is improving, there is a lack of evidence to inform the most effective development pathways to support the next wave of talented youth soccer players. Therefore, the aim of the thesis was to understand what is required to be an expert in Australian youth soccer, and which environmental factors can influence the development of expertise in youth soccer players.

To enhance our understanding of the development of expertise in Australian soccer, the current thesis was guided by the Expert Performance Approach (Ericsson & Smith, 1991) and included three individual studies which captured expert performance, identified underlying mechanisms and examined how expertise was developed. Sixty-two male soccer players (17.0 ± 0.61 y) who represented three cohorts in Australian youth soccer; national elite (Australian Institute of Sport), state elite (state institute) and sub-elite (state league) participated in this study.

Study One captured expert performance through an in-depth analysis of the match characteristics of the three levels of expertise. A total of 24 matches across the three levels of expertise in Australian youth soccer were analysed, with each match videoed and manually coded using SportsCode according to frequently used match characteristics from the literature. A hierarchical cluster analysis was used to see if teams with similar technical characteristics could be grouped together in order to make inferences about distinctive tactics and game styles. There were three game styles identified across the cohorts, with the state and national elite

cohorts forming two distinct clusters, whilst the sub-elite teams clustered together based on technical output. More specifically, the two elite cohorts executed two different possession styles of play, while the sub-elite cohort played a direct style of game. Although it was clear that technical output and game styles differed across cohorts, it was not clear which underlying mechanisms allowed teams to play this way.

The aim of Study Two was to identify which skills could distinguish the three levels of Australian youth soccer players and contribute to an explanation of the different game styles identified in Study One. This was done using a multifaceted testing battery including physical, technical and tactical tests. The physical tests included intermittent endurance, sprinting, change of direction and vertical jumps, the technical tests included short and long passing, dribbling and shooting, while the tactical test was a perceptual-cognitive decision-making task which required players to choose the correct option in a video-based task. There were a number of physical, technical and tactical outcome measures that could distinguish between cohorts based on the Receiver Operating Characteristic curves. The most prominent tests included the Yo-Yo Intermittent Recovery Test Level 1, 30m sprint and 20m flying start, height, Loughborough Soccer Passing Test, long passing test, ball control, shooting test and perceptual-cognitive decision-making task. Furthermore, the multidimensional analysis could clearly differentiate players from each cohort based on a Cumulative Total Score for each player. It is evident that the underlying mechanisms for expert performance in Australian youth soccer included elements of physical, technical and tactical prowess which may contribute to the differences in game styles observed in Study One.

Study Three examined how expertise is developed in Australian youth soccer players. The participants completed the Development History of Athletes Questionnaire (DHAQ) (Hopwood, Baker, MacMahon, & Farrow, 2010). A decision tree induction analysis was used to determine which developmental factors contributed most to the predictor variable, the

Cumulative Total Score. The amount of sport specific practice distinguished the two highest skilled groups from the lower skilled players. There were then two distinct pathways taken by the elite Australian youth soccer players. The first pathway included players who were later born in their family and had older siblings that participated in other sport, which contributed to their development in soccer. The second pathway included those players who were born early in their family (first or second), with this group specialising later in soccer (after the age of 13), compared to the second tier of athletes.

Overall it was clear that there were distinguishing game styles for various levels of Australian youth soccer players. The elite players had underlying physical, technical and tactical attributes that allowed them to execute a possession-based game style. This thesis has provided evidence that the national elite players had followed a different pathway and been exposed to different environmental influences compared to the sub-elite players, factors that had contributed to their current level of expertise and success. This work provides Football Federation Australia and associated personnel with a strong framework upon which to base their talent identification and development programs given this thesis was able to provide evidence of distinct game styles, physical, technical and tactical skills distinguishing playing levels and differing pathways exhibited by the athlete cohorts.

SIGNED DECLARATION

I certify that this thesis does not, to the best of my knowledge and belief:

i. incorporate without acknowledgment any material previously submitted for a degree or diploma in any institution of higher education;

ii. contain any material previously published or written by another person except where due reference is made in the text of this thesis; or

iii. contain any defamatory material;

Signed… 

Brad Keller (20/07/2018)

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Keller, B. S., Raynor, A. J., Bruce, L., & Iredale, F. (2016). Technical attributes of Australian youth soccer players: Implications for talent identification. *International Journal of Sports Science and Coaching, 11*(6), 819-824. doi:10.1177/1747954116676108

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Keller, B.S., Raynor, A.J., Bruce, L., Iredale, F. (2016) Multidisciplinary approach to talent identification in Australian soccer. *Presented at Research to Practice conference (Exercise and Sports Science Australia),* Melbourne, Australia.

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Keller, B.S., (2017) Applications of high performance at a semi-professional level. *Presented at the Adelaide Athletic Development Conference*, Adelaide, Australia.

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ABBREVIATED TERMINOLOGY

ANOVA	Analysis of Variance
ASC	Australian Sports Commission
AUC	Area Under the Curve
DHAQ	Developmental History of Athletes Questionnaire
ES	Effect Size
FFA	Football Federation Australia
FIFA	Fédération Internationale de Football Association
GPS	Global Positioning System
ICC	Intraclass Correlation Coefficient
LSPT	Loughborough Soccer Passing Test
LSST	Loughborough Soccer Shooting Test
MANOVA	Multivariate Analysis of Variance
PHQ	Participation History Questionnaire
ROC	Receiver Operating Characteristic
TEM	Technical Error of Measurement
TID	Talent Identification
VO_2 max	Maximum Oxygen Uptake
WA	Western Australia
Yo-Yo IR1	Yo-Yo Intermittent Recovery Test Level 1

CHAPTER ONE – INTRODUCTION

Soccer, also known as football, is an immensely popular sport with Fédération Internationale de Football Association (FIFA) estimating that there are 250 million soccer players world-wide (Weil, Rollin, Giulianotti, Joy, & Alegi, 2017). This popularity extends to Australia with the most recent Australian Bureau of Statistics survey revealing 309,700 (21.7%) of males between the ages of 5-14 years participated in outdoor soccer around the country, making it the most popular sport for this particular cohort (Australian Bureau of Statistics, 2012). Reilly, Bangsbo, and Franks (2000) explain that the attractiveness of becoming an elite soccer player is growing as a result of the popularity of the sport and the financial benefits associated with playing in high profile competitions. Although the popularity of male soccer in Australia is evident through participation numbers, this has not translated to sustained success on the international stage for the national team. Australia has qualified for the last four male World Cup finals after a 32-year absence, including the 2018 World Cup, however 2006 is the only year they have progressed out of the group stage. In order to create sustained success at the international senior level, it is important to establish thorough and evidence-based developmental pathways to facilitate the improvement of the next generation of players. As such it is critical that we not only identify players who possess the proficiency to play at the highest level of this world-game but also have processes in place to develop them to reach their potential. Australian soccer needs to analyse successful international soccer programs, and even other sports, to create a successful development program to increase long-term sustainable success. Sports scientists need to support and educate Football Federation Australia (FFA) and coaches alike by providing current strengths and weaknesses within the system and identifying performance benchmarks for junior athletes. This will assist to fast track development and focus on the most critical areas along the pathway.

There are many demands throughout a soccer match, including physical, technical and tactical components, and because of this multifaceted nature, it is a difficult sport to achieve a high level of performance (Güllich, 2013; Haugaasen & Jordet, 2012; Reilly, Williams, Nevill, & Franks, 2000; Sarmento, Anguera, Pereira, & Araújo, 2018). Soccer is intermittent in nature, requiring high-intensity running and sprinting (Mohr, Krustrup, & Bangsbo, 2003), however, athletes are also required to have a large aerobic base (Di Salvo et al., 2007). Although the elements of athleticism and endurance are obvious requirements for the expert performer, specific technical and decision-making skills are thought to be the most critical aspect of soccer (Bush, Barnes, Archer, Hogg, & Bradley, 2015; Rampinini, Impellizzeri, Castagna, Coutts, & Wisløff, 2009; Reilly, Bangsbo, et al., 2000). During a match, players perform a number of discrete technical skills including heading, shooting, tackling and crossing, with passing being the most commonly executed skill, which they may execute between 40-60 times a match (Dellal et al., 2011). These technical components can underpin game styles, which also require athletes to have great game sense and decision-making prowess, with previous research investigating different game styles through the execution of these technical actions. Due to the multitude of different skills and attributes required throughout soccer matches, it is clear that developing expertise in this sport can be difficult and there needs to be a scientific approach underpinning the developmental pathways towards success as an individual and team.

From a broader perspective, in almost every aspect of life there are individuals who excel or perform at a higher level compared to the majority of the population (Ericsson & Smith, 1991). Once talented individuals have been identified, they still need to do a considerable amount of work before they can be considered experts in their field. An expert can be defined as “a person who is very knowledgeable about or skilful in a particular area” (Concise Oxford English Dictionary, 2006, p.501). Expert performance has been the focus of an expanding body of literature in many different domains including music, chess, medicine

and sport (Ericsson, 2008; Ericsson, Krampe, & Tesch-Roemer, 1993; Ericsson, Whyte, & Ward, 2007). Researchers have developed several theories and frameworks for acquiring expertise in various fields to help explain the differences between extraordinary and average performers.

Often the expertise debate involves nature (genetics) versus nurture (environment), and although hereditary components have a huge influence on an individual's attainment of expertise, their environment also plays a significant part (Baker, Horton, Robertson-Wilson, & Wall, 2003; Ericsson et al., 1993). There are many environmental factors that have been shown to influence the development of expertise, although the volume of high quality training required to reach expert status has received considerable attention in the literature and is thought to be one of the most important contributors (Côté, Baker, & Abernethy, 2007; Ward, Hodges, Starkes, & Williams, 2007). Initial findings in chess revealed that Grand-master players had significantly more experience compared to lesser skilled chess players, with the authors concluding that individuals are required to complete ten years of experience before becoming an expert (Simon & Chase, 1973). These conclusions have since been applied to many other domains including sport, with this ten year rule being explored in swimming (Kalinowski, 1985), tennis (Monsaas, 1985), hockey, netball and basketball (Baker, Côté, & Abernethy, 2003b), with the consensus that it took athletes ten years to develop expertise in their respective sports. The ten year rule was adapted to include the amount of experience and training within an expert's domain, with musicians accumulating over 10,000 of practice, which has since been applied to multiple domains (Ericsson et al., 1993). Although there is substantial evidence that players do need a base level of practice, there is decreasing support for the blanket '10,000 hours' of practice rule with various domains, including sport, finding experts had substantially less practice hours (Baker, Côté, et al., 2003b; Bruce, Farrow, & Raynor, 2013; Campitelli & Gobet, 2011).

In recent years, this theory has evolved as researchers investigate the various pathways and practice histories of experts to delve deeper into the specific activities that lead to their superior performance, rather than just volume of training (Baker, Côté, & Abernethy, 2003a; Côté, Baker, & Abernethy, 2003). More specifically, scientists are starting to question whether there is a magic number of hours to become an expert in sport, or is it more likely that the type of training and practice is involved in the development of expertise? One area that researchers have explored and debated is whether it is more beneficial for athletes to diversify their time and play a range of sports to develop a wide range of skills and attributes or focus on one sport to increase the sport specific training (Baker, 2003; Baker, Horton, et al., 2003). In English soccer, it has been shown that professional players engage in the sport at an early age and participate in more sport specific practice and play during childhood compared to players who failed to reach the professional level, although the authors stressed that this may not be optimal for developing sporting expertise (Ford & Williams, 2012). Alternatively, in Brazil it was shown that a crucial component in the development of soccer players was the incidental play activities that players experienced whilst growing up (Araujo et al., 2010). This highlights that there are other activities outside of sport specific practice that can contribute to the development of expertise, which may also be country specific due to environmental and cultural aspects.

The global popularity and substantial financial rewards to be gained in a competitive domain such as soccer means developing talent and ultimately attaining expertise is extremely difficult to achieve (Reilly, Bangsbo, et al. 2000). Due to the competitiveness of international soccer and the aforementioned complexities of developing talent and expertise, it is evident that countries which have created strong developmental pathway structures with long-term athlete development in mind have the best chance for sustained success. Due to the lack of predictive value in most talent identification (TID) programs (Durand-Bush & Salmela, 2002;

Reeves, Littlewood, McRobert, & Roberts, 2018), there needs to be a focus on the structure of these development programs. The German Football Association [Deutscher Fußball-Bund] has demonstrated the value of effective TID and development programs in soccer following an overhaul of their structure in 2001 (Güllich, 2013), which has resulted in recent significant on-field international success including winning the 2014 World Cup. To ensure that early and late developers receive the same opportunities to progress, the German Football Association [Deutscher Fußball-Bund] created two stages of their TID and long-term performance progress program (Güllich, 2013). The 'elite promotion' pathway allows identified players to train in their national and elite youth academies, while their 'talent promotion' program ensures talented players, that may have missed selection into the elite programs, still have the opportunity to improve with access to elite coaches and training (Güllich, 2013). This method is supported by the literature as Vaeyens, Lenoir, Williams, and Philippaerts (2008) explains that both innate abilities (nature) and environmental characteristics (nurture) contribute to the successful development of elite performers and also to the unpredictability of gifted youngsters. It is therefore critical that the developmental system does not exclude players who have may develop at a slower rate and still provide them access to an elite environment as has been implemented by Germany. The best methods to identify and develop talent are still unclear (Sarmento et al., 2018) and it is therefore important to continually investigate development programs and processes.

Football Federation Australia (FFA), in an effort to develop elite players who would be competitive on the international stage, released a national curriculum, including a national talented player pathway in 2009, which has been continually remodelled over the last eight years (FFA, 2009, 2017). This national curriculum incorporates specific coaching and game styles, with the aim of developing junior players into expert performers who can represent Australia long-term. This pathway is based on scientific research and philosophies from other

youth academy systems, particularly those from Europe which suggest that youth development should focus on long-term technical development as opposed to short term results (i.e., winning) (FFA, 2009). This has resulted in the national curriculum outlining discrete stages of development including the discovery phase, skill acquisition phase, game training phase and performance phase to manage the development of aspiring players nationwide. For Australia to continually improve the performance of the international team, it is crucial to assist and support the current developmental model and investigate the skills and experiences of the current players at different levels of the developmental pathway. When looking at aspiring soccer players it is essential to take an evidence-based approach and understand the complexity of developing expertise. It is important that sports scientists assist the organisations in the evaluation of players and their progression along the developmental pathway. Reilly, Williams, et al. (2000) outlined a multifaceted model of potential predictors of talent in soccer ranging from physical, physiological and perceptual-cognitive skills to sociological, psychological and personality characteristics, showing the complexity of unearthing junior talent. Establishing benchmarks for these various skills at different points along the pathway will be a useful tool for coaches and administrators to understand players' strengths and weaknesses. Farrow, Reid, Buszard, and Kovalchik (2017) suggest that establishing critical factors and limitations of expert performance is the 'holy grail' for sports coaches, athletes and administrators, as it allows the pathways and systems to become streamlined and efficient.

1.1 Theoretical Framework

The development of expertise is a dynamic and multifaceted process requiring a holistic approach when investigating and understanding progressions. The introduction alluded to the complexity and multidimensional nature of soccer which is why the thesis will use a theoretical framework that captures the development of expertise in a multifaceted manner. Specifically, this thesis will draw on the Expert Performance Approach (Ericsson & Smith, 1991) to

underpin the subsequent investigations into the development of expertise in Australian youth soccer players.

The Expert Performance Approach, established by Ericsson and Smith (1991), guides researchers to take a holistic approach to expertise research. It enables researchers to delve deeper into the understanding of the development and performance of expertise by providing a standardised approach across domains. Having this standardised approach ensures that the ability to capture and analyse superior expert performance within natural environments or in representative tasks is measurable and reproducible, as opposed to intuition or automaticity (Ericsson et al., 2007). This theoretical framework incorporates three discrete stages; a) capturing expert performance, b) identifying underlying mechanisms and c) examining how expertise is developed as shown in Figure 1.

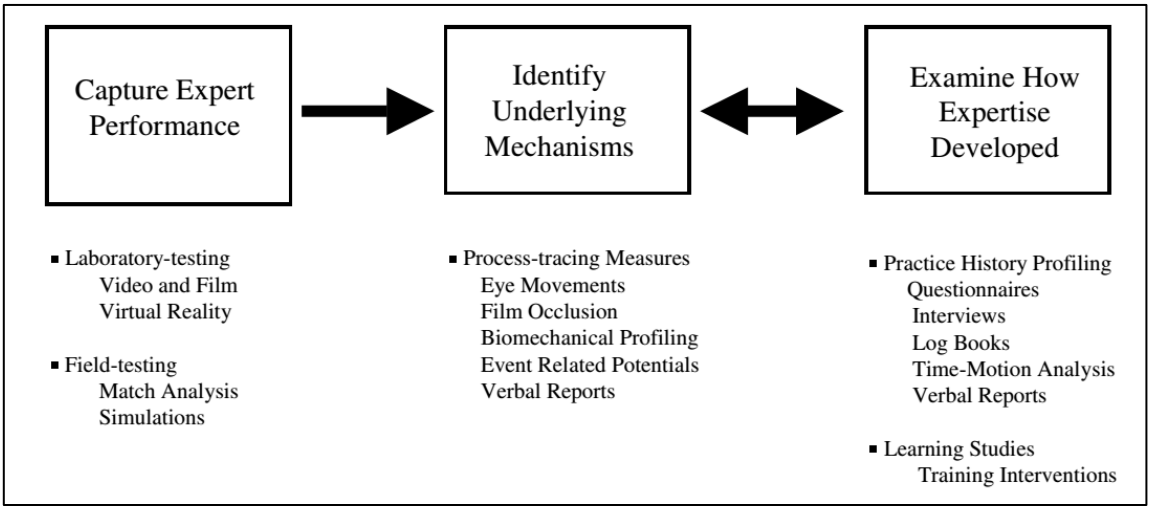

Figure 1. Expert Performance Approach as outlined by Williams and Ericsson (2005) (with permission to reproduce from Elsevier).

The Expert Performance Approach has typically been applied to the analysis of discrete skills within an expert performance e.g., expertise in decision-making, which represents one construct within an overall performance. The current thesis will apply the Expert Performance Approach more broadly to the game of soccer using a multidimensional approach, and as a result will capture expert performance as a whole. Rather than focusing on a single discrete

skill, the current thesis will acknowledge the range of attributes required for successful soccer performance with these attributes broadly classified as physical, technical or tactical skills.

Irrespective of which pathway(s) is(are) determined to be the most effective in the development of expertise, we must initially understand the difference between the expert performer and their less skilled counterparts. Therefore, the first stage of the Expert Performance Approach, capturing expert performance, involves laboratory or field based analysis/testing which should provide a consistent measurement of performance (Ericsson & Smith, 1991). The main goal of this stage is to capture the expert within their domain, therefore if a laboratory setting is used it needs to strictly replicate the same processes experts use in their discipline (Williams & Ericsson, 2005). In an effort to capture experts performing in their natural environment, thus increasing ecological validity, match analysis has been utilised in many sports including netball, soccer and volleyball (Bruce, Farrow, Raynor, & May, 2009; Lago-Peñas, Gómez-Ruano, & Yang, 2017; Sarmento et al., 2014; Silva, Sattler, Lacerda, & João, 2016). Match analysis allows coaches and sports scientists to analyse decision-making (Bruce et al., 2009), classify game styles (Lago-Peñas et al., 2017) and to evaluate how teams of varying standards play their respective sport (Bradley et al., 2013). To enhance our understanding of the expert performer in Australian soccer, we require increased knowledge of what the expert performer is doing during a match, particularly in the youth levels. The current study will 'capture expert performance' of Australian youth soccer through analysing matches and characterising game styles. This will allow the performance of Australian youth soccer players of different expertise levels to be captured during their regular on-field environment, taking a holistic approach and increasing the ecological validity.

Within the second stage of the Expert Performance Approach the purpose is to identify mechanisms underlying expert performance (Ericsson & Smith, 1991). Researchers have typically failed to employ this second phase of the approach, instead opting to only focus on

determining the differences in expert performance (Williams & Ericsson, 2005). This has been done in a number of ways, for example examining visual search strategies which underpin decision-making in sport (Williams & Ericsson, 2005). In this thesis the second stage of the Expert Performance Approach will be used to 'identify underlying mechanisms' of the match play, and will therefore investigate the physical, technical and tactical skills (mechanisms) that allow players to perform at their relative level of expertise. Thus, the skills possessed by each player will be deemed to be the underlying mechanisms which allow them to execute the game style displayed in Study One.

The final stage of the Expert Performance Approach will investigate how a player's expertise has been developed (Ericsson & Smith, 1991). This phase explicitly examines the past experiences of experts to help understand how they acquired the knowledge and skills that enhanced their performance. Although researchers have identified the pathways that athletes could take to reach expertise, including diversification and specialisation (Côté et al., 2003), the development of expertise is most likely a result of a number of related factors (Ward et al., 2007). Environmental factors, such as familial and cultural influences and access to facilities and coaches, play a substantial role in developing expertise (Baker, Horton, et al., 2003), which can constrain the amount and quality of training athletes complete in their developmental years. The third study will use a questionnaire to investigate the developmental history of the participants and examine how expertise is developed in Australian youth soccer players. This will help to understand what might be contributing to potential differences in underlying skill levels and potentially differing game styles between levels of expertise at this point of the developmental pathway.

1.2 Overview of Thesis

The overall aim of this thesis is to understand the development of expertise in Australian youth soccer, through the application of the Expert Performance Approach, at three

different skill levels of age-matched participants; sub-elite youth (under 18 state league), state elite youth (state institute) and national elite youth (national institute). In accordance with the three stages of the Expert Performance Approach this thesis includes three separate cross-sectional studies that capture expertise, identify underlying mechanisms and determine how expertise is developed. This thesis is presented as six chapters which are briefly outlined below. Chapter One provides an introduction to the body of work while Chapter Two synthesises and critiques the background literature to set up the individual research studies. Chapters Three, Four and Five will each present a research study that was designed to answer research questions associated with a specific stage of the Expert Performance Approach. Each chapter will include an introduction to the specific literature, methodology, results and discussion. It is important to note that Chapter Four is based on three peer-reviewed, published journal articles. The article from Chapter Five is currently under review, with revisions applied and re-submission to occur to the same journal following thesis submission. Chapter Six will provide a discussion of the findings that will address the overall aim of the thesis, and practical applications that are based on the knowledge and evidence elicited from this program of studies.

The overall aim and research question for each study can be found below and are also repeated in the introduction of each chapter to assist the reader.

Study One (Chapter Three): The aim of this study was to capture the expert performance in Australian youth soccer by analysing the match characteristics across different levels of expertise.

RQ1. Are there differences in the match characteristics between levels of expertise, namely sub-elite, state elite, and national elite, in Australian youth soccer as measured by technical and tactical parameters? If yes, where do they occur?

H_1: There will be significant differences in match characteristics between the three levels of expertise in Australian youth soccer. Specifically, the national and state elite teams will display a possession style of play due to their involvement in the FFA pathway, whilst sub-elite teams will display a direct style of play.

Study Two (Chapter Four): The aim of this study was to identify the mechanisms underlying the expert performance in Australian youth soccer through an analysis of a range of physical, technical and tactical skills.

RQ2. Are there differences in the underlying physical, technical and tactical skills between levels of expertise (sub-elite, state elite, and national elite) in Australian youth soccer players as measured by a number of performance tests? If yes, where do they occur?

H_1: There will be significant differences in skills (physical, technical and tactical) between the three levels of expertise in Australian youth soccer. Specifically, the national elite players will outperform the state and sub-elite players in physical, technical and tactical testing.

Study Three (Chapter Five): The aim of this study was to examine how expertise is developed in Australian youth soccer players through an analysis of the developmental pathways.

RQ3. Are there differences in the developmental pathway between levels of expertise (based on physical, technical and tactical skill level) in Australian youth soccer players as determined using a developmental history questionnaire? If yes, where do they occur?

H_1: There will be significant differences in the developmental pathway between players of differing skill levels in Australian youth soccer. Specifically, the higher skilled players will follow distinct pathways with specific environmental factors contributing to their development.

1.3 Significance of the Research

Australia invests a significant amount of money into the development of soccer through the FFA and Australian Sports Commission, therefore all decisions made should be evidence-based to ensure the success of the program and the judicious expenditure of public funds. Australian soccer needs to continually improve and modify the development programs around the country to ensure sustained, long-term international success. The objective of any serious athlete is to develop into the best possible player and ultimately become an expert in their sport. Therefore, parents and children are investing substantial time and/or money into participation which necessitates the provision of a system that allows these athletes the best possible chance of achieving their dream of becoming an elite soccer player. Based on the match characteristics of elite players and knowing exactly what skill level youth soccer players need to reach to match their elite counterparts, training programs can be tailored towards the specific demands of each level. This will significantly benefit youth soccer athletes, parents and coaches by elucidating the most appropriate pathway for the development of expertise. Additionally, this research will significantly assist FFA in streamlining the developmental pathways for Australian soccer players to ensure long-term success for the country on the international stage. Although interest is growing, there is still insufficient research on the development of expertise in sport, and a dearth of relevant research specifically on Australian soccer.

1.4 Delimitations

A delimitation of this study is that only male Australian youth soccer players and the associated Australian competition levels were used. It will also be delimited to analysing physical, technical and tactical components of soccer as beyond that (e.g. psychological components) would be outside the scope of the study due to a restriction of time, finances and resources.

CHAPTER TWO – LITERATURE REVIEW

2.1 Chapter Overview

This literature review will be aligned to the three stages of the Expert Performance Approach that underpins the thesis, reviewing literature associated with each of the stages as it relates to soccer. Therefore, this chapter will be structured in three main sections: capturing expert performance, identifying underlying mechanisms and examining how expertise is developed. The first section will review the current literature around match demands in soccer to understand what is involved in expert soccer performance in a natural setting. This will incorporate all elements of match play including physical, technical and tactical characteristics. The second section will review the literature around underlying mechanisms of expert performance in soccer. More specifically, this will include the physical, technical and tactical skills that underpin soccer performance, while also assessing methods to test these skills. The final section of the literature review will investigate how expertise is developed in soccer including training history, familial background, and specific pathways taken by athletes.

2.2 Stage One (Capturing Expert Performance): Match Demands

As with all sports, international soccer has transformed substantially over the previous 40 years (Norton & Olds, 2001; Wallace & Norton, 2014) with player density, passing rate and game speed all increasing significantly in World Cup finals. For this reason, the following review has been limited to studies involving matches from the past ten years which will ensure the focus will be on the recent game style without evolutionary effects. As explained by Williams and Ericsson (2005) the first stage of the Expert Performance Approach looks to capture experts performing their skill within their domain. To better understand what skills are necessary for success or the development of expertise in a particular sport we must first understand the requirements of the sport. Due to soccer being a multifaceted sport, athletes

must move faster, have better anticipation, and demonstrate increased technical and tactical ability compared to the opposition for a longer period of time in order to be successful (Carling, Reilly, & Williams, 2008).

Performance analysis techniques have been used to increase our knowledge in sport through research and practical application, with the depth and accuracy of this information evolving over time due to technological advances (Wright, Atkins, Jones, & Todd, 2013). These techniques have given coaches significant support as they are only able to recall 30-50% of key performance events throughout matches, highlighting the limitation of coaches' observations (Wright et al., 2013). The technological advances and increasing research into performance analysis has allowed for in-depth, reliable and valid information to be used during and after matches (Travassos, Davids, Araujo, & Esteves, 2013). In the practical setting, this information can be used to complement the coach's subjective observations, identify strengths/weaknesses, observe performance over time, and evaluate the effectiveness of training programs (Carling, Williams, & Reilly, 2007; Reeves & Roberts, 2013).

Soccer is a sport that has lent itself to performance analysis with a number of different methods implemented over the years to capture the physical demands (e.g., global positioning systems, heart rate monitoring, semi-automated tracking) or technical and tactical indicators (e.g., manual notational analysis, semi-automated video tracking systems) during match play or training (Randers et al., 2010). A great deal of the literature has focused on the physical demands of the game (Bradley, Di Mascio, Peart, Olsen, & Sheldon, 2010; Bradley et al., 2009; Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009), however other studies have tried to incorporate technical and tactical analysis of soccer matches (Fernandez-Navarro, Fradua, Zubillaga, Ford, & McRobert, 2016; Wallace & Norton, 2014). Through the use of technology and operational definitions, match analysis provides quantitative information to complement subjective observations (James, 2006a). Operational definitions allow consistent measurements

of specific elements of match play. There have been a number of studies describing the physical, technical and tactical features of a game with many factors such as match status, opposition, location, playing position, leagues, fatigue, and the evolution of the game investigated to provide an understanding of the game demands (Carling, le Gall, & Dupont, 2012; Castellano, Casamichana, & Lago, 2012; Dellal et al., 2011; Dellal, Wong, Moalla, & Chamari, 2010; Fernandez-Navarro et al., 2016; Lago-Peñas & Lago-Ballesteros, 2011; Lago, 2009; Wallace & Norton, 2014). The types of analysis are presented in Figure 2 (Sarmento et al., 2014). Underpinning these analyses, there are common variables that sports scientists and coaches analyse to find similarities in game styles or patterns of play within soccer.

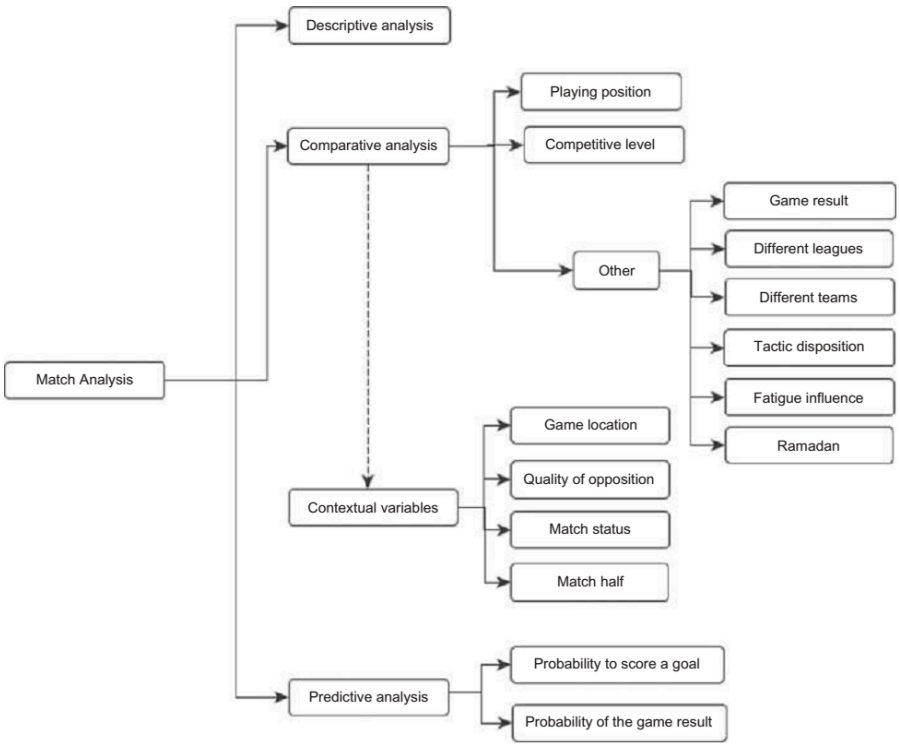

Figure 2. Types of match analysis as outlined by Sarmento et al. (2014) (with permission to reproduce from Taylor & Francis)

The difficulty for researchers and sports scientists alike, is to determine the most crucial performance indicators that will give coaches precise feedback or answer specific questions. It can be a complex task to manipulate and refine the hierarchy of actions with specific outcomes

in order to gain adequate information which is still time efficient. Developing technical codes to represent these variables of interest requires strict definitions that can answer individual research or game performance questions. Hughes and Franks (2004) discuss the difficulty of collecting objective data during dynamic, changing environments, with the authors suggesting the most logical method is using a structured analysis such as flowcharts or hierarchy of the game. More specifically, it is recommended that once the key codes are identified, they can be linked to various refined outcomes (e.g. area, player, time, success, reason) and used for analysis of movement, technical/tactical evaluation or statistical compilation (Hughes & Franks, 2004).

When it comes to analysing technical instances within matches, commonly used variables include possession, passing (success percentage), passing sequence, heading, tackles, shots (on/off target), crosses, dribbling, set pieces, clearances and interceptions (Bradley et al., 2013; Dellal et al., 2011; Dellal et al., 2010; Fernandez-Navarro et al., 2016; Hughes & Franks, 2005; Rampinini et al., 2009). The technical and tactical demands of soccer have been reported in various ways and like the analysis of physical qualities, the technological advancements over the past decade have resulted in a substantial increase in the use of notational analysis. A majority of the notational analysis studies have used manual notational analysis systems (e.g. SportsCode) or semi-automated video analysis systems (e.g. Prozone, Amisco, Sics) to monitor technical instances, listed above, within matches. Each technical code can also have an outcome measurement (for example success or direction of a pass), which have then been used to make inferences about types of tactical styles.

Some studies have further analysed these technical aspects by using different zones to understand what areas of the pitch important instances occur, for example, what part of the pitch passes, interceptions, crosses or shots occur (Fernandez-Navarro et al., 2016). Other ways researchers have looked at potential game styles is to measure types of passes (direction, length

etc), passes per possession (every time the team has the ball before turning it over), shots per 1,000 possessions, and shots after different passing sequences (Fernandez-Navarro et al., 2016; Hughes & Franks, 2005; Rampinini et al., 2009). Some studies have completed more specific analysis on only one aspect of play, for example the passing sequences leading to goals scored in World Cups (Hughes & Franks, 2005). The following sections will provide specific detail on the match demands of soccer for physical, technical and tactical aspects of performance.

2.2.1 Physical match demands of soccer

Soccer is a multidimensional sport which involves numerous interacting components to be successful as has already been highlighted. Although technical parameters have had a higher association with team success compared to physical parameters (Bush et al., 2015; Carling, 2013; Castellano et al., 2012), there is a large physical component required in soccer which will be explored in more detail throughout the review. The importance of physical prowess in soccer is displayed by the physical demands of the game (Stolen, Chamari, Castagna, & Wisloff, 2005), difference in physical output between leagues of various standards (Bradley et al., 2013; Dellal et al., 2011), and the effect that physical performance has on technical proficiency throughout games (Rampinini et al., 2008). There has been a large focus on the physical components of match play in the literature, particularly with the increase in technology to allow accurate, semi-automated trackers to capture various physical parameters of all players on the field (Bradley et al., 2009; Di Salvo et al., 2009; Drust, Atkinson, & Reilly, 2007). This focus on the physical parameters has allowed practitioners to develop specific training regimes to condition soccer players in a more evidence-based way (Carling, 2013; Carling, Bloomfield, Nelsen, & Reilly, 2008), which will continually evolve the physical output of soccer players.

Soccer is intermittent in nature, requiring high-intensity running and sprinting (Mohr et al., 2003), however, athletes are also required to have a large aerobic base. The expectation

of an elite level soccer player is that in a game they can run approximately 10-12 km at 80-90% maximum heart rate (Di Salvo et al., 2007; Stolen et al., 2005), sprint every 90 s and perform short-term high-intensity efforts every 30 s (Reilly, Bangsbo, et al., 2000). These short-term high-intensity bouts include sprinting, jumping, changing direction and kicking, interspersed with short recovery periods (Akenhead, Hayes, Thompson, & French, 2013; Bravo et al., 2008; Stolen et al., 2005). Haugen, Tønnessen, and Seiler (2013) suggest that although sprinting only constitutes 8-12% of the total running distance, it is during this high-intensity running that match outcomes are decided, making the physical capabilities of an athlete crucial to success.

The physiological demands of soccer during matches or training have been examined in numerous ways, particularly as technology has progressed to include techniques such as global positioning system (GPS), heart rate monitoring and time motion analysis. Motion analysis is the technological system that has progressed the most over the years with semi-automated video camera systems progressing rapidly to become reliable and valid monitoring tools for time spent in various movement categories (Carling, Bloomfield, et al., 2008). Although this system is becoming more reliable, there have been distinct differences when comparing the results of GPS and video analysis systems (Randers et al., 2010). Unfortunately, portable monitoring devices were prohibited from use during matches by the international governing body worldwide (Carling, 2013). However, this ban was lifted in 2015 which will help future researchers and practitioners, although it will take some time for longitudinal data to become available and be of use.

The most frequent physical variables that are monitored during game play are the total distance, work rate (distance/time) and time or distance within various velocity bands (e.g. walking, jogging, running, high-speed running and sprinting) with and/or without the ball (Bradley et al., 2013; Buchheit, Mendez-Villanueva, Simpson, & Bourdon, 2010; Bush et al.,

2015; Carling, 2013; Dellal et al., 2011; Di Salvo et al., 2007). Numerous studies have analysed the 'high intensity running' and 'sprinting' distance of various teams around the world, with the classification of velocity bands being slightly different between studies making it necessary to be cautious when interpreting and comparing results. As suggested by Sarmento et al. (2014), there needs to be uniform and standardised categories and classification of activities during matches. Studies generally classify high intensity running as distance covered between 19-21km/h up to 23-25mh/h, whilst sprinting is usually categorised as 23-25km/h and above (Bradley et al., 2011; Bush et al., 2015; Dellal et al., 2010; Di Salvo et al., 2007). Interestingly there has been a huge increase in the percentage of match time spent in high intensity running (between 24-36% increase) and sprinting (50% increase) over the last five years, for all positions, which demonstrates the evolving demands of the game and the physical capacity of players has to mimic this (Bush et al., 2015). Studies have compared the running profiles of players in different countries (Dellal et al., 2011), varying playing standards (Bradley et al., 2013), playing positions (Bush et al., 2015; Dellal et al., 2010; Di Salvo et al., 2007), formation (Bradley et al., 2011), age groups (Buchheit et al., 2010), and in relation to fatigue (Rampinini et al., 2009).

There has been plenty of descriptive research outlining the physical output of senior and junior soccer matches. The majority of the research has shown that senior players cover an average distance of 9000-12000m during the match (Bush et al., 2015; Dellal et al., 2010; Di Salvo et al., 2007; Stolen et al., 2005). To date there has been little work investigating the game demands of youth soccer, however it has been shown that the match running performance (total distance and high speed running) of elite youth players increases rapidly at a young age and then plateaus as they approach the older age groups from U12 to U18 soccer and is dependent on playing position (Buchheit et al., 2010; Saward, Morris, Nevill, Nevill, & Sunderland, 2015). Youth players run less than senior cohorts with Saward et al. (2015) reporting U13 to

U18 cohorts cover between 6500 to 8900 m, with reduced game time in the younger players also influencing the total distance covered.

Another area of research has been how positional differences can influence the physical output of soccer players. As soccer is a nomadic game, players are free to run anywhere on the pitch, however due to tactical and positional structures the physical outputs of players in varying positions has been shown to differ (Bradley et al., 2013; Bush et al., 2015; Dellal et al., 2010; Di Salvo et al., 2007). The most frequently categorised positions in the literature are central defenders, full backs (wide defenders), central midfielders, wider midfielders and attackers, although there are some slight variations with Dellal et al. (2010 and 2011) including attacking and defensive midfielders. Specifically, in terms of total distance run in a match, central midfielders cover 11000-12300m, wide midfielders 11000-12200m, attackers 10300-11400m, central defenders 9800-11000m, full backs 10600-11500m and goal keepers obviously require less running at around 4000m (Bradley et al., 2013; Dellal et al., 2011; Dellal et al., 2010; Di Salvo et al., 2007; Stolen et al., 2005).

As suggested before, the velocity bands and definitions for high intensity running and sprinting differ between studies, however they still give an indication of physical profiles for playing positions. Across multiple studies, central defenders had the lowest amount of high intensity running (230-668m), followed by full backs (274-899m), attackers (300-896m), central midfielders (320-958m) and wide midfielders (335-1095m) (Bradley et al., 2013; Dellal et al., 2010; Di Salvo et al., 2007). Sprinting output followed a slightly different trend with central defenders recording 153-245m, central midfielders 217-339m, full backs 241-402m, attackers 290-405m and wide midfielders 235-485m.

With this information it is possible to start profiling different positions, with central defenders covering the lowest total distance, high speed running and sprinting (excluding goal keepers). Full backs and attackers cover more distance and high intensity running than the

central defenders, however the central and wide midfielders excel in these areas. The central and wide midfielders accumulate the most total distance and high intensity running. Sprinting is the variable that distinguishes the central and wide midfielders, with wide midfielders running at these high speeds more often throughout games. It is evident that specific positions demand a higher physical component than others.

There have been a number of studies that have analysed the physical output of various leagues, whether that be across countries or differing competition levels. In terms of the amount of high intensity running performed in the differing leagues, the research has been equivocal, with Mohr et al. (2003) finding elite players (Elite European team in Champions League, ranked 1-10 on the official FIFA list) sprinted more and performed more high intensity running, which was responsible for them covering further total distance than the moderate class players (Danish team, ranked between 10-20 on official FIFA list). However, this was contradicted by Bradley et al. (2013), who showed players in the English Premier League completed less high intensity running, compared to the lower standard competitions (Championship and League 1). This was reiterated by Rampinini et al. (2009) who found that players from successful teams ran a lower total distance, in all velocity ranges, than less successful teams.

Although it seems that lower level teams elicit a higher physical output, it is interesting that the comparison of leagues has found differing results. In a comparison between the elite Spanish and English competitions, high intensity running was able to distinguish the two leagues, with the English players eliciting substantially more high intensity running irrespective of playing position (Dellal et al., 2011). This is a common trend with Bradley et al. (2010) finding an elite European league and Spanish league covered similar amounts of high intensity running, however they had approximately 40% more high intensity running compared to Danish and Swedish leagues. The authors suggested that the game styles of the elite teams required players to pressure opponents to regain possession, or create space to receive passes,

resulting in the increased physical output (Bradley et al., 2010). These elite players generally cover up to 11% of their total distance while sprinting (Stolen et al., 2005), and perform 900-1100m of high intensity running (Bradley et al., 2013), showing at the top level high speed running is an important component. There are not many studies outlining the physical output of Australian soccer players, although Burgess, Naughton, and Norton (2006) analysed the physical output of Australian National Soccer League matches using manual video analysis. The study found that players ran approximately 10100m throughout a match with 700m sprint (>24km/h) (Burgess et al., 2006), which is lower total distance and higher sprint compared to more recent international work (Bradley et al., 2013; Bush et al., 2015). However, the data collection and analysis tools are outdated.

Increased levels of physical attributes may not necessarily result in a direct increase in performance, however, a lack of certain physical attributes and an associated increase in fatigue has been shown to negatively affect technical skill in the second half of matches (Rampinini et al., 2008; Rampinini et al., 2009). Increasing physical attributes could enhance decision-making and technical ability later in matches. Although it is widely recognised that soccer is a multidimensional sport (Hoare & Warr, 2000; O'Reilly & Wong, 2012; Stolen et al., 2005), it is the physical characteristics highlighted above that have to date received the most attention, despite technical proficiency being reportedly a better predictor for team success (Carling et al., 2012; Castellano et al., 2012). As such Carling et al. (2012) suggests the focus of the sports scientist should be on players attaining a minimum level of fitness to ensure other attributes, such as the technical skills, are not compromised. It is therefore essential when identifying and developing talent that it is understood exactly what attributes underpin physical performance in soccer.

2.2.2 Technical match demands of soccer

There are a number of technical skills that are required to be successful in soccer, including passing, shooting and dribbling (Reilly, Williams, et al., 2000). Various studies have explored which technical aspects of the game can lead to success and trends over time in various competitions (Bush et al., 2015; Jones, James, & Mellalieu, 2004; Wallace & Norton, 2014). In elite senior competitions (European Champions League) it has been shown that winning teams pass the ball 470 times a match at 74% success which led to them shooting 14 times (6.3 on target), compared to teams that draw (453 passes at 71.8% success) and lose (441 passes at 71.4% success), who had 13 (5 on target), and 11 (4 on target) shots on goal, respectively (Lago-Peñas, Lago-Ballesteros, & Rey, 2011). This shows the importance of having highly skilled players who can execute technical demands throughout matches. The requirement for greater technical skill in elite soccer players has also been demonstrated by the evolution of play in the last 12 World Cup finals with increases in player density, ball speed and particularly passing rate all requiring excellent technical skills for teams to be successful (Wallace & Norton, 2014). The increased player density has evidently changed the way teams play with an increased number of passes per shot (Bush et al., 2015), which requires skilful passing to break through opposition defence. Rampinini et al. (2009) showed the importance of technical skill with successful teams having more ball involvements, short passes, successful short passes, tackles, dribbles, shots and shots on target.

Technical proficiency differences have also been analysed between various levels of English soccer with Bradley et al. (2013) comparing the match characteristics of English Premier League teams compared to League One and Championship teams. The lower level teams (League One and Championship) generally played in a way that led to longer balls being played more frequently, with more clearances in the final third, total headers and interceptions (Bradley et al., 2013). Comparatively, the higher level teams (Premier League) would

predominantly maintain possession of the ball, with increased forward passes, total passes, balls received and a higher number of average touches per ball possession (Bradley et al., 2013). This suggests that players in a higher standard of competition had better technical proficiency and tactical knowledge of the game and may maintain possession of the ball, while trying to break the lines more often with forward passes. Conversely, the skill level of the lower leagues does not allow them to play this way which results in more turnovers and a more direct style of play.

Dellal et al. (2011) outlined the extent of involvement of players from all positions, showing players averaged 40-60 ball possessions, passing the ball at 70-80% success rate in two elite competitions (English Premier League and Spanish La Liga). The interesting difference between the Spanish and English leagues was the reduced number of heading and ground duels for all playing positions in La Liga, compared to the English Premier league, leading the authors to suggest the English league plays a long and direct style of game compared to the Spanish counterparts who looked to maintain possession as opposed to these long lofted passes (Dellal et al., 2011). The key technical actions for success in the Spanish soccer league (comparing top 4 clubs to bottom 4 clubs) were shown to be goals, shots on target, total shots, shots per goal, assists and ball possession (Lago-Ballesteros & Lago-Peñas, 2010). This shows that the successful teams in the Spanish League not only created more chances but were also able to convert a higher percentage of shots. Unsurprisingly, the greatest determinant for successful teams is obviously scoring goals (Jones et al., 2004; Lago & Martín, 2007), emphasising the importance of players' ability to execute a shot on target and ensuring that teammates are put into a scoring position.

Although it is obvious that all players require a certain level of technical proficiency, there seems to be differing requirements across the playing positions. A study which used semi-automatic video-analysis system to determine the physical and technical demands of players in

the top French league, showed distinct characteristics for each playing position (Dellal et al., 2010). Forwards lost the greatest number of heading and ground duels and had a greater ratio of ball lost whilst they were in possession. In contrast, defenders (central and full backs) won significantly more ground duels and aerial (heading) duels compared to all other positions. Central defenders had the lowest percentage of successful passes, however, they had the lowest ratio of losing the ball when in possession. Attacking and wide midfielders have possession of the ball for longer more often (Dellal et al., 2010), showing midfielders are required to have sufficient ball control and passing qualities. Interestingly forwards played fewer forward passes than other positions in the top English and Spanish leagues, whilst defenders win more heading and ground duels (Dellal et al., 2011). It is evident that all players require high level technical skills to be successful, however these may also be position specific requirements.

It is clear that technical components of soccer are critical to success for individual players and teams alike. As technical parameters distinctively discriminate leagues of differing levels, and as the game is constantly evolving, the standard of skills required to play is continually increasing. From a development perspective it is important to understand the critical technical components in elite soccer before investigating the underlying skills required to execute these components and how to then develop them. There is currently little evidence in regard to technical characteristics in Australian soccer matches, particularly at the youth level, so a general understanding is initially required.

2.2.3 Tactical match demands of soccer

Physical and technical components have been a feature of the match analysis literature in soccer, however there has been little analysis of the game from a tactical perspective. Rein and Memmert (2016) explained the difficulty of analysing matches to make inferences about game styles. The tactical component of soccer requires players to individually and collectively make decisions about which action to execute next in a complex environment (Rein &

Memmert, 2016). The complexity comes from a constantly changing environment, requiring players to execute the correct decision according to interactions with the opposition and teammates. The overall interaction and behaviours between teammates in the attack and defence throughout a match could then be considered to be the team's style of play (Fernandez-Navarro et al., 2016). In a practical setting, coaches often observe games and make inference about tactical output based on personal experiences (Rein & Memmert, 2016), and although this is often assisted with the use of pre-defined ideas based on their experiences, researchers have failed to follow and publish consistent and detailed operational definitions (James, 2006a). There have been a number of studies that have made interpretations of game styles from various technical instances, although the lack of operational definitions in the literature hinders the progress of match analysis research and should be an area that sports scientists continually work to rectify (James, 2006a).

Performance indicators have been used extensively in the literature to analyse tactical components and game styles, with physical and technical components both being influenced by the way teams elect to play (Fernandez-Navarro et al., 2016). Over the years there have been a number of attacking and defensive tactical methods or game styles analysed. Defensive styles that have been most frequently analysed include high and low pressure, which are based around how quickly, how often and the location from which the defending team pushes towards the ball carrier (Fernandez-Navarro et al., 2016). A selection of the attacking styles of game that have been analysed include counterattacking, total soccer, crossing and the two most frequent styles; direct and possession style of play (Fernandez-Navarro et al., 2016).

Teams executing a direct style of play display shorter passing sequences, longer passes, a lower number of passes and a low number of touches per ball involvement, in comparison with the possession style involving long passing chains, shorter passes, increased number of total passes and more touches per ball involvement (Fernandez-Navarro et al., 2016). Studies

have compared game styles between teams of differing skill level and countries with Bradley et al. (2013) providing evidence that lower level competitions in England (Championship and League One) played a more direct style compared to the possession style of the higher levels (Premier League). The possession style in this competition was characterised by more forward passes, total passes, balls received and more touches per possession. The lower levels had increased clearances, headers and interceptions alluding to the possibility they were trying to be more direct without the ability to execute the pass (Bradley et al., 2013). There could be numerous factors which account for this difference in style of play between levels including technical ability, tactical knowledge or physical prowess.

Interestingly, when the top league in England (Premier League) was compared to the top Spanish league (La Liga), the tactical parameters suggested that the English players executed a direct style of game, which usually involved long aerial passes, whilst the Spanish teams played a possession style (Dellal et al., 2011). Similarly, Fernandez-Navarro et al. (2016) found that one of the most successful Spanish teams in La Liga, Barcelona, played a heavy possession and high pressure defensive style of game which allowed them to score easily when turning the ball over. The authors noted that this was due to the increased technical and tactical ability of the players and philosophy of the club to execute this game style (Fernandez-Navarro et al., 2016). One aspect of the possession style of game is the sideways pass which teams use to disrupt the opposition defence, therefore increasing the efficiency of attacking plays (Fernandez-Navarro et al., 2016). This is reiterated by Tenga, Ronglan, and Bahr (2010) who suggested a possession style can cause imbalance to defensive structures. Tenga et al. (2010) looked at various styles of play and which components resulted in more scoring opportunities in the top Norwegian soccer league. The authors found that counter attacks, final third starting attacks, long passing sequences, and penetrative passes were indicative of more scoring opportunities which suggests that both direct and possession styles of play can be successful

depending on the contextual variables for each match and strengths of players in each team (Tenga et al., 2010). It is obvious that there are a number of tactics and styles of play that can be successful in elite soccer, however it is important to understand exactly what is needed to underpin these game styles and how players can execute them successfully. There is currently no research on styles of play within Australian soccer, including at the youth level. This research is crucial due to the evidence that countries play different styles. Furthermore, there are some overarching methodological issues with these style of play studies which include a) the difference in operational definitions of what constitutes a direct or possession style of play, and b) missing variables such as area of pitch or direction of pass that could strengthen the research.

2.2.4 Summary: Match demands of soccer

The first stage of the Expert Performance Approach involves capturing experts within their specific performance environment. When investigating expertise in soccer it is therefore crucial to understand exactly what the game demands are from all aspects (physical, technical and tactical). The literature review to this point has outlined that there is a myriad of variables that can influence successful performance in soccer at the elite level.

The physical characteristics involved in elite soccer include a large aerobic component, interspersed with high intensity efforts and actions. Throughout the youth pathway it is evident that the physical characteristics required are not to the same level as the senior competition, however players still need a base level of fitness to execute a high standard of technical prowess. It is evident that players need to possess a high level of technical ability to succeed in soccer, with suggestions that it is the most important facet of the game. The technical output in senior elite competitions shows how crucial it is to be able to execute the fundamental technical skills consistently in order to excel. Tactical characteristics have been used to analyse game styles with possession and direct styles of play being most prominent. These game styles

require high technical and decision-making ability to execute sufficiently at the elite level. It is also clear that game styles differ significantly across levels and countries, making it important to understand exactly how Australian athletes play along the FFA pathway.

There has been minimal research into physical, technical or tactical match characteristics in Australian soccer, where the game styles and technical ability may differ to other countries. Internationally there has been some work completed investigating physical demands of youth soccer, however, there has been minimal work investigating the technical and tactical demands at this level. Players clearly need a sufficient level of physical, technical and tactical (decision-making) prowess to be successful, so it is important to understand what level of these skills are required both in Australia and at the youth level.

2.3 Stage Two (Identify Underlying Mechanisms): Sport Specific Testing in Soccer

Stage Two of the Expert Performance Approach involves identifying underlying mechanisms of the expert performance captured in Stage One (Williams & Ericsson, 2005). Although researchers seem to capture expert performance and compare them to novices in their domain, they generally fail to investigate the reasons for the difference by identifying the underlying mechanisms of expert performance (Williams & Ericsson, 2005). Historically, sporting clubs/institutes have tried to identify the underlying skills for successful performance for TID purposes. The aim of this process is to predict talented junior athletes to select into development programs, allowing them to realise their potential, however it is not an exact science and therefore there are no globally accepted models of TID (Reilly, Williams, et al., 2000). Due to the multifaceted nature of soccer, there have been many studies suggesting the need for a multifactorial testing battery including physical, technical and tactical elements (Forsman, Blomqvist, Davids, Liukkonen, & Konttinen, 2016; Reilly, Williams, et al., 2000).

The extensive physical, technical and tactical demands of soccer were highlighted earlier in Chapter Two, with elite players expected to run upwards of 10 km per match, interspersed with high intensity efforts to execute skills under pressure and fatigue, whilst continually trying to make the correct decision. In order to capture the required attributes for successful soccer performance, numerous studies have investigated ways to test athletes (Ali et al., 2007; Deprez et al., 2014; Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Mirkov, Nedeljkovic, Kukolj, Ugarkovic, & Jaric, 2008; Russell, Benton, & Kingsley, 2010; Vaeyens, Lenoir, Williams, Mazyn, & Philippaerts, 2007). Physical performance indicators have typically included a combination of tests including intermittent endurance (Deprez et al., 2014; Krustrup et al., 2006), agility (Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Little & Williams, 2005; Mirkov et al., 2008), vertical jump (Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Turner et al., 2011) and sprinting (Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Turner et al., 2011). There have been a number of soccer technical tests that have been developed for assessing specific abilities in soccer, including passing (Ali et al., 2007; Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Rösch et al., 2000), shooting (Ali et al., 2007; Rösch et al., 2000), and ball control (Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Rösch et al., 2000). Finally, there has been increasing work trying to assess the tactical ability and decision-making of soccer players, through various perceptual-cognitive or perceptual motor tasks (O'Connor, Larkin, & Williams, 2016; Vaeyens, Lenoir, Williams, Mazyn, et al., 2007).

There are a number of critical considerations practitioners and researchers need to take when deciding on which testing battery to use, particularly for technical tests. There has been debate around the representative design, level of specificity, feasibility, reliability and validity of skills tests for various sports (Robertson, Burnett, & Cochrane, 2014). The critical component of skills testing is finding the balance between; a) reliability (being able to trust the

consistency of testing results) and b) validity (how well the test actually represents the task you are trying to assess) (Robertson et al., 2014). In terms of reliability, it is thought that the complex process leading to skilled outcomes in sporting situations has a large amount of inter and intra-individual variability, potentially making any assessment inherently unreliable (Bartlett, 2008; Robertson et al., 2014). The three important types of validity include content (does the test represent all aspects of the construct?), construct (does the test actually measure exactly what it claims to?) and criterion-related variability (a test's correlation with a concrete outcome) (Robertson et al., 2014). Feasibility is also important to consider, as although the validity and reliability of a certain testing battery may be high, it may not be possible for everyone to have access to equipment or reproduce the tests with large volumes of athletes. It is obvious that when choosing a testing battery for sporting performance that there are a number of critical components to consider in order to make the appropriate assessments. There are many studies that have the assessed underlying physical, technical and tactical skills for soccer performance using a range of tests and these aforementioned factors (reliability, validity etc.) will be considered when these are reviewed in the following sections.

2.3.1 Physical testing in soccer

The physicality required in soccer has previously been reviewed in this chapter, with large aerobic attributes typically required for 'off-ball' running, while potentially the most crucial components of match play such as winning possession of the ball, score involvement and conceding goals are fuelled through anaerobic characteristics (Reilly, Bangsbo, et al., 2000). Due to the physical demands of elite soccer, physiological laboratory and field testing has been used in many testing batteries to determine performance indicators and identify talent (Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Gonaus & Müller, 2012; Turner et al., 2011). Laboratory based testing has been used for a range of different attributes from maximum oxygen uptake (VO_2 max), anaerobic threshold, aerobic performance, strength and power

(Stolen et al., 2005), whilst field-based testing typically includes tests of intermittent endurance, change of direction, power and speed (Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Reilly, Williams, et al., 2000; Sarmento et al., 2018). It is necessary for researchers, sports scientists and coaches to employ field-based testing for practicality and feasibility reasons. Due to an extensive amount of the physical demands of soccer literature being covered in 2.2.1, the following section will focus on laboratory and field-based tests for anthropometry, endurance, and anaerobic components of soccer.

Anthropometric assessments have also been used in sports in order to distinguish players of varying standards and positions. Typical anthropometric measures include height, body mass and body fat percentage (le Gall, Carling, Williams, & Reilly, 2010; Mirkov, Kukolj, Ugarkovic, Koprivica, & Jaric, 2010; Reilly, Bangsbo, et al., 2000). It is thought that elite soccer players are reasonably heterogenous in terms of anthropometric measures (Reilly, Bangsbo, et al., 2000), with some evidence of higher level players being taller, heavier and having lower body fat percentage than lower level players (Gil, Gil, Ruiz, Irazusta, & Irazusta, 2007; le Gall et al., 2010). These anthropometrical differences seem to be specific to certain playing positions, with height particularly showing an advantage in goal keepers and central defenders compared to other positions (le Gall et al., 2010; Reilly, Bangsbo, et al., 2000).

Endurance has been a staple attribute to test in soccer players. The gold standard to analyse aerobic endurance is the laboratory-based VO_2 max test, with elite senior soccer players having a VO_2 max of 50-75mL/kg/min, whilst junior players are generally below 60mL/kg/min (Stolen et al., 2005). One of the main field-based intermittent endurance tests used in soccer research is the Yo-Yo Intermittent Recovery Test Level 1 (Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Stolen et al., 2005; Turner et al., 2011) which has been shown to discriminate elite and sub-elite young soccer players across various age groups (Deprez et al., 2014; Reilly, Williams, et al., 2000). Interestingly, Gonaus and Müller (2012) found

differences in endurance between drafted and non-drafted Austrian national players through 14-16 years, however the difference was unable to be established at age 17. Forsman, Blomqvist, Davids, Liukkonen, et al. (2016) tested 15 year old soccer players to see how many progressed to the elite level four years later, finding intermittent endurance was not a distinguishing factor between the elite and sub-elite players for future success. Overall it is clear that while intermittent endurance is an important factor in youth soccer, there may be more components required to succeed, or predict future success at the elite level.

It has been outlined that 96% of sprints in soccer are less than 30m (Barros, Valquer, & Sant'anna, 1999), with 49% being less than 10m (Stolen et al., 2005). For this reason, studies adopting sprint tests in soccer players have opted for 30m maximum sprint, with some including shorter split times (including 5 m and 10 m) (Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Reilly, Williams, et al., 2000). It has been shown that sprinting results can distinguish players of various standards, with Forsman, Blomqvist, Davids, Liukkonen, et al. (2016) showing players who progressed to elite soccer at 19 years of age were faster in a 30m sprint at the age of 15. Gonaus and Müller (2012) differentiated selected and non-selected national level junior soccer players at under 14, 15, 16 and 17 age groups based on 5, 10 and 20 m sprint times. Thus, sprinting skill appears to be an important factor in successful soccer performance.

Given the importance of change of direction in many sports, there have been a number of studies investigating change of direction and agility testing (Nimphius, Callaghan, Bezodis, & Lockie, 2018). True tests of agility involve participants reacting to an external stimulus before choosing which direction to turn, therefore any ‘planned’ testing should be termed ‘change of direction’ testing as opposed to agility testing (Nimphius et al., 2018). Due to anaerobic activities underpinning critical moments in soccer (Reilly, Bangsbo, et al., 2000), athletes need to possess the ability to change direction effectively and efficiently. Specifically,

change of direction testing has been shown to distinguish between selected and non-selected players in a Spanish soccer team, particularly within forwards and midfielders, who need to regularly evade players throughout matches (Gil et al., 2007). There are a number of change of direction tests that have been used in the literature including 5-0-5, Y-shaped and the T-test (Nimphius et al., 2018) with the Zigzag test being used in soccer research due to the simplicity, reproducibility and reliability (Little & Williams, 2005; Mirkov et al., 2008). The Zigzag test includes elements of acceleration, deceleration, balance and change of direction which are all specific to soccer match play, and requires minimal familiarity due to its simplicity (Little & Williams, 2005). There is some evidence for specific change of direction testing in soccer players, which needs to be further examined at the youth level.

Another attribute to assess is maximal power with the vertical jump being used extensively to test this attribute. The gold standard of vertical jump testing is to use a force plate, however other methods such as using a Vertec have been shown to be a reliable, more feasible field test (Castagna et al., 2013). The vertical jump has shown to be discriminatory between levels of expertise in soccer (Reilly, Williams, et al., 2000), with Gonaus and Müller (2012) reporting a difference in the vertical jump performance between elite and sub-elite under 14, 15 and 16 players, however they were unable to distinguish under 17 year old players of different standards. Vertical jump and change of direction testing can be used in conjunction with sprint testing as part of a TID process and routine development monitoring, to gain a rounded understanding of the anaerobic ability of youth soccer players.

Overall studies have been able to distinguish players of different levels based on change of direction, speed, power, endurance and anthropometrical aspects (Mirkov et al., 2010; Reilly, Bangsbo, et al., 2000). As such these tests may be used in TID although some researchers have warned about the potential downfalls of using only physical components in TID, with maturational effects influencing testing results (Mirkov et al., 2010; Unnithan,

White, Georgiou, Iga, & Drust, 2012; Williams & Reilly, 2000). A multivariate approach which includes technical and tactical components of soccer is therefore recommended (Gonaus & Müller, 2012; Williams & Reilly, 2000). FFA believes the international team has always been able to compete with other nations in terms of physicality (FFA, 2017), however there is currently a lack of knowledge about the specific physical levels that are required or expected of elite players in Australian soccer, particularly at the youth level.

2.3.2 Technical testing in soccer

It is evident that the match demands of soccer are continually evolving to become more technically demanding (Wallace & Norton, 2014), with players required to be proficient at a number of skills including passing (short and long), dribbling and shooting (Reilly, Williams, et al., 2000). The importance of technical skills in elite performers has been commonly cited (Bush et al., 2015; Carling, 2013; Castellano et al., 2012) and together with the limitations imposed on physical testing due to maturational status it has been suggested that youth TID models in soccer should therefore include a technical aspect (Carling, le Gall, Reilly, & Williams, 2009; Unnithan et al., 2012). The difficulty of developing tests that analyse the technical skills in a sport, is finding the balance between ecological validity, and reliability, with conjecture in the literature about the correct approach (Kingsley, Russell, & Benton, 2012; Robertson et al., 2014; Vilar, Araújo, Davids, & Renshaw, 2012). There have been a number of studies that have measured the technical skills in soccer, specifically the players ability to pass, shoot and dribble the ball in isolation, or tests combining these skills to increase the ecological validity (Ali et al., 2007; Rösch et al., 2000; Russell et al., 2010). The specific, isolated soccer skills tests will be outlined first, followed by the tests that combine multiple skills.

Passing is a key technical component in soccer, as demonstrated by Lago-Peñas et al. (2011) and Wallace and Norton (2014). Passing tests have been used to distinguish between

soccer players of varying levels and more recently in testing batteries for TID purposes (Forsman, Blomqvist, Davids, Liukkonen, et al., 2016). There have been several different passing tests analysed in the literature including one touch passing test (Haaland & Hoff, 2003), subjective short passing test (Hoare & Warr, 2000), and long and short passing tests (Rösch et al., 2000). The long and short passing tests were able to distinguish youth soccer players of varying levels, with these tests assessing players' ability to pass to targets differing distances away, with the longer version being a target 36m from a stationary ball and short passing test involving a target 11m away with a dribbling start (Rösch et al., 2000). The short passing test has been shown to discriminate between local and amateur senior teams, however the long passing test was unable to (Rösch et al., 2000). Potentially the testing protocol could increase the ability to distinguish between senior groups if players were required to pass with their dominant and non-dominant feet. One passing test that analysed the ability to use both feet was developed by Haaland and Hoff (2003) who analysed a 10m one-touch pass starting from a ball rolling towards the players. Although the study did not analyse players of differing standards, they were able to distinguish players before and after a training intervention on preferred and non-preferred feet (Haaland & Hoff, 2003). Although the rolling ball increases ecological validity as it mimics receiving a pass during a match, it reduces reliability as there was speed of each roll recorded, making it difficult to reproduce consistently. Hoare and Warr (2000) analysed the passing ability of players across 5m and 10m distances for 15 minutes with subjective assessments from state level coaches, however it is thought that this type of approach can have many inherent errors, thus endorsing the use of objective parameters in testing (Ali, 2011).

As identified earlier in this chapter, one of the most critical components for successful soccer performance is the ability to score goals (Jones et al., 2004; Lago & Martín, 2007). As a result, there have been a number of shooting tests developed to measure this attribute. Rösch

et al. (2000) developed two shooting tests with differing strengths, including a shot, 11m out from the goal, from a 20m pass, and a more reliable version of the test with a shot from a stationary ball positioned 16m from goal. Although it can be argued that the stationary shot decreases ecological validity, it increases the reproducibility of the test significantly. The study of multiple countries, ages and levels found no differences in shooting results from either test (Rösch et al., 2000), however this could be explained by the low sensitivity of the scoring system. The other downfall of this test is the lack of shooting speed measurement, which would allow players to shoot at a slower speed than in a typical match (Ali, 2011). A static ball position could also be considered a test of technique, rather than skill (Ali, 2011). Haaland and Hoff (2003) developed an interesting shooting test, requiring the athletes to control the ball from chest height and volley the ball towards the goal with their second touch. Although this is more representative of a match scenario, there are other shooting scenarios that are more frequent than the volley. Overall, there are several shooting tests reported in the literature, and it is evident that some adaptations to the sensitivity and methodology of the testing environment would make them more appropriate for performance indicators and TID.

Due to the speed of the game increasing (Wallace & Norton, 2014), and the amount of possession by all players it is critically important that players have the ability to control the ball and dribble sufficiently throughout a game. This component of the game is thought to be a hallmark of gifted players (Ali, 2011) and has been tested extensively in different populations, with a range of tests analysed in the literature. Most of these tests include dribbling a ball around various objects in a timed situation (Haaland & Hoff, 2003; Reilly, Williams, et al., 2000; Rösch et al., 2000; Russell et al., 2010). Rösch et al. (2000) found dribbling results could distinguish players of all ages and levels, with Reilly, Williams, et al. (2000) finding similar outcomes in their study of elite and sub-elite soccer players. Russell et al. (2010) also showed differences in the precision and success rate of a dribbling test in professional versus

recreational players. It is evident that this attribute is a good discriminator for soccer players of varying levels, with multiple studies showing distinct differences in dribbling and ball control proficiency.

As discussed earlier, there is a fine balance between developing tests that are feasible, reproducible, reliable and valid, and in an effort to increase ecological validity, sports scientists have developed soccer specific tests measuring multiple variables at once. It is believed these are more sport specific as players are often required to perform multiple skills in succession during match play (Ali, 2011). The recent examples of multifaceted soccer tests include the Loughborough Soccer Passing Test (LSPT), Loughborough Soccer Shooting Test (LSST), shooting and passing test, dribbling and passing test, and passing and centring test (Ali et al., 2007; Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Russell et al., 2010). The most regularly used multifaceted test is the LSPT which involves 16 passes of varying distances in a random order, with time restrictions (Ali, 2011; Ali et al., 2007). This test measures various elements of soccer skill including passing ability, ball control, dribbling, and perceptual-cognitive components (Ali, 2011; Ali et al., 2007; Wen, Robertson, Hu, Song, & Chen, 2018). It has also been shown to be a valid and reliable measurement in various populations including adult male (Ali et al., 2007), female (Ali, Foskett, & Gant, 2008) and youth players (Ali, 2011; Le Moal et al., 2014; Wen et al., 2018). There have been at least 25 studies which have used the LSPT for reliability, validity or responsiveness to an external intervention, showing the extensive research conducted using this test (Wen et al., 2018).

The initial LSPT study by Ali et al. (2007) showed that it was able to discriminate between elite and non-elite soccer players and since then it has been used for TID purposes with Huijgen, Elferink-Gemser, Ali, and Visscher (2013) testing youth soccer players across multiple clubs in the Netherlands. Their study showed that development programs can successfully improve the execution time and skill performance on the LSPT across

developmental years, whilst also showing a difference in skill performance between selected and de-selected players (Huijgen et al., 2013). Due to the 'speed and accuracy trade-off' when performing targeted movements, players usually take longer to execute a pass of increased accuracy, however due to their increased skill level, selected players were able to execute more accurate passes in the same time as de-selected players (Fitts & Posner, 1967; Huijgen et al., 2013).

Ali et al. (2007) also developed the Loughborough Soccer Shooting Test (LSST), which involves the player kicking a ball into a bench, controlling the rebound, turning towards goal and shooting past a plywood goal keeper into soccer goals marked with specific scoring zones. To ensure players shoot at match speeds, a radar gun is also used to measure shooting speed, overcoming some of the previously identified issues regarding ecological validity of tests. Elite players displayed a similar score for the shooting component of the test, however performed much faster and struck the ball harder than the non-elite players (Ali et al., 2007), again showing evidence of the speed-accuracy trade off (Fitts & Posner, 1967). Although the ecological validity of this test has been increased with the equipment and procedure, this makes the feasibility of conducting the tests harder for practitioners without the appropriate equipment or funding. Russell et al. (2010) developed a passing and shooting test which involves either passing or shooting a ball rolled in from a ramp, depending on whichever target was illuminated. This test assesses passing and shooting ability, with visual search and decision-making components also required in order to succeed (Russell et al., 2010). Although this test was shown to have construct validity by distinguishing between professional and recreational players (Russell et al., 2010), the set up including multiple video cameras and a custom lighting system makes it difficult for sports scientists to reproduce and facilitate the test. As part of a multidimensional testing battery, Forsman, Blomqvist, Davids, Liukkonen, et al. (2016) also used two technical tests recommended by the Football Association of Finland which included

a test of passing and dribbling, and a test of passing and centring, with both of these tests able to distinguish between elite and sub-elite players.

It is clear that there are many technical tests in soccer, with studies finding technical skill can distinguish players of different levels. It is also evident that the testing battery chosen by practitioners and researchers needs to be reliable, feasible and valid for the level and situation they are in. There are many soccer specific tests in the literature for passing, shooting, dribbling and combinations of these skills, with the LSPT being the most widely used and trusted soccer test in the literature. FFA have indicated that Australia needs to continually focus on the technical aspect of the game (FFA, 2009), if they are to improve at an international level. Unfortunately, there is presently a lack of evidence-based knowledge regarding the technical abilities of Australian soccer players, particularly at the youth level. Therefore, it is important to produce objective data for these athletes to assist with present and future identification and development of talent. There needs to be TID and development models in Australia that includes the technical testing of youth soccer players as part of a multidimensional approach to provide this data.

2.3.3 Decision-making testing in soccer

The physical and technical components have been heavily assessed in the TID and development process over the years, however increasing evidence is arising with regard to players' perceptual or decision-making prowess. The ability to choose the correct option in a rapid time underpins decision-making skill of a player. For this reason, decision-making research has increased significantly in several sports including Australian football (Lorains, Ball, & MacMahon, 2013; Woods, Raynor, Bruce, & McDonald, 2016), netball (Bruce, Farrow, Raynor, & Mann, 2012), squash (Abernethy, Gill, Parks, & Packer, 2001), and soccer (O'Connor et al., 2016; Vaeyens, Lenoir, Williams, Mazyn, et al., 2007; Vaeyens, Lenoir, Williams, & Philippaerts, 2007). It has been shown that expert decision-makers are especially

good at anticipation and pattern recognition, which often makes them look like they have all the time in the world (Farrow & Raab, 2008). As detailed in the tactical match demands of soccer, match environments are extremely complex and dynamic, with players constantly required to make decisions individually and collectively based on external factors (Rein & Memmert, 2016).

Decision-making research in sport has progressed a long way over the last 20 years with McMorris (1997) quantifying amateur soccer players' perceptual-cognitive decision-making ability using still shots from matches projected onto the wall with players giving verbal answers into a microphone. More recently, technology has progressed and perceptual-cognitive decision-making or anticipation tests usually involve a video-based task which simulate aspects of match play specific to their sport. Farrow and Raab (2008) explain that pattern recognition testing and training has positive outcomes in a number of team sports (gridiron, soccer, basketball) where athletes are asked to anticipate the outcome of familiar patterns of play. More specifically, this information can be used to give players feedback so they begin to recognise offensive or defensive situations and make the correct decision (Farrow & Raab, 2008).

Within invasion games it has been shown that young expert performers are more effective decision-makers than novice performers of the same age (Del Campo, Villora, Lopez, & Mitchell, 2011). In a study of Australian rules football players, it was evident that a perceptual-cognitive decision-making test could correctly discriminate the majority of selected and non-selected players (Woods et al., 2016). It has also been shown that expert Australian football players can make correct decisions faster, as they require less information to make the decision (Lorains et al., 2013).

It is important to discuss the different types of decision-making testing that has been utilised in the sporting literature over the years. The main difference has revolved around whether the testing involves perceptual-cognitive skill or perceptual-motor skill (Bruce,

Farrow, Raynor, et al., 2012; Starkes, Cullen, & MacMahon, 2004). There have been studies investigating the differences between perceptual-motor and perceptual-cognitive expertise in sport because it is believed that knowing the correct response and actually executing the motor pattern is a different skill altogether (Bruce, Farrow, Raynor, et al., 2012). Abernethy et al. (2001) showed that perceptual-cognitive and perceptual-motor decision-making tests were able to distinguish between squash players of varying levels. A study involving netball players of differing standards compared video-based decision-making results (perceptual-cognitive) with scenario based testing results which involved actors creating specific situations for players to execute the correct decision (perceptual-motor) (Bruce, Farrow, Raynor, et al., 2012). Although the perceptual-cognitive and perceptual-motor tests were able to distinguish netball players of varying levels, the ability of elite players to couple the correct decision with successful pass execution meant that their performance in the perceptual-motor task was greater (Bruce, Farrow, Raynor, et al., 2012). This shows that although both tests are adequate to distinguish between various levels of expertise, perceptual-motor tests may provide more information in regard to decision-making expertise of athletes.

Williams (2000) explained that due to the environment constantly changing in soccer, perceptual skills are extremely important for success. More specifically, players need to overcome various complexities including information from other players while taking into consideration technical or physical constraints, team strategy, and temporal pressure before making a decision (Williams, 2000). In order to test the perceptual-motor decision-making ability of soccer players, Vaeyens, Lenoir, Williams, Mazyn, et al. (2007) orchestrated different pre-planned offensive scenarios, whilst manipulating the number of offensive and defensive players. In order to make it game like, the camera was situated behind the ball carrier, which was simulated to be the decision-maker, and the image was projected life-size onto a screen with the player required to execute the correct decision in each scenario (pass, shoot or dribble).

This study, conducted with Belgian youth players, found elite youth soccer players (national and international) were more proficient at making and executing decisions compared to regional soccer players and non-players even when the complexity of the task increased. The decision-making task failed, however, to discriminate between the national and international players with the authors suggesting that either the test simply was not sensitive enough to distinguish players who were similar in skill level, or that not all elite players were actually exceptional decision-makers (Vaeyens, Lenoir, Williams, Mazyn, et al., 2007). In a similar study, Vaeyens, Lenoir, Williams, and Philippaerts (2007) split the cohorts into successful and less successful decision-makers to compare visual search strategies between the two groups. Interestingly the successful decision-makers seemed to fixate on the ball carrier more often, however they also had more fixations with a higher fixation order than the less skilled soccer decision-makers (Vaeyens, Lenoir, Williams, & Philippaerts, 2007). It is thought that this strategy for successful decision-makers allowed them to focus centrally, using their peripheral vision to watch 'off-ball' movements, which allowed them to then fixate on other players once they require more information (Vaeyens, Lenoir, Williams, & Philippaerts, 2007). It is therefore evident that players with higher decision-making ability in soccer have a more refined method to assess the situation they are presented with. These findings reiterate the results in elite and sub-elite soccer players in England, with the perceptual-cognitive decision-making task successfully discriminating skilled and lesser skilled athletes (Ward, Ericsson, & Williams, 2013; Ward & Williams, 2003).

In Australian soccer there has recently been some work with perceptual-cognitive decision-making in youth players (under 13, 14 and 15) (Larkin, O'Connor, & Williams, 2016; O'Connor et al., 2016). The study used a multifaceted testing battery in the TID process and found that the perceptual-cognitive decision-making task was able to discriminate between selected and non-selected young Australian soccer players, showing the construct validity in

this cohort (O'Connor et al., 2016). However, this study did not assess older youth Australian players, so further research is required to understand this particular cohort in order to understand how they may progress into senior programs. There is significant support for the use of decision-making (perceptual-cognitive or perceptual-motor) tasks to be used in the TID process as many studies have identified the discriminative power of these tasks in various sports.

2.3.4 Summary: Testing in soccer

In reviewing the measurement of the underpinning skills for successful expert performance in soccer, as per Stage Two of the Expert Performance Approach, it is evident that there is a myriad of important characteristics for soccer players to possess and there are a range of tests that can discriminate between the levels of expertise. It is therefore essential when identifying talent that these tests encapsulate the diverse requirements of soccer, as no one test or skill will define the successful player but rather a combination of skills. In an effort to provide much needed rigor to the TID process in soccer, Reilly, Williams, et al. (2000) outlined a multifaceted model of potential predictors of talent in soccer incorporating physical, sociological, physiological, psychological, perceptual-cognitive and personality showing the complexity of unearthing youth talent. Meylan, Cronin, Oliver, and Hughes (2010) explain how expertise in sport can be realised with a number of unique combinations of skills, as players' deficiencies in one area can be compensated for by strengths in another. For example, Williams and Reilly (2000) suggested that focusing on and increasing technical ability can help to overcome physical disadvantages that late-maturing athletes may experience. It has also been suggested that increased decision-making ability can not only compensate for lacking physical or technical prowess, but junior players may actually rely on this ability more than physical or technical skills to survive in teams of higher standard (Woods et al., 2016). It is clear that performance is multifactorial and testing soccer athletes needs to follow this structure to ensure

a true reflection of their overall ability. The physical, technical and tactical tests used in soccer need to be able to produce consistent results and be as specific to game requirements as possible, whilst allowing researchers and practitioners to reproduce the tests with large volumes of athletes and limited equipment resources.

This literature review has shown that there is very limited knowledge about the level of underlying mechanisms that are required to perform as an expert youth soccer player in Australia. Due to differences in pathways, development and environmental factors the findings from other countries can inform practice in Australia but it is critical to understand exactly what is happening in Australian soccer and develop specific developmental models for the country. It is important that the FFA have clear benchmarks for developmental players in all facets of the game, with stringent testing procedures providing objective measurements to help facilitate TID and development programs in Australia. Once the underlying skills of soccer players have been established it is then important to understand how they are best developed.

2.4 Stage Three (Understanding the Development of Expertise): Developmental Pathways

Now that the first two stages of the Expert Performance Approach have been reviewed, with match demands and underlying skills being outlined, it is important to understand how expertise is developed. Researchers, in particular psychologists, have been interested in how expertise is developed in many areas including art, science, games, professions, music and sports (Hambrick et al., 2014; Plomin, Shakeshaft, McMillan, & Trzaskowski, 2014). The scientific literature around expertise development has expanded drastically over the last 30 years with Ericsson et al. (1993) explaining that initial accounts of exceptional performance were the result of innate and genetic factors. Initial studies overestimated the role that genetics played in expertise development, suggesting environment was not important (Plomin et al., 2014). Genetics play a part, however, environmental and developmental influences also play a large part in developing expertise in any domain (Ericsson et al., 1993; Plomin et al., 2014).

The debate has continued for many years as to whether expertise is a result of nature (genetics) or nurture (environment), with suggestions that genetics influence the size of your 'bucket' and the environment then dictates the contents (Baker, Horton, et al., 2003). It is clear that the environment plays an important role in the inter-individual discrepancies in regard to the attainment of expertise (Baker, Horton, et al., 2003).

Domain specificity is important, as there is thought to be little transfer from being an expert in one area to another. Despite this, there are commonalities in the development of various skills and knowledge across different domains (Ericsson, 2006). Initial studies in chess started to develop the idea that environmental factors were critical to developing procedural knowledge required for expertise, which took over ten years to acquire (Charness, Tuffiash, Krampe, Reingold, & Vasyukova, 2005; Simon & Chase, 1973). This has been applied successfully in music (Ericsson et al., 1993) and expertise research has since tried to branch into other domains including nursing and medicine (Ericsson, 2004; Ericsson et al., 2007).

Due to the world-wide popularity of sport and the ambition to succeed in this area, there has been a huge amount of research investigating how experts are developed in various sports. Farrow et al. (2017) explains how much the 'sport expertise' area has risen over the last 20 years, with the drive to understand the development of sporting expertise increasing so much that it is now a stand-alone discipline. Expertise development is an extremely complex area, with a number of constraints over many years influencing whether an individual becomes an expert. This is no different in soccer which is a complex, multifaceted sport, with a number of different factors and abilities contributing to the success of players (Reilly, Williams, et al., 2000). Vaeyens et al. (2008) highlighted that the unpredictability of gifted youngsters developing into successful elite performers is due to the combination of innate abilities of the individual (nature) and the environmental characteristics (nurture). Coutinho, Mesquita, and Fonseca (2016) outlined the three key components of sporting expertise literature, including a)

early specialisation and early diversification, b) deliberate practice and c) deliberate play. These three components will be the focus of the final section of the literature review, along with environmental and familial factors.

2.4.1 Early specialisation or early diversification

The activities and training completed by athletes play a significant role in determining whether the individual attains expertise in their chosen sport. An area of conjecture is whether junior athletes should focus on one sport from a young age (specialise) or stay involved in numerous sports before specialising later in their development (diversification) (Baker, 2003). This notion was put forward by Côté and colleagues (Côté, 1999; Côté et al., 2003; Côté & Hay, 2002), who believed there are two pathways to becoming an elite athlete, namely early and late specialisation. These pathways are outlined in the *developmental model of sport participation* (Figure 3) which is commonly referred to within the development of expertise literature (Côté, 1999; Côté et al., 2003).

In the developmental model of sport participation, the late specialisation pathway, otherwise known as *diversification*, emphasises that children should play a variety of different sports from a young age before specialising in one sport later in adolescence (around the age of 16 years) (Côté, 1999). This pathway is often found in sports where peak performance is attained after maturity, such as rowing, tennis, triathlon and team sports (Coutinho et al., 2016). There are three stages proposed in the diversification pathway; sampling years, specialising years and investment years (Côté, 1999). This sport diversification pathway encourages children to participate in a number of different sporting activities during the sampling years (six to 13 years of age). Once the child moves into the specialising years (13 to 15 years of age) they will reduce the number of extra-curricular activities they are involved in, including the number of sports, which will increase the amount of time for sport specific practice in the chosen sports. Finally, during the investment years (16 years of age onwards), the individual

will narrow their focus to one particular sport with the goal of reaching the elite level. The diversification pathway emphasises fun and enjoyment through the sampling and specialising years, which has been shown to result in decreased levels of participant dropout in sports (Côté et al., 2003). The main theory behind the benefits of diversification is the transfer of skills from other sports, with training time in other sports counteracting sport specific training at this early age (Côté et al., 2007; Haugaasen & Jordet, 2012). The variation in training stimuli develops basic motor and cognitive components which can then be applied across sports, making it easier to learn sport specific skills (Côté et al., 2007; Haugaasen & Jordet, 2012).

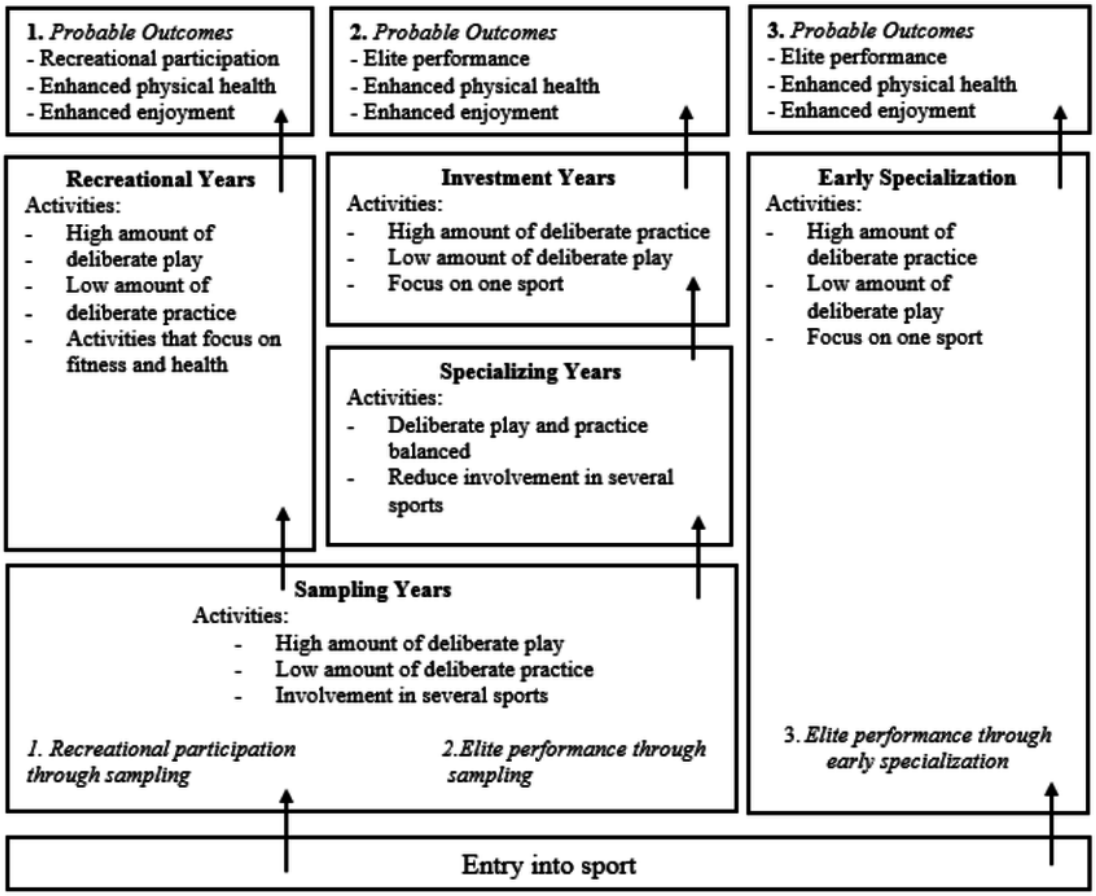

Figure 3. Developmental model of sport participation adapted from Côté et al. (2007) (with permission from John Wiley and Sons)

A study which supported the diversification pathway showed that playing Australian rules football, basketball and cricket was important in developing elite hockey players with attributes such as spatial awareness, physical ability and hand-eye coordination, skills believed

to be transferred from the various sports (Baker, Côté, et al., 2003b). A study involving German junior soccer players (under 11 and 12 years) across two years found that players with increased performance followed the diversification pathway, with more time spent in various sporting activities, and non-organised soccer play (Güllich, Kovar, Zart, & Reimann, 2016). The authors went on to suggest that moderate amounts of soccer-specific practice are clearly still necessary, however the diversification components are the activities that differentiated the two groups (Güllich et al., 2016). Ward et al. (2007) found that the diversification pathway did not appear to increase the development of expertise in English soccer players. Importantly, this might be a cultural and environmental finding, which could differ across countries. More specifically, different countries have varying structure in their developmental systems, which can influence the amount of practice and specific pathways followed by youth players. Furthermore, the everyday culture and environment surrounding youth players will influence how much incidental soccer play or alternative sports they are exposed to.

In contrast to the diversification pathway, the *early specialisation* pathway is where the athlete focuses on one sport from an early age (Côté et al., 2003). This pathway is primarily based on the notion that 10,000 hours of deliberate practice are necessary to become an expert performer (Ericsson et al., 1993), an idea which has created some debate over the years. Unlike the early diversification pathway, early specialisation only has one stage, which is characterised by high amounts of deliberate practice, low amounts of deliberate play and the athlete focusing on one sport (Côté et al., 2007). The early specialisation pathway is more common in sports such as gymnastics and figure skating where peak performance is achieved before adulthood, however it is still evident in team sports (Coutinho et al., 2016). Although the early specialisation pathway has been shown to develop expertise, it has been suggested that due to the monotonous nature it may also result in reduced enjoyment for the individual (Côté et al., 2003). Further evidence of negative outcomes for athletes specialising at an early age include

increased risk of overuse injuries, negative influences on physical health and increased attrition rate at all levels (Côté et al., 2007). For these reasons there is increasing debate and criticism of the specialisation pathway for the development of expertise (Sieghartsleitner, Zuber, Zibung, & Conzelmann, 2018). In saying this, there is some support for the specialisation pathway with Ward et al. (2007) finding that professional soccer players in England followed the early specialisation pathway during their childhood years, which could be a result of the culture and magnitude of the sport in that country.

Since the developmental model of sport participation was developed to include diversification and specialisation pathways, there have been studies that have found athletes developing expertise through alternate pathways. More specifically, it has since been proposed that there is an *early engagement* pathway which differs from specialisation and diversification (Ford et al., 2012; Ford, Ward, Hodges, & Williams, 2009). In this early engagement pathway, the athletes focus on one sport from a young age, having high levels of practice and play in their primary sport (Ford et al., 2009). This is a clear distinction from the early specialisation pathway which involves minimal play activities throughout the development process. This distinguishing factor of increased amount of sport specific play in the early engagement pathway is thought to counteract the negative outcomes of burnout and increased attrition rates that are found in the early specialisation pathway.

The early engagement pathway has been shown to be followed by soccer players in multiple countries such as Brazil and England (Ford et al., 2012; Ford & Williams, 2012). There are still slight discrepancies between countries. For example, in Brazil there are less formal developmental pathways compared to England, which means they have lower amounts of sport specific practice whilst growing up (Ford et al., 2012). In contrast, although English players do have access to increased sport specific training through the academy systems, they also enjoy plenty of sport specific play which does not characterise with the early specialisation

pathway (Ford et al., 2012). Interestingly, in Finland the elite soccer, ice hockey and basketball players also followed the early engagement pathways, with high amounts of sport specific practice and play, however they also tended to have increased practice and play in other sports (Forsman, Blomqvist, Davids, Konttinen, & Liukkone, 2016).

These studies show the importance of sport specific practice and play, and the difference in developmental pathways between countries. As outlined earlier, the FFA developed a National Curriculum which encourages players to increase the amount of deliberate practice they engage in from an early age, with training emphasising 'fun' drills and 'free play' (FFA, 2009). Due to children in Australia being exposed to many different sports, including several football codes, the developmental pathways of junior soccer players may differ to other countries. It has been suggested that in countries such as Australia, the United States of America and Canada, due to cultural and environmental factors, children are more likely to engage in multiple sports during childhood (Ford et al., 2012). Despite soccer having the highest participant rate of Australian males between 5 and 14 years of age (309,700 players), Australian rules football (212,700 players) and both forms of rugby (165,300 players) are also in the top ten sports for this cohort (Australian Bureau of Statistics, 2012). This suggests that soccer participation may not have the same profile in Australia as in many other countries, with other field sports competing for participation. There is a lack of research into the recommended developmental pathways in Australian soccer and which pathways youth players are taking to develop into elite senior soccer players.

2.4.2 Deliberate practice

The development of an expert performer and the need to diversify or specialise has been widely discussed but there is also the issue of how you practice the actual sport or activity to develop expertise. The initial ten year rule for the development of expertise outlined in chess by Simon and Chase (1973) has been expanded by Ericsson et al. (1993) with the authors

suggesting that there is a need for not only a certain quantity of practice but also a certain quality, otherwise known as *deliberate practice*. Deliberate practice is described as a highly structured training, purposeful in nature, with the singular intent of improving the current level of performance (Ericsson et al., 1993). This practice is distinguished from other activities that may improve skill indirectly, with deliberate practice being described as an effortful activity which can only be sustained for a limited amount of time (Ericsson et al., 1993).

The deliberate practice theory has since been applied to many domains. It was documented that expert musicians performed over 10,000 hours of deliberate practice, compared to the 5,000-8,000 hours that was achieved by the less accomplished groups (Ericsson et al., 1993). Although it has been consistently shown that team sport athletes such as hockey and soccer require ten years of training before reaching expertise, the 10,000 hours of deliberate practice has not always applied in this domain (Baker, Côté, et al., 2003b; Helsen, Starkes, & Hodges, 1998). Deliberate practice contributes to the development of expertise in hockey and soccer (Helsen et al., 1998), along with other team sport athletes (Baker, Côté, et al., 2003b), although the latter study reported figures substantially less than the 10,000 hours outlined by Ericsson et al. (1993). The team sport athletes, involved a cohort of netball players who reached expertise status, accumulated just above 2,000 hours of deliberate practice (Baker, Côté, et al., 2003b), well below the reported 10,000 hours required in other domains. This study supports the diversification theory as the netball players accounted for the smaller amount of deliberate netball practice through playing other sports (Baker, Côté, et al., 2003b).

A major difference between domains is that deliberate practice is described as not inherently enjoyable by musicians (Ericsson et al., 1993), which contrasts with team sport athletes, who consider the most enjoyable activities to coincide with relevant training types (tactical, technical and games) (Helsen et al., 1998). Team sport is thought to be a complex domain for the development of expertise as deliberate practice is required for improving

physical attributes, sport specific skills and team strategies (Baker, Côté, et al., 2003b). Therefore, the deliberate practice theory should address all elements of team sport training (Helsen et al., 1998). It has been shown that there is large variability in the number of deliberate practice hours across multiple sports and it has been suggested that although deliberate practice is a crucial component of expertise development in sport, it may not be the most pertinent factor in attaining expertise (Hopwood, MacMahon, Farrow, & Baker, 2015).

In saying this, specifically in English soccer, it has been shown that the amount of deliberate team practice consistently differentiates young elite and sub-elite players throughout the developmental pathway (Ward et al., 2007). This was reiterated by Ford and Williams (2012), who found the amount of childhood deliberate practice was an important component of development for professional soccer players compared to non-professional players. It is clear that deliberate practice plays a significant part in the development of expertise in all sports, although it seems that 10,000 hours of deliberate practice is excessive. The research demonstrates that the developmental pathways are different across countries and need to be interpreted as such. FFA's national talented player pathway has been designed to ensure junior players gain the required deliberate soccer practice from a young age (FFA, 2009). It is important to gain some evidence in regard to exactly what activities Australian youth soccer players have been involved with and whether deliberate practice is influencing the development of talented youth players in Australia.

2.4.3 Deliberate play

Another factor thought to influence the development of expertise is *deliberate play,* a concept referred to by Côté (1999). This type of activity was thought to increase the attainment of expertise, although the motivation for participating was for intrinsic enjoyment of the participant (Côté et al., 2007). Unlike deliberate practice, deliberate play allows children to explore and adapt to the environment without the constraints of traditional practice settings.

More specifically, there are typically no adults or coaches supervising these activities and there is minimal equipment required to execute these activities. The capacity for children to explore and develop problem solving abilities for various scenarios experienced during play activities allows for greater improvement and adaptation which they can later apply to competition and matches (Côté et al., 2003). This was evident in team ball sports, where researchers explored the training history of athletes who had greater levels of creativity according to their coaches, with these players having had increased amount of deliberate play activities in their developmental history compared to less creative players (Memmert, Baker, & Bertsch, 2010).

Finnish soccer, basketball and ice hockey players were shown to have increased deliberate practice in their main sport, as well as increased amounts of deliberate play in their developmental years (Forsman, Blomqvist, Davids, Konttinen, et al., 2016). The authors suggested that the increased time spent in these play activities actually assisted in the development of tactical and technical skills of these players (Forsman, Blomqvist, Davids, Konttinen, et al., 2016). In English soccer it has been shown that professional players compared to non-professional players had more involvement in deliberate play activities, which had a huge influence on their development (Ford & Williams, 2012).

The concept of transitioning from play to practice has also been explored, with the notion that elite athletes are involved with more deliberate play in their early years of development, however this transitions to increased amount of deliberate practice in the later years compared to lesser skilled athletes (Weissensteiner, Abernethy, & Farrow, 2009). It seems that deliberate play has an influence on the development of expertise in many sports and it is necessary to see whether this is a preferred pathway for Australian youth soccer players. The cultural and environmental differences in Australia compared to England and Brazil mean that these activities could differ between countries.

Brazilian football players follow an interesting development pathway (Araujo et al., 2010), with increased play activities, although the authors suggest that these should not be considered deliberate play as the activities barely represent sport due to their environmental constraints. It is important to note that although there is ongoing interpretation of early specialisation going hand in hand with deliberate practice and diversification being associated with deliberate play, this is not always the case (Coutinho et al., 2016). Although early specialisation and deliberate play are discussed in opposing manners (Coutinho et al., 2016), there have been studies in youth soccer showing that players who specialise early still accumulate hours of deliberate play (Ford et al., 2009). This is where the early engagement theory has been implemented to incorporate athletes who still choose to participate in one sport at an early age, yet still have a large amount of sport specific play throughout their developmental years.

2.4.4 Environmental influences

Throughout the literature review it has become evident that the developmental pathways to the attainment of expertise differ between countries with different cultures and systems (Forsman, Blomqvist, Davids, Konttinen, et al., 2016; Forsman, Blomqvist, Davids, Liukkonen, et al., 2016). The environmental influences on the development of expertise in sport include quantity and quality of training and access to resources (coaches, parents, culture, relative age, size of birthplace) (Davids & Baker, 2007).

An investigation into the role of environmental constraints on Brazilian football players concluded that there are a number of crucial constraints which interact in a nonlinear dynamic manner to develop expertise (Araujo et al., 2010). One of the main environmental factors that influence the developmental pathways is the structure of the system. For example, in England there is a very formal and established sporting and soccer system, and as such players follow the early engagement and specialisation pathway, starting formal training at an earlier age

(Ward et al., 2007). Contrasting this, other countries such as Brazil have less structured sporting systems which allows children to engage in play activities and informal coaching environments in soccer (Araujo et al., 2010).

Forsman, Blomqvist, Davids, Konttinen, et al. (2016) suggests that the weather conditions in Finland make it difficult to train outside throughout winter, together with a non-traditional developmental system based around local clubs, rather than academies or schools. In this environment, early engagement and sport specific practice and play increased the chance of soccer, basketball and hockey athletes representing the national team at 15 years of age in their specialised sport (Forsman, Blomqvist, Davids, Konttinen, et al., 2016). Initial studies in Australian youth soccer players (aged under 15 and below), have indicated no difference in coach-led, individual practice or peer-led play activities between selected and not selected national academy players (O'Connor et al., 2016). The authors suggested that the hours accumulated in individual and peer-led activities were lower than other nations however, coach-led hours were similar to other countries (O'Connor et al., 2016). It is important to understand whether this is isolated to that cohort and age group of Australian youth players or whether older elite youth players have accumulated more hours in these activities before they move into senior soccer systems and what environmental factors have enhanced or constrained the development soccer expertise in Australia.

2.4.5 Familial influences (sibling/parental)

Another aspect that has received some attention for expertise development is that of familial influence on sporting achievement. This includes the attitudes, behaviours, values, expectations and support of parents, coupled with the sporting background of parents and siblings. The typical influence of parents along the development continuum includes being supportive in the early years to allow children the freedom of choice, moving into increased dedication, and finishing with a more restricted involvement in the later years which was

generally limited to financial support, whilst the performer increased their commitment (Bloom, 1985; Côté, 1999). Parental expectations and involvement has been found to have either a positive or negative influence on athletic development in various sports (Côté, 1999). There have been a number of studies that have shown the positive benefit of parental support for children participating in sport, including increasing enjoyment and enthusiasm (Power & Woolger, 1994), perceived physical competence (Brustad, 1993), and alleviating performance stress (VanYperen, 1995). It is believed that the expectations and involvement of parents can be classified as low, moderate or high (Côté, 1999). For example, in swimming it was shown that when parents had expectations considered to be high or low, it resulted in children being less enthusiastic about the sport, however with moderate expectations the motivation of children increased (Power & Woolger, 1994). There has been less research conducted on the sporting background and history of the parents of expert athletes. However, research has shown that the parents of expert and developmental Australian netball players reached a higher level during their own sporting careers compared to the parents of recreational players (Bruce, Farrow, & Raynor, 2012a). This suggests that successful sporting experiences may translate to their children. Overall, it is obvious that parents have a large influence on sporting involvement of their children, which can then impact their long-term development.

Similar to the research conducted into the influence that parents have on the development of their children, research has also investigated how siblings can influence each other growing up. Older siblings can be positive roles models, influencing work ethic (Côté, 1999), in sport specific and non-sport specific domains (Hopwood, Farrow, MacMahon, & Baker, 2015). In the sporting domain, it has been shown that siblings provide an unstructured environment for more informal play and practice which can increase technical and psychological parameters required for successful performance (Phillips, Davids, Renshaw, & Portus, 2010; Weissensteiner et al., 2009). Although siblings can have positive supporting roles

while growing up, with their competitiveness and rivalry in sport having a positive influence on motivation, they can also have a negative influence resulting in anxiety and pressure as a result of trying to beat them (Davis & Meyer, 2008; Fraser-Thomas, Côté, & Deakin, 2008). In Australian netball players it was found that expert players had older siblings who had achieved a higher level of sporting representation compared to recreational athletes, emphasising that older siblings can have a positive influence on the development of their younger siblings (Bruce, Farrow, et al., 2012a). It is evident that family influence and in particular, the relationship between siblings, can have significant impact on the sporting involvement of children, both positively and negatively.

Another familial factor that has been found to affect the development of expertise is the birth order of the athlete within their family. Specifically, birth order has been shown to have influence on various traits of children. First born children are more likely to be high achievers and excelling academically, middle born children often have feelings of not belonging, and youngest children are more likely to be empathetic, rebellious and have increased social interests (Eckstein et al., 2010). From a sporting perspective, younger siblings tend to be involved with high-risk activities and therefore tend to choose more dangerous sports such as boxing, car-racing and rugby (Sulloway & Zweigenhaft, 2010). In baseball, younger siblings have been shown to hit more home runs, receive more walks and are more likely to be hit by a pitch (Sulloway & Zweigenhaft, 2010). This was reinforced by Hopwood, Farrow, et al. (2015) who found that elite athletes across multiple sports were later born, whilst pre-elite and non-elite players were generally the older sibling. More evidence for the younger siblings displaying increased sporting expertise was seen in expert netball players who tended to be later born compared to lower level players (Bruce, Farrow, et al., 2012a). Possible reasons for this include older siblings acting as positive role models and socialising agents, encouraging their siblings to participate in sport, while younger children could have observed and imitated

the sporting habits of their older siblings (Hopwood, Farrow, et al., 2015). It is also thought that younger children may want to outperform the older siblings in order to gain higher praise and recognition from their parents, which can increase their commitment to sport from an earlier age (Sulloway, 1996). It is clear that birth order can have an influence on the long-term development of athletes. Although there have been some initial findings related to sibling and parental influence in multiple sports around the world, there is a lack of research related to these influences on Australian youth soccer expertise.

2.4.6 Training history profiling

There have been several studies which have investigated the different pathways and variables that contribute to expertise in numerous sports worldwide, with those examining the developmental history of athletes primarily using retrospective questionnaires to answer their research questions (Baker, Côté, et al., 2003b; Côté, Ericsson, & Law, 2005; Helsen et al., 1998; Ward et al., 2007). These retrospective interviews or questionnaires have been predominantly used to gain an insight into athletes training history, environmental influences and family background. There have been some issues of reliability with the use of these questionnaires to recall training history (Baker, Côté, et al., 2003b; Helsen et al., 1998), with international (elite) players having higher reliability in their recall of practice history which is most likely due to training playing a significant part of their lives (Helsen et al., 1998). The Participation History Questionnaire (PHQ) and Developmental History of Athletes Questionnaire (DHAQ) have been used to gain an understanding of athletes' playing history with the PHQ shown to have high test-retest reliability and concurrent validity (Ford, Low, McRobert, & Williams, 2010). Similarly, the DHAQ has been utilised in multiple sports across different countries with good test-retest reliability, concurrent validity and convergent validity with parents and coaches (Hopwood, Baker, et al., 2010). Both questionnaires include aspects of playing and training history as well as milestones in their main sport, along with engagement

in other sporting activities. In addition to these sections, the DHAQ also covers areas of familial history and background to gain an insight into other influencing factors for athletic development.

2.4.7 Summary: Development of expertise

The final stage of the Expert Performance Approach aims to understand how expertise is developed. When reviewing the literature on developing expertise in sport, and more specifically soccer, it is evident that there are numerous factors and pathways that have an influence on whether a player attains expertise. Diversification, specialisation, early engagement, deliberate practice and play, familial influences and other environmental factors were all explored.

In regard to the developmental pathways outlined in the literature, there was evidence of elite players in Germany following the diversification pathway and players in England specialising early. However, later studies show that English and Brazilian players follow the early engagement pathway, involving elements of soccer practice and play activities from a young age. Deliberate practice and deliberate play both influence the development of expertise in various ways. It seems that deliberate practice is required, although not quite up to the 10,000 hours initially thought to be necessary. Familial influences are also present with siblings and parents having a significant impact on the sporting development of players, with birth order and sporting history of parents and siblings shown to have an impact on the development of sporting expertise.

Overall, it was evident that environmental factors have a significant impact on the development of expertise in soccer, which differs between countries. Although there has been initial research in young Australian soccer players (under 15) (O'Connor et al., 2016), there are many elements of development that were not explored. It is important to understand which factors and constraints are influencing the development of Australian youth soccer players.

2.5 Current Gaps in Literature

As we have seen, the Expert Performance Approach is a complex theoretical approach to apply to expertise research. Combining all three stages of the Expert Performance Approach will provide a holistic examination of Australian youth soccer, which, as shown in the review of the literature, is lacking evidence in a number of areas. Currently there is no research on the game styles or physical and technical skills of Australian youth soccer players. Although there has been some preliminary work in tactical (decision-making) testing and the developmental history of Australian youth players, this needs to be applied to an older cohort and expanded to a multidimensional approach. This thesis will focus on the physical, technical and tactical skills, which are the most prominent components seen in the literature, across all three stages of the Expert Performance Approach.

CHAPTER THREE – CAPTURING EXPERT PERFORMANCE IN YOUTH SOCCER: AN ANALYSIS OF MATCH CHARACTERISTICS ACROSS DIFFERENT LEVELS OF EXPERTISE

3.1 Introduction

In order to understand expertise, it is first important to capture expert performance as outlined in the original Expert Performance Approach framework by Ericsson and Smith (1991). It was initially proposed that this should be done through representative tasks which can be reproduced in the laboratory, however match analysis allows the researcher to broadly capture the expert performance within the performance domain. Instead of redesigning protocols to produce tasks representative of the match environment, match analysis will allow athletes to be assessed in their natural domain. Although match analysis has been around for a considerable time, as teams continually look for cutting edge ways to improve, it has gained increasing support in numerous sports in recent years, particularly soccer (Sarmento et al., 2014). Advances in technology allow for more automated processes and more sophisticated in-depth analyses. As coaches are always looking to analyse the performance of their team and the opposition, match analysis provides quantitative information to complement the usual subjective observations. Although there is always going to be a subjective element of interpretation, the objective nature of match analysis, through operational definitions, is a reliable and useful way to provide coaches and players with feedback on performance to ensure progress can be made (James 2006b).

In soccer there are a multitude of ways that match analyses have been utilised and these were recently investigated and reviewed by Sarmento et al. (2014), as detailed in Figure 2 (Chapter Two). Sarmento and colleagues (2014) categorised the scope of match analysis options into groups including descriptive analysis, comparative analysis and predictive analysis. A descriptive analysis will superficially outline certain parameters of the game, a

comparative analysis could compare a range of different variables from playing positions to competitive level and other factors (game results, location and fatigue), and a predictive analysis aims to determine the most effective way of playing (Sarmento et al., 2014).

The tactical components of soccer have a high level of complexity which leads to frequent individual and group decisions throughout the game (Rein & Memmert, 2016). These decisions are influenced by a number of external factors, including opposition movement, resulting in dynamic outcomes (Rein & Memmert, 2016). Due to the aforementioned complexity and dynamic nature of tactics in soccer, defining and analysing game styles can be difficult. Fernandez-Navarro et al. (2016, p. 1) explain that game styles can be defined as "general behaviour of the whole team to achieve the attacking and defensive objectives in the game", with 'direct' and 'possession' styles of play being the most commonly described in the literature. Short passing sequences, longer passes and low total passes are indicators of a direct style of play, which is the opposite to teams that predominantly play a possession style (Fernandez-Navarro et al., 2016; Tenga & Larsen, 2003). A team who favours a direct style of play often moves the ball quickly through the midfield, with at least one long pass, gaining entry to their offensive third quicker than a team who try to possess the ball for longer, often in their defensive half, switching sides to disrupt the oppositions full ground defensive structure (Fernandez-Navarro et al., 2016).

Differing game styles are often seen between countries with previous studies using technical parameters to differentiate playing styles. Researchers have found that the Norwegian national team and English leagues play a direct style of game with longer passes, and shorter passing chains, while the Brazilian national team and Spanish leagues play a possession style of game with short passes and long passing chains (Carling et al., 2007; Dellal et al., 2011; Tenga & Larsen, 2003). The aforementioned studies concluded that cultural and environmental differences between countries can lead to variations in how teams play the game. Teams of

higher standard in England and Spain have been shown to play a possession style of game compared to their lower level counterparts who play longer balls, resulting in more clearances, interceptions and headers (Bradley et al., 2013; Fernandez-Navarro et al., 2016). However, there is evidence that a direct style of play can create more scoring opportunities depending on the opposition (Tenga et al., 2010). It is clear that match analysis of soccer can identify game styles which are unique to different countries and can differentiate between levels of expertise, although there is limited evidence in regard to playing styles within Australian soccer, particularly at the youth level.

In order to facilitate the development of the technical and tactical skills necessary for successful game play in team sports, coaches and organisations can identify and manipulate constraints, such as the rules and equipment, to facilitate the learning of certain aspects of game play (Chow et al., 2006). An example of how manipulating rules can affect game styles is seen in the way the FFA structure their State Institute Challenge. Representative teams from every state in Australia play each other in an annual carnival-based competition which has two different point systems and ladders. One ladder rewards teams based on the result (i.e. win, lose or draw), and the other ladder rewards teams for playing game styles that are closely related to the national curriculum, emphasising the importance for state coaches to follow the national curriculum throughout training sessions in preparation for the carnival. FFA has developed a certain game style that Australian academies should follow to fast track the development of athletes' technical and tactical ability nationwide (FFA, 2009). This game style is one which FFA believes is the best for Australian athletes. Coaches therefore need to manipulate task constraints (i.e. rules and drills) during training to develop this game style in their teams. Additionally, coaches must be able to identify skills in their individual players or team as a whole which are limiting their ability to execute the game style that is required by the FFA. These limitations must be minimised to achieve success.

The current chapter applied Stage One of the Expert Performance Approach to capture the performance of Australian youth soccer players at various levels of expertise. The technical and tactical parameters of their respective matches were analysed to determine if there were differences in game styles of the various skill levels. This study will inform the subsequent chapters in the thesis about the game styles that are produced by these players and will identify the skills necessary to execute the differing game styles.

The specific research question that was addressed was:

Are there differences in the match characteristics between levels of expertise, namely sub-elite, state elite, and national elite, in Australian youth soccer as measured by technical and tactical parameters? If yes, where do they occur?

It was hypothesised, based on previous research, that the higher skilled teams would be able to maintain possession of the ball for longer periods of time than the lower skilled teams, and thus play a possession style of soccer rather than a direct style. Understanding if differences do exist in Australian youth soccer will allow the FFA to; a) evaluate the state of the current developmental pathway to ensure that the game styles are progressing in the anticipated direction, and b) assess the philosophies, education and structures in place for coaches and players to develop around Australia, whilst allowing the researchers to investigate which skills are then required to execute various game styles.

3.2 Methods

A cross-sectional quantitative research design was used to analyse Australian youth soccer matches across three levels of expertise; the elite national youth competition (National Youth League), State Institute Challenge (academy-based competition) and Western Australian (WA) U18 state league (local youth competition). The National Youth League contains players up to the age of 21 years (with four over-age players allowed), whilst the State Institute

Challenge and WA state league juniors involve players under the age of 18. Eight matches were selected from each competition to represent a range of teams in each of the respective competitions (location and success level). It has been suggested that six matches is a reasonable number to represent a typical performance (Hughes, Evans, & Wells, 2001). At the time of filming, the elite national youth competition was played across 18 rounds, compared to the 22 rounds of WA state league, and a one-week carnival structure for the state institute challenge. The national youth competition and WA U18 state league matches were each 90 minutes in duration (two 45 minute halves plus stoppage time), whilst the state institute challenge was 60 minutes in duration (two 30 minute halves). Ethical approval for the study was provided by Edith Cowan University Human Research Ethics Committee and approval was gained from all relevant governing bodies.

Match footage was captured from a raised perspective (grandstand/scaffold), side-on to the pitch (at the half way line, to capture as much of the field as possible) using a Sony (HDR-XR260VE) video camera. Video footage was captured live via the manual coding software SportsCode Pro (Version 8.5.1, Vigital Pty. Ltd.) and compressed before being analysed retrospectively by quantifying the selected instances for both teams from each match. In order to create code windows that incorporated selected aspects of game play in youth soccer, six elite youth soccer coaches were consulted to discuss game styles and technical parameters that they would prioritise. As a result of the discussions with coaches, who had consensus on critical variables, along with a review of the match analysis literature, a number of technical codes were chosen for analysis. These technical codes followed a similar structure to Bradley et al. (2011) and Andersson, Ekblom, and Krustrup (2008), which can be used to make inferences about game styles. The codes included were: passes, tackles, headers, crosses, shots, clearances, interceptions and goals. For more specific data, a second layer of descriptors was added for each of the above initial codes, including success, execution (grounded/lofted) and

direction (forward/backward/side). As there is currently a lack of consensus surrounding relevant variables (James, 2006b; Rein & Memmert, 2016), and for this study the critical components of soccer match play were defined as offensive and defensive characteristics (see Tables 1 and 2, respectively).

The coding was completed by two experienced performance analysts (at least one season with youth or senior soccer teams), who coded 12 matches each. The analysts coded the matches for both teams, post-game, which allowed them to pause and rewind if required, using the passing and general code windows (Appendix A). Intra-rater reliability was established with both analysts coding two matches, twice over, four weeks apart, ensuring the coders consistently recorded the same outcome and there was no learning effect. The inter-rater reliability was measured by comparing the coding data from two matches, coded by both analysts. The percentage error showed reliability within an acceptable limit (<5% error), as outlined by Hughes, Cooper, and Nevill (2004) and endorsed by Lago (2009).

Table 1. Offensive technical coding definitions

Code	Descriptor	Definition (and secondary codes)
Pass direction	Forwards	Player passes ball to another player at least 45° in front of them
	Backwards	Player passes ball to another player at least 45° behind them
	Sideways	Player passes ball to another player which does not exceed 45° forward or backward as outlined in Figure 4.
Pass execution	Lofted	Player passes the ball in the air
	Grounded	Player passes the ball along the ground
Pass outcome	Successful	Team maintains possession of the ball from pass
	Unsuccessful	Team loses possession of the ball from pass
Passing sequence	1-8+	Number of successful passes in succession for same team before losing possession
Cross		Attacking ball played from either wing into the penalty box
Goal		Number of times ball crosses goal line within goal
Header		Player intentionally uses head to control the ball
Shot	On Target	Player kicks ball at the goal which is on path to go in
	Off Target	Player kicks ball at the goal which misses
Through ball		Attacking pass that is played between/over defenders, intended for an attacker to run onto
Corner		Set piece taken from attacking corner of field along the ground (grounded) or in the air (lofted)
Free kick		Set piece from opposition transgression which is executed along the ground (grounded) or in the air (lofted)
Throw in		Occurs after ball crosses over sideline when opposition player has touched it last
Goal Kick		Set piece taken after ball crosses over goal line when opposition player has touched it last. Executed along the ground (grounded) or in the air (lofted)
Goal Keeper (GK) Possessions	Kick from ground	GK elects to keep ball on ground or drop ball to ground to kick
	Kick from hands	GK elects to kick ball from hands
	Roll/throw	GK elects to roll or throw ball to another player

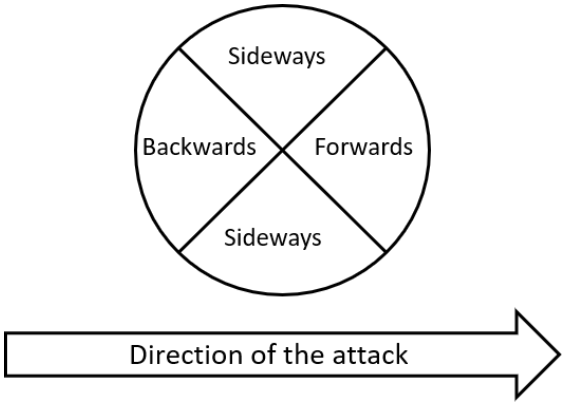

Figure 4. Direction of pass clarification, adapted from Fernandez-Navarro et al. (2016) (with permission to reproduce from Taylor & Francis)

Table 2. Defensive technical coding definitions

Code	Descriptor	Definition
Clearance		Player attempts to abruptly get the ball out of a dangerous position
Defensive pressure	Low Pressure	No players actively trying to dispossess the opposition player
	High Pressure	1+ player(s) actively trying to dispossess the opposition player (percent of total unsuccessful passes being high or low pressure)
Foul		Committing a physical offense, resulting in an opposition free kick
Intercept	Successful	Receive opposition pass and maintain possession
	Unsuccessful	Receive opposition pass and lose possession
Tackle	Successful	Actively try to dispossess opposition and gains possession
	Unsuccessful	Actively try to dispossess opposition and does not gain possession
Turnover	Dispossessed	Player loses possession of the ball by being tackled/blocked
	Opposition received	Player loses possession of the ball by intercept
	Out	Player loses possession of the ball by the ball going out of play

To equate for the difference in game duration, as the state institute challenge matches were shorter (60 minutes compared to 90 minutes of national and sub-elite matches), the variables were multiplied by 1.5 for state institute matches. To distinguish game styles in Australian youth soccer, a cluster analysis was used. The purpose of this cluster analysis was

to determine whether there were certain teams that could be grouped together based on the frequency of their technical instances, and therefore distinguish distinct game styles in each 'cluster'.

An average linkage hierarchical cluster system was used to classify each team and 'cluster' them near other teams who had a similar output from the technical parameters analysed (Yim & Ramdeen, 2015). This is represented by a dendrogram, which is a tree diagram to display the clusters effectively. From the bottom of the dendrogram, each line represents the overall match characteristics of one individual team from one match that was analysed. Each variable was standardised, using a range of -1 to 1 (Yim & Ramdeen, 2015), thus ensuring that the importance of each variable could be determined and allowing for comparison between different variables. The two teams with the most similar characteristics would be grouped (clustered) close together, which continues until they are clustered with similar groups based on match characteristics. This continues to happen until there are larger clusters, with the highest line representing the fusion between the two most dissimilar sites which is referred to as the maximum dissimilarity. The follow up plot displays the standardised values of all the variables for each of the main clusters that are established. As the match characteristics were standardised and displayed as 95% confidence intervals, the variables where the confidence intervals did not overlap zero were identified as the characteristics that were distinct to each game style. This therefore insinuates that the technical variables which do not overlap, are significantly above (positive) or below (negative) the other clusters (game styles).

3.3 Results

As displayed in the dendrogram in Figure 5, there were three distinct styles within these cohorts based on their technical parameters. The teams in each cohort had a letter assigned to denote the three levels of expertise, more specifically, the three denotations were sub-elite (A),

state elite (B) and national elite (C), for example, A.3 represents the match characteristics of sub-elite team 3. The closer the teams are clustered, the more similar the game styles, and the higher the connecting line, the more dissimilar the game styles. The colour of the branches on the dendrogram represent overall match characteristics of teams that were similar, with three clear overarching clusters displayed in Figure 5. All sub-elite (A) teams clustered around game style one (black branches), however, there was a mixture of national (C) and state (B) elite teams grouped together within game styles two (orange branches) and three (blue branches).

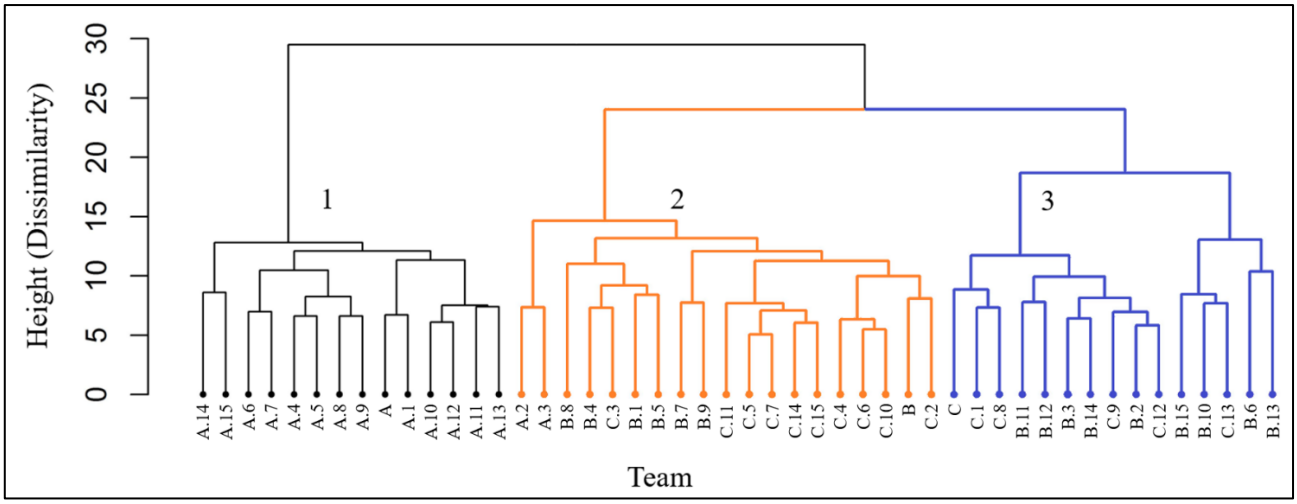

Figure 5. Cluster analysis dendrogram of match characteristics

A = sub-elite B = state elite C = national elite teams

The follow up plot shows the standardised values of each variable, specific to the three main ‘clusters’, or game styles. More specifically, the results in Figure 6 display the mean (black dot) and 95% confidence interval (black line) for every technical variable for each game style, compared to the overall standardised mean (zero). The variables which were above or below the overall mean are represented using a green or red line, respectively and were considered to be distinct to each game style. The descriptive statistics of each variable (M ± SD) for the three game styles are presented as offensive variables in Table 3 and defensive variables with goal keeper possessions in Table 4.

Figure 6. Standardised variables (M ± 95% CI) underpinning the three distinct game styles

1 = Game style 1, 2 = Game style 2 and 3 = Game style 3

Table 3. Offensive variables of each game style (M ± SD)

Match Characteristics		Game style 1	Game style 2	Game style 3	Overall
Pass (%)	**Total**	315.07 ± 71.2	367.79 ± 93.6	379.67 ± 113.1	356.13 ± 96.5
	Forwards	59.64 ± 7.2	43.61 ± 4.1	50.83 ± 7.8	50.54 ± 9.1
	Sideways	25.60 ± 6.1	32.22 5.0	26.14 ± 6.4	28.39 ± 6.5
	Backwards	14.75 ± 2.8	24.17 ± 4.3	23.03 ± 4.4	21.06 ± 5.7
	Successful	60.93 ± 6.2	82.62± 4.2	70.72 ± 7.6	72.57 ± 10.8
	Unsuccessful	39.07 ± 6.2	17.38 ± 4.2	29.28 ± 7.6	27.43 ± 10.8
	Grounded	69.18 ± 6.8	83.30 ± 6.3	80.94 ± 7.6	78.44 ± 9.1
	Lofted	30.82 ± 6.8	16.70 ± 6.3	19.06 ± 7.6	21.56 ± 9.1
Passing sequence	**1**	63.71 ± 17.8	28.39 ± 12.1	27.67 ± 12.8	38.47 ± 21.5
	2	35.14 ± 10.4	22.61 ± 4.6	23.83 ± 8.3	26.65 ± 9.4
	3	20.93 ± 6.0	19.39 ± 7.4	17.37 ± 5.5	19.21 ± 6.4
	4	9.50 ± 3.0	10.32 ± 3.8	10.80 ± 5.2	10.23 ± 4.0
	5	4.29 ± 2.4	7.26 ± 2.5	7.60 ± 4.0	6.50 ± 3.3
	6	3.93 ± 1.9	4.95 ± 2.9	6.07 ± 3.2	5.00 ± 2.8
	7	2.29 ± 1.3	5.55 ± 23.8	4.23 ± 2.9	4.19 ± 3.2
	8+	1.14 ± 1.2	6.39 ± 4.2	7.50 ± 6.8	5.21 ± 5.3
Cross (%)	**Total**	10.93 ± 5.8	10.03 ± 5.1	9.57 ± 3.2	10.15 ± 4.8
	Grounded	22.80 ± 12.8	33.63 ± 11.8	38.03 ± 19.9	31.84 ± 16.0
	Lofted	77.20 ± 12.8	66.37 ± 11.8	61.97 ± 19.9	68.16 ± 16.0
Through ball (%)	**Total**	8.93 ± 7.2	11.03 ± 7.0	5.00 ± 5.8	8.53 ± 7.0
	Grounded	54.62 ± 27.1	58.28 ± 20.3	84.03 ± 20.0	64.44 ± 25.3
	Lofted	45.38 ± 27.1	41.72 ± 20.3	15.97 ± 20.0	35.56 ± 25.3
Free kick (%)	**Total**	12.64 ± 2.4	11.97 ± 3.5	12.73 ± 4.7	12.41 ± 3.6
	Grounded	33.67 ± 13.8	48.88 ± 16.4	67.24 ± 18.3	50.18 ± 20.8
	Lofted	66.33 ± 13.8	51.12 ± 16.4	32.76 ± 18.3	49.82 ± 20.8
Corner (%)	**Total**	6.00 ± 5.0	5.08 ± 3.5	4.17 ± 2.0	5.06 ± 3.6
	Grounded	14.76 ± 17.6	35.69 ± 37.1	40.83 ± 36.2	31.34 ± 33.6
	Lofted	85.24 ± 17.6	64.31 ± 37.1	59.17 ± 6.2	68.66 ± 33.6
Header	**Total**	26.29 ± 10.7	10.05 ± 5.6	13.97 ± 10.5	16.01 ± 11.1
Throw in	**Total**	30.00 ± 6.8	23.55 ± 7.6	22.93 ± 8.0	25.24 ± 8.0
Shot (%)	**Total**	15.00 ± 8.8	13.29 ± 7.9	8.23 ± 4.2	12.21 ± 7.6
	Off target	64.62 ± 16.6	53.57 ± 19.8	48.03 ± 30.1	55.06 ± 23.2
	On target	35.38 ± 16.6	46.43 ± 19.8	51.97 ± 30.1	44.94 ± 23.2
Goal	**Total**	1.86 ± 1.4	1.79 ± 1.7	1.30 ± 0.9	1.66 ± 1.4

Table 4. Defensive variables and goal keeper possessions of each game style (M ± SD)

Match Characteristics		Game style 1	Game style 2	Game style 3	Overall
Passing sequence ended (%)	**High pressure**	57.10 ± 17.3	38.66 ± 17.5	79.72 ± 6.2	56.87 ± 22.7
	Low pressure	42.90 ± 17.3	61.34 ± 17.5	20.28 ± 6.2	43.13 ± 22.7
	Out	15.49 ± 5.7	16.28 ± 6.3	17.37 ± 4.9	16.39 ± 5.6
	Opposition receive	62.48 ± 4.7	67.44 ± 8.4	52.01 ± 8.3	61.17 ± 9.9
	Dispossessed	22.03 ± 7.6	16.29 ± 8.0	30.62 ± 8.3	22.44 ± 9.9
Tackle (%)	**Total**	42.71 ± 20.2	51.21 ± 19.6	29.70 ± 6.6	42.01 ± 18.9
	Successful	69.58 ± 11.3	58.26 ± 11.5	81.61 ± 9.6	68.86 ± 14.5
	Unsuccessful	30.42 ± 11.3	41.74 ± 11.5	18.39 ± 9.6	31.14 ± 14.5
Intercept	**Total**	57.43 ± 8.8	44.03 ± 9.3	40.27 ± 6.4	46.76 ± 10.8
Turnover	**Total**	106.36 ± 22.0	79.21 ± 18.3	82.60 ± 11.6	88.19 ± 21.1
Clearance (%)	**Total**	13.36 ± 4.3	10.05 ± 2.7	7.97 ± 2.3	10.36 ± 3.8
	Grounded	6.72 ± 6.5	15.03 ± 12.4	16.25 ± 13.0	12.99 ± 11.7
	Lofted	93.28 ± 6.5	84.97 ± 12.4	83.75 ± 13.0	87.01 ± 11.7
Foul	**Total**	10.86 ± 3.4	9.32 ± 4.3	12.03 ± 4.6	10.61 ± 4.3
Goal keeper possessions (%)	**Total**	16.29 ± 5.1	15.82 ± 4.5	30.67 ± 10.5	20.59 ± 9.7
	Kick from ground	57.37 ± 12.3	63.54 ± 9.8	76.40 ± 10.0	65.76 ± 12.9
	Kick from hands	24.23 ± 12.7	7.16 ± 7.9	3.00 ± 4.0	10.84 ± 12.3
	Roll/throw	18.40 ± 9.3	29.29 ± 12.9	20.60 ± 9.4	23.40 ± 11.8
Goal kick (%)	**Total**	8.50 ± 1.7	6.84 ± 1.7	7.10 ± 1.9	7.41 ± 1.9
	Grounded	20.45 ± 20.6	48.48 ± 22.4	76.05 ± 29.3	48.92 ± 32.3
	Lofted	78.36 ± 20.9	51.52 ± 22.4	28.10 ± 30.0	52.03 ± 31.1

It was clear that a majority of the sub-elite youth teams played a very similar game style, as they clustered very closely based on their technical outcomes during match play. It was also evident that the state and national elite teams were distinctly different to the lower level, as neither of these elite teams clustered with the sub-elite group, however the two elite teams had an overlap of game styles. Of particular note was the passing output from the lower level teams which incorporated fewer long passing sequences (5-8+) compared to the elite teams, with short passing sequences being a frequent occurrence (see Figure 6 and Table 3 and 4, Game style 1). On average, the sub-elite teams lost possession of the ball on the first pass 35 more times compared to the national and state elite teams.

In contrast to the sub-elite players, it was evident that the two elite cohorts displayed a possession game style. Interestingly, there were two predominant possession styles of game displayed by the state and national elite cohorts. It is important to note that there was a mixture of teams from both elite cohorts clustered across the two possession game styles, and although they both displayed technical parameters that were more possession based compared to the sub-elite cohort, they also demonstrated distinct technical parameters distinguishing them from each other. The second game style revolved around a possession style of game, with these elite teams executing a higher percent of grounded, backward, sideward and successful passes. Together with the decreased frequency of small passing sequences (< 2) this shows the intent to execute a possession style game. Game style three was executed by a combination of the national and state elite teams, and also involved decreased short passing sequences and turnovers which shows the teams looking to maintain possession for as long as possible. Game style three also displayed increased grounded execution of goal kicks and free kicks, and decreased lofted execution of goal kicks, free kicks and through balls. The elite teams valued the possession of the ball compared to the sub-elite teams, however there were distinct differences between the two possession styles of game.

3.4 Discussion

The aim of the current study was to capture performance of Australian youth soccer players in their natural domain. As displayed in the methods, a number of discrete technical parameters were coded, which included various aspects of passing, offensive and defensive actions, set pieces and goal keeper actions.

Looking into some of the most frequently assessed technical parameters, the sub-elite team averaged 330 passes per match, while the state and national elite averaged 350 and 380, respectively. These results were lower compared to one of the premier elite senior competitions in Europe (European Champions League), where the teams average between 440-470 passes

per match. It is clear that all three cohorts in the current Australian youth study failed to reach this level of passing overall, demonstrating how technically proficient one needs to be at the elite senior level. The increased passing rate at the elite senior level could be explained by the increased physical, technical and tactical capability of these players. As expected, by comparing the technical instances, it is apparent that the speed of the game in the Australian youth system is slower than the elite senior competition in Europe, however it gives an insight into the gold standard and level the youth players need to aspire to. Although passing rates seemed to differ substantially between elite senior players and the current youth cohort, it still resulted in the youth teams executing a similar number of shots at goal to the senior teams. The elite senior competition had 11-14 shots per game (4-6 on target), while the Australian youth players had 9-16 shots (4-5 on target). This could be due to the increased focus on defensive structures and zones in the modern elite game which make it harder to create a shot.

Although it is necessary during a match analysis to isolate and compare technical instances compare to the gold standard, it is important that game styles are also accounted for (Fernandez-Navarro et al., 2016). As game styles involve general behaviour which is followed by the whole team, underpinning attacking and defensive aims (Fernandez-Navarro et al., 2016), it is possible to combine the technical instances from each cohort to distinguish game styles. If we reaffirm the definitions of the most prominent game styles in the literature of ‘possession’ and ‘direct’ style of play as described by Fernandez-Navarro et al. (2016) it becomes apparent that, based on technical parameters, these styles of play were evident within Australian youth soccer with three distinct variations.

The style of game exhibited by the sub-elite teams was particularly evident in regard to the passing execution, with an increased percent of forward, lofted and unsuccessful passes compared to the elite teams, which indicates that the lower level teams play a direct style of game, albeit with less success. It was clear that they emphasised getting the ball towards goal

as quickly as possible without the apparent intent to maintain possession for long periods. An example of the lack of intent to maintain possession is the sub-elite players only passing the ball backward 16% of the time in order not to lose field position, compared to the elite cohorts, passing in that direction 23% of the time. Clearly the lofted and forward passing emphasis led to the sub-elite teams struggling to maintain possession of the ball, which ultimately resulted in the turnovers from poor decisions or technical execution, and an increased number of intercepts, throw-ins and headers. One interpretation of this style of play by sub-elite players is athletes believing that they can execute a pass to a certain player, however their technical ability does not allow them to perform this successfully. Although decision-making outcomes in matches was outside the scope of the study, previous research in netball suggests that experts are more equipped to couple the correct decision with their technical ability to execute successfully (Bruce, Farrow, Raynor, et al., 2012), with less skilled players still making the correct decision, despite being unable to successfully execute the pass.

Another example of the direct style displayed by the sub-elite teams in Australian youth soccer included the execution of set pieces. More specifically, when executing free kicks, goal kicks and corners, this cohort had an increased percentage of lofted balls and a decreased percentage of grounded balls. This emphasis on lofted execution also translated to components of general play including clearances and crosses, with goal keepers also opting to kick the ball from their hands as opposed to the goal keepers in the elite teams who were more inclined to throw or roll the ball out. With the prominence of lofted execution of all types of skills for the sub-elite teams, it really emphasises the intent to play longer balls in a direct manner. Multiple studies have explained characteristics of direct style of play which can vary between teams, including, but not limited to, short passing sequences, attacks with at least one long pass or maximum of two passes, and direction of passing execution (Fernandez-Navarro et al., 2016; Hughes & Franks, 2005; Tenga & Larsen, 2003). Clearly, the style of play displayed by the

sub-elite teams elicited numerous aspects of a direct style of game, so it is important to understand which underpinning player skills contribute to this game style. It is clear that the sub-elite players struggled to maintain possession of the ball, while the elite cohorts seemed to execute the first pass more successfully, which could be due to a greater intent to maintain possession or their technical and tactical execution. Further investigation is required into exactly why these sub-elite players elicit this game style and whether it is a result of their underlying skills.

The possession style of play used by the two elite cohorts resulted in fewer total turnovers and headers which can be attributed to the grounded passing focus and direction of passes, as they were content to lose field position to ensure they maintained possession for longer periods of time. Unlike that found in sub-elite teams, game styles two and three were characterised by more ground balls throughout play, with the goal keeper also preferring to play the ball out from defence by foot rather than kick from their hands. This indicates that they would rather play the ball out from the back and build possession before finding the correct option, as opposed to kicking the ball long to a heading contest that has approximately a 50% chance of maintaining possession. Although it is possible to speculate on the defensive styles of teams based on the accumulation of various characteristics, there needs to be further investigation into the defensive styles employed by the teams and how multiple players work together to execute game styles, particularly defensively.

Although game styles two and three, executed by the national and state elite players, were considered to be a possession style of game, there were other differences between the two. Teams that executed game style two had a higher percentage of passing sequences which were ended with low pressure from the opposition, with ‘opposition receiving the ball’ being the most prominent outcome for this cohort. This could either indicate that players were making incorrect decisions or lack the technical ability to execute all of their passes, or the opposition

teams had well executed defensive structures that the players could not get through. Interestingly, game style two involved more attempted tackles compared to game style three, although a higher percentage of these were unsuccessful. This suggests that the opposition players were potentially able to evade tackles more often and/or defenders were attempting to dispossess at the wrong time which would give the player more time to execute a follow up pass. In contrast, the teams executing game style three predominantly had their passing sequences ended through dispossession from the opposition (tackles/blocks), rather than turnovers/intercepts. Furthermore, they also had an increased proportion of successful tackles which demonstrates their decision-making and execution of that particular skill being enhanced. This resulted in a higher proportion of passing sequences ending through high pressure scenarios as the tackler is applying more pressure at the correct time. It is evident that more research needs to be undertaken on the defensive styles of the game and how opposition teams counteract them. Although the elite teams seemed to play a similar offensive style of game (possession), their defensive tactics seemed to differ with tackles, method of turnover and amount of pressure being the differing variables. Further research needs to be conducted into the defensive styles of play and how they are executed at different levels.

3.5 Conclusion

It is evident that there are distinct game styles displayed by the three cohorts in Australian youth soccer, with the elite teams executing a possession style of play, while the sub-elite teams tried to be more direct. A study in England found similar results, with the senior elite competition displaying a possession style game in comparison to the very direct style of play displayed by the lower level teams (Bradley et al., 2013). The specific differences in technical instances were comparable to the current study as the lower levels (League 1 and Championship) performed more headers, interceptions and clearances, with the authors suggesting they displayed a ‘long ball’ or direct tactic, compared to the higher level (Premier

League) teams who played a possession style with passes, ball received and pass completion (Bradley et al., 2013). It is important to remember that due to cultural and environmental factors, technical parameters and game styles between leagues in various countries differ, with Dellal et al. (2011) explaining that elite Spanish teams play even more of a possession based style of play compared to the English leagues. Moreover, direct styles of attack were also evident in Norwegian leagues with long passes and shorter passing chains, in contrast to the possession style of play displayed in Brazilian leagues (Tenga & Larsen, 2003). Therefore, the results from this current study need to be interpreted in respect to the environment of Australia with the ultimate incentive to develop athletes to a level where they can compete with, and beat, the elite senior teams from around the world. It appears that the players in the elite developmental pathways are playing a game style which is indicative of the possession style game that FFA are pursuing.

As suggested in the literature, certain task constraints can be manipulated by organisations, coaches and teachers alike to aid the development of athletes (Renshaw, Chow, Davids, & Hammond, 2010). An example of this is FFA wanting to improve the technical ability of Australian soccer players throughout the developmental pathways, which resulted in the development of a national curriculum and incentives to play certain styles. The emphasis was on technical skill, therefore maintaining possession in matches. It is evident that the technical parameters which are displayed by the elite cohorts involved in this developmental pathway, have been accentuated by the task constraints and coaching philosophies, leading to players executing these possession style games.

It is also important to gain an understanding of which underlying skills are required to maintain the preferred game style of FFA, as the individual constraints of the athletes need to allow them to execute this game style. These individual constraints, for example physiological, technical and tactical components, may help to explain the different game styles displayed by

the three cohorts of Australian youth soccer. In order for teams to play a possession style of game, it is anticipated that players need to have a certain level of technical and tactical prowess. Conversely, the lower level players may lack underlying technical and tactical prowess to maintain possession for long periods of time, leading them to play a more 'direct' style. They may also have coaches who may not have the same knowledge and experience with the national curriculum, as outlined by the FFA. Although assumptions can be made in terms of the physical, technical and tactical ability of the players at these levels of soccer, it is important to quantify the underlying skill-sets that allow players to execute the specific game styles displayed in the current study. It is important to explore why the two elite teams play similar, yet slightly different game styles, while the sub-elite players play in a very different way.

CHAPTER FOUR – IDENTIFYING UNDERLYING MECHANISMS: AN ANALYSIS OF PHYSICAL, TECHNICAL AND TACTICAL SKILLS UNDERPINNING EXPERT PERFORMANCE IN YOUTH SOCCER

4.1 Chapter Overview

Following the theoretical framework underpinning the current thesis, Stage Two of the Expert Performance Approach requires researchers to identify the underlying mechanisms of expert performers. Therefore, it was important to understand the skills that contributed to the different game styles from Chapter Three. The overall aim of this chapter was to describe a series of studies to determine if the national and state elite players possess superior physical, technical or tactical abilities to implement these game styles. To investigate this, the remainder of this chapter comprises three testing batteries that were designed to evaluate a large group of Australian youth soccer players of different skill levels. In order to determine which of these skills are most predictive of superior performance as defined by selection in elite teams, a final analysis was completed to determine which tests were most synonymous with selection in the national elite squad.

A general introduction of how to identify, test and develop soccer specific skills begins below. The physical (Chapter 4.4), technical (Chapter 4.5), and tactical (Chapter 4.6) testing batteries and results will be outlined in individual sections. Finally, a multidimensional analysis will use the tests that are most discriminant of skill level from each of the testing batteries with the resultant output interpreted and discussed in Chapter 4.7.

The specific research question that was addressed was:

Are there differences in the underlying physical, technical and tactical skills between levels of expertise (sub-elite, state elite, and national elite) in Australian youth soccer players as measured by a number of performance tests? If yes, where do they occur?

It was hypothesised that higher level Australian youth soccer players would perform better on the physical, technical and tactical tests compared to lower level players.

4.2 Introduction

For Australia to have long-term success in any sporting code there must be an evidence-based approach to the identification and development of talent that is effective and efficient, and which recognises the inherent requirements of the sport. To date, there has been much reliance on the subjectivity of coaches and team scouts with this methodology shown to be inconsistent, resulting in misjudgements, false positives and false negatives when used in isolation (Meylan et al., 2010; Unnithan et al., 2012). At a time when soccer in Australia is increasing in participation and striving for increased success on the international stage, there is limited evidence to guide the identification of future elite players (O'Connor et al., 2016; Vaeyens et al., 2008). With the continual development of the game and potential differences between male and female game requirements, it is clear that more research and scientific evidence is required in this area. TID is often discriminative in nature, and measures of talent used in a test battery may not be predictive of future performance, however, it is still important that tests can discriminate between athletes of different skill levels.

Talent identification is intended to recognise promising athletes at the earliest possible point in time to ultimately maximise their potential. More specifically TID programs recruit these talented individuals, providing them with access to a variety of extra opportunities with the aim of increasing their ability towards success in senior elite sport. The *National Talent Identification and Development* program that existed within soccer in Australia when collecting data in the current study in 2013, was modified as a result of the *Winning Edge* project (Australian Sports Commission, 2017). This was implemented after the 2012 London Olympic Games by the Australian Sports Commission (Australian Sports Commission, 2017), although there have been a number of structural changes to the Australian Institute of Sport since then.

The national program invested heavily in talent pool expansion, talent transfer and supporting talent pathways. Although there is a national focus on TID, many state-based sporting institutes have also developed their own TID programs (Australian Sports Commission, 2017). Current practices for TID and talent selection in Australian soccer are through 'certified scouts' who identify talented players, reporting back to a centralised system (FFA, 2017). Their objective is to identify talented players without being swayed by physically advanced youth players who might outplay the higher potential players due to their increased physicality (FFA, 2017). In an effort to develop talented players, FFA then plan to increase the pool of athletes that are given access to qualified coaches and quality facilities (FFA, 2017).

Whilst there has been limited evaluation of the current TID programs across sports, it is suggested that they have low predictive value, and thus there has not been a universally accepted model of TID (Reilly, Williams, et al., 2000; Vaeyens et al., 2008). It is also typical that these programs have focused more on individual sports such as cycling, swimming and athletics, given TID in team sports can be far more complex due to their multifaceted nature. These individual sport programs have also tended to focus on physiological and anthropometrical factors (Hoare & Warr, 2000; Reilly, Williams, et al., 2000).

Vaeyens et al. (2008) suggested the unpredictability of gifted young athletes developing into successful elite performers was due to the combination of the innate abilities of the individual (nature) and environmental characteristics (nurture). It is evident that in the past, soccer coaches and scouts have used subjective indicators to select players, which have continually shown to be inconsistent and result in misjudgements if used in isolation (Meylan et al., 2010; Unnithan et al., 2012). Talented youth athletes do not always progress and have success in open age competitions (Wylleman, Alfermann, & Lavallee, 2004; Wylleman & Reints, 2010), therefore optimising TID programs is important. For this reason, it is important to use scientific evidence and holistic approaches in the identification and development of

talent in football to ensure players can get early access to institutes and academies to increase the chance of receiving long-term development (Unnithan et al., 2012). Sport specific physical abilities and anthropometrical attributes have been the focus of TID and development research for a number of years. While it is understandable to focus on this aspect of performance, it only provides one piece of the story and it therefore appears that a multi-disciplinary approach would be more beneficial. Meylan et al. (2010) explain how expertise in sport can be realised with a number of unique combinations of skills, as players' deficiencies in one area can be compensated by strengths in another area.

The variable nature of many team sports, including soccer, means that a TID and development program needs to be inclusive of the elements that contribute to successful soccer performance. Physical, technical and tactical factors should be therefore considered when selecting talented individuals. Whilst many researchers have identified and subsequently assessed the physical and technical skills that are required to perform at the highest level in soccer (Dellal et al., 2010; Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Reilly, Williams, et al., 2000), there has been increasing research into the perceptual-cognitive capabilities of players and the role it may play in TID (O'Connor et al., 2016; Williams & Reilly, 2000). Once the physical, technical and decision-making skills were identified they were analysed together in a multidimensional approach. As indicated on page xiii, three peer-reviewed journal articles have been accepted based on the study presented in this chapter.

4.3 Overall Methods

The study used a cross-sectional observational design, with each player required to complete 11 tests (categorised as physical, technical and tactical), which are presented as individual sections within this chapter, as the findings from each of these sections informed a multidimensional analysis of skills.

Sixty-two male youth soccer players (17.0 ± 0.61 y) representing three cohorts, namely the WA U/18 state league (referred to as sub-elite) (n = 22; 17.1 ± 0.82 y), the WA National Training Centre (referred to as state elite) (n = 22; 17.0 ± 0.50 y), and the Australian Institute of Sport soccer program (referred to as national elite) (n = 18; 17.0 ± 0.46 y) were recruited to participate in the current study. Each cohort included players from all playing positions. Prior to the commencement of any testing, ethical approval from Edith Cowan University Human Research Ethics Committee was gained in addition to permission from all relevant sporting organisations (Australian Institute of Sport, WA National Training Centre, Football West and relevant state league clubs). Informed consent was gained from all participants and if participants were less than 18 years of age at the time of testing, informed consent was also provided by their parents/guardian (Appendix B and C).

4.3.1 Testing battery

Participants completed testing to assess the following skills; physical, technical and tactical. Specifically, in the physical test battery, participants completed tests of standing height, body mass, 30 m sprint, Zigzag test, vertical jump and the Yo-Yo Intermittent Recovery Test level 1 (Yo-Yo IR1). The technical testing required participants to complete the Loughborough Soccer Passing Test (LSPT), the long passing test (passing skills), shooting test (shooting skills) and the ball control test. Finally, the tactical testing comprised a video-based perceptual-cognitive decision-making test. Testing for each cohort occurred during the final two weeks of their respective preseason training period prior to the commencement of their competitive season. All participants from each cohort were assessed as a group in the morning, with each testing battery (physical, technical and tactical) performed on three separate days, within a two-week period, under similar (dry) conditions. Players performed a generic soccer specific warm up, including dynamic movements, run-throughs and basic skills prior to

undergoing any of the physical and technical tests. All tests that required an examiner used the same person, for all cohorts, to eradicate any inter-experimenter bias.

4.3.2 Statistical analysis

A similar statistical approach was followed for each of the testing batteries. Initially, for the physical and technical testing batteries, in order to determine whether there were differences between the three groups, a multiple analysis of variance (MANOVA) for the main effect of cohort [three – national elite, state elite and sub-elite] was used. A univariate analysis of variance (ANOVA) was then used to follow up significant effects. In the tactical testing battery and multidimensional analysis, a univariate ANOVA was performed. Follow up Tukey honest significant difference post hoc analysis was used to discern which of the three cohorts differed on the individual tests where a significant difference had been established. For all analyses, descriptive statistics are presented as mean, standard deviation and effect sizes (ES), with the latter being interpreted by Cohen's *d* statistic; 0.2 = small, 0.5 = moderate and > 0.8 = large (Cohen, 1988). All analyses were completed using SPSS statistical software (Version 21, IBM 1989), with a significance level of $P < 0.05$.

A sensitivity analysis was subsequently performed for each of the variables where a significant difference between groups was observed, using the pROC package (Robin et al., 2011), in the R statistical computing 4 software version 2.15.1 (R, Development Core Team, 2012). Bootstrapped receiver operating characteristic (ROC) curves, along with the area under the curve (AUC) were calculated for each of these variables, with an AUC of 1 indicating there was perfect discriminatory power. The point on the curve at which the sum of the two different groups was maximised was considered to be the cut-off value. The ROC curves were used to show which variables could effectively differentiate between groups and thus give coaches a cut-off value that could be used as a minimum standard for inclusion in a particular cohort. Furthermore, for the sections which only involved one variable (tactical and multidimensional

analysis), a violin plot was produced for each cohort to view the variability and distribution within each group of participants, using the ggplot package in R statistical software (R, Development Core Team, 2012).

4.4 Physical Testing

4.4.1 Introduction

Football Federation Australia (FFA) has identified that a strength of Australian soccer players is their greater physical proficiency when compared to other countries (FFA, 2017). There is however a paucity of information about the specific physical and anthropometrical proficiencies required for success in Australian soccer, and how we would identify these skills in youth players. The expectation of an elite level soccer player is that in a game they will run approximately 10-12 km at 80-90% maximum heart rate (Di Salvo et al., 2007; Stolen et al., 2005), sprint every 90 s and perform short-term high-intensity efforts every 30 s (Reilly, Bangsbo, et al., 2000). The short-term high-intensity efforts include sprinting, jumping, changing direction and kicking, interspersed with short recovery periods (Akenhead et al., 2013; Bravo et al., 2008; Stolen et al., 2005). Haugen et al. (2013) suggest that although sprinting only constitutes 8-12% of the total running distance, it is during this high-intensity running that match outcomes are often decided, making the physical capabilities of an athlete crucial to success. Considering these physical requirements of the game, it is no surprise that a number of studies have found physiological differences between elite and sub-elite players (Williams & Reilly, 2000). The physical tests in the current study were based on a) the physical characteristics of soccer match play, and b) the feasibility, validity and reliability of the tests.

4.4.2 Methods

Physical and anthropometric attributes were assessed using six tests; standing height, body mass, 30 m sprint, Zigzag test, vertical jump and Yo-Yo IR1 as described below.

Following the warm-up as previously described, testing was conducted on an indoor running track (30m sprint and Zigzag test) and a basketball court (vertical jump and Yo-Yo IR1).

Standing height and body mass were measured using a stadiometer (Hart Sport, Queensland, Australia) and calibrated digital scales (A & D Company Limited, Tokyo, Japan) in accordance with protocols outlined by Pyne, Gardner, Sheehan, and Hopkins (2005). Following anthropometric testing, the cohort was divided into three groups and rotated between the vertical jump, 30 m sprint and Zigzag stations. All players completed the Yo-Yo IR1 together as the final station. There was a three minute break between each station, and participants were given two familiarisation trials of increasing intensity prior to each test (except for the Yo-Yo IR1), with the best performance of the recorded trials used for the statistical analysis.

The 30 m sprint was used to assess straight line speed and acceleration of the participants. Swift photocell speed lights (Swift Performance Equipment, Lismore, Australia) (TEM = 0.04) (Pyne et al., 2005) were set up at 5 m, 10 m and 30 m splits to measure acceleration at the 5 m and 10 m times, while the flying 20 m speed was assessed using the 10 m to 30 m split time.

The Zigzag test as used previously in a number of studies related to soccer (Little & Williams, 2005; Mirkov et al., 2008; Sporiš, Milanovic, Trajkovic, & Joksimovic, 2011) required each participant to weave through four poles 5 m apart, situated at 100° angles (as per Figure 7). Two Fusion photocell speed lights (Fusion Sports, Australia) were situated at the start and finish line of the Zigzag test to measure time elapsed. Absolute (ICC = 0.84) and relative (TEM = 0.098) variability and reliability of the Zigzag test has been evaluated in professional soccer players, with the authors also concluding that it carries strong face validity (Mirkov et al., 2008).

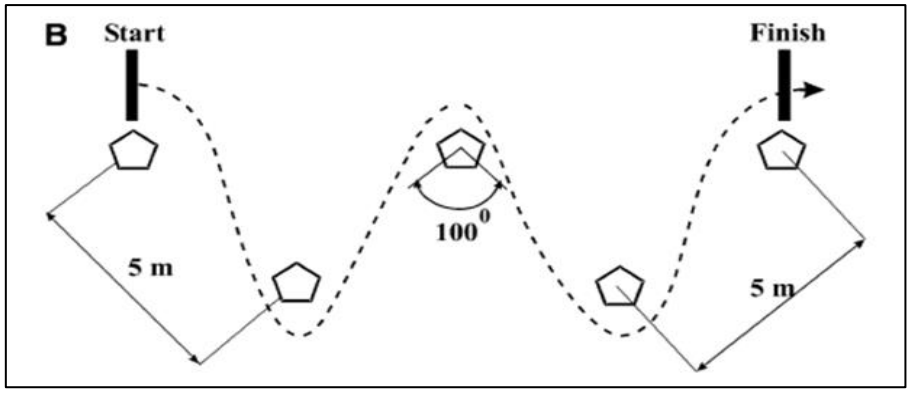

Figure 7. Zigzag test as outlined by Mirkov et al. (2008) (with permission to reproduce from Wolters Kluwer Health, Inc.)

The vertical jump has been used extensively to evaluate maximal leg power in soccer (Stolen et al., 2005). The current study followed protocols outlined by Pyne et al. (2005) and included a stationary double foot countermovement vertical jump and a dynamic vertical jump from a 5 m run up jumping off the dominant and non-dominant kicking leg. For each vertical jump the highest vane reached with the inside hand on the Swift Vertec (Swift Performance Equipment, Lismore, Australia) (Pyne et al., 2005) was recorded as the maximal height (TEM= 1.4 cm).

The Yo-Yo IR1 as described by Krustrup et al. (2003) was used to assess the participants' intermittent endurance as it mimics the high intensity running and match performance of a soccer game. The Yo-Yo IR1 required the athletes to run a 20 m shuttle up and back (including 10 s of active recovery), controlled by auditory signals of increasing speeds, with participants continuing until they failed to reach the line before the beep on two separate occasions. The distance covered (m) for each participant was recorded and used in the analysis. The Yo-Yo IR1 has also been shown to have high reproducibility in young (under 17) soccer players (ICC = 0.94) and high discriminative ability between elite and non-elite young soccer players (P = 0.002) (Deprez et al., 2014).

4.4.3 Results

Using a MANOVA to compare the physical testing results of each cohort, the Pillai's Trace (V) displayed a significant effect of cohort on the anthropometrical and physical attributes ($V = 0.725$, $F(11.00,50.00) = 11.957$, $P = 0.000$). Various between cohort differences were revealed in separate univariate ANOVAs, as shown in Table 5.

Specifically, the national elite cohort were significantly taller than the state elite (ES = 0.94). They were also faster than the sub-elite on the 30 m sprint (ES = 0.79) and 20 m flying start (ES = 0.77). The most notable difference however occurred in the Yo-Yo IR1 with a significant difference between all cohorts which was supported by large effect sizes, with the national elite cohort running on average 1100 m further than the state elite cohort (ES = 1.67), while the state elite cohort ran 400 m further than the sub-elite participants (ES = 0.88).

Receiver Operating Characteristic curves were performed only on those variables where a significant difference was established (Figure 8, 9, 10). The value where the sum of the specificity and sensitivity is maximised is shown by the data point with error bars representing 95% confidence intervals.

Table 5. Physical tests by cohort (M ± SD)

				p-value (effect size)		
Test	**National elite**	**State elite**	**Sub-elite**	**National vs State**	**National vs Sub**	**State vs Sub**
Age (years)	17.1 ± 0.4	17.0 ± 0.5	17.0 ± 0.7	0.92 (0.15)	0.99 (0.04)	0.96 (0.08)
Height (cm)	179.6 ± 5.6	173.8 ± 5.7	174.6 ± 9.2	0.035* (0.94)	0.084 (0.62)	0.924 (0.10)
Body mass (kg)	66.6 ± 8.6	69.3 ± 11.4	69.3 ± 9.8	0.082 (0.79)	0.416 (0.41)	0.601 (0.28)
5 m sprint (s)	1.09 ± .06	1.11 ± .07	1.11 ± .06	0.663 (0.29)	0.528 (0.34)	0.968 (0.07)
10 m sprint (s)	1.81 ± .07	1.85 ± .07	1.79 ± .19	0.665 (0.53)	0.906 (0.12)	0.355 (0.37)
30 m sprint (s)	4.18 ± .09	4.28 ± .12	4.29 ± .17	0.087 (0.73)	0.040* (0.79)	0.921 (0.10)
20 m flying start (s)	2.36 ± .05	2.42 ± .08	2.49 ± .20	0.376 (0.77)	0.013* (0.77)	0.202 (0.45)
Zigzag (s)	5.97 ± .12	5.86 ± .11	5.93 ± .20	0.069 (0.88)	0.825 (0.17)	0.182 (0.50)
Standing VJ (cm)	58.3 ± 4.3	56.3 ± 6.0	59.1 ± 5.2	0.458 (0.38)	0.899 (0.16)	0.191 (0.49)
Running VJ non-dominant (cm)	66.2 ± 5.4	69.2 ± 6.6	68.2 ± 8.5	0.508 (0.48)	0.648 (0.28)	0.970 (0.13)
Running VJ dominant (cm)	61.7 ± 7.1	64.1 ± 6.0	63.7 ± 8.0	0.401 (0.39)	0.660 (0.27)	0.895 (0.07)
Yo-Yo IR1 distance (m)	2524.7 ± 374.4	1398.3 ± 393.9	983.6 ± 467.1	<0.001* (1.67)	<0.001* (1.77)	(0.004* (0.88)

Note: * indicates statistical significance at $P < 0.05$. VJ = Vertical Jump.

Specifically, standing height differentiated the groups with 81% of the national elite cohort being taller than 174.1 cm, while 60.9% of the state elite players failed to reach this height (AUC = 71.1%) (Figure 8).

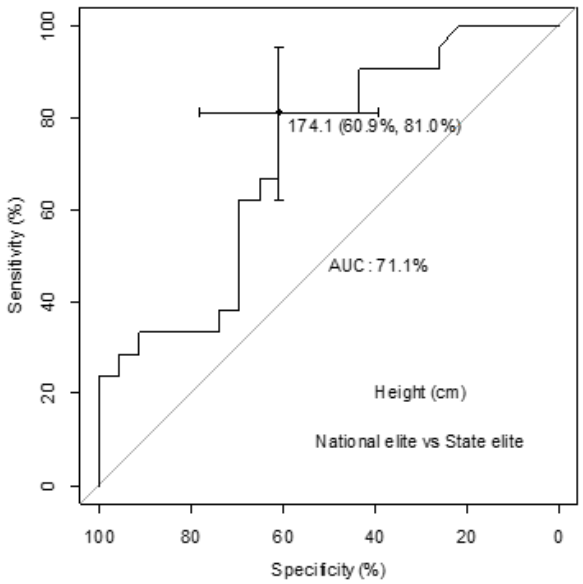

Figure 8. ROC curves and AUC for height (national elite and state elite)

With respect to speed (Figure 9), all national elite players were faster than 4.3 s across 30 m (AUC = 68.3%), and 70.6% completed the 20 m flying start in less than 2.4 s, whereas over 72% of sub-elite players were slower than this (AUC = 75.7%).

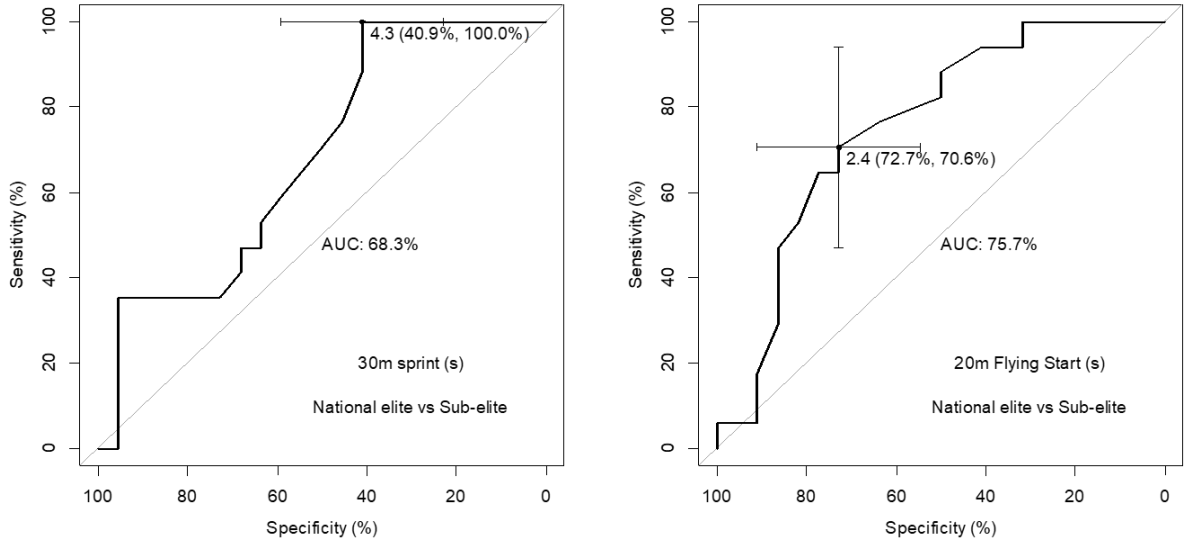

Figure 9. ROC curves and AUC for 30m sprint and 20m flying start (national and sub-elite)

The superior endurance capacity of the national elite cohort when compared to the other two cohorts was evident from the Yo-Yo IR1 results (Figure 10) with 94.1% of national elite players surpassing 1980 m (AUC = 99.5%), while 95.7% of the state elite and 100% of the sub-elite players failed to achieve this distance. Over half of the sub-elite cohort (54.5%) were unable to complete 860 m which is less than half the distance covered by the national elite cohort.

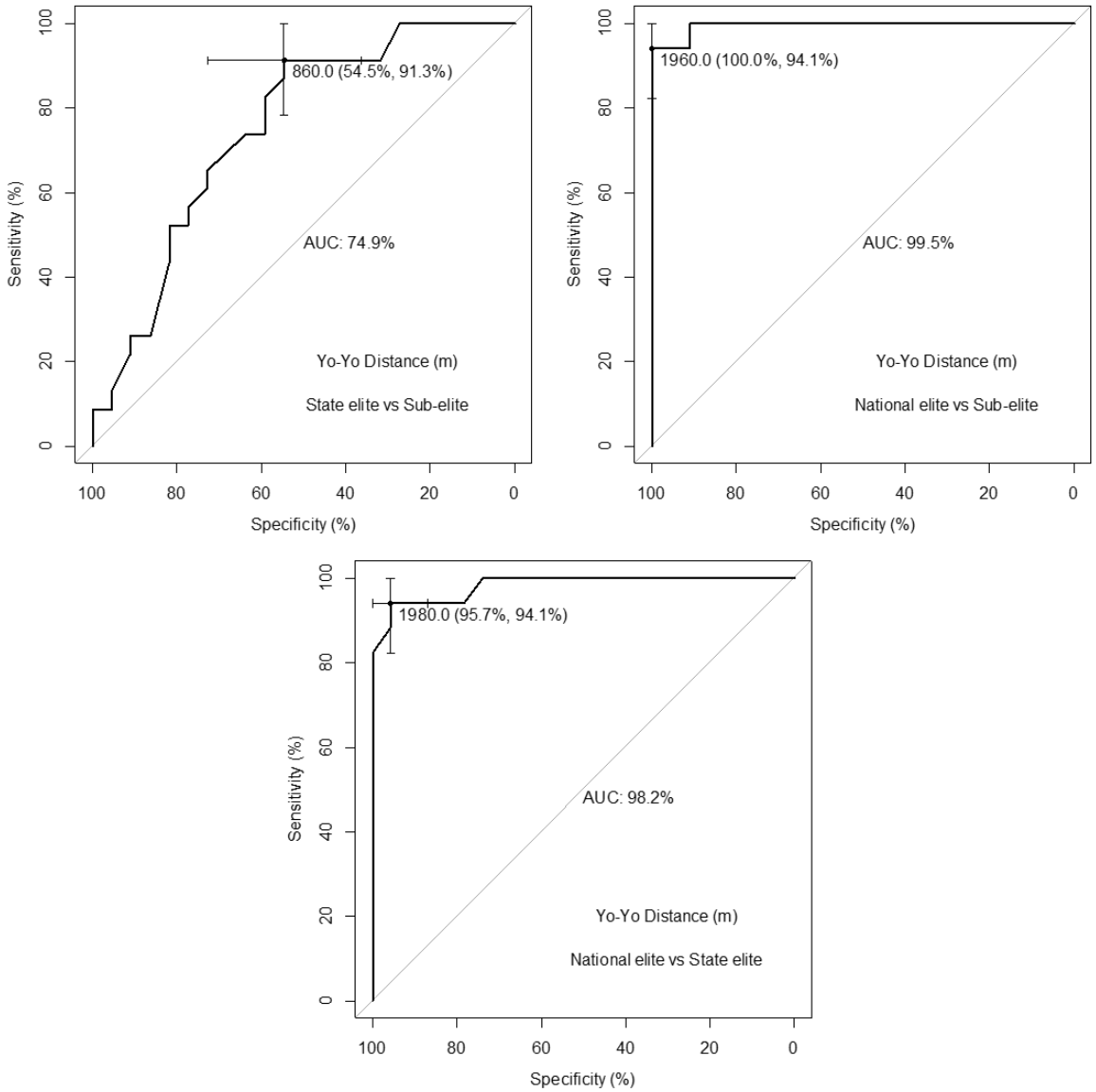

Figure 10. ROC curves and AUC for Yo-Yo IR1 (all cohorts)

4.4.4 Discussion

The purpose of this study was to identify the anthropometric and physical attributes that can distinguish between various levels of youth Australian soccer players. The main findings of the study were that the groups differ significantly on the measures of standing height, 30 m sprint, flying 20 m sprint, and the Yo-Yo IR1, with minimum standards established for each of these variables for athletes to try and achieve to increase their chances of selection in the national elite squad.

The national elite cohort of Australian youth soccer players were taller compared to the state elite cohort. This difference between the two elite cohorts suggests that when the groups are more homogeneous, height may become a discerning and favourable attribute. Interestingly, the difference was not significant compared to the sub-elite cohort, which may be due to the large variability in the height of these less credentialed players. The height of the elite cohort was relatively homogeneous (range 168.5 to 186.2 cm), compared to the larger range and the increased variability of the sub-elite group (range 158 to 196.5 cm), suggesting that height alone is not enough to be successful in youth soccer. Given the multifaceted nature of soccer, it is likely that the taller players in the sub-elite cohort may not have acquired the technical or tactical prowess to be considered in the elite cohort despite their height advantage. Unlike other sports such as basketball where height is recognised as providing a considerable advantage (Torres-Unda et al., 2012), increased height has not traditionally been recognised as an essential attribute in soccer, except for specific positions such as goal keeper (Gil et al., 2007). Given the age of the current participants, caution must be expressed when interpreting the importance of height to elite youth soccer players, as there may be differences in the pubertal status of the participants. This supposed advantage may therefore dissipate once all players have reached their maximum height. Height alone is not sufficient for long-term

success in soccer, therefore coaches should not prioritise this dynamic but untrainable attribute over other trainable attributes when identifying young players for development programs.

Sprint times for the national elite players were significantly faster when compared to the state elite players, with moderate effect sizes for both the 30 m sprint and 20 m flying start. Although the longer sprints were found to be different, the 5 m and 10 m sprint times did not differ between any of the groups, suggesting the difference is in the higher end speed rather than the ability to accelerate. These findings were also supported by the outcome of the vertical jump test which did not differ between the three cohorts, again alluding to the fact that muscular power, in this case in the vertical direction, was not a differentiating feature between groups. The average sprint time during a match is 2-4 seconds (Stolen et al., 2005), which shows how important it is to be fast over this distance (approx. 10-30 m), with many crucial outcomes of a soccer match requiring such a sprint effort (Haugen et al., 2013). The current findings have identified this advantage in the national elite cohort.

Previous literature has shown the importance for players to have an aerobic base, with elite players running upwards of 10 km in a match (Akenhead et al., 2013; Stolen et al., 2005), with each half lasting 45 minutes and teams only allowed three substitutions for the match. The large aerobic base is needed to aid recovery during high-intensity intermittent activities (Reilly, 1997) with Stolen et al. (2005) explaining that a player's physical capacity influences their technical and tactical ability throughout a match. The current study reaffirmed these findings with the Yo-Yo IR1 displaying the greatest divergence between all three cohorts, with all differences between cohorts showing large effect sizes. The national elite cohort ran significantly further in the Yo-Yo IR1, when compared to the state elite, who also ran significantly further than the sub-elite cohort. Given the large effect size and significant difference between all three cohorts it is clear that intermittent endurance is a discerning characteristic of successful youth soccer players. There are a number of performance benefits

that these players will experience as a result of having this increased aerobic base. With the majority of soccer matches being decided by high-intensity movements (Haugen et al., 2013), having a high aerobic base will increase the work intensity and number of sprints performed throughout a match (Helgerud, Engen, Wisloff, & Hoff, 2001). This will allow players to execute the possession style of game displayed in Chapter Three, as they will be able to continually achieve better positions on the field and increase their number of ball involvements. Having a high aerobic base can also counter the effect that fatigue has on technical performance and execution which could occur from cognitive function or muscular fatigue (Rampinini et al., 2009). The results from the current study suggest that aspiring players need to continually develop this physical attribute as much as possible to enhance their likelihood of selection in elite squads. Furthermore, whilst training at the highest level it is expected that this trait would be further developed and as such the current findings must be viewed with caution as the differences observed between groups may be a consequence of selection and further enhanced by the training to which the elite group has been exposed to.

Coaches should be looking for a level of physical expertise in youth soccer players, specifically aerobic capacity and speed over 20 and 30 metres. Although height was found to be a differentiating attribute between cohorts in the current study and has shown to be an advantage for certain positions, coaches need to be careful not to select players based on this attribute throughout youth programs. Based on the findings of the ROC curves, the cut-off scores that players should be aiming for in the physical tests include sub-4.3 s 30 m sprint, sub-2.4 on the 20 m flying start and above 1980 m on the Yo-Yo IR1. Athletes should try to attain these scores to increase the likelihood of being selected. The results of this study highlight the attributes of high performing youth soccer players in Australia, however, achieving these physical outcomes will not guarantee selection, as other factors contribute to successful performance such as technical and tactical skill.

4.4.5 Conclusion

Previous literature has highlighted the importance of possessing a certain level of physical prowess in order to succeed in soccer (Helgerud et al., 2001; Hoff, 2005), and this study has affirmed these findings in a cohort of Australian youth soccer players. It is evident that there are a number of physical attributes that underpin the performance of Australia's elite youth soccer players. Whilst the FFA have emphasised that physical conditioning should not be prioritised over other required characteristics (e.g., advising that physical preparation should not be isolated from technical training (FFA, 2017)), a stronger physical base may provide players with a greater capacity to focus on the technical and tactical skills that also need to be developed. This study determined that height, speed and aerobic fitness are important characteristics of an elite youth soccer player. It is evident that specific physical attributes can distinguish Australian soccer players of varying levels, however this is just one facet of the game. Therefore, it is now important to investigate other areas of soccer performance including technical and tactical skill.

4.5 Technical Testing

4.5.1 Introduction

It is well documented that physical abilities are important in soccer and fatigue can have an effect on performance (Rampinini et al., 2009), however, Ali (2011) has emphasised that the execution of skills is one of the most important aspects of soccer and sound technical ability has been identified as the best indicator for success in soccer (Bush et al., 2015; Rampinini et al., 2009). Williams and Reilly (2000) suggested that focusing on and increasing technical ability can help to overcome physical disadvantages which late-maturing athletes may experience. A number of technical skills are required to be successful in soccer, including passing, shooting and dribbling (Reilly, Williams, et al., 2000). These technical skills allow players to execute specific game styles and various skill-sets may be suited to different styles.

Several studies have explored trends across the years and investigated which aspects of the game can lead to success (Bush et al., 2015; Jones et al., 2004; Wallace & Norton, 2014). An increasing level of technical ability has been demonstrated in the last 12 World Cup finals, with increased player density, ball speed, and passing rate (Wallace & Norton, 2014). The increase in player density has led to an increased number of passes per shot, (Bush et al., 2015) which requires skilful passing to break through opposition defence. Rampinini et al. (2009) showed the importance of technical skill with successful teams having more ball involvements, short passes, successful short passes, tackles, dribbles, shots and shots on target. Technical proficiency has also been demonstrated in the English Premier League matches where there is an increased number of forward and total passes, and pass completions, compared to the lower leagues where there are more interceptions and turnovers (Bradley et al., 2013). This increased technical ability will allow players to execute a possession style of game, but also be direct when required, including quick passes penetrating the forward third. Successful teams evidently need to score goals (Jones et al., 2004; Lago & Martín, 2007), which also emphasises the importance of players having the ability to execute a shot on target.

While the importance of skills testing in TID has been identified, there is debate surrounding the best method to evaluate technical skill in soccer players (Russell et al., 2010; Vilar et al., 2012) due to concerns regarding the ecological validity of the tests and the maintenance of scientific rigour. Soccer specific skill tests assessing shooting, long passing and ball control tests were outlined by Rösch et al. (2000) and replicated by Draganidis et al. (2013) with good test-retest reliability. Rösch et al. (2000) found that the ball control test was the best discriminator between various levels of soccer players (first league, amateur and youth teams), with no systematic differences in the shooting test, however this may suggest that the scoring of the test was not sensitive enough. One of the most frequently used tests is the LSPT

which has also been shown to be valid and reliable for research purposes (Ali et al., 2007; Draganidis et al., 2013).

Football Federation Australia (FFA) (FFA, 2009) has indicated that Australia needs to focus on the technical aspect of the game if it is to improve at an international level. However, the technical ability of Australian soccer players is largely unknown and therefore it is important to provide objective data to assist with TID and subsequent player development. With this knowledge, TID models can then use a multifaceted approach, rather than being reliant on physical measures, as many currently are. The technical tests in the current study were based on the technical parameters of soccer match play, whilst ensuring the tests were valid, reliable and reproducible.

4.5.2 Methods

Passing, shooting, and ball control were assessed using four different tests. The passing skill of the players was assessed using two independent tests which were designed to assess various components of the skill, including speed and accuracy over short and long distances, as well as the ability to utilise both feet. The participants' ability to execute short passes accurately and efficiently was assessed using the LSPT as outlined by Ali et al. (2007), whilst long passing accuracy and skill was assessed using the long passing test (Rösch et al., 2000). Participants' shooting skill was assessed using the shooting test and their ball control was assessed using the ball control test (Rösch et al., 2000). The LSPT was conducted on an indoor basketball court, whilst all other tests were conducted on a soccer pitch.

The LSPT required the athlete to pass the ball as quickly as possible to 16 coloured targets that were located at the centre of four wooden benches (2.5 m long x 0.3 m high) which were arranged in a rectangle (9.5 m x 12 m) (Figure 11). The target was a metal target (0.1 m wide x 0.15 m high) located in the middle of a coloured target (blue, red, green and white;

0.6 m wide x 0.3 m high). Tape was placed on the ground to outline two smaller rectangles (1 m wide x 2.5 m long and 2.5 m wide x 4 m long), with cones placed on each corner.

Players were required to start with the ball in the centre rectangle and time began when the examiner called the first colour and concluded when a total of 16 passes had been completed. This included eight short (red and white) and eight long (blue and green) passes which were called in a randomised order. The participants were required to kick the ball from within the passing zone (between inner and outer rectangle) before receiving the rebound and moving onto the next target. The test was scored as the total time taken which included the time to complete the 16 passes plus the time penalties that were incurred as shown in Table 6.

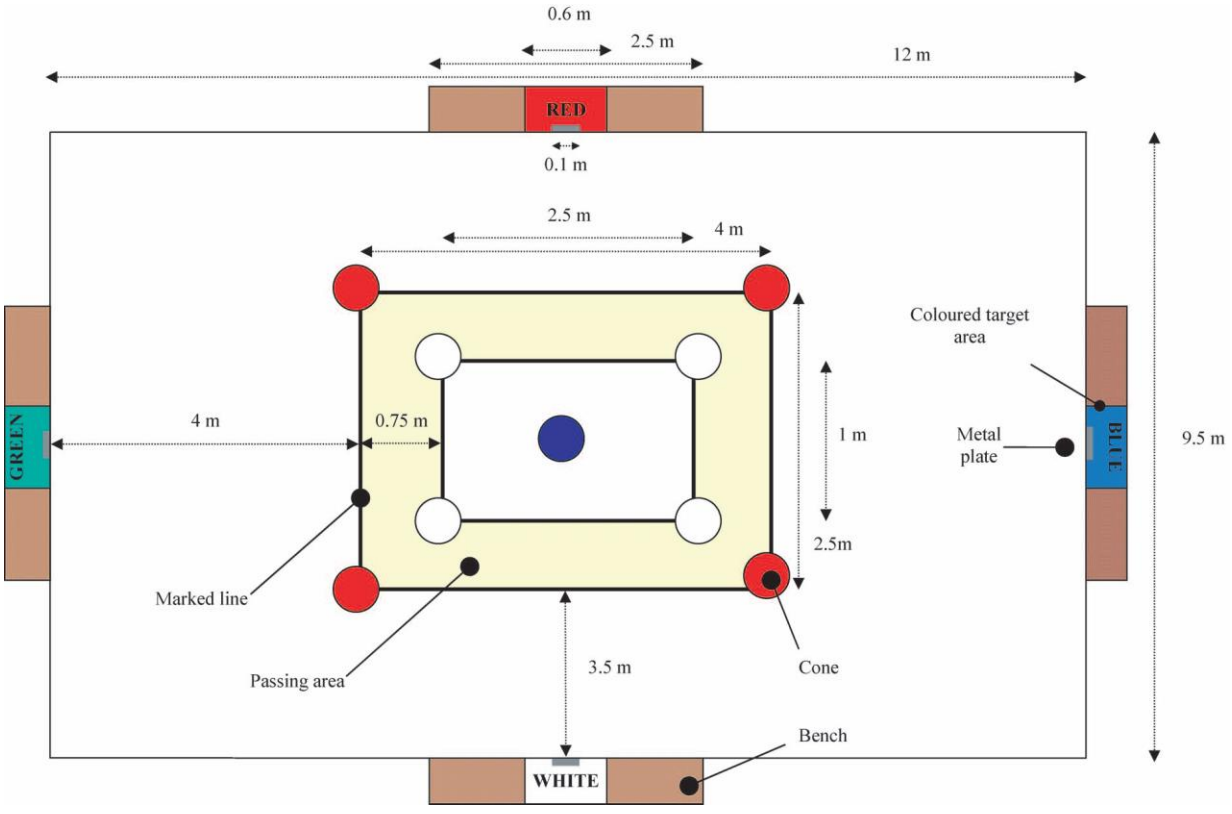

Figure 11. Loughborough Soccer Passing Test schematic (Ali et al., 2007) (with permission to reproduce from Taylor & Francis)

An investigator recorded the weighted time penalties, for missing targets or ball control errors, although the participants could improve their overall time by hitting the metal target. A demonstration and two familiarisation trials occurred to offset any potential learning effects prior to three test trials being completed with the best overall score used for analysis. This test has previously been shown to be a valid and reliable test when used to differentiate young players of differing playing levels following a minimal familiarisation period (Le Moal et al., 2014).

Table 6. Time penalties for LSPT as outlined in Ali et al. (2007)

Error	**Time Penalty (secs)**
Completely missing bench / passing to wrong bench	+ 5
Missing coloured target area	+ 3
Handling the ball	+ 3
Passing ball outside of passing zone	+ 2
Ball touching cone	+ 2
Every second taken above allocated 43s to complete test	+ 1
Ball hit 10 cm strip of metal (middle of target)	- 1

The long passing test assessed accuracy over distance and required players to kick a stationary ball to a target (circle of 2 m radius) located in the middle of a square (10 x 10 m), with the centre of the target being 36 m from the participant (Figure 12). Participants were given two familiarisation trials with each foot, before completing the test six times with their dominant foot, then six times with their non-dominant foot. Three points were awarded if any part of the ball landed in the circle without bouncing and one point if the ball landed in the square, with an investigator standing next to the target to judge and record the outcome.

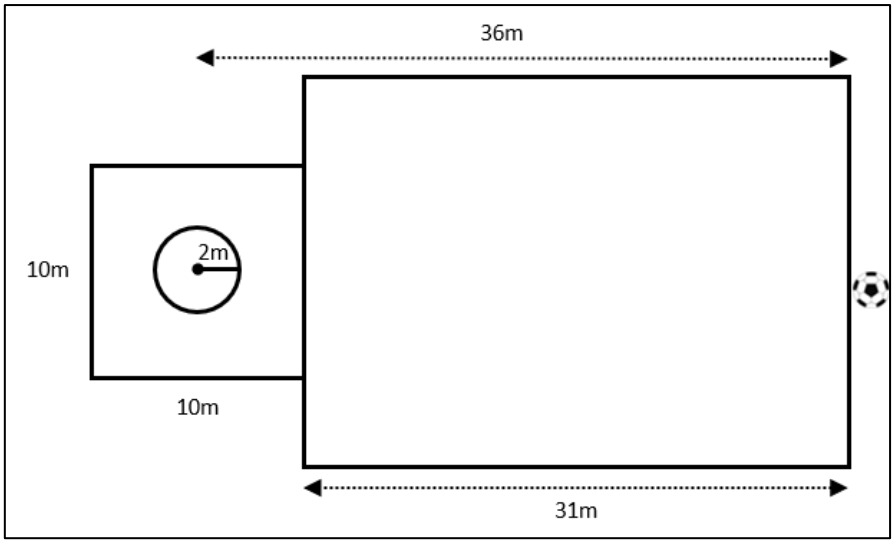

Figure 12. Long passing test, adapted from Rösch et al. (2000) (with permission to reproduce from SAGE Publications)

The players' shooting ability was assessed using a test adapted from Rösch et al. (2000) requiring the participants to shoot from 16 m directly in front of a standard soccer goal (Figure 13). Participants were instructed to aim for the top left and right corners alternately. Two familiarisation trials on each foot were followed by six attempts using their dominant and six attempts using their non-dominant foot. A Stalker Radar Gun (Applied Concepts Inc., New York, USA), situated 1 m behind the participant measured the speed of each shot. All shots were recorded using a Digital Video Camera (Sony, HDR-XR260VE) situated 2 m to the right of the ball placement for post-testing analysis to determine the location of the shot (Figure 13). This was determined using a grid system that was overlaid on the goals and was adapted from Rösch et al. (2000) by increasing the number of squares to increase sensitivity (Figure 14). The test was scored as the total points for the six dominant and six non-dominant shots on goal.

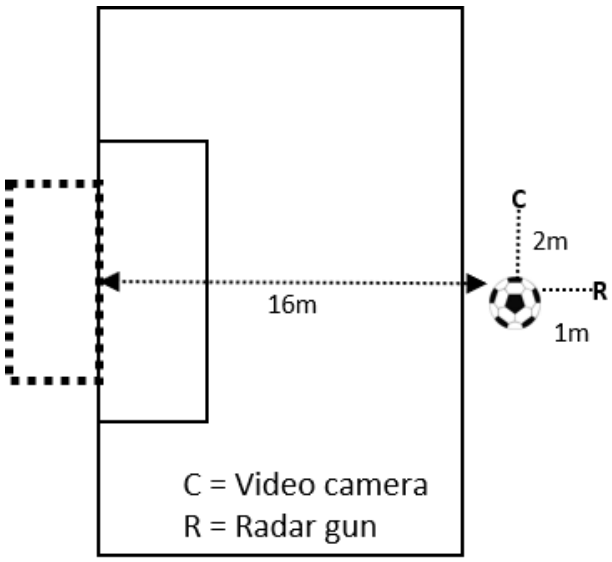

Figure 13. Shooting test, adapted from Rösch et al. (2000) (with permission to reproduce from SAGE publications)

10	8	6	4	2	2	4	6	8	10
8	6	4	2	0	0	2	4	6	8
6	4	2	0	0	0	0	2	4	6
4	2	0	0	0	0	0	0	2	4
2	0	0	0	0	0	0	0	0	2

Figure 14. The scoring system overlayed on the goal for each trial of the video footage

The players' ability to control the ball under time pressure was assessed using a speed dribbling (ball control) test (Rösch et al., 2000). Participants were required to dribble the ball around eight agility poles and two obstacles (boxes) as fast as possible with the total time ceasing when the player had gone through the final agility poles and stopped the ball under their foot (Figure 15). Participants completed two familiarisation trials, with the fastest of three test trials being used for analysis.

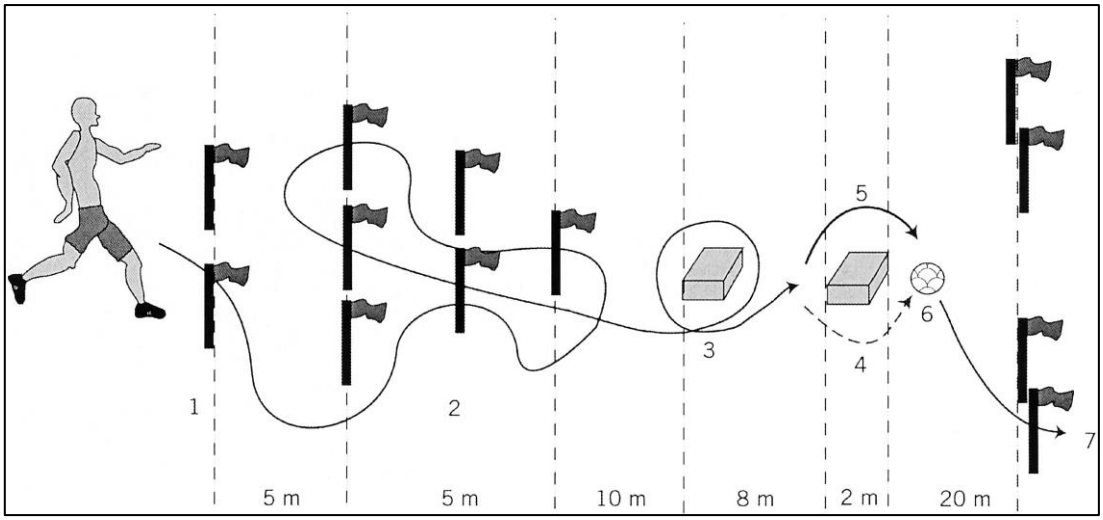

Figure 15. Speed dribbling (ball control) test from Rösch et al. (2000) (with permission to reproduce from SAGE publications)

4.5.3 Results

Technical ability, as assessed using the tests for passing ability (two tests), shooting and ball control, differed significantly between the three levels of Australian youth soccer players with the Pillai's trace (V) showing a significant effect of cohort (V = 0.699, F (10.00,51.00) = 11.853, *P* = 0.000). There were a number of statistically significant differences between cohorts in a number of tests (Table 7).

The LSPT revealed that the national elite cohort performed significantly better than both the state and sub-elite cohorts with large effect sizes reinforcing these differences (ES = 0.83 and 1.42). Despite being slower than the state elite when executing the test, the national elite players had fewer time penalties, giving them a better total score, as shown in Table 7. In regard to the long passing test, large effect sizes were found between the national and sub-elite (ES = 1.01), and between the state and sub-elite cohorts (ES = 1.06) for the dominant foot. These differences were also considered large (ES = 1.32 and 1.32, respectively) when the test was performed with the non-dominant foot.

Table 7. Technical tests by cohort (M ± SD)

				p-value (effect size)		
Test	**National elite**	**State elite**	**Sub-elite**	**National vs State**	**National vs Sub**	**State vs Sub**
LSPT Time (s)	43.9 ± 2.4	41.6 ± 2.3	44.6 ± 3.5	0.031* (0.91)	0.670, (0.25)	0.001*, (0.94)
LSPT Penalties (s)	-3.1 ± 3.0	5.1 ± 7.3	8.8 ± 6.8	< 0.001*, (1.15)	< 0.001*, (1.48)	0.119, (0.52)
LSPT Total (s)	40.8 ± 2.9	46.7 ± 8.3	53.5 ± 8.0	0.032*, (0.83)	< 0.001*, (1.42)	0.006*, (0.78)
Long Passing (D) (score)	8.8 ± 2.6	9.1 ± 2.6	6.0 ± 2.2	0.941, (0.10)	0.003*, (1.01)	< 0.001*, (1.06)
Long Passing (ND) (score)	7.2 ± 3.1	7.6 ± 3.3	2.5 ± 2.5	0.953 (0.10)	< 0.001*, (1.32)	< 0.001*, (1.32)
Ball Control (s)	18.9 ± 0.9	20.4 ± 1.0	20.8 ± 1.6	0.001*, (1.20)	< 0.001*, (1.18)	0.411, (0.35)
Shooting test (D) (score)	16.8 ± 9.8	13.8 ± 6.8	9.6 ± 8.9	0.516, (0.36)	0.030*, (0.72)	0.232 (0.52)
Shooting test (ND) (score)	12.1 ± 6.0	9.6 ± 6.9	7.8 ± 6.6	0.448, (0.39)	0.114, (0.65)	0.647, (0.26)
Shooting speed (D) (km/h)	78.3 ± 5.6	74.4 ± 5.9	71.6 ± 6.7	0.118, (0.65)	0.003*, (0.96)	0.281, (0.44)
Shooting speed (ND) (km/h)	71.2 ± 5.7	65.7 ± 5.0	63.5 ± 5.8	0.008*, (0.93)	< 0.001*, (1.12)	0.365, (0.41)

Note: * indicates statistical significance at $P < 0.05$. D = Dominant foot, ND = Non-dominant foot.

The ROC curves for the LSPT Total (s) had an AUC of 72.6% with 94.1% of the national elite players being faster than 45.5 s, and 56.5% of state elite and 86.4% of sub-elite players being slower than this cut-off score (Figure 16).

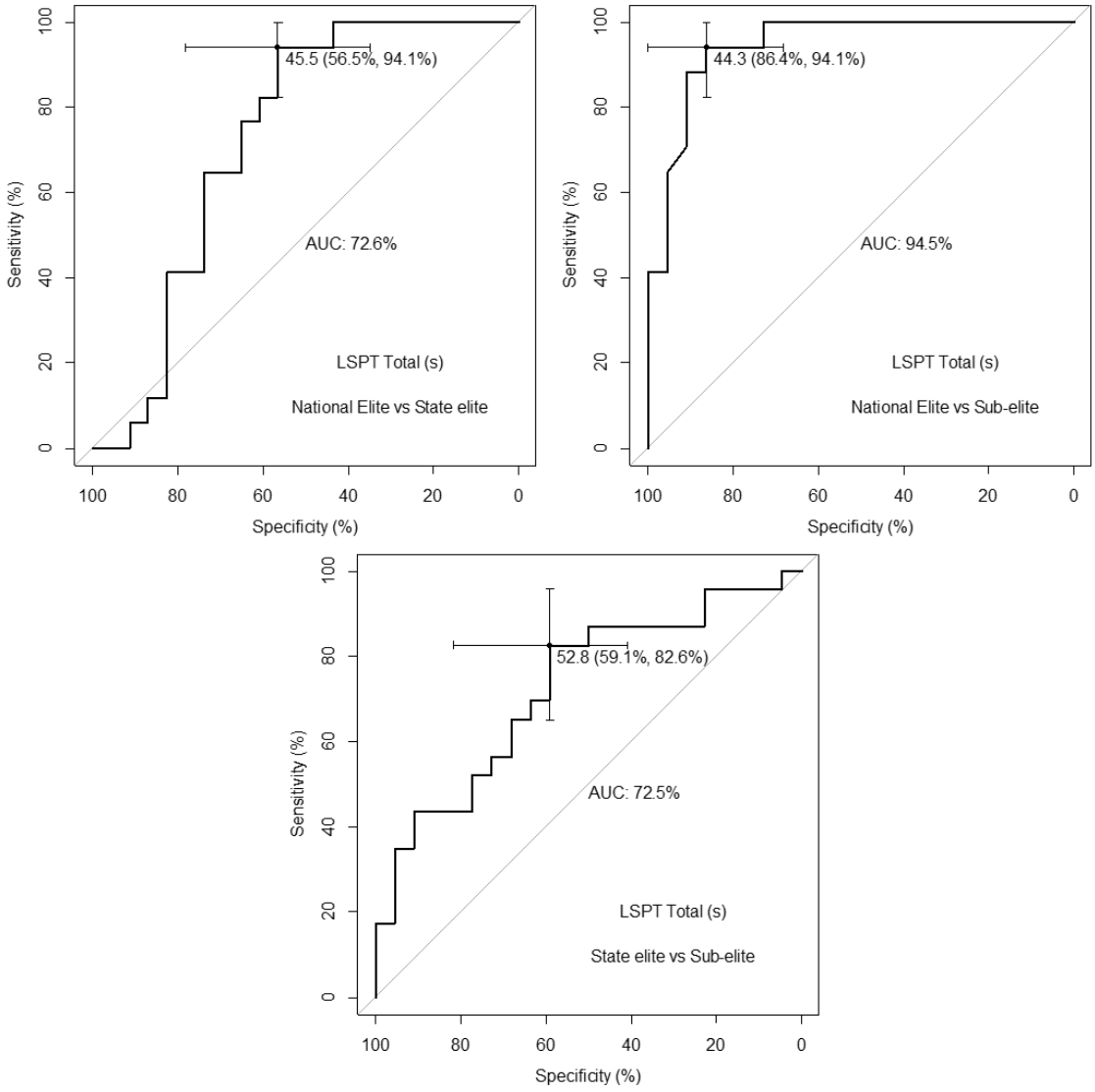

Figure 16. ROC curves and AUC for Loughborough Soccer Passing Test total (all cohorts)

The long passing test on the dominant foot only discriminated between the state and sub-elite cohorts when using the dominant foot (AUC = 80.3%) with a cut off value of 9.5 au being surpassed by 47.8% of state elite players, with only 4.5% of sub-elite players exceeding this score (Figure 17). Surprisingly only 38.9% of the national elite players exceeded this same score. On the non-dominant foot, the discriminatory power was better (AUC = 89.3%), however as expected the cut-off score was much lower with 64.7% of national elite and almost

70% of the state elite scoring above 5.5 au, with over 90% of the sub-elite players below this score.

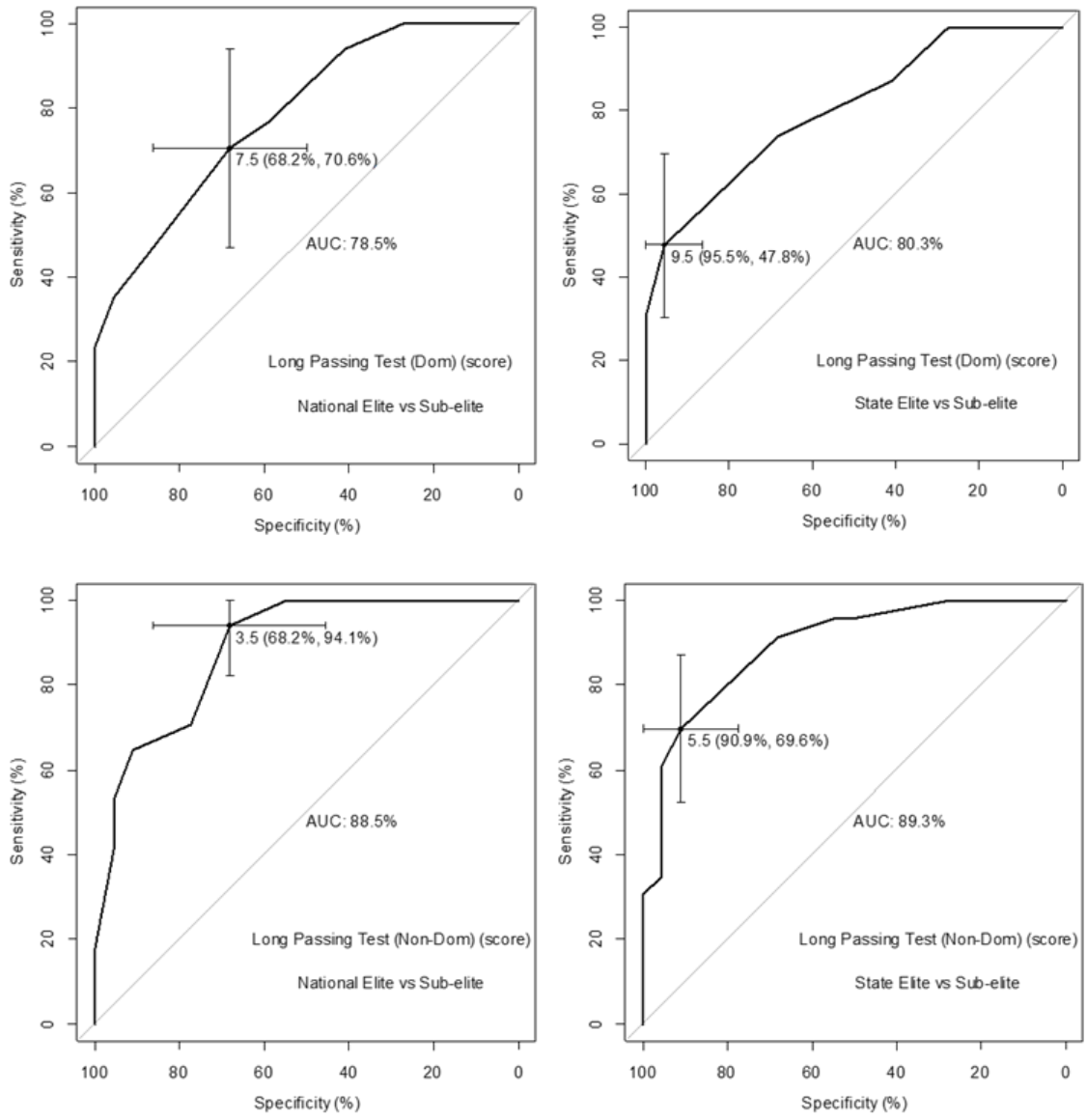

Figure 17. ROC curves and AUC for long passing test on both feet (all cohorts)

The national elite cohort performed significantly better than both the state elite and sub-elite cohorts on the ball control test with large effect sizes (ES = 1.20 and 1.18). The ROC curve showed that 88.2% of national elite players were faster than the 19.6 s on the ball control test, while 86.4% of sub-elite were not (AUC = 89.7%) (Figure 18). When this cut-off was applied to the state elite cohort it was shown that 77.2% of players were also slower than this time.

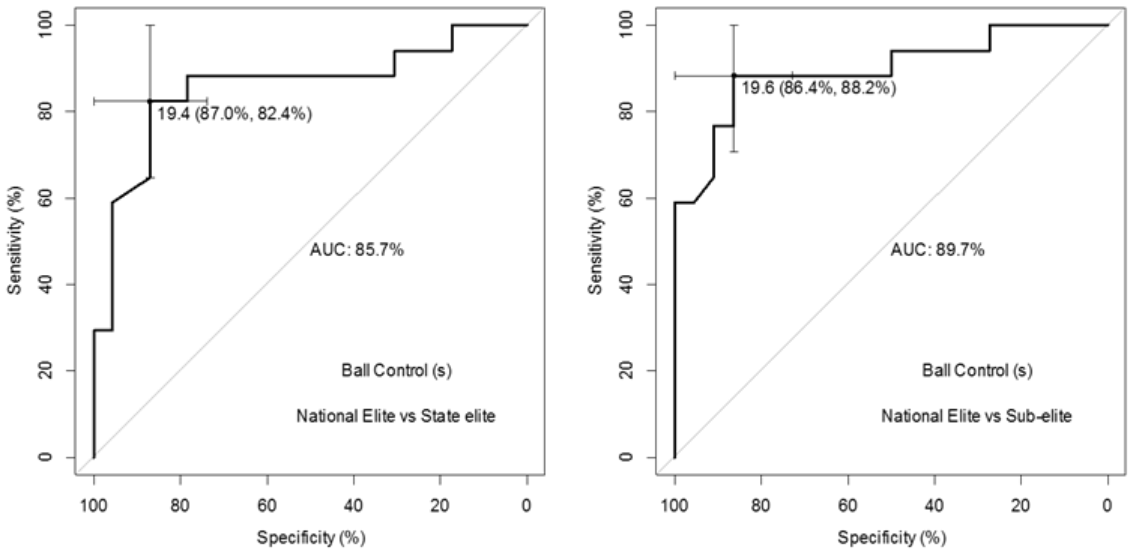

Figure 18. ROC curves and AUC for ball control (all cohorts)

In regard to shooting, the national elite cohort were significantly more accurate and kicked the ball at a faster velocity with their dominant foot when compared to the sub-elite (ES = 0.72, 0.96). On the non-dominant foot there was no significant difference with respect to accuracy, however the national elite cohort kicked the ball at a significantly faster speed than both the state elite and sub-elite cohorts. When the shooting accuracy was analysed, 76.5% of the national elite cohort scored greater than 9.0 on the shooting test (dominant foot), compared to only 36.4% of the sub-elite cohort (AUC = 72.7%) (Figure 19).

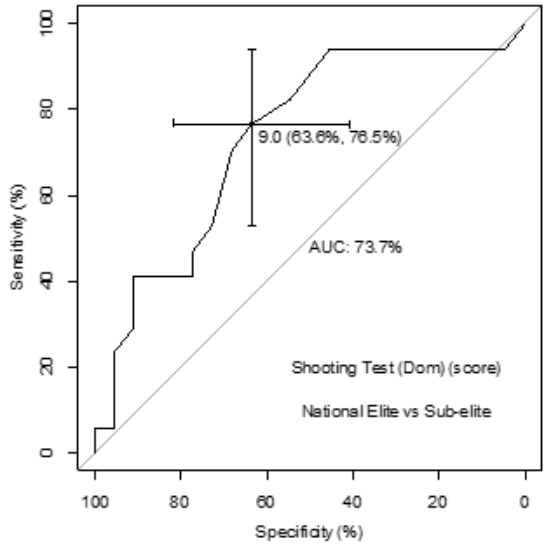

Figure 19. ROC curves and AUC for shooting test dominant foot (national elite and sub-elite)

In terms of shooting speed, 64.7% of national elite players were able to shoot faster than 76.8 km/h using their dominant foot, whereas only 18.2% of the sub-elite cohort achieved this speed (AUC = 77.2%) (Figure 20). On the non-dominant side 58.8% of the national elite, compared to only 8.7% of the state elite cohort, were able to shoot at a speed above 70.4 km/h, (AUC = 76.7%), and when applied to the sub-elite cohort only 9.1% of players surpassed this speed.

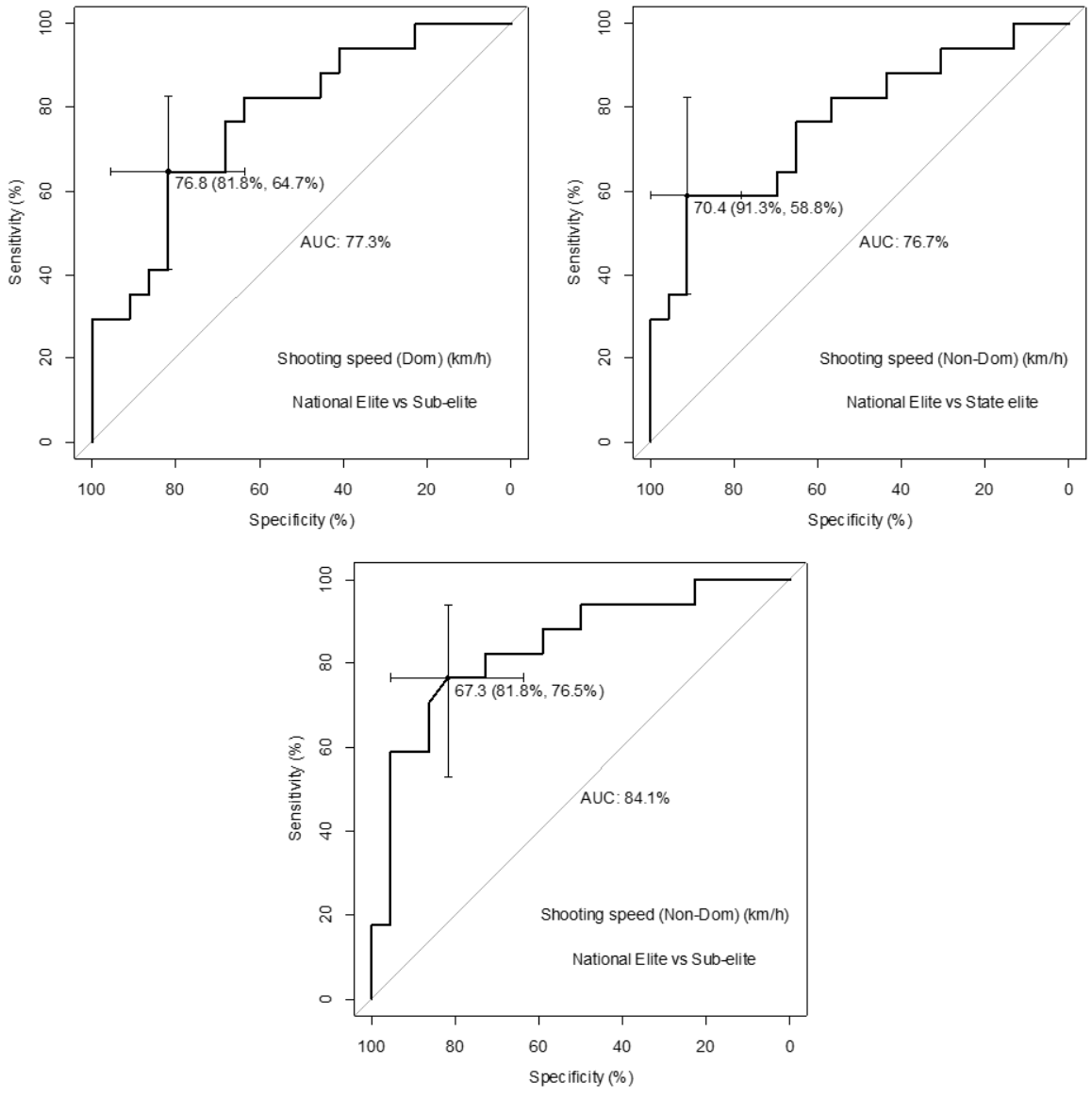

Figure 20. ROC curves and AUC for shooting speed both feet (all cohorts)

4.5.4 Discussion

In this study a selection of technical tests was used to determine the discriminatory ability of these tests and where possible produce minimum standards (cut-off values) for youth soccer players. All of the tests revealed significant differences between the various levels of Australian youth soccer players, with the national elite cohort performing well on all tests.

Both the LSPT and the long passing test showed differences between cohorts. Overall, the LSPT showed differences in a hierarchical order for total time (including penalties). Interestingly, the state elite cohort performed the LSPT in a faster time (before penalties) when compared to the national elite cohort, however the national elite players were more accurate and conceded fewer penalties when compared with the state elite cohort. These results are consistent with the initial study by Ali et al. (2007) with the authors suggesting elite players had better passing accuracy and ball control, as can be seen in the current cohorts. It has long been believed that people who possess lower skills will sacrifice one component of movement to satisfy another, otherwise known as the speed-accuracy trade-off (Fitts & Posner, 1967), and it appears that the state elite prioritised speed over accuracy in the LSPT. Ali et al. (2007) suggests that soccer players with increased skill level will be able to complete the passing test faster, without compromising their accuracy and control. The current study suggests that the national elite cohort are more aware of the speed they could sustain whilst maintaining a very high level of passing accuracy, whereas the speed of the state and sub-elite cohorts impacted on their accuracy, and/or they failed to trade-off speed for accuracy. The cut-off value of 45.5 s discriminated effectively between the cohorts, with a majority of national elite players producing a better result, while over half of the state elite and a majority of sub-elite players failed to achieve this score. Consequently, coaches should focus on improving the short passing accuracy of their youth players, rather than speed, which will further develop once they become

proficient. With increased accuracy their ability to play different game styles, such as the possession style of game, would be enhanced.

It was evident that although the long passing test did not discriminate between the two elite cohorts, both performed better than the sub-elite. The differences indicate that the ability to successfully pass over longer distances is a necessary skill for youth soccer players. From the data presented the performance of this test proved to be the most variable within the elite cohort with not all elite players excelling in this test, however the consistently poor performance of the sub-elite cohort was evident with 21 and 20 players (out of 22) scoring lower than the cut-off on the dominant and non-dominant foot respectively, suggesting this is one area they need to improve.

The current study found that the national elite players were significantly faster than both the state elite and sub-elite players in terms of dribbling speed during the ball control test, yet differences between the state elite and the sub-elite were not apparent. Elite soccer requires players to dribble the ball while sprinting and maintaining possession, making the ability to control the ball crucial to success. As found in this study of youth soccer players, Reilly, Williams, et al. (2000) showed that dribbling could differentiate between elite and sub-elite soccer players. It appears that the sub-elite and state elite players should be aiming to complete the ball control test in less than 19.6 s as a minimum standard to reach the standard of the national elite cohort.

The shooting test focused on the measurement of two variables, accuracy and velocity. In terms of accuracy, the test did not discriminate between the cohorts, however the national elite cohort performed better than the sub-elite on both feet. There was, however, a noted difference between the national elite and sub-elite in terms of ball velocity on both the dominant and non-dominant foot, and between the national and state elite cohorts, when shooting on the non-dominant foot. Again, this shows the importance of possessing proficient skills on both

feet for youth players endeavouring to reach the elite level. This is consistent with previous work by Ali et al. (2007) who found the more elite players were not necessarily more accurate than the lower level players, however they achieve this level of accuracy with a greater ball velocity. The lower speed of the state and sub-elite cohorts may suggest they are trading off speed in an attempt to be more accurate or alternatively it could simply reflect a lack of power, with similar findings and suggestions made by Ali et al. (2007). It appears that sub-elite players looking to improve their soccer performance need to firstly improve their shooting accuracy and subsequently increase their ball velocity on both feet to be comparable to the national elite group.

4.5.5 Conclusion

Overall it is evident that the different levels of Australian youth soccer teams can be differentiated on a number of technical tests, and as such these tests could be used effectively in the TID process. Short passing seemed to be the greatest discriminator between cohorts, with long passing, dribbling speed and shooting (accuracy and speed) all showing significant differences between at least two cohorts. The findings of this study suggest that the TID process of Australian youth soccer players would be enhanced by the inclusion of these specific tests. As can be seen from these first two sections, there are specific elements of physical skill and technical skill that contribute to the performance of higher performing Australian youth soccer athletes. Another factor which has not been examined to date in the Australian context is the tactical skill of the athletes.

4.6 Tactical Testing

4.6.1 Introduction

Decision-making ability has been a topic of interest in numerous sports in recent years. Perceptual-cognitive skills are inclusive of decision-making, anticipation and pattern recall (Williams & Ericsson, 2005). Advanced decision-making ability allows players to execute

offensive or defensive tactics throughout matches. Differences in decision-making ability have been identified at an early age between expert and novice performers in a number of invasion sports (Bruce, Farrow, Raynor, et al., 2012; Lorains et al., 2013; Woods et al., 2016). This enhanced decision-making ability in invasion sports has recently been demonstrated in elite junior Australian Rules football players where 92% of talent identified players were correctly classified according to their superior performance on a perceptual-cognitive decision-making task, whereas physical and technical tests were only able to correctly classify 86% and 84% of players respectively (Woods et al., 2016).

Effective decision-making in soccer requires players to consider and interpret many factors including information from other players, technical or physical constraints, team strategy, and temporal pressure (Williams, 2000). Reilly, Williams, et al. (2000) stated that specific game skills and decision-making abilities were the most critical aspect of soccer, providing support for the identification and development of this attribute. It is an important area, particularly in Australia, with FFA, stating that the national team is currently able to compete physically with higher ranked teams, such as the Spanish or Dutch, but may be less proficient in the technical and tactical areas of the game (FFA, 2017).

Recent studies into decision-making in soccer have provided mixed results, which may in part be due to the varied methodology and the influence of the developmental system (e.g., players selected into academies gaining access to higher quality coaches versus players not selected into academies) which exist in some countries but not others (Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Vaeyens, Lenoir, Williams, Mazyn, et al., 2007; Ward, Hodges, Williams, & Starkes, 2004). Ward and Williams (2003) performed a multidimensional test battery including visual function and perceptual and cognitive skill tests with athletes ranging in age from 9 to 17 years, including elite and sub-elite players. A situational probability test was the best at discriminating across skill groups, whilst structured pattern memory recall

was most predictive of age. Studies specifically focusing on only perceptual-cognitive skill have examined players' ability in generating the potential threats to the defending team (the participants were asked to take the position of a defender) based upon the attacking team structure and ball movement (Belling, Suss, & Ward, 2015; Ward et al., 2013). In these studies, skilled players were able to identify more task relevant options than less skilled players. Similarly, Vaeyens and colleagues completed a series of studies examining decision-making skill in youth soccer players, and also demonstrated that skilled players were more accurate in decision-making tests than less skilled counterparts (Vaeyens, Lenoir, Williams, Mazyn, et al., 2007; Vaeyens, Lenoir, Williams, & Philippaerts, 2007).

Conversely, a different methodological approach by Forsman, Blomqvist, Davids, Liukkonen, et al. (2016) found that tactical skills did not appear to contribute significantly to future performance in youth soccer players. Forsman, Blomqvist, Davids, Liukkonen, et al. (2016) used a skills inventory (Tactical Skills Inventory for Sports) that required athletes to rate their own performance on a number of items compared to the top players in their country for their age group. Thus, all contextual information and ability to perceive and react was removed from this test of tactical skill. Based on these findings it appears that a player's perception of their tactical skill can be quite different to the objective measurement of a decision-making task.

Only one study has examined decision-making skill in selected and non-selected Australian soccer players, with O'Connor et al. (2016) reporting that decision-making skill discriminated selected and non-selected players. The above-mentioned soccer studies have utilised young adolescent athletes, and thus few studies have examined older adolescent athletes who are close to progressing into open age competition. Given the limited knowledge and differing methodologies that have been used to date and the purported importance of decision-making to elite soccer players at the senior level, further knowledge is required to

determine the role of decision-making tasks in the TID and development process, particularly in youth athletes who are nearing open age competition. The current study used a perceptual-cognitive decision-making task to assess tactical performance.

4.6.2 Methods

The tactical ability was assessed using a video-based perceptual-cognitive decision-making task. Participants were tested in small groups of up to 10 players from their own cohort and were seated in front of a projection screen to watch the decision-making task. With permission from the FFA and associated coaches, eight international under 17 soccer matches (which were considered the elite competition for this age group) were filmed by coaches from an elevated position perpendicular to the halfway line to allow the development of this decision-making task. No participants from the current study were involved in any of the matches. The footage was analysed and edited by the primary investigator using Adobe Premiere Elements version 9 (Adobe Systems Incorporated, Australia) to select various scenarios where the ball carrier had at least two possible options at the time when the video clip was occluded (e.g., passing options, or shot on goal). Some clips may have contained more than two options (e.g., two teammates available to pass the ball to as well as the option to shoot), however, the option to play-on (i.e., dribble the ball) was not provided for the participants. These scenarios were chosen in the offensive, midfield and defensive areas of the pitch to minimise positional advantages of the task. A total of 80 decision-making clips were initially selected and edited for the next stage of analysis. Three elite youth coaches, each with at least state institute experience, independently assessed each scenario for what they believed to be the 'correct' decision. The three coaches agreed on the correct option for 31 individual scenarios, which were included in the current study. The clips comprised eight clips in the offensive third, 17 clips in the midfield and 6 clips from the defensive third. However, with soccer being a nomadic sport, all playing positions were in possession of the ball in each area.

The final 31 clips were presented in a random order with each clip displayed for 15 seconds in duration and then frozen for 5 seconds before being occluded. There was a 5 second interval between clips, during which time the participant was required to circle on a print out of the final screenshot, the most appropriate option to pass to, or circle the goal if they would shoot at goal. If a participant did not respond within 5 seconds, then the decision was considered incorrect. Five warm-up clips were shown prior to the main trials, which allowed the participants to be familiarised with the task procedures and timing. After the practice clips all participants completed the task independently with no conversation or feedback provided during the task. The task was scored with one point provided for each 'correct' decision, resulting in a maximum possible score of 31. This dichotomous scoring system was in line with previous work in Australian Rules football players (Woods et al., 2016).

In order to examine the test re-test reliability of the decision-making task, ten of the players were re-tested a week after the initial test. They were not provided with any feedback on the results between trials, with a two-way mixed intra-class correlation coefficient of 0.96 showing that the decision-making task had a high level of test re-test reliability.

4.6.3 Results

There was a significant increase in decision-making performance with increasing levels of expertise across the three groups ($F(2, 61) = 26.13$, $P = 0.000$), with mean scores ranging from 14.2 ± 2.7 (%) for the sub-elite to 20.2 ± 2.5 (%) for the national elite cohorts. Follow up analysis indicated there was significant differences with large effect sizes calculated between all three cohorts (Table 8).

Table 8. Decision-making total score (/31) by cohort (M ± SD)

				p-value (effect size)		
Test	**National elite**	**State elite**	**Sub-elite**	**National vs State**	**National vs Sub**	**State vs Sub**
Decision-making	20.2 ± 2.5	17.4 ± 2.8	14.2 ± 2.7	0.003* (0.97)	0.000* (1.52)	0.001* (1.00)

Note: * indicates statistical significance at $P < 0.05$

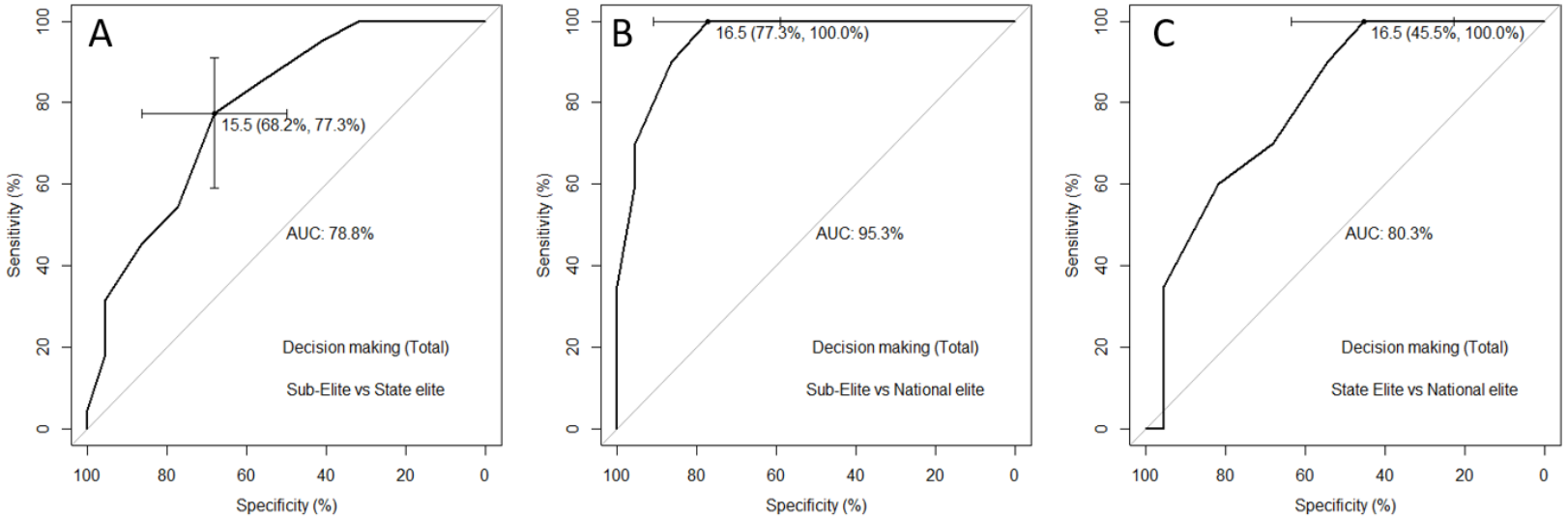

Figure 21. ROC curves and AUC for decision-making task (all three cohorts)

As there were significant differences between all three cohorts, three ROC curves were produced with each demonstrating a high discriminatory power between each cohort; sub-elite and state-elite (AUC = 78.8%; cut-off point = 50.0%), sub-elite and national-elite (AUC=95.3%, cut-off point = 53.2%) and state-elite and national elite (AUC = 80.3%, cut-off point = 53.2%) as shown in Figure 21A, 21B and 21C, respectively. Results indicated that 100% of the elite cohort scored above 53% on the decision-making, however, 12 state elite (Figure 21C) and 5 sub-elite players (Figure 21B) also scored above this cut-off representing 27% or 17/62 false positives for the raw data when the suggested cut off is applied. The distribution of each cohort in the violin plot (Figure 22), shows that although the decision-making results had significant differences, there was some overlap between all three cohorts.

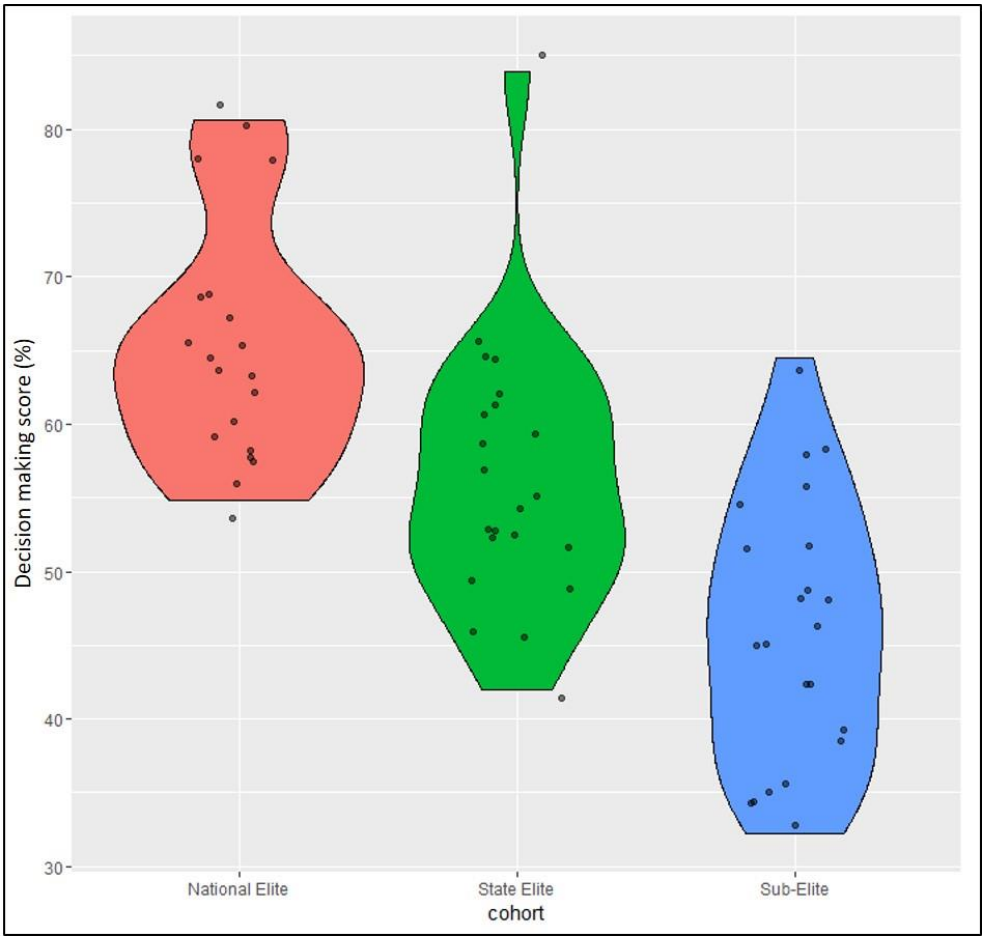

Figure 22. Violin plot displaying the distribution of the decision-making task (all cohorts)

4.6.4 Discussion

The results of the perceptual-cognitive decision-making task demonstrated skill level differences between the three cohorts, confirming results of previous research indicating that a video-based soccer decision-making test can differentiate more highly skilled players from age-matched lesser skilled players (O'Connor et al., 2016; Ward et al., 2004; Ward & Williams, 2003). Despite the observed differences between groups, the relatively low scores suggest that many players, even those currently playing at the state and national elite levels of competitions, need to further develop their decision-making skill with some players making the correct decision on less than half the occasions. Clearly, the decision-making skill of many players, including some in the national elite program, could therefore be considered less than satisfactory. One explanation for this could be the nature of the decision-making task, and the absence of the perception-action coupling process as is required when making decisions in matches. This has been shown previously in netball with athletes scoring higher in decision-making tasks which included the execution of the skill (pass) as opposed to the video-based response (Bruce et al, 2012). In order to assist their transition into senior competition, it is recommended that these players improve their decision-making skill to allow them to become more competitive in senior competition.

It was also interesting to note the large number of players from the state and sub-elite cohorts who also scored above the cut-off for the national elite cohort, suggesting that players with high-level decision-making abilities may not necessarily be being selected into elite teams, presumably due to deficits in other areas (e.g., physical or technical). Conversely, it appears that players with lesser ability in the decision-making aspects of the game are being selected into elite teams (based upon their poor decision-making performance in the current study).

These findings reinforce the need for a multidimensional approach to TID, as some players appear to have been talent identified into a national-elite cohort despite indications that

they may lack sufficient decision-making skills. In multi-faceted sports such as soccer, a player's physical maturation may reduce the need to use their tactical skill, however the converse may also be true, whereby a slower developing athlete may have superior tactical skills as they cannot rely upon their physical prowess to beat an opponent. Players in the national-elite cohort may compensate for their lesser ability in decision-making skills with above average performance in other attributes, such as physical or technical skills. The opportunity to compensate for one skill with another, or 'bridge the gap' as suggested by (Abbott & Collins, 2004), may be more likely in youth level sport when physical differences between players may be maximised due to differing maturational levels. This increased physicality may provide a physical advantage and a perceived difference in ability and match performance. However, when an athlete's physical advantage is lost (i.e., due to maturation of peers or entering open age competition), unless specific attention and development has been paid to other attributes such as technical and tactical skill, players' progression may be limited. Future research may look to examine whether current TID practices sufficiently identify areas of weaknesses that need development, as well as identifying athletes who possess other skills that will allow them to be successful in the long-term (whilst hopefully still developing their weakness/es).

The current findings are in agreement with O'Connor et al. (2016) who found that as a group, players in the elite squads demonstrated superior decision-making skills compared to players at lower levels of competition. Whilst decision-making is by no means the only skill required for success as a youth soccer player, this enhanced decision-making skill that was displayed by a large number of the players in the national-elite squad may have contributed to their initial selection. Once selected, because of the training they are exposed to, it is expected that the difference between players could be exacerbated. Current selection processes often rely on a coach's subjective assessment when assessing a player's decision-making ability,

however, the current findings and those of O'Connor et al. (2016) suggest that video-based decision-making tasks could make a valuable contribution to the TID process, due to the ability of these tests to discriminate between differing skill levels. The identification of players who have greater perceptual-cognitive skills may support the endeavours of Australian soccer to improve the tactical abilities of Australian teams. To achieve this outcome, coaches must use objective tools to initially identify players with above average perceptual-cognitive skills, teach game styles and tactics which are in line with the national curriculum and then use similar perceptual-cognitive tasks to monitor the development of their decision-making ability.

Whilst beyond the scope of the current study, it is important to acknowledge that a number of different factors may influence perceptual-cognitive skill. There is an increasing body of evidence that suggests team sport athletes who diversify are more successful decision-makers (Baker, Côté, et al., 2003b; Coutinho et al., 2016; Memmert et al., 2010), with previous studies showing good decision-makers may come from a variety of backgrounds and experiences. These include having greater exposure to different sports throughout adolescence (Bruce et al., 2013) and familial factors such as a greater number of siblings (Bruce et al., 2013; Hopwood, Farrow, et al., 2015). There are also some trends showing that athletes who are exposed to adult competition at an earlier age may have improved perceptual-cognitive skills (Abernethy, Côté, & Baker, 2002; Bruce et al., 2013).

4.6.5 Conclusion

The current research suggests that a video-based decision-making test is able to discriminate between differing levels of expertise for youth athletes. It is recommended that TID processes include perceptual-cognitive tasks to objectively measure decision-making skill of athletes. The results of the tactical video-based test along with the physical and technical skill testing reveal that the differing skill levels were able to be discriminated on at least one test from each of the attributes. Whilst this is important to know, in order to provide a greater

understanding of the contribution of these skills to performance, it is important to try and distinguish which test/s provide the greatest contribution to the overall performance and how a multifaceted approach underpins performance levels.

4.7 Multidimensional Analysis: Physical, Technical and Tactical Skills

4.7.1 Introduction

The current chapter intended to identify the underlying mechanisms of the expert performance in Australian youth soccer players, which was achieved through three testing batteries, including physical, technical and tactical tests. This chapter has presented the results from each individual testing battery in detail and it is apparent that the higher level soccer players in Australia possess superior physical, technical and tactical skills when compared to lower level athletes. Previous research in various countries has shown that TID and development models in soccer need to be multidimensional (Reilly, Williams, et al., 2000; Unnithan et al., 2012) and for this reason, the final part of this chapter reports on a multidimensional approach. This approach was used to better understand the combination of skills that differentiate each of the cohorts.

4.7.2 Methods

The multidimensional approach was based on the variables which had previously been identified to significantly discriminate between the three cohorts for the physical, technical and tactical testing with a Cumulative Total Score calculated for each individual player. The results from height, 30m sprint, 20m 'flying start', Yo-Yo IR1 (distance), LSPT (total), long passing test (both feet), ball control (s), shooting test (score dominant, speed both feet), and decision-making task (total score) were used in the Cumulative Total Score. As a lower score was deemed to be better for a number of tests, the total time in sprints were subtracted from 20 (i.e. if a player recorded a sprint time of 4.20 seconds, their score would be 15.80), ball control time was subtracted from 50 and LSPT (total) was subtracted from 100 to ensure there were no

negative testing scores. In order to understand which cohorts scored consistently well across the testing battery, the Cumulative Total Score was analysed using an ANOVA with follow up Tukey honest significant difference post hoc to find out which cohorts differed. Similarly, to the decision-making results, a violin plot was created to display the distribution of the Cumulative Total Score. Finally, ROC curves and AUCs were calculated using the statistical software, R (R, Development Core Team, 2015).

4.7.3 Results

The ANOVA for the Cumulative Total Score showed a significant difference between cohorts ($F(2, 59) = 72.43$, $p = 0.000$), with clear disparities between all cohorts, particularly with the national elite cohort. Table 9 shows the national elite cohort were significantly superior compared to the other two cohorts based on the Cumulative Total Score, with large effect sizes.

As there were significant differences between all three cohorts, three ROC curves were produced. These ROC curves, as displayed in Figure 23, showed clear discrimination between the national elite and state elite players (AUC = 98.5%, cut-off point = 2482.2 au, Figure 23A), as well as the national elite and sub-elite players (AUC 99.5%, cut-off point = 2437 au, Figure 23B). As anticipated, it seems that the state elite and sub-elite cohorts were harder to discriminate with an AUC of 66% and a cut-off value of 1337.8 au (Figure 23C).

Table 9. Cumulative Total Score by cohort (M ± SD)

Test	National elite	State elite	Sub-elite	p-value (effect size)		
				National vs State	National vs Sub	State vs Sub
Cumulative Total Score (au)	3030.9 ± 377.9	1876.2 ± 390.2	1434.6 ± 473.0	0.000* (1.69)	0.000*, (1.78)	0.002*, (0.93)

Note: * indicates statistical significance at $P < 0.05$

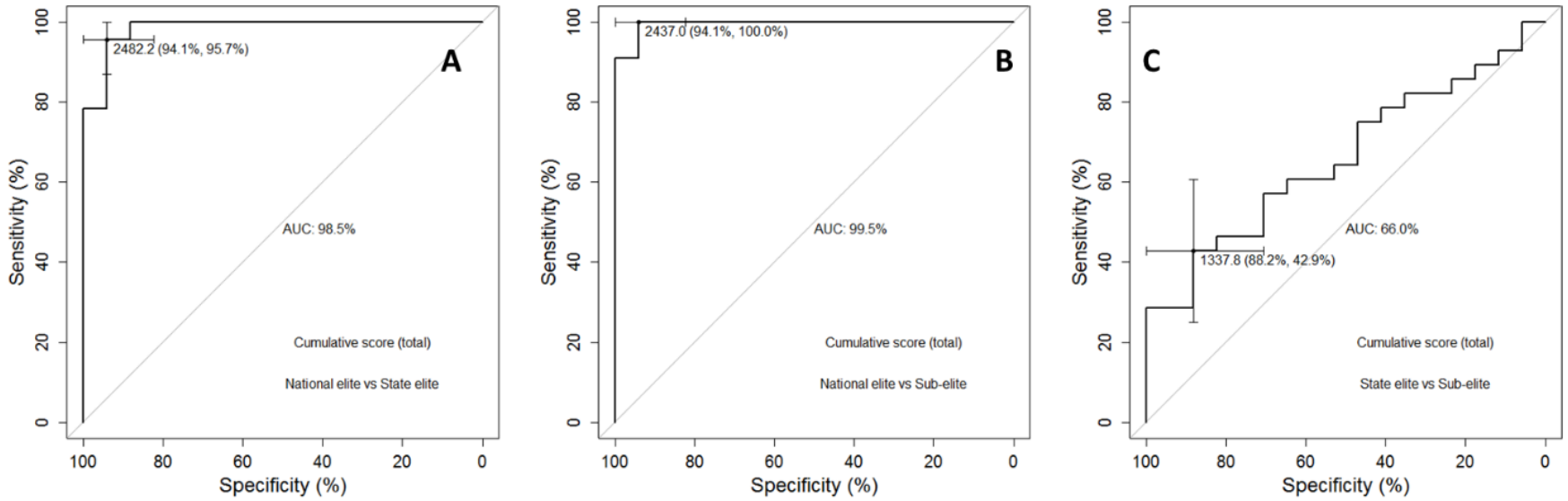

Figure 23. ROC curves and AUC for Cumulative Total Score (au) (all cohorts)

The superiority of the national elite cohort was accentuated by the violin plot (Figure 24), with the distribution showing that the majority of national players are above all state elite and sub-elite players. It also displayed the large overlap of the state and sub-elite players, however the distribution of the state elite players was towards the top of their 'violin', while the sub-elite players were skewed towards the bottom of their 'violin'.

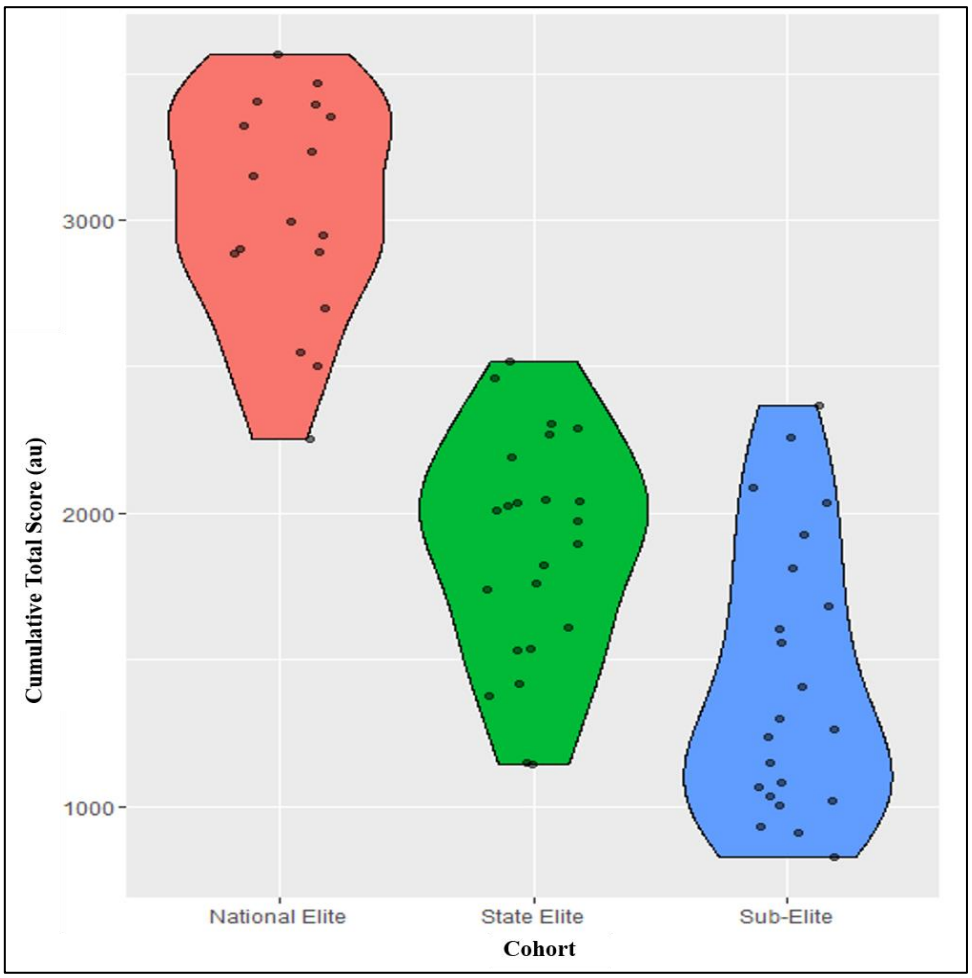

Figure 24. Violin plot displaying the distribution of the Cumulative Total Score (all cohorts)

4.7.4 Discussion and conclusion

In team sports there are a multitude of factors that can contribute to creating successful players. To this point, the thesis has investigated the match characteristics of Australian youth soccer players and identified a variety of physical, technical and tactical skills that are critical to possess in order to execute the game styles outlined in Chapter Three. The early sections of

this chapter have elucidated the individual physical, technical and tactical tests of importance to Australian youth soccer. It became evident that a number of tests and underlying skills could discriminate between the three levels of expertise. The most prominent tests included the Yo-Yo IR1, 30m sprint and 20m flying start, height, LSPT, long passing test, ball control, shooting test and perceptual-cognitive decision-making. The physical, technical and tactical testing batteries were reasonably powerful in their discrimination of groups in their own right, however the next step was to determine the required skills from a multidimensional perspective. The purpose of the final study in Chapter Four was to investigate whether the testing battery was more powerful when combining the physical, technical and tactical testing results.

When interpreting the multidimensional testing results it quickly became evident that the national elite players were performing at a consistently higher standard compared to the state and sub-elite cohorts, emphasising the importance of multidimensional approaches. The critical cut-off point for the discrimination between the national and state elite cohorts on the Cumulative Total Score was 2482.2 au, and as shown by the violin plot, there was one national elite player below this cut-off value, and one state elite player above. Interestingly, the national elite player who scored below the cut-off value was a goal keeper which shows that outfield players are required to have a different skill-set to the goal keepers. Obviously, the nomadic players are required to have increased intermittent endurance, ball control (dribbling) and shooting ability, which is justification for the goal keepers to have a different battery of tests to complete. The state elite player who scored above the cut-off score ran the furthest distance in the Yo-Yo IR1 from his cohort, which shows that excelling in one area will not guarantee selection into the elite squads. It could be speculated that although he excelled with his intermittent endurance, he lacked in another component of his game which held him back from selection into higher levels. Further investigation showed that this player was well below average (at least one SD) compared to the national elite cohort for height, sprint, LSPT

penalties, LSPT total score and ball control. It is clear that although a player may excel in one test, there are a multitude of skills that contribute to overall performance in soccer.

The state and sub-elite cohorts were found to be significantly different, although the overlap shown on the violin plot and with the AUC being only 66%, thus showing it was more difficult to distinguish between these groups when using the current tests. The distribution of the violin plot shows that most of the state elite players scored above the 1337.8 au cut-off, whilst many of the sub-elite players scored below this. Meylan et al. (2010) explain how expertise in sport can be realised with a number of unique combinations of skills, as a player's deficiency in one area can be compensated by strengths in another area. The overlap between these two cohorts shows there are different combinations of skills that can be advantageous to some players, and certain skills might be more important for the selection into the state elite group.

The current study reinforces the need for a multidimensional approach to testing and selecting players, with the combined physical, technical and tactical testing battery having higher discriminating power than the isolated tests. As previously shown in soccer, it is important to capture all facets of the game, as it is such a multidimensional sport (Reilly, Williams, et al., 2000; Vaeyens et al., 2006; Williams & Reilly, 2000). The current study has built on the recent findings from O'Connor et al. (2016) that decision-making can discriminate Australian youth soccer players of different levels. Whilst decision-making is one important aspect of TID, a multidimensional approach is more powerful. Specifically, the results will allow FFA to recommend a specific multidimensional testing battery to all youth coaches at various levels for performance testing, TID and development purposes. Findings from the current studies suggest that future testing batteries should include intermittent endurance, sprinting, height, short and long passing, dribbling, shooting and decision-making, specifically the tests used in the current study, together with the calculated cut-off scores. Players can strive

towards the benchmark of a Cumulative Total Score of 2482.2 au which was the point of best discrimination between the two elite cohorts. The current study has now established the underlying mechanisms for expert performance in this age group of Australian soccer players, and it is recommended that FFA adopts these tests.

One notable finding was the considerable overlap of the state and sub-elite cohorts, and with the unpredictability of TID and long-term development, it shows the importance of coach and player education to ensure a widespread group of players are continually improving. This is one aspect that FFA is trying to improve (FFA, 2017). The interesting discussion point is whether or not to have a 'talent promotion' pathway for players who may not necessarily be ready to make an impact on successful performance, however are identified as having the potential to develop later than the 'talent identified' players. This has been successfully implemented in the German academy systems, where there are a number of youth academies which include talent identified elite pathways and talent promotion pathways for athletes whom scouts and coaches believe might take longer to develop (Güllich, 2013). The benefit of having an elite pathway is the 'radiating effect', which results in players external to the program striving to increase their performance above the benchmarks of the elite players in order to gain selection (Güllich, 2013). Although the non-selected players do not get access to the elite coaching and support, knowledge of the standards and skills required for selection into the academy motivates external players to continually improve and put pressure on the players within the program (Güllich, 2013). This can have long-term benefits, creating competition for places and forcing players to develop, whereas opening the pathway up for more players can potentially remove this effect. Another aspect to consider is the amount of turnover from year to year in talent identified programs, with Güllich (2013) reporting a 24.5% turnover of players each year. Furthermore, only 5.9% of athletes were a part of the national under age team for a five-year duration (Güllich, 2013), showing how unpredictable TID and development can be.

The challenge within Australia will be to promote the widespread development of soccer players throughout the developmental pathway, ensuring that there is a large pool of athletes to choose from. It is critical that FFA continue to educate all coaches of youth athletes at all levels. Although Australia will not be on the same scale as Germany, who have increased their youth academy system to include 49 accredited academies, with 650 accredited coaches for 414 junior teams (Güllich, 2013), they can provide the best possible system for Australian youth soccer. Whilst it is important to understand the skills contributing to successful performance, we also need to understand what experiences (both nature and nurture) can best develop these skills.

CHAPTER FIVE – EXAMINING HOW EXPERTISE IS DEVELOPED: AN ANALYSIS OF THE DEVELOPMENTAL PATHWAYS OF YOUTH SOCCER PLAYERS

5.1 Introduction

The development of expertise would seem to be a complex mix of factors rather than a dichotomous nature (genetics) versus nurture (environment) debate, particularly for team sport athletes. Sport specific practice is required to achieve a high level of performance in a sport (Baker, Côté, et al., 2003a). However, the required amount and whether other factors such as deliberate play, other sporting experiences and milestone achievements contribute to player development and can 'make up' for fewer hours of sport specific practice is unclear. Furthermore, there appears to be other environmental (e.g., birthplace) and sociological (e.g., familial) factors which can positively (and negatively) influence a young athlete (Baker & Horton, 2004).

The debate as to whether nature or nurture has more of an influence in developing expertise is popular amongst those people who marvel at elite performers and similarly amongst researchers who are trying to determine the key to success. Often, it is explained that genetics limit the level of improvement athletes can achieve through training (Baker, Horton, et al., 2003; Georgiades, Klissouras, Baulch, Wang, & Pitsiladis, 2017). Early research in this area suggested that experts within a field required 10 years or 10,000 hours of deliberate practice to achieve their status as one of the best performers (Ericsson et al., 1993; Simon & Chase, 1973). However, evidence for this was not forthcoming in the domain of sport, particularly team sports in which participants consistently reach approximately 4,000 – 4,500 hours of sport specific practice (Baker, Côté, et al., 2003b; Güllich, 2014; Hornig, Aust, & Güllich, 2016) and more recently the strict interpretation of this 'rule' has been softened (Coutinho et al., 2016). The benefits of sampling various sports, and even diversifying the experience within a specific sport during the early years has provided evidence for the potential

transfer of abilities such as movement (physical and technical skills), perceptual (decision-making) and cognitive ability (strategies) (Baker, 2003; Côté et al., 2007; Schmidt & Wrisberg, 2008). Diversification can also reduce adverse effects of injury and dropout from early specialisation and increase an athlete's learning ability which helps the athlete increase progression once they specialise (Güllich, 2018; Güllich, 2017; Güllich & Emrich, 2014). Trialling multiple sports means an athlete's main sport is more likely to be their 'best fit' due to enjoyment, time demands, performance progress and social reasons, which has been termed 'functional matching' (Güllich & Emrich, 2014).

It is recognised that athletes from different countries will often follow specific pathways in their quest to elite status in their chosen sport due largely to the sociological and environmental constraints of the country in which they grew up (Araujo et al., 2010). In countries where soccer is the main sport of choice, it has been shown that athletes are more likely to specialise or engage in soccer from an earlier age (Ford & Williams, 2012). This was evident in England where Ward et al. (2004) found that players tended to specialise in soccer at a younger age to develop their soccer specific attributes. Interestingly in Brazil, despite the high soccer participation rates, children were found to be more active in informal soccer play than in structured activities (Ward et al., 2004). The fact that Brazilian soccer players are typically very successful despite having a reduced proportion of structured involvement suggests that the 'play activities' which they are exposed to at an early age have a huge influence on skill development (Araujo et al., 2010). Most soccer development research has been based on skilled youth athletes, however in a study of German professional senior soccer players, it was evident that an increased amount of play (structured, incidental and in other sports) was a critical component of long-term success (Hornig et al., 2016). There are distinct pathways and factors which contribute to successful soccer development in other countries, however there has been limited work in this area in Australia. O'Connor et al. (2016) found

that selected and non-selected (national institute program) youth soccer players were not able to be differentiated based upon their playing history, although there was only a small selection of variables analysed in this under 15 cohort.

One area that has received some interest in the literature is the degree to which an athlete's family can influence athletic development, with varying effects being ascertained in different sports (Bruce, Farrow, et al., 2012a; Côté, 1999; Hopwood, Farrow, et al., 2015). Although initial studies surrounding familial influence on athletic development focused on pressure, support, involvement, and the environment provided by parents and siblings (Côté, 1999; Wuerth, Lee, & Alfermann, 2004), some studies have looked at the sporting history and background of family members (Bruce, Farrow, et al., 2012a; Hopwood, Farrow, et al., 2015). The key aspects of sibling dynamics in relation to elite athlete development are birth order and their sibling's involvement in sport. Bruce, Farrow, et al. (2012a) and Hopwood, Farrow, et al. (2015) have shown that elite athletes are typically born later in their family, with their siblings more likely to be involved in a higher level of physical activity and other sports compared to siblings of lesser skilled athletes.

Older siblings can have an influence on the development of younger athletes in various ways, including increased competition for their parents' attention, role modelling and imitation of positive actions such as sport participation (Bandura, 1977; Hopwood, Farrow, et al., 2015; Sulloway, 1996). Recent findings in gold medal athletes showed these athletes have significant rivalries with their siblings, and although non-medallists also had strong rivalries, gold medal athletes focused on the process, along with the outcome, allowing them to perform better under pressure (Hardy et al., 2017). These findings suggest that familial influences are another important aspect of athletic development and warrant further investigation.

The specific research question that was addressed was:

Are there differences in the developmental pathway between levels of expertise (based on physical, technical and tactical skill level) in Australian youth soccer players as determined using a developmental history questionnaire? If yes, where do they occur?

It was hypothesised, based on previous research, that highly skilled Australian youth soccer players would follow distinct pathways based upon their training history and familial background. Highly skilled athletes were expected to have more sports specific practice than less skilled athletes and family members who are more engaged with sport participation.

5.2 Methods

All participants who took part in the physical, technical and tactical testing as described previously in Chapter Four also participated in this study. The reader is referred to Section 4.3 for full details of the sample characteristics. This study was included in the overall project ethics approval. All participants were asked to complete the Developmental History of Athletes Questionnaire (DHAQ) (Appendix D), which is comprised of ten sections including, demographics, sporting career, milestones, competitive history, practice history, competition history, participation in other organised sports, participation in playful sporting games, familial information and places of residence (Hopwood, MacMahon, Baker, & Farrow, 2010). The DHAQ has shown good to very good agreement for test-retest reliability ($r = 0.90$), concurrent validity ($r = 0.86$) and convergent validity ($r = 0.72$) (Hopwood, MacMahon, et al., 2010).

Participants completed the questionnaire online using Survey Monkey (Sydney, Australia), with the principal researcher available by phone to assist with queries where required. In order to capture as many participants as possible, emails and phone calls were used to follow up with participants who missed the original session, asking them to complete the questionnaire in their own time, with assistance provided if required. Participants took

approximately one hour to complete the DHAQ. Despite every effort to capture all participants who completed the physical, technical and tactical testing (n = 62), due to the nature of questionnaires there was a 68% partial and 58% full completion rate for the current study. This is however above the 52.7% average response rate for surveys and questionnaires reported by Baruch and Holtom (2008). In order to explore every aspect of the athletes' developmental history, it was decided to progress with the questionnaires that were completed in full. This resulted in 36 participants being included in the subsequent analysis (national elite n = 15, state elite n = 11, sub-elite n = 10) of the DHAQ.

When responding to the question on practice history, athletes were asked to recall the average hours performed each week, and number of months performed each year, from age 5 years to their current age, in various types of practice (e.g. sport specific physical practice or informal play). Accumulated hours of practice history were then calculated by summating the hours per month, multiplied by months per year for the analysis.

It is well established that coaches have typically selected potential players based on subjective opinions and biases which may not actually translate to long-term success (Christensen, 2009; Meylan et al., 2010; Sarmento et al., 2018; Unnithan et al., 2012; Williams & Reilly, 2000). For this reason, the current study used the objective testing battery from Chapter Four to classify players into four quartiles of skill expertise, as opposed to the predetermined cohorts, which may have had subjective assessments for selection. As reported previously, the following tests were most predictive of higher performance in their respective test battery:

- Physical – height, 30m sprint, 20m 'flying start', and Yo-Yo IR1 (distance),
- Technical – Loughborough Soccer Passing Test (total), long passing test (both feet), ball control (s), shooting test (score – dominant foot, speed - both feet), and
- Tactical – decision-making task (total score).

To determine an overall skill level for the players, the Cumulative Total Score, as calculated and described in Chapter Four (see Section 4.7.2), was used to rank players into quartiles for subsequent analysis on the DHAQ. The purpose of this was to categorise players based on objective measurements, as opposed to current classifications, in order to develop a model for future selection. Each quartile contained nine participants, as displayed in Table 10.

Table 10. Breakdown of cohorts into quartiles based on testing results

Quartile	Cumulative Total Score	AUC	Participants	Sub-elite	State elite	National elite
1	2949 - 3565	94%	9	0	0	9
2	2303 - 2904	94%	9	1	2	6
3	1608 - 2090	97.5%	9	2	7	0
4	824 - 1408	94.7%	9	6	3	0

The DHAQ factors listed in Table 11 were included in the analysis based upon findings from previous research (Bruce, Farrow, et al., 2012a; Bruce et al., 2013; Côté, MacDonald, Baker, & Abernethy, 2006; Ford et al., 2010; Hopwood, Farrow, et al., 2015; Hopwood, MacMahon, et al., 2015; O'Connor et al., 2016; Ward et al., 2007).

A decision tree induction analysis was undertaken using JMP (version 13.1.0, SAS Institute Inc. 2016). Using several algorithms, the decision tree calculated which factors contributed most to the predictor variable (Cumulative Total Score). More specifically, the developmental factors from the DHAQ that resulted in the attainment of important soccer specific skills were revealed. The input factors that best separated the data partitions into individual classes were then teased out in hierarchical fashion (Han, Kamber, & Pei, 2006). ROC curves were then used to determine the accuracy of the decision tree induction analysis by expressing the rate of true positives and false positives, with the AUC then displaying the accuracy of the model (Table 10).

Table 11. DHAQ factors and definitions included in analysis

Variable	Definition
Predicted peak performance	Specific age athletes predict that they will achieve their highest level of performance
Highest level of competition	Specific level of competition players predicted they would play in
Years participating in soccer	Total number of years players have been participating in soccer
Age of first participation in soccer	First participation in soccer of any format (coach-led practice, peer-led play etc.)
Age they specialised in soccer	Athlete stopped involvement in all other sports to concentrate on soccer
Number of sport specific physical practice hours	Accumulated hours of specific soccer practice (coach or individual-led)
Number of physical preparation hours	Accumulated hours aimed at improving physiological and muscular capacities
Number of hours engaged in soccer play activities	Accumulated hours of soccer play activities with no formal instruction or coaching
Total hours in soccer participation	Accumulated hours of soccer specific practice and play
Number of other sports participated in	Sporting activities involving regular practice sessions under formal supervision
Number of hours in sampling years in soccer *	Accumulated hours of soccer practice and play between ages of six and thirteen
Number of hours in specialising years in soccer *	Accumulated hours of soccer practice and play between ages of thirteen and fifteen
Number of hours in investment years in soccer *	Accumulated hours of soccer practice and play from sixteen years onwards
Mother's highest level of sporting competition	Recreational, local, state, national, international (senior or junior) sporting competition
Father's highest level of sporting competition	Recreational, local, state, national, international (senior or junior) sporting competition
Either parents' highest level of sporting competition	Recreational, local, state, national, international (senior or junior) sporting competition
Siblings' highest level of soccer competition	Recreational, local, state, national, international (senior or junior) soccer competition
Siblings' highest level of other sporting competition	Recreational, local, state, national, international (senior or junior) sporting competition
Number of siblings	Number of biological brothers or sisters
Birth order	Chronological order of athlete's birth in comparison to other siblings
Birth town population	Number of residents in birth town in athletes birthyear
Mother's place of birth	Town or city biological mother was born
Father's place of birth	Town or city biological father was born

Note: * denotes variables which are derived from the DHAQ and are not specific questions.

5.3 Results

The AUC values from the ROC curve analysis, shown in Table 10, ranged between 94-97.5%, which represents good accuracy for predicting all quartiles based on the DHAQ included factors. The decision tree induction analysis (see Figure 25) showed that the factor that best discriminated between the top two versus bottom two quartiles was the number of hours spent in sport specific structured practice. Specifically, 2122 hours was the point of highest discrimination of the four quartiles, with other factors following in hierarchical fashion. A total of 26 out of the 36 participants had accumulated greater than 2122 hours of sport specific structured practice and this included players from all four quartiles, however most prominent were players from quartiles one and two with all players in these two quartiles meeting this criterion.

With all the players in quartile one accumulating greater than 2122 hours of sport specific structured practice, the second factor to differentiate this elite group of players was their birth order. The analysis revealed that for those players who were born later in their family (third or later) (n = 6), the majority had siblings who had participated in a sport other than soccer, at a recreational level or above. The quartile one players who were born first or second (n = 3) had specialised in soccer at a later age (>13 years old). In contrast, the majority of the quartile two players who were born first or second in their family, specialised in soccer before the age of 13.

Following the pathway of the players from quartile three and four who had spent less than 2122 hours in sport specific structured practice, the distinguishing factor between these two quartiles was their total volume of soccer play hours. The six players from the third quartile had all accumulated more than 564 hours of soccer play, whilst the five players in quartile four had all experienced fewer hours of play.

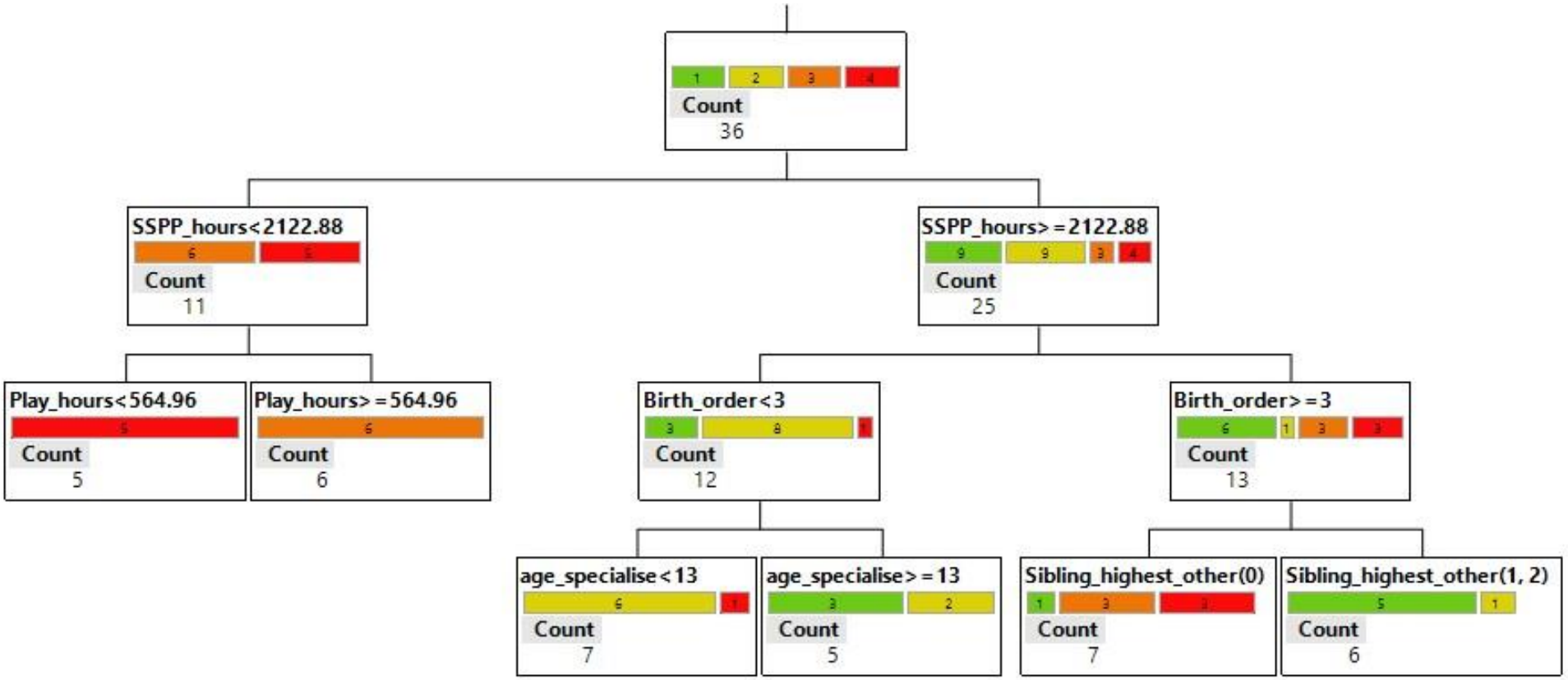

Figure 25. Decision tree for developmental pathways.

Colours are representative of the quartiles (Q1 = green, Q2 = yellow, Q3 = orange, Q4 = red). The numbers in each box then represent the number of participants from each quartile that followed that specific developmental pathway. Note: SSPP_hours = sport specific physical practice hours.

5.4 Discussion

As the aim of this thesis was to investigate the development of expertise in Australian youth soccer, the discussion will initially follow the pathway of the quartile one players to determine personal factors and experiences that differentiated them from the other players. It should be remembered that all national elite players had been assigned to quartile one based on their Cumulative Total Score. It is important to note that although there are some interesting and justified results that should be investigated in further detail, this is just one cohort of Australian youth soccer players and the inference for developmental pathways in this demographic should be interpreted carefully.

Although the first distinguishing factor was the amount of sport specific structured practice accumulated (which was defined as team or individual coach led practice), the fact that all of the quartile one and two players accumulated more than 2122 hours (the point of highest discrimination) shows that this is essential for those aspiring to an elite status in youth soccer. However, it may not be the only factor for the development and acquisition of expertise as sport specific structured practice in isolation does not seem to be sensitive enough to discriminate between the two highly skilled, homogenous groups of athletes who formed quartiles one and two. These findings are supported by Güllich (2017) who suggested sport specific structured practice is important, however there are clearly more discerning factors for sporting success. The key factor that discriminated those athletes who had amassed higher amounts of sport specific structured practice was their birth order with different experiences dependent on this factor.

Specifically, a greater number of quartile one athletes (n = 6) were born with at least two older siblings (born third or later), whereas the majority of the quartile two athletes (n = 8) were first or second born in their family. The significance of birth order and having older siblings has also been noted by Bruce, Farrow, and Raynor (2012b) who found that elite netball

players were typically not the oldest child, whilst the poorest decision-makers in netball had less than two siblings. Similarly, Hopwood, Farrow, et al. (2015), in a study across multiple sports, found that elite athletes were more likely to be later born children. There are thought to be many advantages afforded to the later born athletes developing increased sporting skill. It is particularly interesting that the highest point of discrimination in the current study required athletes to have at least two older siblings whereas Hopwood, Farrow, et al. (2015) had previously reported that elite athletes are more likely to have at least one older sibling. There could be extra benefits of having two older siblings whilst growing up, potentially increasing the likelihood of informal play activities, and competition between siblings.

In addition, the factor that subsequently distinguished between the quartile one and quartile two athletes, who were at least third in their family's birth order, was the participation of the athlete's oldest sibling in a sport other than soccer. This is well supported by Hopwood, Farrow, et al. (2015) who showed that elite athletes tended to have older siblings who participated in more physical activity and recreational sports. Although the dynamics between sibling sporting involvement and the attainment of expertise is obviously complex, there are many possible reasons for the positive influence of sibling interactions and their involvement in other sports. If younger athletes see their older siblings being involved in sport and physical activity, it is likely that due to modelling and imitation they may engage in these activities (Bandura, 1977; Hopwood, Farrow, et al., 2015). Furthermore, Hopwood, Farrow, et al. (2015) suggested that siblings act as socialising agents, encouraging their brothers and/or sisters to first participate in sport, and if drawn to a different sport, children trying to find a niche in their family in order to compete with siblings for their parent's gratification. It is also thought that once introduced to sport, the younger sibling/s will constantly strive to outperform their older counterpart/s, who are generally bigger and stronger, in order to gain the attention from their parents (Sulloway, 1996). Seeing their older sibling/s participate in sport from a young age

may also instil a positive work ethic and drive that will allow the younger sibling to pursue and succeed in their sporting endeavours (Côté, 1999; Hopwood, Farrow, et al., 2015). It is clear that sibling dynamics and familial influence have an impact on the development of expertise in Australian youth soccer players, with the engagement of older siblings in other sports contributing positively to the development of soccer specific skills in their younger siblings.

Whilst some of the quartile one athletes in the current study showed similar birth order patterns to previous research, there were a group of quartile one athletes who contradicted the findings of Hopwood, Farrow, et al. (2015). Although there was a strong pathway for athletes who were born later in their family (third or later), athletes could still acquire the highest level of soccer specific skills if they were first or second born. The current findings suggest that these athletes (earlier born) were still able to achieve a high level of soccer skill if they specialised in soccer at a later age. The current study suggests for athletes who were not born with at least two older siblings, they followed a different pathway to make up for the environmental disadvantage that came from having less access to training partners, role models and the other benefits previously ascribed to having older siblings. If athletes were born first or second in their family, specialising later (> 13 years) seemingly afforded them a greater chance of success, as those who specialised earlier were ranked in quartile two.

There are numerous ways to interpret this particular finding, however it seems that the incidental play, extra competitiveness and an environment provided by having older siblings can potentially be counteracted by delaying specialisation in soccer until after the age of 13. Due to the smaller sample size, the specific activities these players were involved in prior to specialising is unclear, however based on previous research they could have either diversified at an early age, engaged in more playful soccer activity, or simply specialised later. The extra time these players took to specialise in soccer could have allowed them to increase their functional matching with soccer (Güllich & Emrich, 2014).

Although all players in the first two quartiles who were first or second born played a similar number of different sports as a child, those who were classified as being more highly skilled (quartile one) appear to have stayed involved in these multiple sports for a greater period of time, as they did not specialise until after the age of 13. The benefits of this diversified approach include reducing injury and dropout, increasing functional matching between athlete and sport, transferring perceptual-cognitive, physical conditioning and psychological skills (Güllich, 2018; Güllich, 2017). Furthermore, it is thought that playing multiple sports as a junior allows the athlete to transfer their learning ability, facilitating faster subsequent performance progress in their main sport due to an increased network of perceptual motor skills (Güllich, 2018; Güllich, 2017). Alternatively, the athletes may have followed the early engagement pathway which involves increased soccer specific play activity during the early stages, before increasing the sport specific structured practice later (Ford et al., 2012; Ford et al., 2009). Simply delaying the specialisation into the athletes' main sport is thought to increase long-term sustainable athletic careers due to the risk buffering (decreased chance of injury or burnout) in their early development (Hornig et al., 2016). There are many explanations for the benefit of delaying specialisation. Given the different pathways followed by players according to their birth order, the long-term effect of this on injury and burnout needs to be assessed in a longitudinal study and with a bigger cohort to make inferences about these development activities prior to specialisation in Australian youth soccer players.

The pathway in Australia seems to differ from England where children generally engage or even specialise in soccer at an early age and persevere until they reach the elite level (Ford & Williams, 2012; Ward et al., 2007; Ward et al., 2004). It could be argued that with soccer being such a popular sport in England, in addition to a large population, the participation rate provides a bigger pool of athletes to choose from, with athletes who burnout or lose interest not impacting on the talent pool as much as in a country such as Australia with a smaller

population and less participants (Ford & Williams, 2012). Importantly, these studies involve youth athletes who were recruited into soccer academies at a young age, which could result in selection effects, compared to investigating successful senior athletes. It is evident that Australian soccer pathways appear to be similar to those for elite youth players in Germany who have a similar amount of sport specific structured practice as their peers, however they have an increased number of hours spent in organised practice of other sports (Güllich et al., 2016). Interestingly in German soccer players it has also been shown that increased amounts of peer-led play can benefit later performance progress (Güllich et al., 2016) and international success (Hornig et al., 2016).

Sport specific structured practice is an important part of development and it is evident that specific training within your domain is required throughout the developmental process. In the two lesser skilled quartiles (three and four), the majority of the athletes accumulated less than 2122 hours of deliberate practice throughout their development. It may be that these players had not trained for enough hours in their sport to acquire the same physical, technical and tactical attributes as the higher skilled players. Interestingly the number of hours they accumulated in play activities was the factor that best distinguished these two lower skilled quartiles, and although this is an important finding, it should be noted that the validity and reliability or recalling play hours is poor compared to other activities due to the informal and unorganised nature of play (Hopwood, Baker, et al., 2010). There are however a number of studies that have found that 'play' contributes to the development of expertise in various sports, with Côté et al. (2003, 2007) suggesting that higher amounts of play prior to maturation can lead to increased motivation and learning, although this has been widely untested and even counteracted by Hendry, Crocker, and Hodges (2014) in youth soccer players. Although incidental play has shown to be crucial in some countries, particularly Brazil (Araujo et al.,

2010), the current study suggests there are more pertinent factors when developing expertise in Australian youth soccer players.

There were also a number of quartile three and four athletes who had acquired more than the apparent 2122 hours (minimum) of sport specific structured practice, meaning they were initially categorised with the quartile one and two athletes. These quartile three and four athletes were typically later in the family birth order further supporting that having older siblings was a positive influence on a player's participation. These players were able to accumulate the required sport specific structured practice, however, in contrast to the majority of the quartile one athletes who were later born, their oldest sibling/s did not take part in other sports. This meant that they may not have been exposed to the role modelling, competition, instruction or extra play activities in soccer or other sports with their siblings and were thus more like those athletes who were first or second born in the family.

5.5 Conclusion

The current study found that there were distinct pathways that contributed to the development of expertise in Australian youth soccer players. First and foremost, the amount of sport specific structured practice discriminated between high and low skilled players, however there were other more discerning variables that further differentiated the two highly skilled groups. It is evident that family influences and the environment are important aspects for development, with an athletes' family composition and/or age of specialisation influencing their Cumulative Total Score and their apparent selection in the elite national squad. This was evident with the first two pathways, involving factors not always specific to soccer, with later specialisation and sibling sport participation discriminating between high levels of skill. This combination of factors may be dependent on the country and culture with respect to the development of elite soccer players, however, coaches, administrators and importantly parents

of aspiring players need to understand the importance of these factors in the development of expertise for Australian soccer.

The current study has some interesting and logical findings, however, it is acknowledged that these findings are based on a small group of athletes and as such the methodology and analysis techniques need to be applied to a larger, more diverse group of players.

CHAPTER SIX – SUMMARY AND FUTURE DIRECTIONS

6.1 Introduction

The development and attainment of expertise has been a popular area of research across many domains (Baker & Horton, 2004; Baker, Horton, et al., 2003; Ericsson et al., 1993; Ericsson & Smith, 1991; Sadideen, Alvand, Saadeddin, & Kneebone). There have been various theories explored and applied to different populations as the processes and experiences of experts become more evident. Although identifying and developing talent in sport, and more specifically, soccer, has received significant research attention, these applications had yet to be investigated within Australia. Soccer is such a multifaceted sport, which meant there was still a substantial gap in the literature, with many suggesting a multidimensional approach to understanding expertise was required. Due to the aforementioned complexity of developing expertise in any area, it was critical that the current study followed an in-depth, evidence-based approach to expertise research. Accordingly, the current thesis was structured around the Expert Performance Approach, which has been a standardised approach across multiple domains (Ericsson & Smith, 1991).

The first stage of the Expert Performance Approach involves *capturing expert performance*, in their performance environment (Williams & Ericsson, 2005). The current study applied this through analysing match characteristics of Australian youth soccer players in competition matches. As discussed, there are many game styles that are implemented by teams around the world, with ‘direct’ or a ‘possession’ style of play being the most common among the literature. Due to environmental and cultural influences, it has been shown that Brazilian and Spanish teams play a possession style game, whilst English and Norwegian leagues play a more direct style of soccer (Carling et al., 2007; Dellal et al., 2011; Tenga & Larsen, 2003). Another layer of complexity is added as previous research has shown that styles

of play also differ between levels of expertise. Bradley et al. (2013) showed that teams who have a lower skill level play an increased number of long, direct passes, which typically leads to more turnovers. Although there have been a number of studies investigating game styles in soccer around the world, there is a paucity in the literature within Australian soccer, particularly at the youth level.

Stage Two of the Expert Performance Approach requires *identification of the underlying mechanisms* of the expert performance that was observed in Stage One. It was important to gain an understanding of which skills were required to execute the distinct game styles found in Stage One (Chapter Three). Previous studies have shown that in order to be successful in soccer, as with most team sports, there are a combination of physical, technical and tactical skills required (Reilly, Williams, et al., 2000; Williams & Reilly, 2000). If these skills are possessed by the majority of the team, it will allow them to execute their intended game style more successfully than teams whose athletes may not have the desired skills to play a certain game style. It is evident that soccer players need a high level of physical fitness with elite players running 10-12km at 80-90% maximum heart rate (Di Salvo et al., 2007; Stolen et al., 2005), including many high intensity efforts (Bradley et al., 2009). Although physicality is critical, and influences other aspects of the game, it is argued that this is not the most important attribute to possess (Bush et al., 2015; Carling et al., 2012; Rampinini et al., 2009), with many believing that technical and tactical skill is the most crucial aspect for high performance in soccer (Ali, 2011; Sarmento et al., 2018). As such there has been many technical soccer tests have been developed and numerous studies have analysed the reliability and validity of each test to ensure the test actually represents what is it testing, and is reproducible across trials (Ali et al., 2007; Rösch et al., 2000; Russell et al., 2010). Despite this Ali (2011) stated that it is surprising that there is little research on skill execution or the technical components of the game even though it is accepted to be the most important aspect of soccer play.

Recently there has been more interest in the tactical knowledge and decision-making ability of players across various sports (Bruce, Farrow, et al., 2012b; Bruce, Farrow, Raynor, et al., 2012; Lorains et al., 2013; Woods et al., 2016). Within soccer there have been a few studies investigating various components of decision-making with mixed results (Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Vaeyens, Lenoir, Williams, Mazyn, et al., 2007; Ward et al., 2004). Multiple studies have discriminated groups as a result of decision-making tasks in soccer (Belling et al., 2015; Vaeyens, Lenoir, Williams, Mazyn, et al., 2007; Vaeyens, Lenoir, Williams, & Philippaerts, 2007; Ward et al., 2013). Recently there has been preliminary work investigating the decision-making skill and developmental pathways of junior (under 15) Australian soccer players (O'Connor et al., 2016). This study provided some good insights into the decision-making ability of junior players, however, they were unable to establish any distinct developmental pathways within that cohort (O'Connor et al., 2016). It is also important to investigate the latter stages of the junior developmental pathways to allow later maturing players more time to develop. Prior to this program of research, the physical, technical and tactical proficiency of Australian youth soccer players had not been investigated, particularly through a multidimensional approach. Studies in other countries have found multidimensional testing batteries were able to discriminate certain cohorts throughout the developmental pathway (Forsman, Blomqvist, Davids, Liukkonen, et al., 2016; Huijgen, Elferink-Gemser, Lemmink, & Visscher, 2014; Reilly, Williams, et al., 2000; Sarmento et al., 2018), although this was yet to be applied in Australian youth soccer.

Stage Three of the Expert Performance Approach *examines how expertise is developed*. It is important to understand which pathways and developmental variables can influence the development of crucial skills. As discussed in detail throughout the thesis, there are numerous factors and pathways soccer players can take to develop these required skills. With environmental and cultural elements differing between countries (Forsman, Blomqvist, Davids,

Liukkonen, et al., 2016) it is difficult to relate findings from England, Brazil or Germany to other countries in order to mimic their successful development of soccer players. Therefore, the final study of this thesis aimed to determine the critical pathways that were followed for the development of the required physical, technical and tactical prowess in Australian youth soccer.

The overall aims of the current thesis were to capture expert performance, identify underlying mechanisms and determine how expertise is developed in Australian youth soccer players. This was completed over three detailed, integrated studies, including analysing game styles, testing soccer specific skills, and determining developmental pathways. The Expert Performance Approach was used to structure the thesis, thus integrating the three studies. Although there have been various studies investigating game styles, soccer skills and developmental pathways in isolation, this is the first study to take a structured, wide-ranging approach based around the theoretical framework of the Expert Performance Approach and using the same cohort of athletes.

6.2 Summary of Findings

Overall, the current study has applied the Expert Performance Approach, holistically to Australian youth soccer players. As previous research has typically focussed on only one stage of the Expert Performance Approach, the thesis added to the body of literature by applying all three stages to this cohort of athletes which has not been completed on this scale before. This has provided a great insight into current game styles, skills and developmental components of Australian youth soccer players that will have good practical benefits for the talent development process in the country, whilst opening up explicit gaps for future research.

Study One (Chapter Three) examined match characteristics of Australian youth soccer players, following Stage One of the Expert Performance Approach, *capturing expert*

performance. The examination of game styles revealed that the two elite Australian youth cohorts played a different style to the sub-elite teams. The characteristics of the elite teams were towards a possession style of game, however the sub-elite teams elicited a direct style of play, as defined by Fernandez-Navarro et al. (2016). The two elite teams' possession style of play was characterised by longer passing chains and increased grounded, backward, sideward and successful passes. Because of this passing method the elite teams had fewer turnovers and headers. The sub-elite teams played a direct style through long, lofted passes, resulting in more turnovers, intercepts and headers. These distinct game styles could be a result of numerous factors from systemic influences from FFA such as coaching expertise, with the elite athletes being exposed to more experienced coaches, thus being able to provide game style/s that suit their players, or in response to the individual skill level of players.

Study Two (Chapter Four) investigated the skills underpinning expert performance in youth soccer through the second stage of the Expert Performance Approach, *identifying underlying mechanisms*. In order to understand why the elite players were able to implement a more successful game style, we examined their physical, technical and tactical skills. The elite players performed better in an array of physical, technical and decision-making testing, with a cut-off score established for each significant test, and then a Cumulative Total Score summed. Physical and anthropometrical results revealed several significant differences between the cohorts with the elite cohort being taller, faster over 30m and the 20m flying sprint, and running further in the Yo-Yo IR1. Similarly, the technical and tactical tests that the elite cohort excelled at included ball control, shooting (score and speed), LSPT and the perceptual-cognitive decision-making task. Overall, the multidimensional approach showed the national elite players significantly outperformed the other two cohorts on the Cumulative Total Score which was a summation of the tests reported above. This was evidenced by the violin plot of the Cumulative Total Score showing a clear visual discrimination of the national elite players

compared to the other cohorts, reinforced by the ROC curves. The multidimensional testing battery provides a distinct benchmark for striving soccer players with 94.1% of national elite youth players scoring more than 2482.2 au overall. It was clear that the superior physical, technical and decision-making abilities possessed by the national elite cohort allowed them to execute their possession game style.

Study Three (Chapter Five) examined the developmental pathways of Australian youth soccer players, to determine the factors assisting in the development of these key soccer skills. This fulfilled the final stage of the Expert Performance Approach, *examining how expertise is developed.* As the cohorts were split into quartiles (which did not necessarily match the three original cohorts) based on the Cumulative Total Score that was calculated in Chapter Four, the analysis determined which developmental factors and pathways led to increased physical, technical and tactical skill level for Australian youth soccer players.

In the elite quartiles, it was evident that sport specific practice was important for development, although there were other factors that were more influential in distinguishing between the two highly skilled quartiles. The highly skilled players who were born later than second in their family had older siblings who competed in sport. Alternatively, the highly skilled players in the current study who were born earlier in their family had specialised in soccer after the age of 13, which supports the delayed specialisation theory. The pathway of the lower skilled players showed they all had a reduced amount of sport specific practice compared to the higher skilled cohorts. The group that had the lowest Cumulative Total Score had a reduced amount of play hours throughout their development. A couple of distinct pathways exist for the highly skilled Australian youth soccer players, which should be used to inform the next generation of athletes and coaches.

The findings from the three studies have provided an insight into the game style, underpinning mechanisms and the developmental pathway of Australia's elite youth soccer players. Specifically, in response to the research questions:

RQ1. Are there differences in the match characteristics between levels of expertise, namely sub-elite, state elite, and national elite, in Australian youth soccer as measured by technical and tactical parameters? If yes, where do they occur?

There were differences in match characteristics and game styles between the three cohorts, more specifically, the sub-elite teams played a direct style of game, while the national and state elite teams played possession styles of game.

RQ2. Are there differences in the underlying physical, technical and tactical skills between levels of expertise (sub-elite, state elite, and national elite) in Australian youth soccer players as measured by a number of performance tests? If yes, where do they occur?

There were significant differences in the underlying physical, technical and tactical skills between all three cohorts. More specifically the national elite cohort were taller, faster over 30m sprint and 20m flying start, had increased intermittent endurance on the Yo-Yo IR1, better scores for ball control, shooting (accuracy and speed), long passing, the Loughborough Soccer Passing Test and perceptual-cognitive decision-making task results.

RQ3. Are there differences in the developmental pathway between levels of expertise (based on physical, technical and tactical skill level) in Australian youth soccer players as determined using a developmental history questionnaire? If yes, where do they occur?

There were distinct pathways followed by players of differing skill level, with the highest skilled players having increased sport specific structured practice and either specialising later or having older siblings participate in sport, depending on their birth order.

6.3 Limitations

Due to the nature of applied sports science and using the highest level of youth soccer players in the country, the national elite sample only included 18 athletes. This sample size was a limitation of the current study and it also meant that it was difficult to analyse any influence of positional differences due to the smaller number of participants in each cohort. Unfortunately, when this data was collected the FIFA had an international restriction on wearable devices during soccer matches, which prevented the use of GPS. Combining this restriction with the absence of semi-automated tracking devices in Australian stadiums, physical match data was unable to be collected, and technical instances had to be coded manually. Furthermore, the tactical skill was assessed through an offensive perceptual-cognitive decision-making task, and there may be other skills that contribute to a player's tactical ability (e.g. anticipation and game sense). The thesis analyses various stages of the developmental pathways outlined by FFA which means a small number of elite youth athletes may choose different pathways to those outlined in the national curriculum (for example trialling for youth teams around the world) which means those athletes were not examined in the current study. Due to logistical reasons the data for 'sub-elite' and 'state elite' players were only collected from one state (WA teams) and may not be completely representative of the nation.

6.4 Practical Implications

The current study has added to the literature through an integrated approach of expertise research. This is the first study to utilise the Expert Performance Approach to examine expertise in this broad, comprehensive way. This thesis investigated which specific physical, technical and tactical skills underpin the execution of the different game styles and which personal factors and experiences contribute to the development of these skills in Australian youth soccer players. Not only will the framework adapted for the current thesis be applicable in other sports

or countries, it will also have impact in the applied setting. The findings will allow coaches and sports scientists around Australia to administer a battery of tests to monitor the progress of athletes. It has provided evidence to refine the developmental framework outlined by FFA. As Australia are investing a large amount of money into soccer through FFA and the Australian Sports Commission, there needs to be an evidence base and critical analysis of the current methods to continually develop players and strive for international success.

Now that we have a greater understanding of the levels of physical, technical and tactical skills required by elite youth Australian soccer players to play the game style that is expected at this level, this information can be used by FFA, coaches and players to set evidence-based benchmarks. There needs to be a systematic approach from FFA to continually improve these key aspects of soccer in a larger pool of athletes. This will ensure the state elite athletes can also develop these required skills and provide a larger pool of athletes who are competing for positions. Improving these physical, technical and tactical components throughout their development will then allow athletes to execute specific game styles that are evident in higher level competitions (e.g. possession style soccer).

Distinct cut off points have been established for each of the critical tests within the physical, technical and tactical skills. Specifically, the tests we would recommend be included in a test battery include physical (Yo-Yo IR1, height, 30m sprint and 20m flying start sprint), technical (LSPT, long passing test, ball control and shooting test) and tactical (decision-making), with a Cumulative Total Score of 2482.2 au being used as a minimum standard for the national elite players. It is evident that if players can improve their skills to above this level, then they will have the greatest chance of being involved in the elite development pathway and national elite teams.

Of all the skills that were assessed it was disappointing to note the low level of performance, even for the national elite cohort, for the decision-making test with an average of

65.1% correct responses. This is however comparable to work in Australian rules football and soccer (O'Connor et al., 2016; Woods et al., 2016), suggesting that may be a general weakness in the development of football players of both codes. Due to the poor performance on the decision-making test, it is possible that some athletes are compensating for their poor decision-making skill with either increased physical or technical skills. It is clear more attention needs to be given to the development of tactical skills, however, coaches need to be better supported by improved assessment and training methods in this area.

Although the attainment of these standards will not guarantee success, to achieve widespread systematic improvement of these attributes, all coaches and sports scientists working within the developmental pathway need to understand the importance of these underlying skills. It is also critically important that there are education programs and resources that are widespread and mandatory for all junior coaches, which then allows all players access to high quality coaching during the formative years when they are investing in the sport specific structured practice that is shown to be critical to success.

Player development needs to cover a broad group of players, without solely focusing on the 'talent identified', elite pathways. This is a critical outcome from this study as it is evident that talent identified players do not always progress to elite senior players, with previous TID models being poor predictors of long-term athlete potential (Baker, Schorer, & Wattie, 2018; Sarmento et al., 2018). Trying to decrease the gap between the national elite and state/sub-elite programs will ensure that there is a bigger pool of well-developed athletes to potentially progress to the elite senior programs, which will only strengthen Australian soccer. FFA is attempting to do this through the national curriculum which includes skill acquisition models and coach development programs. Youth coaches at all levels need to have a greater understanding of these concepts to ensure all youth athletes are receiving quality training.

Although it may seem counterintuitive for youth coaches and governing bodies, it is important that the diversification pathway be promoted in Australian soccer to allow athletes to develop other skills. This will also ensure that players who specialise in soccer at a later age will continually enjoy their involvement and have increased intrinsic motivation to improve. Unlike England, who have a high percentage of juniors specialising in soccer at an early age (Ford & Williams, 2012), soccer in Australia competes with multiple other field sports for athletes. Due to the smaller overall pool of soccer athletes in Australia compared to other countries, if specialisation is promoted in Australian soccer, it might have a greater negative effect on the overall development program due to burn out. In England there will be enough talented players coming through the elite pathways to succeed even if players are burning out, however the abundance of numbers will not be present in Australia to cope with this. Due to the relatively smaller pool of soccer athletes, it is important that the retention rate is high longer term, which can be achieved through increased motivation of athletes who have chosen to pursue soccer as their main sport at a later age. Therefore, FFA should look to promote the diversification or early engagement pathways, involving increased amount of soccer 'play' activities or training in alternate sports, which will also allow players to develop multiple skills which are important for soccer (e.g. decision-making and/ or athletic attributes). These processes will allow the greatest development for youth players, allowing them the best chance to succeed long-term. Although players are unable to choose their birth order, coaches and sports scientists can identify the junior players who are born earlier in their family, and specifically encourage them to play multiple sports, or increase incidental soccer play throughout their development. As found with the highly skilled first/second born players, they specialised in soccer later. Players who have multiple older siblings seem to have access to more incidental activities, or have role models and competition from their siblings, which allows them to develop a broad range of skills that are required to succeed in soccer.

6.5 Future Research

Whilst this study has provided a critical snapshot of current elite youth soccer players in Australia and provided significant information that will inform the future development of Australia's soccer players, there is still much more research needed if we are to produce individual players and teams which can be successful on the world stage. There needs to be longitudinal studies monitoring when and how various components of expertise develop and shift the focus to long-term development. This can be extended to identify whether there are critical periods of development for different skills, which is not possible to establish from cross sectional research. Furthermore, there may be periods in development where one skill is more developed than another and compensation between skills occur. A greater understanding of these periods is warranted.

Future research needs to follow the career progression of players within the Australian talent development programs to see whether they succeed in senior competitions. Further studies also need to be completed to validate the current findings, by applying these results to a larger sample of youth players and predicting their level of participation long-term. This testing battery can be utilised on a large cohort of players to 'predict' players' long-term soccer success, with a longitudinal study following the athletes to assess the success rate of the prediction according to the number of athletes who have 'made it'. This framework can also be applied to the female soccer pathways in Australia to understand the intricacies of expertise development across genders.

It is important to quantify the physical match demands in Australian youth soccer now that the FIFA regulations allow players to wear GPS units during matches. It is also critical to compare the game styles of the elite youth cohort with the senior Australian team to close the gap between youth and senior competition. Future research should also investigate specific decisions that are made during matches by the players of differing levels and reasons for their

execution. It is also important to test the perceptual-motor decision-making ability of the players to understand whether the perception-action coupling process influences their decision-making outcome.

An area that was beyond the scope of the current study, was to expand the match analysis research into better quantification of complex, interacting systems, rather than a description of technical variables. The next layer on this analysis is to combine physical, technical and tactical match data so they are not analysed in isolation, giving a multifaceted breakdown of performance for individual players or teams. This approach would then allow the physical, technical and tactical testing results to be compared to individual player performances. It would be an important advancement in TID and development to be able to compare isolated testing results to individual player performances in their real-world environment (game day). As discussed earlier, players deficiencies in one area can be compensated by strengths in another area, therefore, using a multidimensional match analysis system would show which skill-set was more beneficial to performance and how these unique combinations of skills influence performance.

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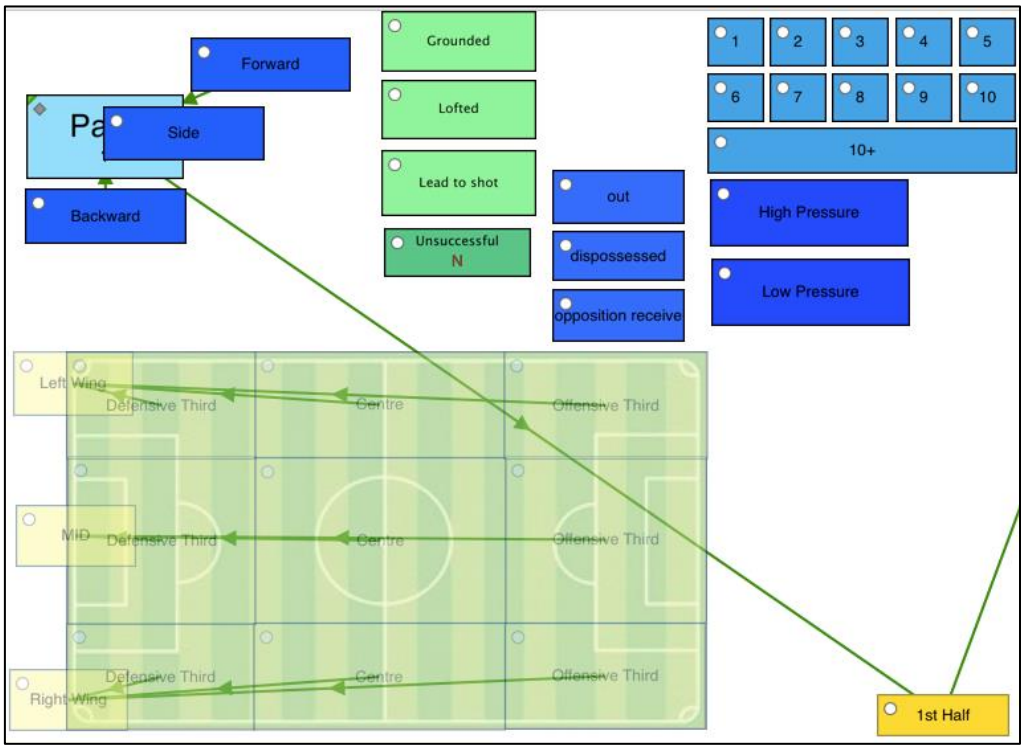
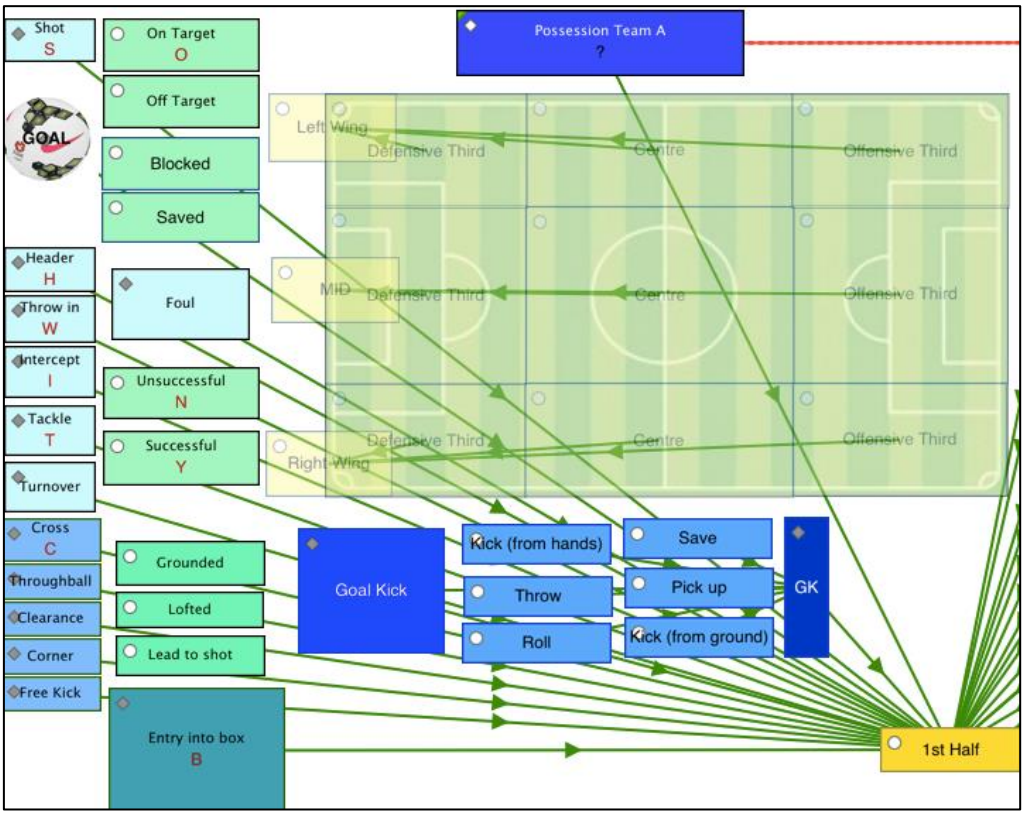
APPENDIX A – CODE WINDOWS

Passing and general code windows used in Chapter Three to analyse the key passing variables in Australian youth soccer matches.





APPENDIX B – INFORMATION SHEET

Information sheet - Participants

'Developing expertise in Australian junior soccer players'

Supported by Edith Cowan University (School of Exercise and Health Sciences), Football Federation Australia and Football West. This research project is being undertaken as part of the requirements of a PhD at Edith Cowan University.

Contact Details and affiliations of researchers

Brad Keller – Chief Investigator (PhD Candidate)
Faculty of Computing, Health and Science
School of Exercise and Health Sciences, Edith Cowan University, Joondalup, Western Australia (WA)
Ph: (08) 6304 3821 or e: **b.keller@ecu.edu.au**

Assoc. Prof. Annette Raynor - Principal supervisor
Faculty of Computing, Health and Science
School of Exercise and Health Sciences, Edith Cowan University, Joondalup, WA
Ph: (08) 6304 2771 or e: **a.raynor@ecu.edu.au**

Dr. Lyndell Bruce - Secondary supervisor
School of Medical Sciences, Royal Melbourne Institute of Technology University, Melbourne, Victoria
Ph: (03) 9925 7349 or e: **lyndell.bruce@rmit.edu.au**

Fiona Iredale - Secondary supervisor
Faculty of Computing, Health and Science
School of Exercise and Health Sciences, Edith Cowan University, Joondalup, WA
Ph: (08) 6304 2259 or e: **f.iredale@ecu.edu.au**

You are invited to participate in the following research study, which will be voluntary and you are free to withdraw without prejudice at any time. You have been selected for participation in this project as a result of representing the AIS football program. As part of participating in this research you will be provided with information regarding your testing results and skill level in soccer.

If you wish to participate in this study, please sign the attached informed consent form provided by the chief investigator.

Purpose: The aim of this study is to identify the underlying mechanisms and characteristics contributing to the development of expertise in Australian soccer players.

Requirements: You will be required to complete a number of soccer related tests (physical, technical and video-based decision-making). The outline and requirement of each test is below:

Test	Requirement
Yo-Yo IR1 test	20m shuttle run to assess endurance
Zigzag test	Required to weave around five poles as quickly as possible to assess change of direction.
30m sprint	Maximal sprint for 30 metres, including 5m and 10m split times
Vertical jump (VJ)	Required to perform maximal jump to assess leg power. Standing and running VJ will be assessed.
Loughborough soccer passing test	Required to pass soccer ball to four targets a number of times
Soccer-specific shooting accuracy test	Required to shoot soccer ball, aiming for top left and top right corners.
Soccer-specific long passing test	Required to kick lofted pass at a target with dominant and non-dominant feet.
Soccer-specific ball control test	Required to weave around a number of obstacles controlling a soccer ball
Video-based decision-making test	Watch a series of soccer clips and describe which decision you would make in each situation, once the video stops

The testing will take approximately 6 hours (across multiple sessions) to complete and all testing will occur at either the AIS gymnasium, indoor sprint track or football pitch. The physical testing session will occur on Wednesday (4th Sept) at 430-630pm in the basketball court/indoor sprint track. The technical testing session will occur on Friday (6th Sept) at 430-630pm on the football pitch. The decision-making task will be completed at a date TBC.

The final part of this study you will be required to complete a training history questionnaire which will require you to complete written responses to the questions presented. The questionnaire could take up to two hours, depending on how fast it is filled in. The associated

risk and discomfort with participating in this study are minor and unlikely, however the physical tests may induce some local muscular fatigue or muscle soreness. In the unlikely event of an injury, the supervision team will have the adequate first aid training to assist with the acute injury.

Ethical issues related to the conduct of this study: All information collected will be retained at Edith Cowan University in a locked store for five years in a locked filing cabinet or password protected hard drive. All records containing personal information will remain confidential. Data will potentially be published in scientific journals and/or presented at conferences, however, no information that could lead to identification of any individual participant will be released. The de-identified data will possibly be used in future research within the area. The research team named above will have access to the training data as well as potential research assistants who will be required to sign a confidentiality form. This project has been approved by the ECU Human Research Ethics Committee.

Further information and consent: If you require any further information regarding the specific details of the study, please contact the chief investigator, Brad Keller (**b.keller@ecu.edu.au** or (08) 6304 3821). Alternatively, if you are willing to take part in this study please sign the attached consent form. Participants can obtain a summary of research findings by contacting the principal researcher. If you have any concerns or complaints about the research project and wish to talk to an independent person, you may contact:

Research Ethics Officer
Edith Cowan University
270 Joondalup Drive, JOONDALUP WA 6027
Phone: (08) 6304 2170
Email: **research.ethics@ecu.edu.au**

APPENDIX C – CONSENT FORM

Consent form - Participants

Research title: Developing expertise in elite junior soccer players

Chief Investigator – Brad Keller (PhD Candidate)
School of Exercise and Health Sciences, Edith Cowan University, Joondalup, Western Australia (WA)
Ph: (08) 6304 3821 or e: **b.keller@ecu.edu.au**

Supervisors: Assoc. Prof. Annette Raynor, Dr. Lyndell Bruce and Fiona Iredale

This is to certify that I, _____hereby agree to (give permission to have my child) participate as a volunteer in a scientific investigation as authorised part of the research program of Edith Cowan University under the supervision of _____.

The investigation and my (child's) part in the investigation have been defined and fully explained to me by _____ and I understand the explanation. A copy of the procedures of this investigation and a description of any risks and discomforts has been provided to me and has been discussed in detail with me.

I give permission for my (child's) testing results to be released to the coaches and club if they wish to review the results: ☐ Yes ☐No (Tick)

- I have been informed about the aim and purpose of the research
- I understand my (child's) involvement in the study
- I understand that I am (the child is) free to withdraw consent and to discontinue participation in the project at any time and that this will not affect my status now or in the future
- I understand that the data collected in the study may be published, however I (my child) will not be identifiable and personal details will remain confidential
- I understand there is an unlikely risk of a minor injury occurring, in which case appropriate first aid will be applied

- I certify to the best of my knowledge and belief, I have (the child has) no physical or mental illness or weakness that would increase the risk to me (him/her) of participating in this investigation.
- I understand that the results from this study will be distributed to my coach, and previously acknowledged researchers and no one else
- I am (the child is) participating in this project of my (his) own free will and I have (the child has) not been coerced in any way to participate.
- I understand that the data will be stored at Edith Cowan University in a locked filing cabinet. Access will be limited to the chief investigator (Brad Keller). The supervisors of the project (Assoc. Prof. Annette Raynor, Dr. Lyndell Bruce and Fiona Iredale) will be provided access if clarification is required on a trial

Participant name:_____

Date of Birth:_____

Soccer Club:_____

Playing position:_____

Dominant leg: _____

Contact details: ph: _____email:_____

Signature of Participant: _____
Date:_____

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

_____ Date:

_____

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

Signature of Chief investigator: _____ Date:_____

APPENDIX D – THE DEVELOPMENTAL HISTORY OF ATHLETES QUESTIONNAIRE

THE DEVELOPMENTAL HISTORY OF ATHLETES QUESTIONNAIRE

Please note: This page will be removed and separated from the remainder of the questionnaire. Your responses will remain completely anonymous.

Name: _____

Email address: _____

Today's date: _____

DD / MM / YYYY

What time is it right now?

☐ AM ☐ PM

_____

HH : MM

Please note:

When you read a question requiring you to state or then allude to *"your main sport"* please refer to **Association Football (Soccer)**

For example, if asked "*What sport do you presently consider to be your main sport?"* Your answer would be **Association Football (Soccer)**.

Section 1 of 10: Demographic Information

*To begin we would like to ask a few **questions about yourself**.*

Are you male or female?

☐ Male

☐ Female

What is your date of birth?

_____
Day Month Year

In which country have you resided for the majority of your life?

_____

What is the highest level of education that you have completed?

☐ Less than secondary school

☐ Some secondary school

☐ Completed secondary school

☐ Some post-secondary college / undergraduate university

☐ Completed a post-secondary college diploma / undergraduate university degree

☐ Some postgraduate university

☐ Completed a masters degree

☐ Completed a law / professional degree

☐ Completed a doctoral degree

☐ Other – Please specify:

_____

Section 2 of 10: Your Sporting Career

*Next we would like to ask some general **questions about your career in your main sport**.*

What sport do you presently consider to be your main sport?

_____

The majority of the remaining questions will relate to the main sport that you have identified above. If you participate in more than one sport, please complete the remaining questions as they relate to the sport you have identified above.

For your main sport, what is the highest level of competition that you have participated at?

- ☐ No competition - Recreational involvement only (at the junior level)
- ☐ No competition - Recreational involvement only (at the senior / open level)
- ☐ No competition - Recreational involvement only (at the masters level)
- ☐ Competition against others within the local area (at the junior level)
- ☐ Competition against others within the local area (at the senior / open level)
- ☐ Competition against others within the local area (at the masters level)
- ☐ Competition against others within the state / province (at the junior level)
- ☐ Competition against others within the state / province (at the senior / open level)
- ☐ Competition against others within the state / province (at the masters level)
- ☐ Competition against others from across the country (at the junior level)
- ☐ Competition against others from across the country (at the senior / open level)
- ☐ Competition against others from across the country (at the masters level)
- ☐ Competition against others from different countries (at the junior level)
- ☐ Competition against others from different countries (at the senior / open level)
- ☐ Competition against others from different countries (at the masters level)
- ☐ Other – Please specify:

_____

For your main sport, do you feel that you have reached the peak of your career?

☐ Yes

If yes: At what age did you reach the peak of your career? _____

If yes: Are you still participating in practice activities for your main sport?

☐ Yes

☐ No

If no: At what age did you cease participation in practice activities for your main sport? _____

If yes: Are you still participating in competition activities (at any level) for your main sport?

☐ Yes

☐ No

If no: At what age did you cease participation in competition (at any level) for your main sport? _____

☐ No

If no: At what age do you predict that you might reach the peak of your career? _____

If no: What is the highest level of competition that you predict you will participate at?

☐ No competition - Recreational involvement only (at the junior level)

☐ No competition - Recreational involvement only (at the senior / open level)

☐ No competition - Recreational involvement only (at the masters level)

☐ Competition against others within the local area (at the junior level)

☐ Competition against others within the local area (at the senior / open level)

☐ Competition against others within the local area (at the masters level)

☐ Competition against others within the state / province (at the junior level)

☐ Competition against others within the state / province (at the senior / open level)

☐ Competition against others within the state / province (at the masters level)

☐ Competition against others from across the country (at the junior level)

☐ Competition against others from across the country (at the senior / open level)

☐ Competition against others from across the country (at the masters level)

☐ Competition against others from different countries (at the junior level)

☐ Competition against others from different countries (at the senior / open level)

☐ Competition against others from different countries (at the masters level)

☐ Other – Please specify:

_____

Section 3 of 10: Sporting Milestones

Now we would like to ask about your career progression in your main sport. The following section relates to the ***ages at which you reached various sporting milestones****.*

Thinking specifically about your involvement in your main sport, at what age did you reach the following sporting milestones?

	Age when reached this milestone	*This milestone is not applicable to me*	*This milestone is not applicable to my sport*
First participated in your main sport (in any format)		☐	☐
First participated in regular supervised practice for your main sport (i.e. practice with a coach)		☐	☐
First participated in regular unsupervised practice for your main sport (i.e. practice without a coach)		☐	☐
First participated in non-sport specific training (e.g. physical conditioning, weights, pilates etc.)		☐	☐
First participated in off-season or year-round training for your main sport		☐	☐

Stopped involvement in all other sports to concentrate on your main sport	☐	☐
The idea of becoming an elite athlete first emerged	☐	☐
Made a conscious decision to become an elite athlete	☐	☐
All of your leisure time began being spent on activities relating to your main sport	☐	☐
Moved house for reasons relating to your main sport	☐	☐
Established a close and extended relationship with a coach for your main sport	☐	☐

*The following question relates to your involvement in your main sport at the **junior** levels of competition. Junior age group categories can vary from sport to sport. When answering this question please think about your participation in all competitions that would be classified as junior level competition according to the rules of your main sport.*

Any competition involving participation against adults is classified as senior / open competition and should not be considered when answering the following question.

Thinking specifically about your involvement in junior competition for your main sport, at what age did you reach the following competition milestones?

Please provide a response to each item for all of the different levels of *junior* competition indicated.

	*Competition against others within the **local area***	*Competition against others within the **state / province***	*Competition against others from **across the country***	*Competition against others from **different countries***
First participation on a team at this level of competition	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport
First became a regular starting player on a team (i.e. a player who regularly begins the competition / match on the playing surface and receives regular playing time)	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport
First became one of the top 5 players on a team	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport
First became the best player for my position on a team	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport
First became the best player overall on a team	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport

*The following question relates to your involvement in your main sport at the **senior / open** levels of competition.*

Senior / open competition refers to adult competition. In some sports for reasons relating to safety, a lower age limit may apply, however in the majority of cases senior / open competitions are free of age restrictions, allowing junior athletes to participate in senior / open competition events. Any competition involving participation against adults is classified as senior / open competition.

Thinking specifically about your involvement in ***senior / open* competition for your main sport, at what age did you reach the following competition milestones?**

Please provide a response to each item for all of the different levels of ***senior / open* competition indicated.**

	*Competition against others within the **local area***	*Competition against others within the **state / province***	*Competition against others from **across the country***	*Competition against others from **different countries***
First participation on a team at this level of competition	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport
First became a regular starting player on a team (i.e. a player who regularly begins the competition / match on the playing surface and receives regular playing time)	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport
First became one of the top 5 players on a team	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport
First became the best player for my position on a team	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport
First became the best player overall on a team	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport	Age: ☐ Not applicable to me ☐ Not applicable to my sport

Section 4 of 10: Your Competitive History

Within a single year of involvement, athletes often participate in their main sport at multiple levels of competition. Athletes also occasionally participate in more than one age group category.

For example, a 16 year-old field hockey player may play for their local club team in the 16 years and the Open age group categories, while also playing for their state / provincial team in the Under 18 age group category.

*The following section relates to your **participation in the various levels of competition** across your career in your main sport, along with the **age group categories** in which you were involved.*

For each of level of competition specified below, please indicate all of the age group categories in which you competed during each year of your participation.

More than one response is permitted in each box below, so for each level of competition and for year of your involvement in your main sport please enter all age group categories that you participated in.

	*Competition against others within the **local area***	*Competition against others within the **state / province***	*Competition against others from **across the country***	*Competition against others from **different countries***
Example	15/16 years, Under 18, Open	15/16 years, Under 18	15/16 years	N/A
Age 5				
Age 6				
Age 7				
Age 8				
Age 9				
Age 10				

	*Competition against others within the **local area***	*Competition against others within the **state / province***	*Competition against others from **across the country***	*Competition against others from **different countries***
Age 11				
Age 12				
Age 13				
Age 14				
Age 15				
Age 16				
Age 17				
Age 18				

Section 5 of 10: Your Practice History

*We would now like to ask about your practice history for your main sport. The following section takes a detailed look into the **amount of practice** and the **types of practice** activities that you have engaged in throughout your career in your main sport to date.*

The next set of questions will address your participation in:

1. ***Sport specific physical practice***
2. ***Physical preparation*** *(e.g. strength and conditioning, weights, fitness, pilates, yoga, flexibility)*
3. ***Mental preparation*** *(e.g. working with a psychologist, video analysis / review, reading about your sport, talking about your sport, searching the internet for news and results)*
4. ***Informal play*** *involving activities relating to your main sport (e.g. pick-up basketball, street hockey, swimming in the backyard pool)*
5. ***Training camps***

First, we would like to ask about your participation in **sport specific physical practice** for your main sport.

Sport specific physical practice includes those **activities that directly resemble the technical and/or tactical demands associated with your main sport**. These activities require physical effort as well as concentration, and are aimed directly at improving performance.

Please note that sport specific physical practice **does not include**:

- Non-sport specific physical preparation activities such as strength and conditioning, weights, fitness, yoga, pilates, or flexibility.
- Informal playful games relating to your main sport that you engage in for fun with friends and family such as pick-up basketball, street hockey, or swimming in the backyard pool.

Your involvement in these activities will be discussed in a moment.

There are four conditions in which sport specific physical practice can take place:

1. A **coach is present** at the training venue providing supervision to **you and 1 or more other athletes**.
2. A **coach is present** at the training venue providing **one-on-one** supervision to you and only you in an individual practice session.
3. **No coach** is present to provide supervision but **you and 1 or more other athletes** are practicing together.
4. **No coach** is present to provide supervision, no-one else is practicing with you, but you are practicing **on your own**.

The next questions relate to your participation in sport specific physical practice under each of the four conditions described above. **Please consider your involvement in each of the four practice conditions separately.**

During each year of your participation in sport specific physical practice for your main sport, please indicate how many hours per week (on average) you engaged in this type of activity within the four conditions outlined below, and for how many months of the year.

	*A **coach is present** at the training venue providing supervision to **you and 1 or more other athletes***		*A **coach is present** at the training venue providing **one-on-one** supervision to you and only you in an individual practice session*		***No coach** is present to provide supervision but **you and 1 or more other athletes** are practicing together*		***No coach** is present to provide supervision, no-one else is practicing with you, but you are practicing **on your own***	
	Hours per week	*Months per year*	*Hours per week*	*Months per year*	*Hours per week*	*Months per year*	*Hours per week*	*Months per year*
Example	6	10	1	10	0	0	1	12
Age 5								
Age 6								
Age 7								
Age 8								
Age 9								
Age 10								
Age 11								
Age 12								
Age 13								
Age 14								
Age 15								
Age 16								

	*A **coach is present** at the training venue providing supervision to **you and 1 or more other athletes***		*A **coach is present** at the training venue providing **one-on-one** supervision to you and only you in an individual practice session*		***No coach** is present to provide supervision but **you and 1 or more other athletes** are practicing together*		***No coach** is present to provide supervision, no-one else is practicing with you, but you are practicing **on your own***	
	Hours per week	*Months per year*	*Hours per week*	*Months per year*	*Hours per week*	*Months per year*	*Hours per week*	*Months per year*
Age 17								
Age 18								

Next, we would like to ask about your participation in **physical preparation activities** for your main sport.

Physical preparation includes all activities aimed at **improving physiological and muscular capacities** such as strength, power, endurance, and flexibility. Examples of physical preparation activities include, but are not limited to, strength and conditioning, weights, fitness, pilates, yoga, and flexibility training.

These activities are sometimes completed during sport specific physical practice sessions, however, for the following questions please refer only to your participation in physical preparation activities **completed outside of sport specific physical practice** as separate stand-alone practice sessions.

There are four conditions in which physical preparation activities can take place:

1. A **coach / specialised instructor is present** at the training venue providing supervision to **you and 1 or more other athletes**.
2. A **coach / specialised instructor is present** at the training venue providing **one-on-one** supervision to you and only you in an individual training session.
3. **No coach / specialised instructor** is present to provide supervision but **you and 1 or more other athletes** are training together.
4. **No coach / specialised instructor** is present to provide supervision, no-one else is training with you, but you are training **on your own**.

The next questions relate to your participation in physical preparation activities under each of the four conditions described above. **Please consider your involvement in each of the four training conditions separately.**

During each year of your participation in physical preparation activities for your main sport, please indicate how many hours per week (on average) you engaged in this type of activity within the four conditions outlined below, and for how many months of the year.

If you have never participated in physical preparation activities for your main sport please place a tick in the box below and continue to page 11:

☐ I have never participated in physical preparation activities for my main sport

	*A **coach / specialised instructor is present** at the training venue providing supervision to **you and 1 or more other athletes***		*A **coach / specialised instructor is present** at the training venue providing **one-on-one** supervision to you and only you in an individual training session*		***No coach / specialised instructor** is present to provide supervision but **you and 1 or more other athletes** are training together*		***No coach / specialised instructor** is present to provide supervision, no-one else is training with you, but you are training **on your own***	
	Hours per week	*Months per year*	*Hours per week*	*Months per year*	*Hours per week*	*Months per year*	*Hours per week*	*Months per year*
Example	4	10	0	0	2	12	2	12
Age 5								
Age 6								
Age 7								
Age 8								
Age 9								
Age 10								
Age 11								
Age 12								
Age 13								
Age 14								
Age 15								
Age 16								
Age 17								
Age 18								

Now we would like to ask about your participation in **mental preparation** activities for your main sport.

Mental preparation includes all activities aimed at **improving your knowledge** of your sport, your team, and/or your opponents. Examples of mental preparation activities include, but are not limited to, working with a psychologist, video analysis / review, watching your sport live or on television, reading about your sport, surfing the internet for websites and articles about your sport, or talking about your sport with others.

These activities are sometimes completed during sport specific physical practice sessions, however, for the following questions please refer only to your participation in mental preparation activities **completed outside of sport specific physical practice** as separate stand-alone practice sessions.

There are four conditions in which mental preparation activities can take place:

1. A **coach / specialised instructor is present** at the training venue providing guidance to **you and 1 or more other athletes** as you learn.
2. A **coach / specialised instructor is present** at the training venue providing **one-on-one** guidance to you and only you in an individual session.
3. **No coach / specialised instructor** is present to provide guidance but **you and 1 or more other athletes** are learning together.
4. **No coach / specialised instructor** is present to provide guidance, no-one else is learning with you, but you are learning **on your own**.

The next questions relate to your participation in mental preparation activities under each of the four conditions described above. **Please consider your involvement in each of the four training conditions separately.**

During each year of your participation in mental preparation activities for your main sport, please indicate how many hours per week (on average) you engaged in this type of activity within the four conditions outlined below, and for how many months of the year.

If you have never participated in mental preparation activities for your main sport please place a tick in the box and continue to page 13:

☐ I have never participated in mental preparation activities for my main sport

	*A **coach / specialised instructor is present** at the training venue providing guidance to **you and 1 or more other athletes** as you learn*		*A **coach / specialised instructor is present** at the training venue providing **one-on-one** guidance to you and only you in an individual session*		***No coach / specialised instructor** is present to provide guidance but **you and 1 or more other athletes** are learning together*		***No coach / specialised instructor** is present to provide guidance, no-one else is learning with you, but you are learning **on your own***	
	Hours per week	*Months per year*	*Hours per week*	*Months per year*	*Hours per week*	*Months per year*	*Hours per week*	*Months per year*
Example	2	6	1	6	0	0	3	12
Age 5								
Age 6								

	*A **coach / specialised instructor is present** at the training venue providing guidance to **you and 1 or more other athletes***		*A **coach / specialised instructor is present** at the training venue providing **one-on-one** guidance to you and only you in an individual session*		***No coach / specialised instructor** is present to provide guidance but **you and 1 or more other athletes** are learning together*		***No coach / specialised instructor** is present to provide guidance, no-one else is learning with you, but you are learning **on your own***	
	Hours per week	*Months per year*	*Hours per week*	*Months per year*	*Hours per week*	*Months per year*	*Hours per week*	*Months per year*
Age 7								
Age 8								
Age 9								
Age 10								
Age 11								
Age 12								
Age 13								
Age 14								
Age 15								
Age 16								
Age 17								
Age 18								

The following question relates to your participation in **informal play** involving activities relating to your main sport.

Informal play includes activities that **resemble the skills and goals of your main sport** but involve **modified rules and/or equipment**, with very little to **no formal instruction, coaching, or supervision**. The main emphasis of these activities is on fun and enjoyment rather than performance improvement.

Informal play relating to your main sport often occurs in the home, the backyard, the school yard, the local park, and/or the local streets. Examples for basketball may include pick-up basketball or shooting hoops for fun with friends. Examples for swimming may include swimming at the beach or playing in the backyard pool with your family.

Please note: These questions relate to informal play involving activities **relating to your main sport only**. Your participation in informal play involving other sporting games will be addressed elsewhere.

There are two conditions in which informal play relating to your main sport can take place:

1. **With 1 or more other people** such as your team mates, friends, or family.
2. **On your own**.

The next questions relate to your participation in informal play relating to your main sport under each of the conditions described above. **Please consider your involvement in each of the conditions of play separately.**

During each year of your participation in informal play involving activities relating to your main sport, please indicate how many hours per week (on average) you engaged in this type of activity within the two conditions outlined below, and for how many months of the year.

If you have never participated in informal play involving activities relating to your main sport please place a tick in the box below and continue to the bottom of page 14:

☐ I have never participated in play involving activities relating to my main sport

	With 1 or more other people *such as your team mates, friends, or family*		***On your own***	
	Hours per week	*Months per year*	*Hours per week*	*Months per year*
Example	2	8	4	12
Age 5				
Age 6				
Age 7				
Age 8				
Age 9				
Age 10				

	With 1 or more other people *such as your team mates, friends, or family*		***On your own***	
	Hours per week	*Months per year*	*Hours per week*	*Months per year*
Age 11				
Age 12				
Age 13				
Age 14				
Age 15				
Age 16				
Age 17				
Age 18				

The following question relates to your participation in **training camps** for your main sport.

Training camps refer to **intensive periods of training** during which your team comes together for an extended time to participate in practice activities that **exceed your regular** week to week training commitments.

Training camps can last from one weekend to several months in duration, and they are often held at a location away from your regular training venue.

Typical activities involved in a training camp include sport specific physical practice, supplementary practice activities such as physical conditioning and video review, education sessions, team building exercises, and mock competitions.

Training camps are commonly held in the pre-season training period or in the lead up to an important competition. They can also serve as a regular practice opportunity for teams who do not train together on a weekly basis.

For each year of your involvement in training camps for your main sport, please indicate how many training camps you participated in, along with the average duration of each camp.

If you have never participated in any training camps for your main sport please place a tick in the box below and continue to page 16:

☐ I have never participated in training camps for my main sport

	Total number of training camps	*Average duration of each training camp*
Example 1	3	2-4 days
Example 2	2	2 weeks
Age 5		
Age 6		
Age 7		
Age 8		
Age 9		
Age 10		
Age 11		
Age 12		
Age 13		
Age 14		
Age 15		
Age 16		
Age 17		
Age 18		

Half Way There!

Well done, you have just completed Section 5 of 10. You are half way there.

Section 6 of 10: Your Competition History

Next we would like to ask about your competition history for your main sport.

*The following section takes a detailed look into the **types of competitions** that you typically participate in for your main sport, the **number of competitions** you have participated in, and the **time** that you have invested into competitions throughout your career in your main sport to date.*

Competitions can follow many different formats. The 3 main competition formats are:

1. Regular season competitions
These include any competitions involving a series of regularly occurring matches / events over an extended period of time. Competitions are typically scheduled once a week, once every two weeks, or once a month.

2. Occasional competitions
These include any competitions that typically occur less often than once a month and last only one day in duration.

3. Tournaments
These include any competitions that typically occur less often than once a month and involve a series of matches / events held over two or more consecutive days.

The following questions relate to your participation in each of these different competition formats.

This question relates to your participation in **regular season** competitions for your main sport. As a reminder, regular season competitions involve a series of **regularly occurring matches / events** over an extended period of time. Competitions are typically scheduled **once a week, once every two weeks, or once a month**.

For each year of your involvement in your main sport, please tell us about the regular season competitions that you have participated in.

If you have never participated in regular season competitions for your main sport please place a tick in the box below and continue to page 17:

☐ I have never participated in regular season competitions for my main sport

	Total number of months involved in regular season competitions	*Average number of regular season matches / events per month*	*Average time spent at the competition venue for each match / event (hours)*	*Average time actively participating in competition during each match / event (including preparation and de-brief activities) (hours)*
Example	8	4	3	2
Age 5				
Age 6				
Age 7				
Age 8				

Age 9				
Age 10				
Age 11				
Age 12				
Age 13				
Age 14				
Age 15				
Age 16				
Age 17				
Age 18				

The next question relates to your participation in **occasional** competitions for your main sport. As a reminder, occasional competitions typically occur **less often than once a month** and last only **one day** in duration.

Any competitions that occur less often than once a month but involve two or more consecutive days of matches / events are considered tournaments and should not be included in this question.

For each year of your involvement in your main sport, please tell us about the occasional competitions that you have participated in.

If you have never participated in occasional competitions for your main sport please place a tick in the box below and continue to page 19:

☐ I have never participated in occasional competitions for my main sport

	Total number of occasional competitions	*Average number of matches / events that you participated in within each occasional competition*	*Average time spent at the competition venue on each day of occasional competition (hours)*	*Average time actively competing during each day of occasional competition (including preparation & debrief activities) (hours)*
Example	4	2	5	2
Age 5				
Age 6				

Age 7				
Age 8				
Age 9				
Age 10				
Age 11				
Age 12				
Age 13				
Age 14				
Age 15				
Age 16				
Age 17				
Age 18				

The next question relates to your participation in competition **tournaments** for your main sport. As a reminder, tournaments include competitions that typically occur **less often than once a month** and involve a **series of matches / events** held over **two or more consecutive days**.

For each year of your involvement in your main sport, please tell us about the tournaments that you have participated in.
If you have never participated in a competition tournament for your main sport please place a tick in the box below and continue to page 20:

☐ I have never participated in a competition tournament for my main sport

	Total number of tournaments	*Average number of matches / events that you participated in within each tournament*	*Average time spent at the competition venue for each match / event (hours)*	*Average time actively participating in competition during each match / event (including preparation and de-brief activities) (hours)*
Example	2	6	3	1.5
Age 5				

Age 6				
Age 7				
Age 8				
Age 9				
Age 10				
Age 11				
Age 12				
Age 13				
Age 14				
Age 15				
Age 16				
Age 17				
Age 18				

Section 7 of 10: Your Participation in Other Organised Sports

Athletes often participate in a variety of sports before choosing to specialise in their main sport.

*The following questions relate to your involvement in **organised sports other than your main sport**.*

*Organised sports include sporting activities in which you have **regular practice sessions** under the **formal supervision** of a coach or adult. They may or may not involve competitions. Participation in organised sports often requires registration with a team or a club.*

When answering the following questions about your involvement in other organised sports, please do not include sporting activities completed as part of compulsory physical education classes at school, but do include any school sporting activities in which you participated in regular, supervised practice sessions.

*Also, **please do not include the informal playful sporting games** that you engage in every now and again, for fun with your friends and family, in the back yard or local streets (such as pick-up basketball or street hockey). Your involvement in these activities will be discussed in a moment.*

*Please include all organised sports that you participated in for **at least one season or more**, but do not include your main sport.*

For each year of your involvement in all of the organised sports that you participated in, please indicate:

a) The type of sport. Please be specific as possible e.g. indoor volleyball, football–soccer, football–american, field hockey, ice hockey etc.

b) How many hours per week (on average) you were involved in all practice and competition activities relating to that sport.

c) How many months of the year you were involved in that sport.

d) The highest level of competition that you participated at for that sport. To identify the highest level of competition that you participated at please refer to the codes provided on the back page of this questionnaire. You may rip off the back page for your convenience. For example, please enter a '5' in the box below if the highest level of competition you participated at for a particular age was "competition against others within the local area (at the senior / open level)".

If you have never participated in any other organised sports other than your main sport please place a tick in the box below and continue to page 26:

☐ I have never participated in any other organised sports other than my main sport

	Sport 1			***Sport 2***			***Sport 3***		
	Hours per week	*Months per year*	*Highest level of competition*	*Hours per week*	*Months per year*	*Highest level of competition*	*Hours per week*	*Months per year*	*Highest level of competition*
Example	Swimming			Basketball			Artistic Gymnastics		
	4	6	8	2	5	4	3	11	1
SPORT									
Age 5									
Age 6									
Age 7									
Age 8									
Age 9									
Age 10									
Age 11									
Age 12									
Age 13									

	Sport 1			*Sport 2*			*Sport 3*		
	Hours per week	*Months per year*	*Highest level of competition*	*Hours per week*	*Months per year*	*Highest level of competition*	*Hours per week*	*Months per year*	*Highest level of competition*
Age 14									
Age 15									
Age 16									
Age 17									
Age 18									

	Sport 4			***Sport 5***			***Sport 6***		
	Hours per week	*Months per year*	*Highest level of competition*	*Hours per week*	*Months per year*	*Highest level of competition*	*Hours per week*	*Months per year*	*Highest level of competition*
Example	Swimming			Basketball			Artistic Gymnastics		
	4	6	8	2	5	4	3	11	1
SPORT									
Age 5									
Age 6									

Age 7									
Age 8									
Age 9									
Age 10									
Age 11									
Age 12									
Age 13									
Age 14									
Age 15									
Age 16									
Age 17									
Age 18									

	Sport 7			***Sport 8***			***Sport 9***		
	Hours per week	*Months per year*	*Highest level of competition*	*Hours per week*	*Months per year*	*Highest level of competition*	*Hours per week*	*Months per year*	*Highest level of competition*
Example	Swimming			Basketball			Artistic Gymnastics		
	4	6	8	2	5	4	3	11	1
SPORT									
Age 5									
Age 6									
Age 7									
Age 8									
Age 9									
Age 10									
Age 11									
Age 12									
Age 13									

	Sport 7			*Sport 8*			*Sport 9*		
	Hours per week	*Months per year*	*Highest level of competition*	*Hours per week*	*Months per year*	*Highest level of competition*	*Hours per week*	*Months per year*	*Highest level of competition*
Age 14									
Age 15									
Age 16									
Age 17									
Age 18									

Section 8 of 10: Your Participation in Playful Sporting Games

*Athletes also often participate in **informal playful sporting games** during their leisure time. Informal playful sporting games include activities that resemble competitive sports but involve **modified rules and/or equipment**, with very little to **no formal instruction, coaching, or supervision**. The main emphasis of these activities is on fun and enjoyment rather than performance improvement.*

Informal playful sporting games are often played in the backyard, the school yard, the local park, and/or the local streets. Examples include pick-up basketball, street hockey, backyard cricket, running games, and bike riding.

The following questions relate to your involvement in informal playful sporting games.

Please list all of the informal playful sporting games that you have typically participated in:

If you have never participated in any informal playful sporting games please place a tick in the box below and continue to the bottom of page 28:

☐ I have never participated in informal playful sporting games

Playful sporting game 1 _____

Playful sporting game 2 _____

Playful sporting game 3 _____

Playful sporting game 4 _____

Playful sporting game 5 _____

Playful sporting game 6 _____

Playful sporting game 7 _____

Playful sporting game 8 _____

Playful sporting game 9 _____

Playful sporting game 10 _____

Playful sporting game 11 _____

Playful sporting game 12 _____

Playful sporting game 13 _____

Playful sporting game 14 _____

Playful sporting game 15 _____

Playful sporting game 16 _____

Playful sporting game 17 _____

Playful sporting game 18 _____

Playful sporting game 19 _____

Playful sporting game 20 _____

For each age that you regularly participated in informal playful sporting games, please indicate approximately how many <u>hours per week</u> and <u>months per year</u> that you would play these games.

Please consider all informal playful sporting games together, and provide an overall number of hours representing the total time that you participated in playful sporting games of any description, during a typical week.

	Hours per week	*Months per year*
Example	2	6
Age 5		
Age 6		
Age 7		
Age 8		
Age 9		
Age 10		
Age 11		
Age 12		
Age 13		
Age 14		
Age 15		
Age 16		
Age 17		
Age 18		

Of all the informal playful sporting games that you listed previously, which two have you spent the most time participating in?

Most frequent playful sporting game _____

Second most frequent playful game _____

In general, what percentage of your total sporting play time would you have devoted to your participation in each of the two informal playful sporting games identified above?

For example, if you have devoted approximately half of the time that you have participated in informal playful sporting games to pick-up basketball, please enter 50%.

Please note: *These values will not necessarily add up to 100%, but together they may not exceed 100%*

Percentage of time devoted to your most frequent playful sporting game _____

Percentage of time devoted to your second most frequent playful game _____

Nearly Finished!

Keep going - You have nearly finished the Developmental History of Athletes Questionnaire!

Section 9 of 10: Your Family

We would now like to ask some questions about your immediate family, and their participation in sport and physical activity.

First we would like to ask about your ***biological mother****.*

What is your mother's date of birth?

_____
Day Month Year

In which country has your mother resided for the majority of her life?

_____

What is the highest level of education that your mother has completed?

☐ Less than secondary school

☐ Some secondary school

☐ Completed secondary school

☐ Some post-secondary college / undergraduate university

☐ Completed a post-secondary college diploma / undergraduate university degree

☐ Some postgraduate university

☐ Completed a masters degree

☐ Completed a law / professional degree

☐ Completed a doctoral degree

☐ Other – Please specify:

_____

How old were you when you started living with your mother?

☐ From when I was born

☐ I have never lived with my mother

☐ From age:

_____

How old were you when you stopped living with your mother?

☐ I still live with my mother

☐ I have never lived with my mother

☐ At age:

_____

During the time that you lived with your mother, on average, how often did she participate in the following types of physical activity?

Please tick one box within each row.

	Never	*Occasionally*	*1-2 times per week*	*3-5 times per week*	*More than 5 times per week*	*N/A – I have never lived with my mother*
General fitness activities	☐	☐	☐	☐	☐	☐
Recreational sport / informal sporting games	☐	☐	☐	☐	☐	☐
Competitive sport	☐	☐	☐	☐	☐	☐

Throughout her life, has your mother ever participated in any competitive sports for an extended period of time (i.e. 3 years or more)?

☐ No

☐ Yes

If yes, in which competitive sport(s) has your mother participated in for an extended period of time (i.e. 3 years or more), and what is the highest level of competition that she has participated at?

To identify the highest level of competition that your mother participated at please refer to the codes provided on the back page of this questionnaire. You may rip off the back page for your convenience. For example, please enter a '5' in the space below if the highest level of competition your mother participated at was "competition against others within the local area (at the senior / open level)".

	Sport type (Please be specific as possible)	*Highest level of competition (Please enter the corresponding code from the list on the back page of the questionnaire)*
Sport 1		
Sport 2		
Sport 3		
Sport 4		
Sport 5		

*Next we would like to ask about your **biological father**.*

What is your father's date of birth?

_____
Day Month Year

In which country has your father resided for the majority of his life?

_____

What is the highest level of education that your father has completed?

☐ Less than secondary school

☐ Some secondary school

☐ Completed secondary school

☐ Some post-secondary college / undergraduate university

☐ Completed a post-secondary college diploma / undergraduate university degree

☐ Some postgraduate university

☐ Completed a masters degree

☐ Completed a law / professional degree

☐ Completed a doctoral degree

☐ Other – Please specify:

_____

How old were you when you started living with your father?

☐ From when I was born

☐ I have never lived with my father

☐ From age:

_____

How old were you when you stopped living with your father?

☐ I still live with my father

☐ I have never lived with my father

☐ At age:

_____

During the time that you lived with your father, on average, how often did he participate in the following types of physical activity?

Please tick one box within each row.

	Never	*Occasionally*	*1-2 times per week*	*3-5 times per week*	*More than 5 times per week*	*N/A – I have never lived with my mother*
General fitness activities	☐	☐	☐	☐	☐	☐
Recreational sport / informal sporting games	☐	☐	☐	☐	☐	☐
Competitive sport	☐	☐	☐	☐	☐	☐

Throughout his life, has your father ever participated in any competitive sports for an extended period of time (i.e. 3 years or more)?

☐ No

☐ Yes

If yes, in which competitive sport(s) has your father participated in for an extended period of time (i.e. 3 years or more), and what is the highest level of competition that he has participated at?

To identify the highest level of competition that your father participated at please refer to the codes provided on the back page of this questionnaire. You may rip off the back page for your convenience. For example, please enter a '5' in the space below if the highest level of competition your father participated at was "competition against others within the local area (at the senior / open level)".

	Sport type (Please be specific as possible)	*Highest level of competition (Please enter the corresponding code from the list on the back page of the questionnaire)*
Sport 1		
Sport 2		
Sport 3		
Sport 4		
Sport 5		

*Next we would like to ask about your **step-mother or female legal guardian**.*

If you have never had a step-mother or female legal guardian other than your biological mother, please place a tick in the box below and continue to page 34:

☐ I have never had a step-mother or female legal guardian other than my biological mother

Please describe this person's relationship to you:

☐ Aunt

☐ Foster parent

☐ Godmother

☐ Grandmother

☐ Step-mother

☐ Other – Please specify:

_____

What is this person's date of birth?

_____
Day Month Year

In which country has this person resided for the majority of her life?

_____

What is the highest level of education that this person has completed?

☐ Less than secondary school

☐ Some secondary school

☐ Completed secondary school

☐ Some post-secondary college / undergraduate university

☐ Completed a post-secondary college diploma / undergraduate university degree

☐ Some postgraduate university

☐ Completed a masters degree

☐ Completed a law / professional degree

☐ Completed a doctoral degree

☐ Other – Please specify:

_____

How old were you when you started living with this person?

☐ From when I was born

☐ I have never lived with this person

☐ From age:

_____

How old were you when you stopped living with this person?

☐ I still live with this person

☐ I have never lived with this person

☐ At age:

_____

During the time that you lived with this person, on average, how often did she participate in the following types of physical activity?

Please tick one box within each row.

	Never	*Occasionally*	*1-2 times per week*	*3-5 times per week*	*More than 5 times per week*	*N/A – I have never lived with my mother*
General fitness activities	☐	☐	☐	☐	☐	☐
Recreational sport / informal sporting games	☐	☐	☐	☐	☐	☐
Competitive sport	☐	☐	☐	☐	☐	☐

Throughout her life, has this person ever participated in any competitive sports for an extended period of time (i.e. 3 years or more)?

☐ No

☐ Yes

If yes, in which competitive sport(s) has this person participated in for an extended period of time (i.e. 3 years or more), and what is the highest level of competition that she has participated at?

To identify the highest level of competition that this person has participated at please refer to the codes provided on the back page of this questionnaire. You may rip off the back page for your convenience. For example, please enter a '5' in the space below if the highest level of competition this person participated at was "competition against others within the local area (at the senior / open level)".

	Sport type (Please be specific as possible)	*Highest level of competition (Please enter the corresponding code from the list on the back page of the questionnaire)*
Sport 1		
Sport 2		
Sport 3		
Sport 4		
Sport 5		

*Now we would like to ask about your **step-father or male legal guardian**.*

If you have never had a step-father or male legal guardian other than your biological father, please place a tick in the box below and continue to page 36:

☐ I have never had a step-father or male legal guardian other than my biological father

Please describe this person's relationship to you:

☐ Uncle

☐ Foster parent

☐ Godfather

☐ Grandfather

☐ Step-father

☐ Other – Please specify:

_____

What is this person's date of birth?

_____
Day Month Year

In which country has this person resided for the majority of his life?

_____

What is the highest level of education that this person has completed?

☐ Less than secondary school

☐ Some secondary school

☐ Completed secondary school

☐ Some post-secondary college / undergraduate university

☐ Completed a post-secondary college diploma / undergraduate university degree

☐ Some postgraduate university

☐ Completed a masters degree

☐ Completed a law / professional degree

☐ Completed a doctoral degree

☐ Other – Please specify:

_____

How old were you when you started living with this person?

☐ From when I was born

☐ I have never lived with this person

☐ From age:

_____

How old were you when you stopped living with this person?

☐ I still live with this person

☐ I have never lived with this person

☐ At age:

_____

During the time that you lived with this person, on average, how often did he participate in the following types of physical activity?

Please tick one box within each row.

	Never	*Occasionally*	*1-2 times per week*	*3-5 times per week*	*More than 5 times per week*	*N/A – I have never lived with my mother*
General fitness activities	☐	☐	☐	☐	☐	☐
Recreational sport / informal sporting games	☐	☐	☐	☐	☐	☐
Competitive sport	☐	☐	☐	☐	☐	☐

Throughout his life, has this person ever participated in any competitive sports for an extended period of time (i.e. 3 years or more)?

☐ No

☐ Yes

If yes, in which competitive sport(s) has this person participated in for an extended period of time (i.e. 3 years or more), and what is the highest level of competition that he has participated at?

To identify the highest level of competition that this person has participated at please refer to the codes provided on the back page of this questionnaire. You may rip off the back page for your convenience. For example, please enter a '5' in the space below if the highest level of competition this person participated at was "competition against others within the local area (at the senior / open level)".

	Sport type (Please be specific as possible)	*Highest level of competition (Please enter the corresponding code from the list on the back page of the questionnaire)*
Sport 1		
Sport 2		
Sport 3		
Sport 4		
Sport 5		

*The next few questions relate to your **siblings** (brothers and sisters). Please include any step-siblings and/or half-siblings when responding to the following questions.*

If you do not have any siblings, please place a tick in the box below and continue to page 46:

☐ I do not have any siblings

*First we would like to ask about your **oldest sibling**.*

Is this sibling male or female?

☐ Male

☐ Female

Please describe your relationship to this sibling:

☐ This sibling is my identical twin (monozygotic twin)

☐ This sibling is my non-identical twin (dizygotic twin)

☐ This sibling and I share the same mother and father

☐ This sibling and I have a different mother and/or father

What is this sibling's date of birth?

_____
Day Month Year

In which country has this sibling resided for the majority of their life?

_____

What is the highest level of education that this sibling has completed?

☐ Less than secondary school

☐ Some secondary school

☐ Completed secondary school

☐ Some post-secondary college / undergraduate university

☐ Completed a post-secondary college diploma / undergraduate university degree

☐ Some postgraduate university

☐ Completed a masters degree

☐ Completed a law / professional degree

☐ Completed a doctoral degree

☐ Other – Please specify:

_____

How old were you when you started living with this sibling?

☐ From when I was born

☐ I have never lived with this sibling

☐ From age:

_____

How old were you when you stopped living with this sibling?

☐ I still live with this sibling

☐ I have never lived with this sibling

☐ At age:

_____

During the time that you lived with this sibling, on average, how often did they participate in the following types of physical activity?

Please tick one box within each row.

	Never	*Occasionally*	*1-2 times per week*	*3-5 times per week*	*More than 5 times per week*	*N/A – I have never lived with my mother*
General fitness activities	☐	☐	☐	☐	☐	☐
Recreational sport / informal sporting games	☐	☐	☐	☐	☐	☐
Competitive sport	☐	☐	☐	☐	☐	☐

Throughout their life, has this sibling ever participated in any competitive sports for an extended period of time (i.e. 3 years or more)?

☐ No

☐ Yes

If yes, in which competitive sport(s) has this sibling participated in for an extended period of time (i.e. 3 years or more), and what is the highest level of competition that they have participated at?

To identify the highest level of competition that your sibling participated at please refer to the codes provided on the back page of this questionnaire. You may rip off the back page for your convenience. For example, please enter a '5' in the space below if the highest level of competition your sibling participated at was "competition against others within the local area (at the senior / open level)".

	Sport type (Please be specific as possible)	*Highest level of competition (Please enter the corresponding code from the list on the back page of the questionnaire)*
Sport 1		
Sport 2		
Sport 3		
Sport 4		
Sport 5		

*Now we would like to ask about your **second oldest sibling**.*

If you do not have any more siblings, please place a tick in the box below and continue to page 46:

☐ I do not have any more siblings

Is this sibling male or female?

☐ Male

☐ Female

Please describe your relationship to this sibling:

☐ This sibling is my identical twin (monozygotic twin)

☐ This sibling is my non-identical twin (dizygotic twin)

☐ This sibling and I share the same mother and father

☐ This sibling and I have a different mother and/or father

What is this sibling's date of birth?

_____
Day Month Year

In which country has this sibling resided for the majority of their life?

_____

What is the highest level of education that this sibling has completed?

☐ Less than secondary school

☐ Some secondary school

☐ Completed secondary school

☐ Some post-secondary college / undergraduate university

☐ Completed a post-secondary college diploma / undergraduate university degree

☐ Some postgraduate university

☐ Completed a masters degree

☐ Completed a law / professional degree

☐ Completed a doctoral degree

☐ Other – Please specify:

_____

How old were you when you started living with this sibling?

☐ From when I was born

☐ I have never lived with this sibling

☐ From age:

_____

How old were you when you stopped living with this sibling?

☐ I still live with this sibling

☐ I have never lived with this sibling

☐ At age:

_____

During the time that you lived with this sibling, on average, how often did they participate in the following types of physical activity?

Please tick one box within each row.

	Never	*Occasionally*	*1-2 times per week*	*3-5 times per week*	*More than 5 times per week*	*N/A – I have never lived with my mother*
General fitness activities	☐	☐	☐	☐	☐	☐
Recreational sport / informal sporting games	☐	☐	☐	☐	☐	☐
Competitive sport	☐	☐	☐	☐	☐	☐

Throughout their life, has this sibling ever participated in any competitive sports for an extended period of time (i.e. 3 years or more)?

☐ No

☐ Yes

If yes, in which competitive sport(s) has this sibling participated in for an extended period of time (i.e. 3 years or more), and what is the highest level of competition that they have participated at?

To identify the highest level of competition that your sibling participated at please refer to the codes provided on the back page of this questionnaire. You may rip off the back page for your convenience. For example, please enter a '5' in the space below if the highest level of competition your sibling participated at was "competition against others within the local area (at the senior / open level)".

	Sport type (Please be specific as possible)	*Highest level of competition (Please enter the corresponding code from the list on the back page of the questionnaire)*
Sport 1		
Sport 2		
Sport 3		
Sport 4		
Sport 5		

*Now we would like to ask about your **third oldest sibling**.*

If you do not have any more siblings, please place a tick in the box below and continue to page 46:

☐ I do not have any more siblings

Is this sibling male or female?

☐ Male

☐ Female

Please describe your relationship to this sibling:

☐ This sibling is my identical twin (monozygotic twin)

☐ This sibling is my non-identical twin (dizygotic twin)

☐ This sibling and I share the same mother and father

☐ This sibling and I have a different mother and/or father

What is this sibling's date of birth?

_____

Day Month Year

In which country has this sibling resided for the majority of their life?

_____

What is the highest level of education that this sibling has completed?

☐ Less than secondary school

☐ Some secondary school

☐ Completed secondary school

☐ Some post-secondary college / undergraduate university

☐ Completed a post-secondary college diploma / undergraduate university degree

☐ Some postgraduate university

☐ Completed a masters degree

☐ Completed a law / professional degree

☐ Completed a doctoral degree

☐ Other – Please specify:

_____

How old were you when you started living with this sibling?

☐ From when I was born

☐ I have never lived with this sibling

☐ From age:

_____

How old were you when you stopped living with this sibling?

☐ I still live with this sibling

☐ I have never lived with this sibling

☐ At age:

_____

During the time that you lived with this sibling, on average, how often did they participate in the following types of physical activity?

Please tick one box within each row.

	Never	*Occasionally*	*1-2 times per week*	*3-5 times per week*	*More than 5 times per week*	*N/A – I have never lived with my mother*
General fitness activities	☐	☐	☐	☐	☐	☐
Recreational sport / informal sporting games	☐	☐	☐	☐	☐	☐
Competitive sport	☐	☐	☐	☐	☐	☐

Throughout their life, has this sibling ever participated in any competitive sports for an extended period of time (i.e. 3 years or more)?

☐ No

☐ Yes

If yes, in which competitive sport(s) has this sibling participated in for an extended period of time (i.e. 3 years or more), and what is the highest level of competition that they have participated at?

To identify the highest level of competition that your sibling participated at please refer to the codes provided on the back page of this questionnaire. You may rip off the back page for your convenience. For example, please enter a '5' in the space below if the highest level of competition your sibling participated at was "competition against others within the local area (at the senior / open level)".

	Sport type (Please be specific as possible)	*Highest level of competition (Please enter the corresponding code from the list on the back page of the questionnaire)*
Sport 1		
Sport 2		
Sport 3		
Sport 4		
Sport 5		

*Now we would like to ask about your **fourth oldest sibling**.*

If you do not have any more siblings, please place a tick in the box below and continue to page 46:

☐ I do not have any more siblings

Is this sibling male or female?

☐ Male

☐ Female

Please describe your relationship to this sibling:

☐ This sibling is my identical twin (monozygotic twin)

☐ This sibling is my non-identical twin (dizygotic twin)

☐ This sibling and I share the same mother and father

☐ This sibling and I have a different mother and/or father

What is this sibling's date of birth?

_____
Day Month Year

In which country has this sibling resided for the majority of their life?

_____

What is the highest level of education that this sibling has completed?

☐ Less than secondary school

☐ Some secondary school

☐ Completed secondary school

☐ Some post-secondary college / undergraduate university

☐ Completed a post-secondary college diploma / undergraduate university degree

☐ Some postgraduate university

☐ Completed a masters degree

☐ Completed a law / professional degree

☐ Completed a doctoral degree

☐ Other – Please specify:

_____

How old were you when you started living with this sibling?

☐ From when I was born

☐ I have never lived with this sibling

☐ From age:

_____

How old were you when you stopped living with this sibling?

☐ I still live with this sibling

☐ I have never lived with this sibling

☐ At age:

_____

During the time that you lived with this sibling, on average, how often did they participate in the following types of physical activity?

Please tick one box within each row.

	Never	*Occasionally*	*1-2 times per week*	*3-5 times per week*	*More than 5 times per week*	*N/A – I have never lived with my mother*
General fitness activities	☐	☐	☐	☐	☐	☐
Recreational sport / informal sporting games	☐	☐	☐	☐	☐	☐
Competitive sport	☐	☐	☐	☐	☐	☐

Throughout their life, has this sibling ever participated in any competitive sports for an extended period of time (i.e. 3 years or more)?

☐ No

☐ Yes

If yes, in which competitive sport(s) has this sibling participated in for an extended period of time (i.e. 3 years or more), and what is the highest level of competition that they have participated at?

To identify the highest level of competition that your sibling participated at please refer to the codes provided on the back page of this questionnaire. You may rip off the back page for your convenience. For example, please enter a '5' in the space below if the highest level of competition your sibling participated at was "competition against others within the local area (at the senior / open level)".

	Sport type (Please be specific as possible)	*Highest level of competition (Please enter the corresponding code from the list on the back page of the questionnaire)*
Sport 1		
Sport 2		
Sport 3		
Sport 4		
Sport 5		

*Now we would like to ask about your **fifth oldest sibling**.*

If you do not have any more siblings, please place a tick in the box below and continue to page 46:

☐ I do not have any more siblings

Is this sibling male or female?

☐ Male

☐ Female

Please describe your relationship to this sibling:

☐ This sibling is my identical twin (monozygotic twin)

☐ This sibling is my non-identical twin (dizygotic twin)

☐ This sibling and I share the same mother and father

☐ This sibling and I have a different mother and/or father

What is this sibling's date of birth?

Day Month Year

In which country has this sibling resided for the majority of their life?

What is the highest level of education that this sibling has completed?

☐ Less than secondary school

☐ Some secondary school

☐ Completed secondary school

☐ Some post-secondary college / undergraduate university

☐ Completed a post-secondary college diploma / undergraduate university degree

☐ Some postgraduate university

☐ Completed a masters degree

☐ Completed a law / professional degree

☐ Completed a doctoral degree

☐ Other – Please specify:

_____

How old were you when you started living with this sibling?

☐ From when I was born

☐ I have never lived with this sibling

☐ From age:

_____

How old were you when you stopped living with this sibling?

☐ I still live with this sibling

☐ I have never lived with this sibling

☐ At age:

_____

During the time that you lived with this sibling, on average, how often did they participate in the following types of physical activity?

Please tick one box within each row.

	Never	*Occasionally*	*1-2 times per week*	*3-5 times per week*	*More than 5 times per week*	*N/A – I have never lived with my mother*
General fitness activities	☐	☐	☐	☐	☐	☐
Recreational sport / informal sporting games	☐	☐	☐	☐	☐	☐
Competitive sport	☐	☐	☐	☐	☐	☐

Throughout their life, has this sibling ever participated in any competitive sports for an extended period of time (i.e. 3 years or more)?

☐ No

☐ Yes

If yes, in which competitive sport(s) has this sibling participated in for an extended period of time (i.e. 3 years or more), and what is the highest level of competition that they have participated at?

To identify the highest level of competition that your sibling participated at please refer to the codes provided on the back page of this questionnaire. You may rip off the back page for your convenience. For example, please enter a '5' in the space below if the highest level of competition your sibling participated at was "competition against others within the local area (at the senior / open level)".

	Sport type (Please be specific as possible)	*Highest level of competition (Please enter the corresponding code from the list on the back page of the questionnaire)*
Sport 1		
Sport 2		
Sport 3		
Sport 4		
Sport 5		

Section 10 of 10: Where You Have Lived

*Finally, we would like to ask you a few questions about all of the **towns / cities in which you have lived**.*

***Please note:** When answering the following questions, if you lived in a particular town / city, moved away for a period of time, and then returned, please treat the return relocation as an entirely new town / city of residence.*
For example, if you were born in Melbourne and lived there until you were 19, then you moved to Canberra for 2 years before returning to Melbourne, for purposes of this questionnaire you have lived in 3 separate towns / cities.

***Please also note:** When answering the following questions, you do not need to tell us about relocations to a new suburb / neighbourhood within the same town / city. We are only interested in relocations to completely different towns / cities. For example, if you moved from Manly to Bondi, both of these suburbs are still considered to be within Sydney, and you do not need to tell us about this relocation. However, if you moved from a suburb in Sydney to a suburb in Brisbane, then this relocation must be documented. If you are unsure whether to include a particular relocation, please err on the side of caution and document it.*

*Please include all towns / cities in which you have lived, regardless of the duration of time that you lived there. **Even residences of short duration are important.***

Where were you born?

Name of the town / city _____

State / Province _____

Country _____

If you have never moved away from the town / city in which you were born, please place a tick in the box below and continue to page 51:

☐ I have never moved away from the town / city in which I was born

Where was the second town / city in which you lived?

Name of the town / city _____

State / Province _____

Country _____

How old were you when you moved to this town / city?

_____

Why did you move to this town / city?

☐ Education related reasons

☐ Family related reasons

☐ Lifestyle related reasons

☐ Personal relationship related reasons

☐ Sport related reasons

☐ Unspecified personal reasons

☐ Work related reasons

☐ Other – Please specify:

_____

If you have never moved away from the second town / city in which you lived, please place a tick in the box below and continue to page 51:

☐ I have never moved away from the second town / city in which I lived

Where was the third town / city in which you lived?

Name of the town / city _____

State / Province _____

Country _____

How old were you when you moved to this town / city?

_____

Why did you move to this town / city?

☐ Education related reasons

☐ Family related reasons

☐ Lifestyle related reasons

☐ Personal relationship related reasons

☐ Sport related reasons

☐ Unspecified personal reasons

☐ Work related reasons

☐ Other – Please specify:

_____

If you have never moved away from the third town / city in which you lived, please place a tick in the box below and continue to page 51:

☐ I have never moved away from the third town / city in which I lived

Where was the fourth town / city in which you lived?

Name of the town / city _____

State / Province _____

Country _____

How old were you when you moved to this town / city?

_____

Why did you move to this town / city?

☐ Education related reasons

☐ Family related reasons

☐ Lifestyle related reasons

☐ Personal relationship related reasons

☐ Sport related reasons

☐ Unspecified personal reasons

☐ Work related reasons

☐ Other – Please specify:

_____

If you have never moved away from the fourth town / city in which you lived, please place a tick in the box below and continue to page 51:

☐ I have never moved away from the fourth town / city in which I lived

Where was the fifth town / city in which you lived?

Name of the town / city _____

State / Province _____

Country _____

How old were you when you moved to this town / city?

_____

Why did you move to this town / city?

☐ Education related reasons

☐ Family related reasons

☐ Lifestyle related reasons

☐ Personal relationship related reasons

☐ Sport related reasons

☐ Unspecified personal reasons

☐ Work related reasons

☐ Other – Please specify:

_____

If you have never moved away from the fifth town / city in which you lived, please place a tick in the box below and continue to page 51:

☐ I have never moved away from the fifth town / city in which I lived

Where was the sixth town / city in which you lived?

Name of the town / city _____

State / Province _____

Country _____

How old were you when you moved to this town / city?

_____

Why did you move to this town / city?

☐ Education related reasons

☐ Family related reasons

☐ Lifestyle related reasons

☐ Personal relationship related reasons

☐ Sport related reasons

☐ Unspecified personal reasons

☐ Work related reasons

☐ Other – Please specify:

_____

If you have never moved away from the sixth town / city in which you lived, please place a tick in the box below and continue to page 51:

☐ I have never moved away from the sixth town / city in which I lived

Where was the seventh town / city in which you lived?

Name of the town / city _____

State / Province _____

Country _____

How old were you when you moved to this town / city?

_____

Why did you move to this town / city?

☐ Education related reasons

☐ Family related reasons

☐ Lifestyle related reasons

☐ Personal relationship related reasons

☐ Sport related reasons

☐ Unspecified personal reasons

☐ Work related reasons

☐ Other – Please specify:

_____

If you have never moved away from the seventh town / city in which you lived, please place a tick in the box below and continue to page 51:

☐ I have never moved away from the seventh town / city in which I lived

Where was the eighth town / city in which you lived?

Name of the town / city _____

State / Province _____

Country _____

How old were you when you moved to this town / city?

_____

Why did you move to this town / city?

☐ Education related reasons

☐ Family related reasons

☐ Lifestyle related reasons

☐ Personal relationship related reasons

☐ Sport related reasons

☐ Unspecified personal reasons

☐ Work related reasons

☐ Other – Please specify:

_____

If you have never moved away from the eighth town / city in which you lived, please place a tick in the box below and continue to page 51:

☐ I have never moved away from the eighth town / city in which I lived

Where was the ninth town / city in which you lived?

Name of the town / city _____

State / Province _____

Country _____

How old were you when you moved to this town / city?

_____

Why did you move to this town / city?

☐ Education related reasons

☐ Family related reasons

☐ Lifestyle related reasons

☐ Personal relationship related reasons

☐ Sport related reasons

☐ Unspecified personal reasons

☐ Work related reasons

☐ Other – Please specify:

_____

If you have never moved away from the ninth town / city in which you lived, please place a tick in the box below and continue to page 51:

☐ I have never moved away from the ninth town / city in which I lived

Where was the tenth town / city in which you lived?

Name of the town / city _____

State / Province _____

Country _____

How old were you when you moved to this town / city?

_____

Why did you move to this town / city?

☐ Education related reasons

☐ Family related reasons

☐ Lifestyle related reasons

☐ Personal relationship related reasons

☐ Sport related reasons

☐ Unspecified personal reasons

☐ Work related reasons

☐ Other – Please specify:

_____

Final Comments?

You have just completed the final section of the Developmental History of Athletes Questionnaire!

What time is it right now?

☐ AM ☐ PM

_____

HH : MM

Did you have any difficulties understanding or answering any of the questions relating to your family or where you have lived?

☐ No

☐ Yes

If yes, please describe the question(s) and the difficulties you have had:

_____

_____

_____

_____

_____

_____

Do you have any final comments that you wish to make about the Developmental History of Athletes Questionnaire, your own sport involvement, or any other issues that you feel are important to mention?

_____

_____

_____

_____

_____

Participant ID: _____

(Office use only)

Congratulations!

You have now completed the Developmental History of Athletes Questionnaire.

Thank you very much for your time, patience, co-operation, and assistance.
Your participation in the research project is extremely valuable.

Participant ID: _____

(Office use only)

Level of Competition Code Sheet

Please use this code sheet to answer:

- Section 7 of 10: Your Participation in Other Organised Sports
- Section 9 of 10: Your Family

You may remove this page for your convenience.

To identify the highest level of competition when responding to items within sections 7 and 9, please refer to the codes provided below.

For example, please enter a '5' in the relevant space if the highest level of competition is "competition against others within the local area (at the senior / open level)".

1. No competition - Recreational involvement only (at the junior level)

2. No competition - Recreational involvement only (at the senior / open level)

3. No competition - Recreational involvement only (at the masters level)

4. Competition against others within the local area (at the junior level)

5. Competition against others within the local area (at the senior / open level)

6. Competition against others within the local area (at the masters level)

7. Competition against others within the state / province (at the junior level)

8. Competition against others within the state / province (at the senior / open level)

9. Competition against others within the state / province (at the masters level)

10. Competition against others from across the country (at the junior level)

11. Competition against others from across the country (at the senior / open level)

12. Competition against others from across the country (at the masters level)

13. Competition against others from different countries (at the junior level)

14. Competition against others from different countries (at the senior / open level)

15. Competition against others from different countries (at the masters level)

16. Other – Please be sure specify the appropriate level of competition in the corresponding space