CONTEXTUAL SPRINTING IN PREMIER LEAGUE FOOTBALL

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ABSTRACT

The demands of football are well researched. The sport is typically characterised by periods of low-intensity running interspersed by intermittent, intense, high-velocity multidirectional running (Shephard, 1999; Bloomfield et al., 2007; Bradley et al., 2009, 2013; Bush et al., 2015). Recently there has been substantial research in the area focused on quantifying the locomotor demands of football. However, some have questioned this abundance of research as potentially being reductionist and one-dimensional in nature (Ade et al., 2016; Bradley and Ade, 2018). This has led to suggestions for the application of a more integrated model whereby more contextualised data supplements these locomotor outputs to provide a more holistic view of match demands.

Sprinting has been noted as crucial to the outcome of a match (Faude et al., 2012). Alongside this, it has been suggested as the key injury mechanism behind the most frequent muscular injury (Hamstring strain) in football (Schache et al., 2012; Schuermans et al., 2017). Thus, sprinting is a key area for performance enhancement and injury prevention. It is anecdotally accepted that sprinting in football differs from that of track and field. Yet, surprisingly little is known beyond the aforementioned locomotor data. It has been observed that high-intensity running in football is highly variable in how and why it occurs during a match (Ade et al., 2016). Therefore, the current thesis sought to provide a comprehensibly detailed description of sprinting in football. Particular focus was placed upon defining how and why sprinting occurs.

Study 1 (Chapter 3), therefore, sought to develop effective and subsequently reliable means of quantifying how and why sprinting occurs in a football match. Two classification systems were accordingly developed. Firstly, to quantify the movements associated with sprinting in football. And secondly, to quantify the tactical-contexts within which these sprints occurred. Through the application of a previously outlined model, both systems were successfully developed. These were then both deemed adequately reliable for their application in Premier League football. The developed systems were thus judged acceptable for application in subsequent research.

Study 2 (Chapter 4) aimed to classify the specific movements associated with sprinting in Premier League football. A previously developed classification system (Chapter 3), The Sprint Movement Classification System, was applied to classify and quantify all movements present in sprinting during football. The analysis was categorised in three main areas: Transition Movements, Initiation Movements and Actualisation Movements. This allowed for a comprehensive description of sprinting and its constituent movements. Sprinting in football was found to consist of a large variety of different movement patterns. These findings suggest that training to enhance match sprinting performance should not be confined to traditional track and field-based sprinting programmes. Practice should reflect the specific-nature of football-based sprinting.

Study 3 (Chapter 5) then sought to explain further why these different movements may occur during sprinting in football. The aim was to define the tactical-context in which these efforts happen, thus attempting to explain why sprinting occurs. To achieve this, a previously developed classification system (Chapter 3) was employed, The Sprint Tactical-Context Classification System. This system focused on two key areas: Phase of Play and Tactical Outcome. This allowed for the sprint effort to be contextualised within the match itself, providing a comprehensive understanding of why sprinting occurs. The study found that sprinting occurs across a variety of different phases of play and tactical outcomes. Thus, the findings suggest that key contexts such as Closing Down, Covering and Run the Channel should be the focus of training programs seeking to enhance sprinting ability during a match. Drill design should reflect the findings of the most common contexts in which sprints occur to ensure transfer to match play through enhanced specificity.

In summary, the findings of the current thesis provide a deeper understanding of the specific nature of sprinting in football. The results should be used accordingly to enhance training programme design. Sprinting is characterised by a variety of different movement patterns and occurs within a wide variety of contexts during a match. This more holistic understanding of sprinting in a football match should assist practitioners in designing highly specific drills and exercises that aim to enhance performance and reduce injury risk.

Alongside the scientific research, the doctoral programme sought to achieve development professionally. Within this, aims were set for both research and professional skills. The journey towards these aims is presented periodically throughout the thesis, within the reflective threads. These included growth in general research skills, leadership qualities and the creation of a personal brand within the subject area. Much of these aims were met and developments occurred professionally alongside the scientific research outcomes.

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LIST OF ABBREVIATIONS

British Association of Sport and Exercise Sciences	BASES
Central Defenders	CD
Central Midfielders	CM
Centre Forwards	CF
Change of Direction	COD
Continued Professional Development	CPD
Deceleration	Decel.
Effect Size	ES
English Premier League	EPL
Figure	Fig.
Full Backs	FB
Global Positioning Systems	GPS
High Intensity Distance (>5.5 $m.s^{-1}$)	HID
In Possession	IP
Liverpool John Moore's University	LJMU
Localised Positioning Systems	LPS
One-way analysis of Variance	ANOVA
Out of Possession	OP
Perception-Action	P-A
Premier League	PL
Purposeful Movement	PM

Researcher Development Framework	RDF
Sprinting (>7 $m.s^{-1}$)	SPR
The Sprint Movement Classification System	SMC
The Sprint Tactical-Context Classification System	STC
Total Distance	TD
United Kingdom Strength and Conditioning Association	UKSCA
Velocity-Based Training	VBT
Wide Midfielders	WM

CHAPTER 1

GENERAL INTRODUCTION

1.1 INTRODUCTION

Professional Doctorate programmes of study seek to develop an individual as both a researcher and a professional practitioner. Through this, the aim is to identify areas for improvement within one's professional practice and employ scientific methods to develop solutions. Thus, the current thesis consists of a Scientific Research Focus where traditional research will be employed over four studies to develop solutions to an identified area. Concurrent to this, will be a Professional Focus. The aim of this will be to progress as a practitioner and will consist of both research and professional skills (Fig. 1.1).

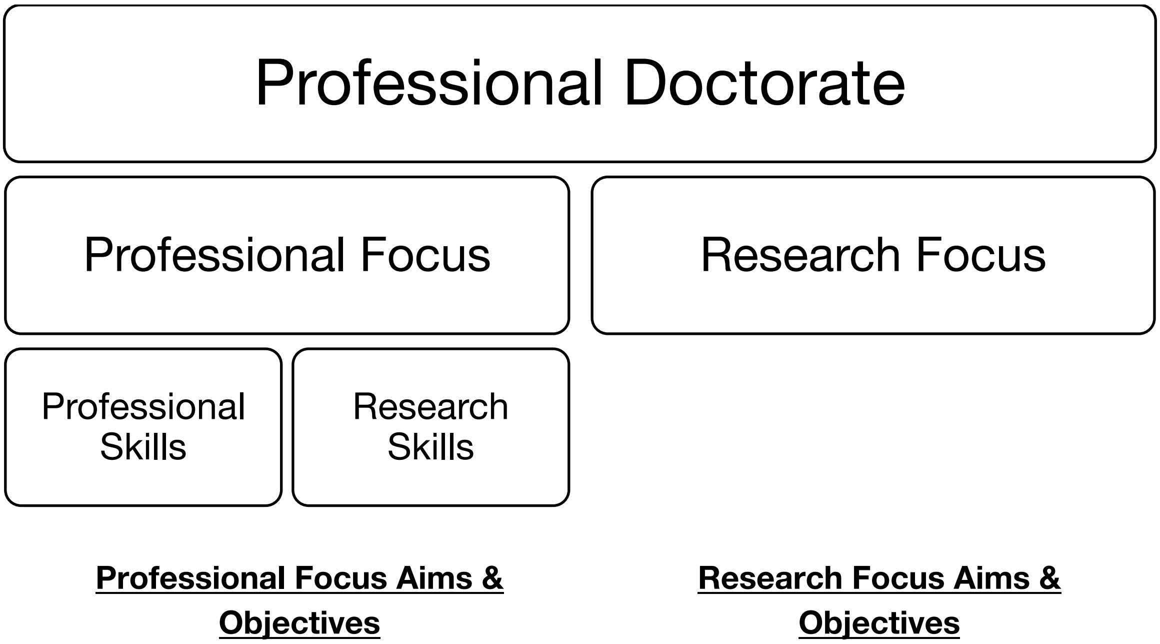

Figure 1.1 A graphical representation of the developmental aims of the programme.

Following my undergraduate study in Sport and Exercise Science, I undertook an MSc program where I specialised my studies within my chosen practice of Strength and Conditioning. During this period of Masters' study, I progressed from interning part-time in youth rugby to full-time at a professional football club. My ultimate aim was to progress up to leading a Performance department in elite football and following the completion of my postgraduate study I had the opportunity to commence this journey, firstly, briefly employed as a Head of Academy Strength & Conditioning and then as Assistant 1st Team Strength and Conditioning Coach at my current club, within the Premier League.

During my initial two years at the club, my focus was to attain professional accreditation within Strength and Conditioning (The United Kingdom Strength and Conditioning Association - UKSCA), which was supported by my employers. This process involved attending weekend workshops focused on key areas within the profession, ultimately leading to an examination day to prove competency within each area. Following the achievement of this, I turned my focus to attaining a similar international accreditation. Also, during this period as a part of my regular Continued Professional Development (CPD) and maintenance of accreditation, I was regularly attending conferences within Sport Science and Strength and Conditioning.

Following the completion of all necessary accreditation, I began to assess my options for further continued professional development opportunities. Throughout my academic studies, I had always considered further study to Level 8 and doctoral-level work. A colleague had recently commenced the Professional Doctorate programme at Liverpool John Moore's (LJMU) as a part of the first cohort, and with professional-research links being established between the club and the institution I was encouraged to pursue the programme. This involved a proposal to the club detailing the benefit to the organisation to secure funding, and I began the programme at the next available start date.

I felt that with my ultimate goal being to lead a performance department, attaining academic qualifications at doctoral level would support me by being an expert in my chosen field. The professional doctorate programme particularly appealed due to its focus on developing a thesis based upon an identified professional performance problem. This process of identifying a problem from my working practice, developing an eventual potential solution and disseminating these findings both internally and externally, I believed, would aid me in developing the necessary skills for a leadership role within the area.

1.2 PROFESSIONAL FOCUS

As noted, a Professional Doctorate aims to develop professional skills alongside research skills. For the Professional Focus of the programme, a Training Plan (Chapter 9.1) was completed prior to commencement. Here a Self-Audit was conducted to establish areas for improvement. As discussed, this consisted of two areas: Professional Skills and Research Skills. Each was analysed on its own merits through separate means. Firstly, a psychological assessment relating to professional skills was completed (PDA International, USA). Alongside this, a professional competency scale was completed to ascertain areas for improvement as a Sport Science practitioner (BASES, UK). Together these allowed for a plan to be devised for the programme focused upon professional development. Similarly, a competency framework specifically focused on research skills was completed (Vitae Researcher Development Framework) (Vitae, UK). Again, this provided a platform from which to progress through the programme and seek to develop my research skills.

Throughout the current thesis, there will exist a reflective thread. This will focus on the two key areas of Professional and Research skills (Fig. 1.1). Each chapter will consist of a chronological reflection within these two areas pertaining to the journey through the programme and the thesis itself. These reflective pauses will be led by the conclusions made during the Self-Audit with the explicit aim of chronicling my personal progression through the programme. This will run concurrently to the main Research Focus of the thesis and both threads to the project will support one another.

Reflective Practice is a purposeful and complex process that facilitates the examination of experience by questioning the whole self and our agency within the context of practice (Knowles et al., 2007, 2012; Huntley et al., 2014). Reflective Practice thus develops mere experiences into learning opportunities. This process can take many practical forms, typically personal to the individual, and often involving diary-style recording of experiences (Knowles et al., 2012; Huntley et al., 2014). Reflections can typically be observed across three levels: Technical, involving standard and competencies of practice; Practical, relating to the personal experience of the practitioner and their understanding of the context; and finally, Critical, involving the challenging of habitual practices (Knowles et al., 2007, 2012).

Throughout my progression through the programme, I maintained a diary of my thoughts and experiences. These were periodically reflected upon and finally developed into chapters for their inclusion within the thesis.

Having worked as a practitioner in elite football for numerous years I have always attempted to apply the knowledge developed during my academic education. Having progressed from a more holistic Sport and Exercise Science undergraduate programme into a more focused Strength and Conditioning post-graduate programme, I believe I possessed a good grounding in the fundamentals of science that underpinned my practice as a Strength and Conditioning Coach. However, I believe that my strength always lay with the practical aspects of coaching, as opposed to theoretical scientific research that supported it. It was for these reasons I was motivated to complete a Professional Doctorate programme of study that consisted of a strong professional element alongside the fundamental research. As my career progressed, I saw it as necessary to upskill my academic ability. The programme provided me with an opportunity to do this alongside enhancing my professional skills with a view to attaining leadership roles in the future. With this in mind, I settled upon the area of focus of the thesis, as I saw sprinting as fundamental to the development of physical preparation in football. This ability to relate directly to the project was crucial for me personally.

1.2.3 Professional Focus Aims and Objectives

Through the completion of the Self-Audit, key areas of focus were established for personal professional development through the programme. As noted, these were categorised as Professional and Research Skills. This process led to the establishing of clear aims:

1. To improve my general research skills.

2. To enhance my professional skills, particularly relating to effective leadership.

3. To create a personal brand within the area of focus of the research.

1.3 RESEARCH FOCUS

Football is a game defined by periods of low-intensity activity, punctuated by brief bouts of anaerobic, high-intensity multidirectional movement. Typically, players at the elite-level will cover between 10-12 km of total-distance during a match (Bradley et al., 2009, 2011, 2013; Bush et al., 2015). As a part of this, around 1500 m will be covered at higher-velocities (>5.5 $m.s^{-1}$) (High-intensity distance/running), and typically 300 m of this will be defined as sprinting (>7 $m.s^{-1}$) (Bradley et al., 2009, 2011, 2013; Bush et al., 2015). Alongside these basic locomotor demands, football is characterised by multidirectional movement. Players may complete 726 turns during a match (Bloomfield et al., 2007; Ade et al., 2016). These demands are known to vary according to playing position

Sprinting in football appears to be crucial to match outcome (Faude et al., 2012). This has been observed for both the scoring and the assisting player. Players typically perform around 20-50 sprints during a match, for an average of 5-20 m per effort (Andrzejewski et al., 2013; Barnes et al., 2014; Russell et al., 2016). These sprint efforts can occur every 200-500 s over the course of a match (Andrzejewski et al., 2015). Furthermore, sprints appear to be increasing in number in the Premier League (Barnes et al., 2014). Thus, this sprinting ability appears to be a crucial area for the future preparation of footballers.

The advent of load monitoring systems, typically utilising Global Positioning System (GPS) technology, has been fundamental to the increased understanding of the demands of football match play in recent years. However, following a plethora of research within the area, recently the question has arisen how much value further analysis provides. This focus on locomotor metrics has been suggested as potentially one-dimensional in nature (Ade et al., 2016; Bradley and Ade, 2018). A model for integrating such data with more contextualised variables has been presented recently (Bradley and Ade, 2018). The aim being to progress the knowledge within the area by providing performance practitioners and coaches alike with a more holistic understanding of the demands of football.

It would benefit practitioners to provide an understanding of why and how the locomotor distance is achieved. As noted, football is a sport that demands multi-directional movement. Previous attempts have been made to quantify these movements and thus how distance is attained (Bloomfield et al., 2007; Ade et al., 2016). However, the literature within the area is comparatively scarce when compared to those describing locomotor distances. Further, stark differences have been observed by playing position. Currently available methods for classifying the movements associated with the achieved distances in football are much more time consuming than those available through GPS systems. These methods often require manual collection without any currently available automated process.

Similarly, initial attempts have been made previously to begin to contextualise locomotor data by describing why efforts may be completed. A recent study sought to define aspects such as the tactical aims and movements associated with high-intensity efforts (Ade et al., 2016). Here variation was seen broadly for these efforts, and further unique demands were observed between positions. It is clear that merely reporting the distance covered at high-intensity is a misrepresentation of the demands of football and further research should seek to provide this additional contextualised information.

It is believed that due to the additional physical demands of sprinting, its decisiveness to match outcome and its increased potential as an injury mechanism, increasing the understanding of sprinting in football would be a huge benefit. Accordingly, the current thesis will aim to define the movements associated with sprinting in a football match (how sprinting occurs), and the tactical-contexts within which they occur (why sprinting occurs). Thus, providing a comprehensive description of sprinting in football. This will provide practitioners and researchers with the possibility of increased specificity to their training programmes and future research.

Following this, and in line with the professional focus of the thesis, an investigation will be completed into methods of dissemination of the results. Here particular attention will be made to how more contemporary methods may compare to traditional peer-review. With the highly practical nature of the thesis, it anticipated that these methods may provide a supplemental means of disseminating the findings to coaches much sooner than the traditional method of peer-review. This could then potentially heighten the impact of eventual publication and improve the thesis as a whole through professional discussion and collaboration throughout the process.

1.3.1 Research Focus Aims and Objectives

The overall aim of the current thesis is to provide a detailed description of sprinting in Premier League football. This will be achieved by describing how and why sprinting occurs during a match. The investigation will include realising the following objectives:

1. To develop two systems of classifying firstly, the movements associated with sprinting in football. And secondly, the tactical-contexts within which sprints are performed.

2. To describe the movements associated with sprinting in football through the employment of a movement classification system.

3. To describe the tactical-contexts within which sprinting occurs in football through the employment of a tactical-context classification system.

4. To develop and analyse the application of contemporary methods of scientific research dissemination.

CHAPTER 2

REVIEW OF THE LITERATURE

2.1 INTRODUCTION

Association football is a sport that is well accepted to be evolving athletically over the past decade into a game involving greater and greater demands for running at high velocities (Barnes et al., 2014; Bush et al., 2015). Match play typically consists of periods of lower intensity running, punctuated by high-intensity anaerobic efforts (Shephard, 1999; Bradley et al., 2009, 2013). Whilst total distance covered was seen to slightly increase over this period, larger increases were seen in the speeds at which this distance is covered. This is due predominantly to an increase in running speeds, the nature of sprinting and more frequent efforts (Barnes et al., 2014; Bush et al., 2015). It is crucial that players are adequately prepared to cope with these increasing demands.

2.1.1 The General Demands of Football

2.1.1.1. Match Demands

Only by intricately understanding the demands of match play are practitioners able to plan programmes that prepare players adequately for these demands. With the advent of GPS technology in sports, it is now easier than ever to quantify the locomotor distances achieved during a football match. Typically, an outfield payer will cover between 10,000 and 12,000 m on average of total running distance during a match. This can vary significantly between playing position, playing standard and sex (Bloomfield et al., 2007; Bradley et al., 2013; Gabbett et al., 2013; Bradley and Vescovi, 2015; Abbott et al., 2018; Baptista et al., 2018). In the English Premier League (EPL), Wide Midfielders (WM) were shown to cover the greatest Total Distance (11,612 m) compared to Central Defenders (CD), the lowest (9,816 m). The third tier of English football was shown to cover more total distance (11,607 m) than the second tier (11,429 m), and the second, more than the first (10,722 m) (Bradley et al., 2013). This was cited as potentially due to the lower tactical and technical abilities in the lower tiers resulting in increased physical demands. Female tier 1 players have been shown to cover lower distances than their male equivalents (10,205 m), this could again be assumed to be due to the differences in tactics between the male and female games (Mara et al., 2017). It is clear that physical outputs during a game are dictated by its context and the tactical demands, and it is, therefore, crucial that practitioners understand how these specific factors relate to their own team when guiding physical preparation.

Whilst quantifying the total volume of work completed is important, it is accepted that running completed at higher velocities may prove even more significant for performance and injury prevention (Faude et al., 2012; Schache et al., 2012; Schuermans et al., 2017). Thus, in addition to total distance, studies have aimed to establish the amount high-intensity running completed during matches. The majority of studies observing high-intensity running have been conducted using video analysis and velocity thresholds of >5.5 $m.s^{-1}$. In the EPL, high-intensity running volumes of 1,151 m across all positions have been observed, and 929 m reported elsewhere (Bradley et al., 2013; Barnes et al., 2014). As with total distance, greater amounts of high-intensity running were observed in the second (1,111 m) and the third (1,242 m) tiers of English football. Alongside this, positional difference also exists. Those playing in lateral positions have been observed as covering greater amounts of high-intensity distance than their centrally located counterparts

(Ingebrigtsen et al., 2015). Again, further suggesting a tactical-technical context to distances observed in match play that must be understood to truly prepare players for these demands (Bradley and Ade, 2018).

2.1.1.2. Training Demands

In addition to the match derived metrics, researchers have aimed to quantify the demands of a training week. Through training practices, practitioners seek to prepare players for the match demands. During a typical training week, Premier League players have been observed completing between 3,498-5,181 m of total distance per training day (Gaudino et al., 2013; Malone et al., 2015). These distances were usually recorded from training weeks consisting of 4 sessions between the previous match and the next, suggesting a total weekly running distance of between 13,992 m and 20,724 m for a typical week. Total distance has been shown to vary over the course of a season with a reported difference of 1,304 m total distance per training session between the first and final phases of a season. It is suggested that this periodised approach is due to a focus still being placed on conditioning in the early stages of the season, whereas freshness is a focus towards the end, resulting in a lower volume of training (Malone et al., 2015).

High-intensity running volumes have been reported between 88-118 m per training session for Premier League teams. If a four-day training week is assumed this would suggest volumes of 352-472 m. It is evident that a standard in-season training session does not adequately reflect the demands of match play. Players may complete total running volumes of up to 45% (5,181/11,612 m) of a match during an average training session but only 13% (118/929 m) of the high-intensity running. It is unclear whether this is by the design of the coach or sports science staff or merely a result of training practices. Nevertheless, players appear to be completing larger volumes of work relative to intensity. This is further emphasised when the starting status of the squad of players is considered. Players categorised as fringe or non-starters were shown to complete significantly lower high-intensity running and sprinting volumes than starting players, but similar total distances (Anderson et al., 2016). It is suggested that this is due to the content of training not adequately reflecting match play intensities, thus resulting in the lower volumes. However, the fringe and the non-starting group did complete additional work during the training week to make up for the volume missed from a lack of match minutes. But this does create questions around the training practices of football teams and their suitability for preparing players for match day. If sprinting is as crucial to match outcome as believed, this is clearly a key area for practitioners to understand in more depth (Faude et al., 2012).

2.1.2 Sprinting in Football

2.1.2.1 Introduction to Sprinting in Football

Though sprinting typically constitutes a small proportion of total distance covered, this distance covered at high velocities is accepted as being key to performance outcomes and injury risk. Linear sprinting has been shown to be the key action during the most decisive moment in football, goal-scoring (Faude et al., 2012). This was found to be true for both the scoring and assisting player on the attacking team. The scorer is typically sprinting without the ball and the assisting player typically with the ball. In addition, sprinting is accepted as the most common mechanism involved during the most frequent non-contact injury in football, hamstring strains (Schache et al., 2012; Schuermans et al., 2017). This coupled with the knowledge that the amount of sprinting in football is increasing season on season are significant to the future direction of practice in the physical preparation of footballers.

Over the course of seven recent seasons, 2006-07 to 2012-13, the amount of sprint distance completed in the EPL was shown to increase year on year with a total increase, averaged across positions, of 35-50% (Bradley et al., 2013; Bush et al., 2015). Moderate increases have been observed across all positions with wide players being seen to increase more than central positions and defensive positions more than attackers (Bush et al., 2015). This was noted as being likely due to tactical changes over the time period, with wide defenders being required to become involved in attacking situation as well as their defensive duties. The increase in physical capacity of players can be attributed to improved physical training, or merely the signing of more athletically 'gifted' players. Regardless of the cause, it is clear that footballers are required to perform more and more running at greater velocities than previously, and training practices must reflect this.

Distance completed whilst sprinting is typically reported in the literature as velocities greater than 7 $m.s^{-1}$ (Bradley et al., 2013; Barnes et al., 2014; Ingebrigtsen et al., 2015; Sweeting et al., 2017). Reported distances are thus, typically, distance travelled above 7 $m.s^{-1}$ for longer than 0.5 s. Average sprint distances in the Premier

League have been reported between 248-350 m; between 2.3 and 3.2 % of total distance covered. In Europa League matches, the second tier of European club competition, distances of 237 m (2.1%) were reported, lower than that seen in the Premier League (Andrzejewski et al., 2015). Again, it would be reasonable to assume that as this competition consists of elite European clubs, there is a relationship of lower distances with greater standards of competition. This trend is further evident when comparing sprint distances in the second and third tiers of English football, exhibiting 308 m and 360 m respectively. It is possible to elucidate that higher standard players are either more selective with their sprint efforts or the tactical nature of higher-level match play doesn't allow for higher amounts of sprinting. It is unclear whether those playing in higher level matches compete at levels significantly within their capacities compared to lower-level competitors.

2.1.2.2 The Sprinting Demands of Football

The key determinant of a sprint effort is achieving high velocities over short distances (Moir et al., 2018). During matches, footballers have been observed reaching maximum velocities of 8.86 $m.s^{-1}$ - 9.55 $m.s^{-1}$ across all positions (Barnes et al., 2014; Andrzejewski et al., 2015). Of this, forwards were seen to attain the greatest velocities and central midfielders the lowest. Highly trained youth players have been shown to achieve running speeds 10-15% lower than their absolute maximum sprinting velocity during matches, and that faster players attain greater speeds during matches (Mendez-Villanueva et al., 2011). If this is extrapolated out to professional players, it would suggest absolute maximum velocity values of 9.84 $m.s^{-1}$ - 11.24 $m.s^{-1}$. This would compare quite high against elite sprinters where a maximum velocity during the 100m World Championship finals was observed of 11.8 m.s-1 (Krzysztof and Mero, 2013), therefore it would be reasonable to assume that during matches professional players sprint at greater percentages of their maximum velocity than youths. Elite rugby players have been recorded achieving speeds of 8.98 $m.s^{-1}$ across all positions, with wingers, the most speed dominant positions, attaining 10 $m.s^{-1}$ (Barr et al., 2013). Consequently, due to the demands of team sports, it could be expected that professional footballers would achieve maximum velocities of between 9.5 $m.s^{-1}$ - 10 $m.s^{-1}$ averaged for all positions in a sprinting test. Such information is crucial to in the preparation of players able to compete in professional footballers and has implications for scouting and physical preparation alike.

Though total sprint distance covered during a match allows practitioners to begin to understand the demands of football match play, it fails to fully describe the context of the sprints performed and how they relate to technical or tactical elements. Without this added level of detail and context any training programmes designed to prepare players would be inadequate. In the Premier League, the number of sprint efforts performed during a match has been shown to be increasing from 31-57, however, the distance per effort has been shown to be decreasing from 6.9 m - 5.9 m (Barnes et al., 2014). Though distance per effort from the Europa League has been shown to be longer, an average of 21.1 m (Andrzejewski et al., 2015). A trend is evident for a greater proportion of efforts to be categorised as ‘Explosive’ (34-47%) rather than ‘Lead-in’, suggesting that sprints are being performed with more rapid increases in velocity (Di Salvo et al., 2010; Barnes et al., 2014; Bush et al., 2015). Though it is worth noting that the majority of sprints are still classified by a more gradual acceleration, there is a clear trend for sprinting in football becoming more frequent, shorter and more explosive in nature. This could potentially suggest tactical evolutions such as greater amounts of pressing.

Whilst general data is important, as discussed previously, large differences exist between positions and sprinting demands in football. Therefore, individualised preparation is crucial in football and demands must be thought of accordingly. During elite European competition (Europa League), forwards were seen to sprint the furthest during a match (345 m), with central midfielders (CM) the least (165 m) (Andrzejewski et al., 2015). External midfielders (314 m) were second, followed by external defenders (265 m) and finally CB (186 m). A prior study observing elite European competition (UEFA Cup and Champions League) saw similar positional differences with the exception of external midfielders having sprinted the most rather than forwards (Di Salvo et al., 2010). However, absolute distances were slightly lower in this study, possibly due to its age. More detail was provided though regarding the nature of the sprints completed, it was found that between 22 and 24% of sprints completed were Explosive in nature rather than more gradually accelerated Lead-in sprints. WM and attackers, those who also covered the most sprint distance overall, had the greatest proportion of their sprints in the Lead-in category (78%). Whereas CD and CM completed the most explosive sprints (24%). Once more showing the importance of tactical context to the individual demands of football and suggesting potential implication for physical preparation.

It is clear that optimal training practices should exhibit position-specific differences to ensure complete specificity when seeking sprinting enhancement adaptations. Although differences could be deemed small, over the course of a career at the elite level, with the known significance that sprinting has on the match outcome it appears imperative that players are trained differently for the specific match demands. CB and CM, for example, may require a greater emphasis on pure acceleration abilities from little to no velocity, as opposed to their WM and CF counterparts who could potentially benefit more from work aimed at improving maximum velocity, upright running ability due to the greater proportion of their sprints being Lead-in in nature. It is important however to note the one-dimensional nature of much of the literature currently detailed sprinting in football. Contextualising of this knowledge appears key to increasing the further understanding of the demands of football. Without this, demands may be misrepresented.

2.2 CONTEXTUAL SPRINTING IN FOOTBALL

With the increased demands of match play in recent years and a necessity for efficiency within training practices, conditioning programmes that are as integrated into regular soccer training as possible are crucial (Bush et al., 2015). Due to their sport-specific nature, methods such as small-sided games, combination drills that replicate the game and position-specific demands, are popular in elite environments (Ade et al., 2016). These consequently have been suggested to create greater coach acceptance and increased athlete enjoyment. (Hill-Haas et al., 2011). To be most effective though requires these methods to be specific to the demands of the game, to allow for specific overload and subsequent adaptation to occur (Brearley and Bishop, 2019). Thus, an understanding of match play beyond standard distance metrics is essential (Bradley and Ade, 2018).

Although using measurement systems such as time-motion and GPS allows us to gain a good understanding of the demands of football, it is not without its limitations, and has recently been described as one-dimensional and potentially too reductionist (Bradley and Ade, 2018). This ‘one-dimensional approach’ has been noted as lacking ecological validity due to the omission of information regarding the tactical constraints to these physical outputs. Movements that do not require significant changes in location, such as jumping and duelling, alongside football specific actions such as heading and blocking are often omitted, particularly the intricacies of how these physical actions are performed during the game (Bloomfield et al., 2007; Bradley and Ade, 2018).

Progressing to a more integrated model, where distance metrics are combined with technical and tactical information, would, therefore, progress the current understanding of match demands. From an energy expenditure perspective, it is well known that these football-specific actions such as dribbling, accelerating and decelerating, and travelling in a lateral or backwards direction possess different physiological requirements than travelling at a constant velocity linearly (Williford et al., 1998). Alongside the difficulties with reporting the bioenergetics demands of these specific actions, a lack of insightful data regarding the contextual actions involved in sprinting in football creates issues when designing athletic development programmes aimed at enhancing on the field sprinting ability - specificity being a fundamental concept of programme design (Jeffreys, 2011; Brearley and Bishop, 2019).

As noted, simply relying on locomotor distance can be argued as being reductionist and one-dimensional in nature due to the lack of tactical and technical context alongside this rudimentary information. During a match, a player's physical outputs will be restricted, or dictated, by their playing position. They are only able to exert themselves as a reflection of the technical, tactical and physical factors concerning their positional relation to the match (Ade et al., 2016; Bradley and Ade, 2018). This has led some to question even if highly relative speed thresholds attained outside of a match and used during to report match demands are even valid. Potentially 'in-game' running speeds could be used for these thresholds, thus enhancing the validity of outputs relative to positional demands as opposed to arbitrary physiological markers; particularly pertinent due to the submaximal nature of football (Schimpchen et al., 2016; Bradley and Ade, 2018).

Previous work has attempted to use an integrated approach to provide descriptive data of the actions completed in and out of possession (Ade et al., 2016). Here, CM, Full Backs (FB) and Centre Forwards (CF) were seen to be completing similar amounts of high-intensity running. Without the additional dimension of the nature of these efforts from a technical and tactical perspective, a practitioner could easily conclude incorrectly that the demands of these positions are very similar. However, we know that this running is completed in very different contexts. For example, the authors showed the majority of a defensive players out of possession distance is completed during covering runs. This new integrated model is therefore much more useful to practitioners aiming to understand the performance of a player within the tactical structure of the team (Ade et al., 2016; Bradley and Ade, 2018).

Large differences exist positionally in football. As noted, these differences can be mainly attributed to the tactical nature of each position and how they relate to their team's formation and strategy (Ade et al., 2016). It is therefore these large differences in tactical requirements that ultimately dictates which movement patterns are employed by each individual player. As discussed previously, sprint distances vary widely between different positions. However, not only do distance metrics show high variability, other metrics such as movement patterns, location on the pitch, technical skills, tactical actions and combination play all exhibit differences as a result of position, formation and tactical strategy (Ade et al., 2016).

The formation that a player is playing within has the potential to dictate the physical outputs during a match. For example, a team of Brazilian footballers exhibited greater distances and at higher speeds across all positions when playing a 4-3-3 formation as opposed to a 4-4-2 (Aquino et al., 2017). A potential explanation for this was the requirement for midfielders to assist more in defence and attack. Also, during a 4-3-3 formation, the forwards are typically required to assist in defending the wide positions when out of possession, and Wide Defenders to assist more in the development of attacks. Reporting typically average locomotor metrics across leagues, for example, would potentially omit this crucial detail.

An earlier study aimed to observe any differences in physical outputs between 4-4-2, 4-3-3 and 5-3-1 formations, whilst against an oppositions 4-4-2 formation (Bradley et al., 2011). Though no broad significant differences were observed, those playing in the 4-5-1 formation ran less high-intensity distance when their team was in possession, but greater when out of possession. Attackers were also singled out for the greater high-intensity running completed when in a 4-4-3 formation. Again, this is likely due to the additional defensive requirements when out of possession.

Though it appears that differences do occur as a result of the formation employed, it is difficult at this time to make clear conclusions due to factors such as the formation employed by the opposition and a lack of intervention studies. Outputs are also a result of a particular team's strategy and not necessarily always consistent across different formations. However, it is clear that locomotor distances will vary significantly depending upon the team's, and the opposition's, formation. Thus, the game itself should always be the reference point for any physical development programme (Jeffreys et al., 2018).

When looking to contextualise the readily available locomotor distances, two key areas appear (Ade et al., 2016; Bradley and Ade, 2018). Firstly, as discussed, how the distance occurs, and also why. Therefore, when seeking to contextualise sprinting in football, the movements associated with the sprint effort and the tactical-context within which the sprints occur would aid in better describing sprinting during a football match.

2.2.1 Movement

As noted, standard load monitoring practices such as GPS analysis, lack intricate information regarding the types of movements employed whilst achieving the distances measured. Less than half of ‘purposeful movement’ (PM) in football has been classed as occurring in a forward direction, with a range of directions, types and intensities being seen (Bloomfield et al., 2007). These movements are likely dictated by the tactical constraints of a match and therefore large positional differences exist. For example, though defenders completed less amount of time sprinting and running, they completed the highest amount of skipping and shuffling movements. Thus, standard GPS locomotor analysis may potentially underestimate the demands placed upon defensive players by merely focusing on predominantly distance metrics (Bloomfield et al., 2007). These skipping and shuffling movements are likely a response to positional demands, whereby a midfielder or attacker may be required to apply intense pressure to an opponent, potentially through sprinting, whereas a defender may likely hold their position and tactical shape more and react off the oppositions' movements to maintain their structure within the defensive unit.

Alongside the basic differences in locomotor movements, defenders were also observed performing the largest amount of backwards and lateral movements, whilst midfielders and strikers used forward diagonal and arc movements more (Bloomfield et al., 2007). This is an example of the tactical constraints of match play and the effect this has on different positions above and beyond basic distance metrics. Typically, play happens in front of defenders, allowing a pass or an opponent between yourself and the goal is accepted as potentially critical. Therefore, lateral and backwards movements would allow the defender to maintain their position between the ball and their own goal. Conversely, midfielders and attackers aim to exploit space and evade defenders to create scoring opportunities. Thus, demanding more forwards actions, with diagonal and arc running allowing them to create this space, manipulate their velocity, and observe the buildup in play.

Due to this complex nature of movement within sports such as football, it is useful to identify the discreet movements that comprise these complex patterns. This can be achieved through the use of a Movement Classification (Jeffreys et al., 2018). Only then can we begin to quantify and better understand the complex nature of football actions. The most complete of these employs a Target Classification, where broad Target functions are distilled down to Target Movements. (Jeffreys et al.,

2018) (Table 2.1). The aim being to account for all potential movement patterns associated with the sport. The movement patterns within the target classification are then highly useful as they describe the movements used within a match, from which training can be based upon. This can become even more useful when the most commonly utilised are understood.

Table 2.1 An example movement classification system (Jeffreys et al., 2018).

Target Function	Category	Target Movement
Actualisation	Acceleration	*Static*
		Rolling
	Max Speed	*Linear*
		Curved
Initiation	Starting	*Linear*
		Lateral
		Rear
	Change of Direction	*Front/Back*
		Lateral
Transition	Static	*Athletic Position*
	In Motion	*In Place*
		Linear
		Lateral
		Rearwards
		Deceleration

Previous literature has shown that during a match a player can complete up to 700 changes of direction. 300 of these will be within 90° of forward. Around 45 will be between 90° and 180°. Only 3 between 180-270°. And 1, 270-360° degrees (Bloomfield et al., 2007). Ideally, players will aim to maintain the play in front of them and thus seek to avoid the necessity for extreme changes of direction by manipulating the direction they are facing. This likely explains the greater amounts of changes of direction within smaller angles.

Another study sought to describe the contextual nature of high-intensity movement. It was observed, for example, when their team is in possession of the ball, Centre Backs preceded 6.7% of their high-intensity movement with a turn of between 90-180°. However, whilst out of possession, this movement accounts for 21.7% of efforts. This difference seems to be as a response to the tactical demands of the position, where out of possession Centre Backs will be reacting strongly to the oppositions attacking players, likely leading to turns which require them to drop 'deeper' towards their own goal to maintain their position between the ball the goal. This detail and positional differences are key when looking to develop sprinting ability in footballers.

Another consideration is the direction of efforts. Whilst in possession, between 49.6% and 68.6% of efforts across positions were recorded as being nonlinear in nature (Ade et al., 2016). In the study, these were described as either Arc, where a player is moving in a semi-circular direction, or Swerve, where a player changes direction at speed without rotating the body. Potential issues may exist with measuring distances completed in curvilinear movements due to the necessary body lean and location of the GPS unit between the scapulae (Townshend et al., 2008). However, it seems likely that a large portion of high-intensity distance in football is not typically linear.

Differences exist biomechanically when running a curvilinear direction rather than strictly linear. For example, when looking at bend sprinting, clear differences were observed such as a reduction in velocity due to an overall reduced force production of the inside leg, decreased step length and frequencies, and crucially, an increased demand of the inside leg to generate inward impulse and turning (Churchill et al., 2016). Such differences can have major impacts on the physical preparation of football players, bioenergetically as well as biomechanically. This could potentially have huge ramifications for injury prevention and performance enhancement programmes.

As noted previously, recently Lead-in sprints (more gradual, rolling acceleration) have increased by 39-59%, whereas those deemed Explosive have by between 125-171%. Though most sprints in football are still Lead-in in nature (across all positions, 51-56%) (Bush et al., 2015). The differences in the nature of the acceleration phase during sprinting is as a result of the task demand during the match. Styles of play more focused on counter-attacking, for example, would demand a greater number of explosive acceleration sprints as players attempt to break fast during transitions into attack, and vice versa in the defensive team.

Without there being a full all-encompassing analysis within the literature on the specific nature of sprinting in football, it is reasonable to assume that rarely do footballers sprint linearly in a 'track and field style' and that there will be significant variation in the type of sprints completed dependent on position. Thus, it would be highly useful for practitioners to have data on general differences in the type of sprints completed in football, and access to a system of being able to classify the different types of sprints completed by their own athletes.

2.2.2 Tactical

Within the context of the tactical and strategic makeup of the team, individual players are required to perform movement to satisfy football-specific tasks in response to constantly changing situations from events, teammates, opponents, and objects. In response to these demands, the theory of Ecological Dynamics is often employed (Davids et al., 2013; Immonen et al., 2017; Seifert and Davids, 2017; Myszka, 2018). This combination of ecological psychology and dynamical systems theory outlines the importance of perception-action (P-A) coupling, whereby constant exchange of information occurs between the environment and the selected movement responses to ultimately elicit task completion (Seifert and Davids, 2017; Myszka, 2018). Thus, it is crucial that when seeking enhanced performance, an understanding of the representative task environment is present to elicit specificity and consequent transfer (Bradley and Ade, 2018; Myszka, 2018).

Ecological validity seeks to ensure transfer to match performance occurs. The concept of affordances underpins this relationship between decision making and the ultimate action performed (Fajen et al., 2008; Esteves et al., 2011; Headrick et al., 2012; Davids et al., 2013; Myszka, 2018). Affordances are defined as potential opportunities for action and are ‘constrained’ by the nature of the task itself, the individual’s own characteristics (e.g. physical capacity), and the environment within which they are performing (Fajen et al., 2008; Headrick et al., 2012; Myszka, 2018). This interplay is ultimately what determines the problems faced by the athlete and thus, the amount and type of sprinting occurring during a match.

It has been proposed that enhancing movement ability is best achieved by exploration through on-going problem solving, where the athlete can develop motor-dexterity by developing solutions to the presented tasks (Myszka, 2018). This theory is commonly described as Motor Degeneracy, whereby more skilled performers can achieve the same outcome through differing movement coordination strategies (Mason, 2015; Seifert et al., 2016; Seifert and Davids, 2017; Myszka, 2018). Thus, the ultimate aim of movement training should be the ability of the athlete to find a movement solution to any situation in any condition. A prominent method of achieving such an outcome is through 'repetition without repetition' (Myszka, 2018). Here a 'constraints-led approach' is utilised by the manipulation of the task, environment and individual to facilitate the development of movement solutions. Therefore, to enhance sprinting during match play, it is key to understand the task-specific nature (representative learning design) of when these efforts occur (Davids et al., 2013). An absence of this knowledge can lead to ineffective training practices that lack the fundamental perception-action coupling that would lead to ultimate transfer to match play (Warren, 2006; Pinder et al., 2011; Davids et al., 2013). This could lead to the athlete potentially missing relevant perceptual information necessary to solve movement problems, making inaccurate or mistimed decisions for action, and a lack of ability to adjust their biomechanical movement to satisfy the task presented (Myszka, 2018).

Two key areas have been observed previously in an attempt to contextualise distance metrics in football (Ade et al., 2016; Bradley and Ade, 2018) through the framing of efforts within the Phase of Play and Tactical Outcome. These cover the moment of the game that the effort occurs in and also the tactical reasoning behind why the effort may have occurred. Thus, provided a detailed description of the effort within the context of the game.

2.2.2.1 Phases of Play

To fully understand the movement demands of match play it is important to gain an understanding of the game itself, as this ultimately leads to the football-specific tasks that must be solved by each individual through the aforementioned constraints. A game can be categorised as consisting of four key phases: Attacking Organisation; Attacking Transition; Defensive Organisation; and Defensive Transition (Delgado-Bordonau and Mendez-Villanueva, 2012; Jeffreys et al., 2018). Within each of these phases, players are expected to complete different tasks relating to the aims of each phase.

During Attacking Organisation, players are aiming to disorganise the oppositions defensive organisation through movement and manipulation of the ball to create scoring opportunities. When Transitioning to Attacking situations, a team is looking to take advantage of potential defensive disorganisation of the opposition to create scoring oppositions and are typically characterised by the rapid movement of the ball into attacking positions. In Defensive Organisation, the aim is to maintain a cohesive defensive unit and thus avoid potential scoring opportunities of the opposition and win back possession of the ball. Finally, during Defensive Transition, a team is aiming to either win the ball back rapidly to prevent attacks or regain Defensive Organisation as fast as possible. Each phase possesses its unique task, and consequently, movement demands (Delgado-Bordonau and Mendez-Villanueva, 2012; Jeffreys et al., 2018).

2.2.2.2 Tactical Outcome

Within each Phase of Play exists key tactical tasks relative to each position within the formation (Bloomfield et al., 2007; Ade et al., 2016; Bradley and Ade, 2018; Jeffreys et al., 2018). Attempts have been made previously to develop methods for classifying these tactical contexts within match play. The first significant attempt was the development of the Bloomfield Movement Classification, where PM and technical demands were quantified (Bloomfield et al., 2007). ‘On the Ball’ activities were quantified such as the type of pass attempted, with which foot, and similarly for the receiving of passes. Conclusions were made such as Strikers completed the fewest number of long passes.

However, more recently, a more holistic approach has been attempted. Looking at High Intensity running (>5.83 $m.s^{-1}$), efforts were classified with 5 descriptive categories: Movement Pattern; Pitch Location; Technical Skill; Tactical Outcome; and Combination Play (Ade et al., 2016). Therefore, providing a more integrated description of the demands of soccer match play (Ade et al., 2016). As noted, each position on the pitch has its own unique tactical purpose within the wider team strategy, for example, a Defenders role being to predominantly prevent the opposition from scoring. Therefore, each position demands the player perform more of certain tactical focused tasks than others. It is clear that different positions will dictate different movement outputs during a match, even beyond typical distance metrics. For example, when out of possession, attacking positions such as CF and WM complete the majority (81.5% & 54.0%) of their High Intensity running during tactical actions where they attempt to Close Down an opposition player. Whereas more defensive positions (CB, FB, CM) complete their majority (74.1%, 69.7% & 72.9%) in Covering runs, where the aim is to cover space or an opposition player (Ade et al., 2016). Such distinct differences in running when out of possession emphasise the specific nature of each position during a football match. Those in attacking positions are typically required to press an opposition player, whereas defensive focused positions would more often seek to maintain the integrity of the team's formation rather than frequently running out of position.

Similar differences exist whilst in possession. Where those in wide positions, FB and WM, complete the majority of the high-intensity efforts (64.0% & 38.8%) by Running the Channel, defined as running down the external areas of the pitch. The centrally located positions naturally complete the majority of their runs through the middle of the pitch towards the opposition's goal. CB predominantly Push Up the Pitch (38.1%), whereby they move up the pitch to support the play or play an opposition player offside, from the defensive and middle third of the pitch. Similarly, CM and CF mainly complete runs defined as Drive through the Middle (45.8% & 58.7%), involving running with or without the ball through the middle of the pitch (Ade et al., 2016).

Conversely to this, CB, CM and CF very rarely complete runs categorised as Overlap ('On the external channel, the player runs from behind to in front of, or parallel to the player on the ball') due to the nature of their tactical positions dictating their location on the field. Additionally, though very common for CB, all over positions very seldom complete runs due to a Ball Down the Side or Ball over the Top (Ade et al., 2016). It is thus clear that different positions required different tasks to be completed and each will present its own unique perceptual and movement demands to the player which would be absent if a GPS system was solely utilised.

An example of this would be, immediately prior to the majority of their high-intensity efforts, WMs often receive passes from CMs, or pass to a CF, and immediately following the effort receive passes from CMs or make passes to CMs and CFs. The majority of these also consist of a 'trick' pre effort and post effort a 'cross' (Ade et al., 2016). This additional level of detail beyond those such as distance and frequency, provide the necessary data to begin to understand the complex interplay of a football match and how drill design can be made more specific to the environment within which movement is to be expressed.

2.3 METHODS OF SCIENTIFIC DISSEMINATION

2.3.1 Peer-Review

Peer-review publication remains the ‘gold standard’ method of scientific dissemination. Oher methods are typically employed to support the reach of published articles rather than replace them. Peer-review publication was developed to be the ultimate method of ensuring scientific quality control through the assessment of manuscripts by independent qualified reviewers (peers) (Ferreira et al., 2016). However, it is not without its potential flaws such as voluntary review, unstandardized review criteria and a decentralised process. These have raised questions on the process’s efficiency, efficacy and quality control (Hochberg, 2010; Lortie, 2012; Ferreira et al., 2016). Alongside this, the process to publication can take multiple years. Whilst this is necessary to ensure the robustness of published articles, it can create a ‘lag’ period between the completion of research and its eventual publication. More contemporary methods allow for consistent messages from researchers during a studies completion, and a possibility to present findings much earlier than a typically slower peer-review process (Yuan et al., 2010). It could, therefore, be of potential benefit to the scientific community to begin to discuss research before, during and immediately after publication with other researchers and interested parties. Contemporary methods thus allow a researcher to begin this process and build anticipation of the research within the area – ultimately, hopefully, improving the reception of the finalised, published work.

2.3.2 Contemporary Methods

Over recent years there has been an increase in the use of these more contemporary methods for scientific dissemination (Letierce et al., 2010; Robinson-Garcia et al., 2017; Hotez, 2018). Though peer-review publication continues to be the leading source of scientific research worldwide, scientists are looking at these modern methods as a means of drawing additional attention to their publications, sharing insights throughout the development of the research, reaching a wider audience, and building their scientific brand (National Institute for Health Research, n.d.; Ward et al., 2009; Letierce et al., 2010; Robinson-Garcia et al., 2017; Hotez, 2018). It is key to scientific progression that research results reach as wide an audience as possible, both within and outside of the scientific community (National Institute for Health Research, n.d.).

2.3.2.1 Social Media

In addition to traditional peer-review, methods being utilised consist of those such as social media, podcasts and presentations. Each has its strengths and weaknesses and are employed accordingly. Of these more contemporary methods, social media, specifically Twitter, is likely the most widely used and has been noted as a 'great source for disseminating and discovering information' (Letierce et al., 2010; Robinson-Garcia et al., 2017). 68% of academics were noted as 'always' or 'usually' publishing their academic work online, with 92% possessing a Twitter account which was quoted as the participants favoured service (Letierce et al., 2010). The main motivations for academics publishing online were to share knowledge and communicate their research projects (Letierce et al., 2010). Twitter has been seen to be promising in its ability to increase the visibility of scientific work to a wider audience, and this has been suggested as a key to creating a ‘scientist brand’ within and outside of one’s specific area (Hotez, 2018). However, caution has been suggested when using currently available metrics as a comparison to traditional citation measures due to issues such as duplicate tweets and ‘bots’ (Robinson-Garcia et al., 2017). Both factors can artificially inflate the reach of a post. Bots (computer-generated Tweets and accounts), for example, can inflate data by around 18% (Robinson-Garcia et al., 2017). The platform also limits the character count of ‘tweets’ to 280. Whilst links to longer amounts of text can be used, this restriction could potentially lead to only a headline point being disseminated, creating a possibility of misrepresentation of findings due to a lack of background information.

2.3.2.2 Podcast

Podcasts are another relatively contemporary method often utilised by scientists and has been noted for its ability to engage its audience (MacKenzie, 2019). Through a more ‘relaxed and reflective’ style, podcasting allows the listener to hear the ‘true voice’ of the protagonist, rather than the typically ‘cold’ scientific writing of peer-review publication (Merzagora, 2004; MacKenzie, 2019). This has been shown to lead to improved scientific uptake (Johnson et al., 2012; Prakash et al., 2017; Thoma et al., 2018). Additionally, many podcasts have been noted as strongly utilising Social Media and websites as a means of encouraging a two-way dialogue with their audience (MacKenzie, 2019). Such practice is believed to support a personal connection between listener and producer typically unseen in more traditional dissemination methods (Markman and Sawyer, 2014). In addition to this enhanced uptake, podcasting is typified by its convenience. Podcasts are usually free, opt-in series available on most app-enabled devices such as smartphones (MacKenzie, 2019). Though audience metrics are noted as under-developed, surveys have shown population proportions of ~25% utilises the medium, on average listening to over 6 hours of material per week (Edison Research, 2018). Whilst figures are difficult to ascertain, around 1,000 science-based podcasts were recently observed (MacKenzie, 2019).

2.3.2.3 Presentation

Scientific Presentations offer many of the same advantages as Podcasts. Whereby the researchers are able to discuss their findings in a style they believe to suit the intended audience. The main difference between the two mediums being that unless the researchers produce their own Podcast, outputs will typically consist of an interview format. Here the producers interview the invited guest (the researcher) and likely dictate the agenda of the show much more so than in a Presentation. Whilst the researcher is again typically invited to present as a part of a larger conference, the material presented is rarely directed by the organisers. Beyond these strengths of the methods, it important to note the lack of peer-review quality control inherent with podcasting. Thus, as discussed, scientific rigour cannot be expected with these methods. For this reason, rarely are they seen as a replacement of traditional peer-review, rather as adjuncts.

2.4 SUMMARY

Thus, as noted, two distinct areas appear to exist to further the understanding of sprinting in football. Broadly, these are the movements associated with sprinting, which further details 'How' sprints are completed, beyond standard distance metrics. And also, the tactical context within which these efforts occur, suggesting 'Why' the sprint may have been completed. Increased knowledge in these areas would progress the literature beyond the current understanding of largely distance data and provide the practitioner with a more contextualised understanding of the demands of match play.

It is clear that movement in football is highly variable (Bloomfield et al., 2007). However, many currently widely available load-monitoring systems may likely misrepresent this variability of movement. Due to its highly physically demanding nature and its potential impact upon match outcome, it is important to understand further the movements associated with sprinting in football (Faude et al., 2012). Currently, no automated process exists for such an analysis. The most effective method currently available is a qualitatively utilised Movement Classification System (Jeffreys et al., 2018). Only by employing such a system, can we begin to understand the complex nature of football sprinting actions. This increased knowledge will then provide a more in-depth understanding of how sprinting in a football match occurs and the consequent demands of match play in general. With this, more effective training programmes can be designed to prevent injuries and enhance performance.

Whilst an enhanced understanding of the specific movements seen during sprinting would provide greater insight into the physical demands of a match, movement is not completed in isolation in football. Thus, it would be beneficial to seek to understand greater why sprinting may occur during a match. This insight would allow for training to be highly specific to the contextual demands of match play and, when combined with the movement demands, lead to potentially more effective training of perception and action concurrently. As discussed, attempts have been made to develop methods for classifying the tactical context of efforts within match play. Looking at High Intensity running (>5.83ms^{-1}), efforts were classified with 5 descriptive categories: Movement Pattern, Pitch Location, Technical Skill, Tactical Outcome and Combination Play. Therefore, providing a more integrated description of the demands of soccer match play (Ade et al., 2016). Large variations were seen between and within positions. Whilst High Intensity running efforts are a useful starting point for analysis, with the game evolving to be ever faster and the extreme physical demands of sprinting, it is the author's opinion that a classification of sprinting would provide crucial information around key, potentially match-defining moments. Thus, beginning to describe why sprinting may occur during a match. Such data would allow practitioners to gain a greater understanding of how to best prepare their athletes for better performance and to aid in the prevention of injuries. Drills that represent these specific tasks can be designed to provide highly ecologically valid training.

Additionally, it appears that many researchers are employing more contemporary methods of scientific dissemination as a means of supplementing peer-review publication. It is believed that this may aid in the sharing of information throughout a studies completion, reaching a wider audience and developing a professional brand in the subject area. This could lead to a greater reach of eventual publication and smoother, more successful progression. However, it is critical to understand how these methods compare to one another and the means by which they may be employed to achieve these outcomes. Currently, little knowledge exists within the area.

2.5 METHODS

As discussed, the overall aim of the current thesis is to describe sprinting in Premier League football in detail. To achieve this aim, objectives were outlined to quantify the Movements and Tactical-Contexts associated with sprinting during football match play. Additional to this, and in line with the broader aims of a Professional Doctorate thesis (Fig 1.1), a final objective was developed to seek to ascertain the effectiveness of contemporary methods of scientific dissemination.

To achieve the outlined aims of describing the Movements and Tactical-Contexts associated with sprinting in Premier League football, following the Review of the Literature, it was decided that novel processes were required. Thus, the focus of Study 1 is to develop two systems capable of reliably quantifying these actions. To achieve this, a Methodological study was completed to develop the required methodologies. The study was completed following a previously outlined 5-stage model for the development of observation classification systems (Brewer and Jones, 2002; Roberts and Fairclough, 2012; Murtagh, 2016). This allowed for the finalised, reliable systems to be employed further within the thesis to satisfy the remaining objectives.

Studies 2 and 3 thus consisted of the application of the developed systems from Study 1. With the thesis seeking to describe the intricacies of sprinting in football, it was decided the most effective method for this would be to employ actual match footage of Premier League football. Therefore, the two studies each consisted of a classification of sprint efforts completed by the analysed team during match play. This methodological approach allowed for enhanced practicality of the eventual outcomes. Similarly, the produced could successfully enhance the working practice within the club.

Finally, Study 4, as described, sought to compare and describe contemporary methods of scientific dissemination within a broad model. The methods employed in this study sought to enhance both the Research Focus and Professional Focus of the thesis. Through the application of a study of this nature, it was believed that the author would develop themselves professionally as both a researcher and a practitioner, develop a personal brand with the research area, and ensure a large reach and uptake to the final conclusions of the thesis. To achieve this a methodology employing a qualitative approach was designed. Whilst this differed greatly from the previous studies, this was seen as the most effective means of quantifying the effectiveness of the strategy employed. This involved the designing, processing and analysing of qualitative questionnaires to practitioners; this was also supplemented by quantitative data where possible. The application of such methods was a departure from the typical means employed previously by the researchers, however, as noted, was decided as the most effective methodological approach the achieve the objectives of the study and thus the thesis broadly.

The methodological approach, it is believed, will ensure the maximal impact to practice, particularly to the club analysed. Firstly, by the development of the two reliable and accurate classification systems that can be applied by practitioners in other clubs and within future research. In addition to this, the results produced in Studies 2 and 3, due to their highly practical nature as a result of being attained directly from match footage, should support future programming consideration for practitioners. Finally, the investigation into contemporary methods of scientific dissemination will improve future understanding within the area through discussions with active practitioners and researchers. Similarly, the design of the study should lead to enhanced uptake of the current thesis' results.

CHAPTER 3

THE DEVELOPMENT OF A SPECIFIC MOVEMENT AND A TACTICAL CONTEXT CLASSIFICATION SYSTEM FOR SPRINTING IN FOOTBALL.

3.0 PERSONAL REFLECTIONS

As discussed within the Introduction, the thesis consists of a Scientific Research Focus and a Professional Development Focus. Outside of the traditional scientific structure of the thesis will exist periodic reflections. These will consist of my professional progression through the programme, categorised as Research Skills and Professional Skills. The aim of these being to chart the advancement towards the professional aims.

3.0.1 Research Skills

Through my study at Levels 6 and 7, my major research projects always finished a level below my results in other areas. I was therefore aware that my research skills would need to improve as I progressed through the programme. These areas are detailed as a part of the Training Plan. An assessment of my current skill set was completed and aims set for the duration of the programme.

From the initial proposal to the finalised version, the outline of the thesis progressed through varying iterations and ideas. The initial programme proposal outlined a plan to investigate the implementation of velocity-based training in an elite football environment, in the hope of establishing recommendations for enhancing sprinting ability from effective gym-based training. Velocity-Based Training (VBT) was a very 'current' topic at the time, with presentations on its application appearing at national conferences. As the reading in the area became deeper and deeper the plan altered to look more at pitch-based training methods due to their inherent specificity and potential transfer. This was led mainly through discussions with researchers within the area. Here the focus became on force-velocity profiling and the consequent impact on training needs of the athlete. However, after further early-stage reading and needs analysis work, this thought process was again further 'peeled back' as a general lack of understanding of the details surrounding sprinting in football became apparent.

Following discussion with practitioners and researchers within the area, it became clear that rectifying this lack of understanding in the area was paramount before any intervention study be conducted. It was discussed how a lack of understanding of what sprinting in football actually looked like existed. Without this, no training programme could claim to be truly specific to match demands. Thus, the focus of the thesis became to better understand how sprinting in football occurs; beyond the current locomotor distances that are commonly utilised. An initial plan for the thesis was developed, ultimately ending with an intervention study aimed at improving the sprinting ability of footballers:

1. The development and implementation of a football Sprint Movement Classification System.
2. A biomechanical assessment of the key movements associated with sprinting in football.
3. An intervention study using the information gained from studies 1 and 2 to improve sprinting in football.
4. An investigation into scientific dissemination of these research findings.

However, following initial pilot work into the development of a classification system it began to become apparent that the lack of descriptive detail surrounding sprinting in football was even less than first thought and that progressing ahead to further stages of research such as biomechanical assessments and interventions would bypass a lot of crucial information. It became apparent that to fully understand ‘how’ sprinting was completed in football, an understanding of ‘why’ this sprinting occurs would be necessary. Therefore, similar to an existing study looking into high-intensity running, it was decided that a classification system for quantifying the tactical-context of sprints would be important. This would provide the required context to the detail surrounding the movements quantified. As a result, the basic plan for the thesis was adjusted:

1. The development of a football Sprint Movement Classification System and a football Sprint Tactical-Context System.
2. The implementation of a football Sprint Movement Classification System and a football Sprint Tactical-Context System.
3. An intervention study using the information gained from studies 1 and 2 to improve sprinting in football.
4. An investigation into scientific dissemination of these research findings.

This stage of the development of the research allowed me to begin to learn skills around the defining of a performance problem. By reading deeper into the area of enhancing sprinting in football and having discussions with researchers and practitioners in the area, the true scale of the problem became evident. This investigation into the ‘root cause’ of the problem developed skills specific to the identification of this and future issues that may arise in my professional practice.

During the Training Plan, it was identified that my ability to work as a part of a team would need to improve to be successful on the programme. The ability to work collaboratively with my supervisor would be key to this. I attribute failure in this skill previously as the main cause of my weak previous research projects. The development of the focus of the thesis was a good demonstration of me applying this. Through this process, I worked closely with my supervisor and others within the study area to formulate the approach to the project. The thesis will certainly benefit from this approach.

3.0.2 Professional Skills

During my time at the club, the impetuous of the department began to shift from one of injury prevention to a more performance enhancement orientation. This was led by the Technical Director through to the Performance Director as a direction for the club as a whole and was specifically aimed to develop a faster style of play. Within the performance department, this was interpreted as assisting players in being as fast as possible and injury-free. Whilst the club's broad aim was to sign a specific type of player that had proven ability in the area, as a department we aimed to improve the ability of the existing playing squad.

As a result of this, the department began a process of developing the best possible speed enhancement programme. Experts were sought in the area for internal CPD events to create discussion within the department. These including a former Olympic sprinter, now strength coach; Olympic level sprint coaches, also involved in team sport practice; and other practitioners deemed to be leading within the area. This was the initial stage of the process and from this practice was adjusted as and when necessary. During this time, I began the professional doctorate programme and it seemed obvious to make this area the focus of the project. As discussed above this initially began as a plan to improve the strength training practices with respect to enhancing sprinting ability and progressed to the final plan to describe in detail sprinting in football.

As a part of this process of seeking out experts within the area I personally discussed my doctoral plans with these practitioners to gauge their opinion on the direction of the project. These assisted in the development of the final plan. As a part of this, I received advice on the process as a whole and was advised to view the project as a product and to become the ‘expert’ within the area. This is something I specifically attempted to achieve through the creating of a ‘buzz’ on the area via social media dissemination. Which would become the focus for the final study. Additionally, this involved focusing on the practical outcomes of the project and what it would ultimately mean for practitioners.

3.1 INTRODUCTION

Association football is a game defined by periods of low-intensity activity punctuated by brief high-intensity bouts of sprinting. It has been noted that, though a lot less frequent than lower speed running, it is these bouts of sprinting that have a large influence upon the outcome of a match. This is as a result of their involvement in goal scoring and assisting (Faude et al., 2012). Over the course of 5 seasons, distances covered sprinting has been shown to be increasing in the EPL, thus further enhancing the importance for athletes to be able to sprint effectively (Barnes et al., 2014; Bush et al., 2015). High-velocity running is also the most frequent mechanism involved in hamstring injuries in football; the most commonly occurring non-contact injury (Schuermans et al., 2017).

As discussed in the review of the literature, there exists a plethora of data describing sprinting in football; the majority of which is measured through camera tracking systems and GPS. Currently, the body of literature provides an in-depth understanding of sprinting total distances, distances per effort, frequencies and positional differences, all over a longitudinal period of time (Barnes et al., 2014; Bush et al., 2015). In addition to this, comparisons have been made between playing standard, sex and age (Bradley et al., 2013; Mara et al., 2017; Abbott et al., 2018). Whilst data derived from GPS technologies provide practitioners with a good understanding of the match demands of football, such information has been noted as being potentially reductionist in its approach to quantifying the true demands of football match play (Bradley and Ade, 2018). The technology is limited by its inability to quantify specific movements patterns utilised to achieve the measured distances or the tactical context within which they occur, and consequently may underestimate total workload and lack detail required to design effective programming.

With the knowledge that, for example, sprinting along a curve asymmetrically increases the anteroposterior impulse demand of the outside leg, and that poor running mechanics could be a large risk factor for a hamstring injury, it is clear that more detailed data around sprinting beyond basic locomotor distances is required (Churchill et al., 2016; Schuermans et al., 2017). It is also well accepted that accelerating, decelerating, dribbling with the ball and turning all have different energy costs to constant velocity running; thus, merely stating the average distances that sprints are performed over during match play will grossly underestimate any bioenergetic demand. (Hatamoto et al., 2013). Therefore, it is crucial that practitioners gain a greater understanding of the actual, specific movements being utilised during sprinting.

Alongside the importance of a deeper understanding of the intricacies of how sprints are performed, it is also crucial for practitioners to understand why they occur, in relation to the match itself. As discussed, sprinting is common during goal-scoring and assisting as attacking players aim to create separation from the defensive players in order to score (Faude et al., 2012; Jeffreys et al., 2018). It is fundamental to understand that any sprint occurring is as a result of the match itself, as a player responds to their environment; therefore, the match is always the driving context behind these actions (Jeffreys et al., 2018). As a result of this, any performance enhancement programme would be remiss to discount the contextual stimuli that these efforts occur within.

Previous classifications of movement specific to football have been outlined in the review of the literature. The first of these, the Bloomfield Movement Classification attempted to classify and quantify the PM during football match play and quantified such categories as Turns, Motion, and Direction (Bloomfield et al., 2007). More recently, an attempt has been made to classify the discrete movement patterns associated with Game Speed in football (Jeffreys et al., 2018). Alongside this, systems have been developed that seek to classify the tactical context and outcome of high-intensity efforts during football in an attempt to explain why certain types of running may occur (Ade et al., 2016). Whilst previous work has begun to attempt to contextualise the locomotor demands of match play, no studies have directly sought to describe sprinting and how and why it may occur in football.

Due to the absence in the literature of a suitable system for the current purposes, the development of novel systems will be required. Consequently, reliability will be a key concept. The attainment of satisfactory intra-reliability and inter-reliability will ensure any system developed currently will be acceptable for application in the current thesis and externally by researchers and practitioners.

3.1.1 Aims

Therefore, the aim of the current study is to develop two classification systems. Firstly, to classify the specific movements associated with sprinting in football and secondly to classify the tactical-context within which sprints occur in. A further aim will be to determine both intra-reliability and inter-reliability of the systems.

3.2 METHODS

3.2.1 Classification System Development

As discussed, two broad contexts exist that seem to have relevance to the classification of sprint efforts in football. The first pertains to detailing the physical movements utilised to complete the sprint effort. The second area relates broadly to potentially why the sprint efforts are completed within the context of the game. This would seem to implicate the detailing of the tactical-contexts which sprinting occurs within the sport. Therefore, the development of two distinct classification systems are required to fully describe and understand sprinting in football more deeply: The Football Sprint Movement Classification System (SMC), and The Football Sprint Tactical-Context Classification System (STC).

A process outlined previously (Brewer and Jones, 2002; Roberts and Fairclough, 2012; Murtagh, 2016) in developing observational systems was used to inform the production of the systems. This process involved five stages of development (Fig. 3.1). Firstly, a familiarisation stage whereby the researcher became aware of the concepts and actions that may be classified. The second stage involved a critical analysis of the methodologies of any current similar systems in the area. Thirdly, a broad outline of a new system was developed before this was refined to its final iteration. Following this process, the final systems were tested for reliability.

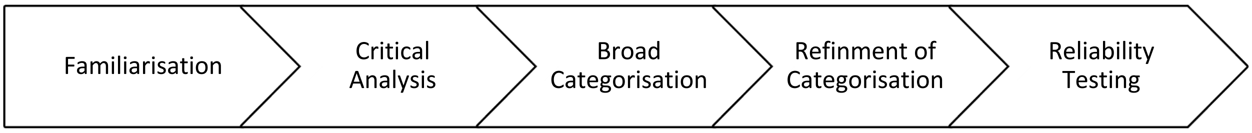

Figure 3.1 The five-stage process for the development of the Sprint Movement and Sprint Tactical-Context Classification Systems.

3.2.2 Stage 1: Familiarisation with Currently Available Methodologies and Analysis Techniques

In the current investigation, the familiarisation stage was initiated by performing a literature search. This search attempted to identify all of the potentially available notation systems that are currently reported in the literature that relates to intense movements in football. Due to the lack of direct data in sprinting, the most similar actions were chosen. This included movements that were deemed ‘purposeful’, ‘powerful’ and ‘high-intensity’ in nature. A systematic search of the literature was completed via the PubMed.gov database. For the development of a system to quantify the movements associated with sprinting in football, the terms ‘soccer movement’ and ‘football movement’ were searched, returning 2,746 and 2,246 results respectively (Figure 3.2). These results were narrowed down by selecting only those results that outlined a system for movements that were deemed similar to sprinting activities. This process left four key papers to consider in the development of the novel system (Table 3.1). For the development of a system to quantify the tactical-contexts of sprinting in football, a similar initial literature search was completed using new terms such as ‘soccer tactical’ and ‘football tactical’ (Figure 3.3). Articles were omitted that did not include an attempt to quantify football sprint-like activities in relation to their tactical context. Of these, one study was deemed acceptable (Table 3.1).

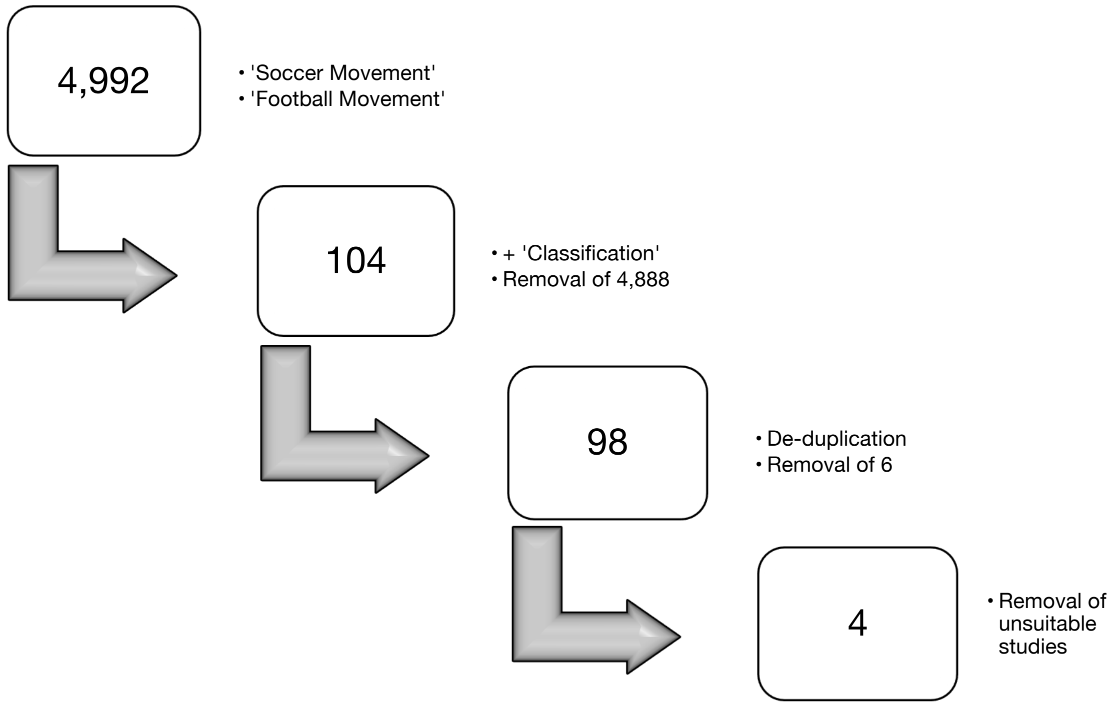

Figure 3.2 A flow chart representing the systematic process of identifying currently available literature for the familiarisation stage of the development of a Sprint Movement Classification System.

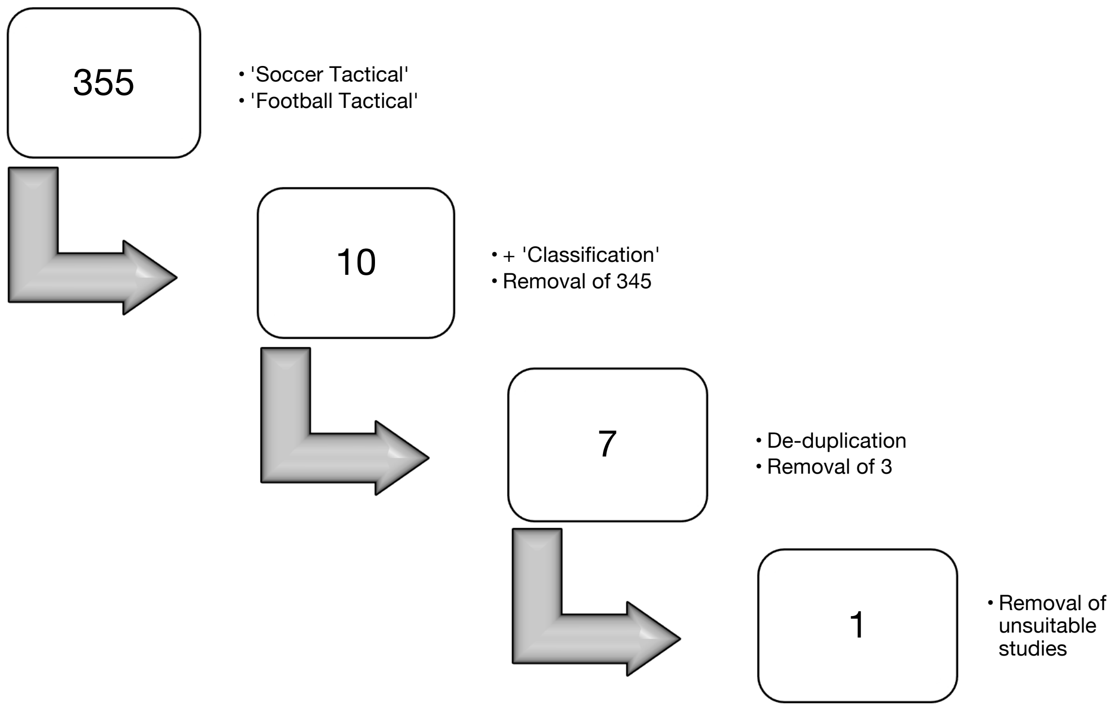

Figure 3.3 A flow chart representing the systematic process of identifying currently available literature for the familiarisation stage of the development of a Sprint Tactical-Context Classification System.

Table 3.1 An outline of the details of the systematically identified football 'sprint-like' movement classification studies for the familiarisation stage of development.

Authors	Systems	Type of Action Classified	Detail of Actions	Data Collected	Reliability
Jeffreys et al. (2018)	*Movement*	*Football Specific Movement(detail)l*	*'Game Speed' Speed and Agility Movements*	*None*	*N/A*
Ade et al. (2016)	*Movement* *Tactical-Context*	*'High-Intensity Movement'*	*'Movement Pattern', 'Technical Skill', 'Tactical Outcome'*	*20 Players 46 Home Matches*	*Inter 'Strong'. Intra 'Almost Perfect'*
Faude et al. (2012)	*Movement*	*'Powerful' Actions*	*'Rotation', 'Linear Sprint', Change-in-Direction Sprint', 'Jump'*	*360 Goal Scorers 322 Goal Assisting*	*Inter 'Moderate'. Intra 'Strong'*
Bloomfield et al. (2007)	*Movement*	*'Purposeful Movement'*	*'Motion', 'Turns', 'On the Ball Activity'*	*55 Players 15min Match Period*	*Inter 'Good'*

Prior to the development of any new system, it has been suggested that one employs similar systems that are currently available, thus becoming familiar with both the discipline area and techniques that are available (Brewer and Jones, 2002). Through this activity, the researcher becomes accustomed to the required processes important for the completion of notational analysis such as the following of descriptive categories and the subsequent recording of data. This process will reduce the likelihood of any potential future errors and lead to gains in understanding of system design. This will include the following of operational procedures and the successful writing of category descriptions. Early pilot work was completed on live match footage. Here, a system outlined in previous work observing high-intensity efforts was employed (Ade et al., 2016). As a result of this, the researcher began to understand the system's process and how the category definitions were observable in live match footage. It was anticipated this would lead to more consistent analysis in the future through creating a deeper understanding of how descriptive categories reflect match-based activities. This initial screening process, on the whole, should allow a more appropriate design of any future novel system.

Another important part of the familiarisation stage is the understanding of the technical aspects of the application of systems in a practical sense. The researcher spent time with a trained Performance Analyst to discuss various technical aspects of notational analysis such as accessing, clipping, transferring and storing match footage. During this process, the researcher spent time observing the analyst in their regular role analysing football matches and training. This allowed the researcher to develop basic familiarisation with the techniques used when watching video footage. Additionally, the identified study's (Bloomfield et al., 2007; Faude et al., 2012; Ade et al., 2016; Jeffreys et al., 2018)(Stage 1) (Table 3.1) methods were discussed regarding the definitions used and how best to identify these match-based, football-specific activities. Methodological intricacies such as how certain movements and phases of a game may be identified were discussed. Alongside this, the language used within the descriptions to represent these actions were discussed. Together these processes enabled a key insight into the pragmatics of using these types of systems to carry out this type of research project. For example, how a system classifies an Attacking Transition from a description such as 'exploit defensive disorganisation to create scoring opportunities'. This was achieved by identifying the corresponding key match 'sub-principle' description of 'moving the ball rapidly into available space' (Delgado-Bordonau and Mendez-Villanueva, 2012; Jeffreys et al., 2018). Such pragmatics clearly enable key decisions to be made that influence the operation of these systems to collect data.

The stage proved successful in familiarising the researchers with the key methodological elements of classification systems. As a part of this, key literature was identified to inform the development of novel systems. Following the stage, it was believed that researchers would be better placed to design the required systems for quantifying the movements and tactical-contexts associated with sprinting in football as a result of gaining a better understanding of the previously employed systems and the key processes involved in performing such an analysis.

3.2.3 Stage 2: Critical Analysis of Currently Available Methodologies

Following the familiarisation stage, the second stage involved the critical analysis of the identified systems (Table 3.1) by investigating the strengths and weaknesses of each (Table 3.2). Pilot work was again completed utilising these previously outlined methods to aid in this critical analysis. 10 randomly selected available sprint efforts were used for the analysis. Each identified system was then employed on these efforts and each critiqued accordingly. Systems were critiqued on areas such as how category descriptions matched with the current purposes of categorising sprinting efforts, whether the study had previously been applied in football, and the comprehensiveness of each system as it relates to potentially informing future training practices. Conclusions could then be made on the suitability of each. Additionally, any potential gaps in the current systems could be ascertained and suggestions made for possible requirements for any new systems.

Table 3.2 An outline of the strengths and weaknesses of the identified football movement and context classification studies.

Authors	Strengths	Weaknesses
Jeffreys et al. (2018) (Movement)	*Attempts to outline all possible movements utilised in football.* *Specifically details the movement patterns used.* *Full descriptions available.*	*No current data from the application of the system.*

Ade et al. (2016) (Movement)	*Previously applied with football match footage.* *Full descriptions available.*	*Describes degrees of change of direction, not movement patterns.*
Ade et al. (2016) (Context)	*A comprehensive outline of football tactical-contexts.*	*Only previously used for High-intensity running and not sprint focused.*
Faude et al. (2012) (Movement)	*Full descriptions available.* *Differentiates types of sprints.*	*Categories are broad.* *Focused only on goal scoring actions.*
Bloomfield et al. (2007) (Movement)	*Comprehensive system.* *Previously applied in football.*	*Describes degrees of change of direction, not movement patterns.*

3.2.3.1 The Sprint Movement Classification System

Of the four key studies identified, one was recognised as being most suitable for the basis of the development of a new system to classify the movements associated with sprinting in football (Bloomfield et al., 2007; Faude et al., 2012; Ade et al., 2016; Jeffreys et al., 2018) (Table 3.1). The study categorising 'Game Speed' movements was deemed the most comprehensive and appropriate of those identified (Jeffreys et al., 2018) (Table 3.2). This was mainly due to nature of the study being the only one to describe directly the movement patterns utilised during high-intensity efforts rather than, for example, the angle of turns (Jeffreys et al., 2018). It was felt that this movement information would be most useful for practitioners when prescribing training programmes, returning a player from injury and for potential further biomechanical research. Information detailing the specific movements employed, it was felt, would provide novel data on match-specific movements in football and potentially enhance the current understanding of match demands beyond the angle of change of direction. However, it was decided that this system may require further refinement to suit the needs of the current research. The study was not necessarily designed for application specifically with sprint efforts and thus lacked some of the desired descriptive data to comprehensively label the movements associated with sprinting in football. For example, the system was only designed to describe the nature of the acceleration and the direction of the effort during maximum velocity running. A more comprehensive description of these efforts was desired. Additionally, there was no previous known published work from the application of the system, thus its practical operational applicability was unknown.

Following a critical analysis of the currently available systems, one system was selected as being the most suitable for the basis of a new system. However, as discussed, it was felt that the system would need to be adjusted to suit the current purposes of quantifying the movements associated with sprinting in football (Stage 3). Specifically, Action descriptions would be required for the adjustment of the system to make it more relevant to sprinting specifically. It was also noted that due to the system lacking published previous application in football, the process of operating the system may need to be devised through the current development. This was important to consider in the subsequent stages of development (Broad Categorisation).

3.2.3.2 The Sprint Tactical-Context Classification System

With regards to the development of a Tactical-Context classification system, one key relevant study existed in the area specific to football (Ade et al., 2016) (Table 3.1). This study was conducted on high-intensity movement in football and defined the Tactical Outcome of these efforts (Ade et al., 2016). The study looked at all efforts that achieved a velocity greater than 5.8 $m.s^{-1}$ and categorised their Tactical Outcome depending on whether the player's team was in or out of possession. The methods outlined provided a strong basis for the current work due to its inherent similarities to sprinting analysis by its detailing of the Tactical Outcome of high-intensity running efforts. The study also produced high inter-tester reliability scores ($k > 0.8$), suggesting its effective applicability beyond the original research. However, again it was noted that refinement would be required to successfully employ the methods to sprinting, due to the study being designed specifically for high-intensity efforts rather than sprinting (Table 3.2). It may be that the Tactical Outcomes associated with sprinting are different from those of high-intensity efforts and that new or different categorisation and consequent descriptions may be required to fulfil the current needs.

3.2.4 Stage 3: Broad Categorisation of the Novel Systems

The third stage involved further pilot work where a combination of the previously utilised methods and novel developments were employed to begin to broadly categorise sprinting actions in football for the development of the new systems. As discussed, key previous works (Stage 2) were used as a basis for the current systems (Ade et al., 2016; Jeffreys et al., 2018). Again, 10 sprint efforts were randomly chosen for the pilot work to begin to refine these systems for current purposes. This involved the adjustment of the previous broad category descriptions to more suitable sprinting-specific descriptions. This led to the finalising of these broad categories for the current systems. This process was completed for both systems.

3.2.4.1 The Sprint Movement Classification System

As previously outlined (Stage 2) the system focusing on categorising ‘Gamespeed’ movements was seen as a useful starting point for the analysis of the movements involved in sprinting in football (Jeffreys et al., 2018). This was due to its comprehensive approach to categorising sprint-like movements. As discussed, the system was again piloted to establish broad categories for the novel system. Critique of the system was now focused on its logistical applicability to sprinting efforts. Broad categories for the classification of sprint efforts were desired. The Main-Categories outlined in the original system were accepted as sufficient for current purposes as a result of this pilot work. It was thought these would provide practitioners with an understanding of how sprinting occurs during a match. These broad categories outline key kinematic information around how a sprint is approached and completed. New sprint-specific descriptive definitions were written for these Main-Categories to suit the current requirements. These Main-Categories include Transition, Initiation and Actualisation (Table 3.3).

As discussed, little adjustment to the original system was required from a broad categorisation perspective. The key to this stage was defining these categories in relation to sprinting and thus how they will be applied operationally in the new system. As noted, it was believed that these would provide a comprehensive description of sprinting movements in football.

Table 3.3 The Broad Categorisation of the movements involved in sprinting in football.

Main-Category	**Description**
Transition	*The movements completed immediately prior to the sprint effort.*
Initiation	*The movements associated with the beginning of the effort.*
Actualisation	*The movements employed during the sprint effort.*

3.2.4.2 The Sprint Tactical-Context Classification System

Similarly, for the development of the Tactical-Context system, pilot work was completed with the key previous method identified (Ade et al., 2016). From this, novel adjustments were made to provide the detail required for the current analysis. These included the adaptation of the broad categories for sprint-specific purposes.

(Ade et al., 2016). The Tactical Outcome category was accepted as being suitable for providing the necessary data for the current study regarding 'why' a particular sprint may have occurred. However, an additional category was created to attempt to frame this data further within the context of the game. A category labelled Phase of Play was thus created. The Phase of Play describes the 'Moment of the Game' and provided the opportunity to frame the Tactical Outcome within the match itself (Delgado-Bordonau and Mendez-Villanueva, 2012). Therefore, two broad categories for the description of the Tactical-Context of sprinting were chosen. Descriptions were written accordingly (Table 3.4). Knowledge of these broad categories would allow for the designing of specific training drills that replicate these efforts and further the understanding within the literature on sprinting in football.

Table 3.4 The Broad Categorisation of the tactical-context within which sprinting occurs in football.

Main-Category	**Description**
Phase of Play	*The phase of play of the subject's team within which the sprint occurs.*
Tactical Outcome	*The tactical outcome of the sprint; the specific context of the action.*

During this stage, the previously identified systems broad categories were adjusted to suit the current needs of quantifying the tactical-contexts within which sprints occur in football. Primarily this involved the omission of specific categories such as Movement Pattern and Technical Skill. It was believed that these areas would be covered by the Sprint Movement Classification System. The current system, it was felt, should focus on its originally stated aims of defining ‘why’ a sprint occurs during a match, whereas the previous system did not explicitly have this similar aim. For this reason, also, it was decided that the addition of the Phase of Play category would assist in relating the Tactical Outcome with the match itself. This would provide further understanding of why the effort occurred.

3.2.5 Stage 4: Refining of Categorisation and Process Development for the Novel Systems

The fourth stage of the process consisted of the final refinement of the two systems. This included the finalising of all sub-category and action descriptions, and detailed processes of data collection (Table 3.5). Further work was completed with the previously collected pilot work to develop and finalise the main-categories from Stage 3. As a part of this, the necessary sub-category descriptions within each main-category were written and tested (Table 3.6 & Table 3.8). The finalised systems were then outlined in full (Table 3.7 & Table 3.9). For both systems, it was decided that, in line with previous research, a sprint was classified as the attainment of a velocity of at least 7 $m.s^{-1}$ (Bradley et al., 2013; Barnes et al., 2014) Whilst no official consensus exists, this is noted as the most widely employed velocity threshold in football analysis and would, therefore, be in line with previous study and practice (Sweeting et al., 2017).

Finally, an external practitioner was used to validate both system's descriptions for sprinting in football. Here an experienced practitioner within football systematically endorsed the descriptions of each category. Firstly, with the aim of validating each description with the corresponding title. Following this, previously used piloted sprint efforts were observed and the corresponding category descriptions authenticated or reviewed and adjusted as deemed necessary by the practitioner. Thus, providing validity to the category description and the related match footage.

3.2.5.1 The Sprint Movement Classification System

Refinement of the categories of the original system to its current purpose of focusing on sprinting efforts was mainly required within the Actualisation category (Table 1.8) (Jeffreys et al., 2018). This category sought to describe the movements completed during the actual sprint effort and consequently was the category most specific to sprinting movements. The original system consisted of only two sub-categories, Acceleration, and Maximum Velocity. For the development of a sprinting specific system, Torso Orientation, Action During and Action End categories were deemed necessary. These provided greater depth to the detail of the sprint efforts themselves and were seen as important for comprehensively describing the movements utilised in sprinting. Through the refinement of the system during the development phase, the pilot work completed saw all efforts fully classified with no omissions.

Another key development during this phase was the operational process of the systems. Here it was necessary to confirm the definition of a sprint, and the consequent initiation and the cessation of the sprint effort within which the classification will be completed. To achieve this, a combination of observing pilot sprint efforts and utilising sprint-phase definitions within the literature were used to define these key moments (Table 3.5) (Moir et al., 2018). Typically sprinting is viewed as consisting of an Acceleration and a Maximal Velocity phase. Whilst highly interdependent, each consists of its own unique mechanical profile. To attain the requisite velocity for categorisation as a sprint, the athlete will first accelerate by adopting an accentuated forward lean followed by a more upright posture as they enter the Maximal Velocity phase (Moir et al., 2018). Upon completion of this effort velocity will decrease as the athlete no longer seeks to maintain velocity. Descriptions were written to identify these phases as Sprint Initiation (the beginning of Acceleration) and Sprint Cessation (the end of the Maximal Velocity phase). These definitions were then employed in the methodology alongside velocity threshold time-stamp data. These operational processes were used for both the Sprint Movement and Sprint Tactical-Context Classification Systems.

Table 3.5 Process detail for the SMC and STC.

Process Detail	**Description**
Sprint Initiation	*The individual presents typical acceleration mechanics involving an accentuated body lean, faster leg turnover, increased stride length, faster arm cycle and a consequent noticeable increase in velocity.*
Sprint Effort	*The period between the initiation of the sprint effort and the cessation, within which the velocity threshold of a sprint effort is achieved.*
Sprint Cessation	*The individual exhibits a clear decrease in velocity and no longer maintains mechanics typical of upright sprinting.*

Table 3.6 The refining of the broad categorisation of the movements involved in sprinting in football into defined sub-categories acceptable for the new system.

Main-Category	**Sub-Category**	**Description**

Transition	Transition Movement	*The movements completed immediately prior to the sprint effort.*
Initiation	Starting Position	*The position from which the sprint effort begins.*
	Change of Direction	*The presence of any change of direction from the transition movement to the beginning the sprint effort.*
Actualisation	Acceleration	*The type of acceleration used to complete the sprint effort.*
	Maximum Velocity	*The direction of the sprint effort.*
	Torso Orientation	*The existence of any dissociation of the torso.*
	Action During	*Any possible action completed during the sprint effort.*
	Action End	*Any possible action completed at the end of the sprint effort.*

Table 3.7 An outline of the finalised Football Sprint Movement Classification System, detailing all categories and Action descriptions.

Main-Category	Sub-Category	Action	Description
Transition	Transition Movement	Static	***No movement*** *of the feet*
		Jockeying	*Shuffling and readjustment steps* ***without significant displacement***

		Linear	***Forward** direction of travel at any velocity*
		Ball	*Dribbling with the **ball***
		Lateral	*Shuffling of the feet to travel in a **sideways** direction, no crossover*
		Diagonal	*Crossover steps to travel in a **diagonal** direction*
		Rear	*Travelling directly **backwards** to the direction of facing*
		Rear Plus	*Travelling backwards to the direction of facing with the addition of **shoulder drops** for readjustment*
		Deceleration	*Significant **deceleration mechanics** including landing, passing, tackling and receiving the ball*
Initiation	Starting Position	Linear	*Typical initiation of an acceleration in a **forward** direction*
		Lateral	*The completion of a **hip turn** movement where the foot opposite to the intended sideways direction of travel steps over the other to set up for standard acceleration mechanics*
		Rear	*The completion of a **drop step**, followed by a hip turn to initiate standard acceleration mechanics in the direction opposite to the way the individual is facing*
	Change of Direction	None	***No** alteration to the current direction of travel*

		Lateral	*The completion of a **cutting step**, where the foot opposite to the intended direction change is planted outside the centre of mass to initiate a sideways change of direction. Typically, short contact times*
		Front-Back	*The completion of a **plant step** where momentum in the forwards direction is stopped and a movement in the opposite direction is begun. Typically, longer contact times than cut stepping*
		Back-Front	*The completion of a **plant step** where momentum in the backwards direction is stopped and a movement in the opposite direction is begun. Typically, longer contact times than cut stepping*
Actualisation	Acceleration	Explosive	*A **rapid acceleration** including a sudden increase in leg turn over and overall velocity*
		Rolling	*A **gradual acceleration** where an increase in velocity is achieved over a more prolonged period. Less of a sudden increase in leg turnover.*
	Maximum Velocity	Linear	*The upright running portion of the sprint is completed in a completely **forward** direction*
		Curved	*The upright running portion of the sprint is completed with the presence of any*

			*degree of **curvature**. Typically involves a lean of the torso towards the direction of the curve and the placement of the inside foot inside the centre of mass*
	Torso Orientation	No Rotation	*During the upright running portion of the sprint the torso is kept facing directly **forwards***
		Rotation	*During the upright running portion of the sprint is completed with the presence of any amount of rotation at the **torso away from the direction of travel***
	Action During Sprint	None	***No other action** is performed during the sprint*
		Duel	*During the sprint there is presence of a **duelling action with another body**. Any action that is not typically of standard sprinting mechanics*
		Ball	*During the sprint there is some **ball involvement,** including a pass, or dribbling with the ball where the individual kicks the ball and sprints after it*
	Action at the End of Sprint	None	*The sprint **does not** end with any action*
		Duel	*The sprint ends with a duelling action. Including a **tackle, or engagement of another body***
		Ball	*The sprint ends with an action including the **ball** such as a pass, shot, header or dribble*

3.2.5.2 The Sprint Tactical-Context Classification System

Only minimal refinement of the previous work was required to create a system specific to sprinting (Ade et al., 2016). However, as discussed, it was decided that an additional category describing the Phase of Play within which the sprints occurred would provide important contextual data. This would more accurately describe how the efforts related to the match itself. Here the Actions themselves were again taken from previous work in the area (Delgado-Bordonau and Mendez-Villanueva, 2012). These are commonly utilised terms by both football coaches and physical performance practitioners.

The original system contained a category description label 'Other' for both in and out of possession. This was, however, not required during the current developmental pilot work. All efforts were successfully classified. Nevertheless, as this was contained within the original system and required when applied on a large data set, it was deemed necessary to maintain this in the new system. This would allow any potential efforts that did not fit within the system's Tactical Outcome category to be noted. It may be that the current pilot work was too small a sample to raise any unclassifiable efforts.

Table 3.8 The refining of the broad categorisation of the tactical-context within which sprinting occurs in football into defined sub-categories acceptable for the new system.

Main-Category	Sub-Category	Description

Phase of Play	Phase of Play	*The phase of play of the subject's team within which the sprint occurs.*
Tactical Outcome	In Possession	*The subject's team is in possession of the ball when the sprint effort occurs.*
	Out of Possession	*The subject's team is not in possession of the ball when the sprint occurs.*

Table 3.9 An outline of the finalised Football Sprint Tactical Context System, detailing all categories and Action descriptions.

Main-Category	Sub-Category	Action	Description
Phase of Play	Phase of Play	Attacking Transition	*In possession move to Attacking Organisation following the **recovery of possession.***
		Attacking Organisation	*In possession: **Attacking build up** aiming to create scoring opportunities by disorganising the opposition defence.*
		Defensive Transition	*Out of possession move to Defensive Organisation following the **surrendering of possession.***

		Defensive Organisation	*Out of possession: Assuming of **defensive structure** to prevent the creation of goal scoring opportunities.*
Tactical Outcome	In Possession	Break into Box	*Player sprints into the opposition **penalty box**.*
		Overlap	*Player sprints from **behind to in front of or parallel** to the player on the ball.*
		Push-Up Pitch	*Player sprints up the pitch to support the play (**defensive and middle third of the pitch** only).*
		Run the Channel	*Player sprints with/without the ball down to one of the **external areas of the pitch.***
		Run-in Behind	*Player aims to **beat the opposition offside trap** to sprint through onto the opposition goal.*
		Drive inside	*Player sprints with/without the ball **from the external flank into the central area.***
		Drive through the middle	*Player sprints with/without the ball **through the middle** of the pitch.*
		Run with the Ball	*Player moves **with the ball** either dribbling with small*

			touches or sprinting with the ball with bigger touches.
		Other	*All other in possession variables that could not be categorised.*
	Out of Possession	Closing Down	*Player sprints **directly towards the opposition player** on the ball.*
		Interception	*Player sprints to **cut out a pass** from an opposition player.*
		Covering	*Player sprints **to cover space or a player** on the pitch while remaining goal side.*
		Recovery Run	*Player sprints back towards their own goal when **out of position** to be goal side.*
		Ball over the top	*Player sprints after an opposition pass **over the defence through the centre**.*
		Ball down the side	***Player sprints after an opposition pass in behind the defence down the side of the pitch.***
		Track the Runner	*Player runs **alongside opposition player** with or without the ball*

		Other	*All other out of possession variable that could not be categorised.*

3.2.6 Stage 5: Reliability

When developing any novel system, it is imperative to ascertain its reliability to ensure reproducibility of any results (McHugh, 2012; Murtagh, 2016). Whilst core aspects of the current systems are derived from previous work, consisting of their own reliability testing. As a result of the novel employment of these methods in sprinting, it is important to produce reliability scores for the new systems. This will ensure the system is adequate for its current research purposes within the thesis and any future replication by practitioners or researchers. Therefore, intra-reliability and inter-reliability assessments were completed for both systems to ensure acceptable within and between researcher reliability. System reliability ensures data collected are an accurate representation of the variables measured by ensuring repeatability (McHugh, 2012). The kappa statistic was selected to measure this reliability as a result of its ability to take into account potential chance agreement, a factor missing from standard percentage agreement (McHugh, 2012).

Therefore, to establish the reliability of the two classification systems, both were employed using match data and statistical analysis subsequently completed to ascertain inter and intra-reliability. Firstly, a match involving the studied team was chosen at random from the 2016-17 season for analysis. Raw video-based locomotor coordinates were taken from official Premier League sources, Tracab (ChyronHego, USA). The raw data was then processed and filtered through a load management software, to create velocity-time data (OpenField. Catapult Sports, Aus.). From this, time-stamps from the match clock were established for each effort deemed a sprint - where a player achieves a velocity of 7 $m.s^{-1}$ and above. These were then recorded for each player involved in the match (Table 3.10), including those that were substituted out, and those that were substituted into the match. To classify these sprint efforts, official match footage was obtained from the official Premier League DVMS online system (Premier League, UK); a portal database of all match footage powered by Hudl (Hudl, USA). Multiple camera angles were used: Tactical (high, wide-angle view from the centre of a lateral side of the pitch), High Behind (high angle, behind one of the goals) and Broadcast (standard television broadcast view). Due to its ability to observe the most match-action, the Tactical view was selected as the primary angle for analysis. If this view was obscured in any way, High Behind and Broadcast were respectively employed until the effort could be fully classified. Reliability testing could then occur for both systems.

Table 3.10 An example Time-Stamp output for a single player in a single match.

Player No.	Sprint 1	Sprint 2	Sprint 3	Sprint 4	Sprint 5
Player 9	*12.07*	*36.17*	*54.58*	*91.50*	*92.33*

3.2.6.1 The Sprint Movement Classification System Protocol

The finalised methodological protocol was followed to generate data for reliability testing. Using the time-stamps established for when a player achieves a sprint effort, the match footage was rewound to the Sprint Initiation (Table 3.5). The SMC (Table 3.7) was then employed until the Sprint Cessation (Table 3.5). The footage was employed firstly to establish the Transition category (Table 3.3). The final movement observed immediately before Sprint Initiation was categorised according to the most similar description from the SMC (Table 3.7). Following this, the movements observed to achieve Sprint Initiation were categorised. Again, the movements observed were corresponded with the most similar descriptions in the SMC for the two Sub-Categories (Starting Position & Change of Direction) within the Main-Category of Initiation. Finally, the same process was employed to fulfil all five Sub-Categories of Actualisation (Acceleration, Maximum Velocity, Torso Orientation, Action During Sprint & Action at the End of Sprint). As noted in Table 3.3, this analysis pertained to the sprint effort itself, the period between Sprint Initiation and Cessation (Table 3.5). Thus, a single Action was recorded for each sprint effort (Table 3.8), from within each Sub-Category. Therefore, each sprint consisted of 8 Action descriptions, under the 3 Main Categories. An example output from the system is provided in Table 3.11, this process was followed periodically and in match time order for each player analysed. This was completed in order of position (FB, CB, WM, CM, CF), and then alphabetically by each player's surname within positions.

Table 3.11 An example of a single sprint effort classified using the Sprint Movement Classification System.

Main-Category	Sub-Category	Action
Transition	Transition Movement	*Deceleration*
Initiation	Starting Position	*Lateral*
	Change of Direction	*Lateral*

	Acceleration	*Explosive*
	Maximum Velocity	*Linear*
Actualisation	Torso Orientation	*No Rotation*
	Action During Sprint	*None*
	Action at the End of Sprint	*None*

3.2.6.2 The Sprint Movement Classification System Reliability

Following the classification of each effort, the system was tested for reliability. To establish intra-reliability, the lead tester completed the classification of all players within the same match a second time. This was completed at the same time of the day, under the same conditions, one week later. In addition to this, a second tester was recruited. With the assistance of the lead tester, the current process of classification was explained and piloted, following the described protocol. Following this, the second tester completed the analysis of the same match to provide inter-reliability measures. This inter-reliability measure was completed one week following the intra-reliability testing. A Cohens Kappa Coefficient was established for each of these reliability tests.

The SMC was tested for reliability within and between tester, and all methods showed excellent agreement ($k > 0.90$). 'Almost perfect' agreement was observed within tester, through an intra-reliability Kappa Coefficient of 0.98. Between tester reliability also saw 'almost perfect' inter-reliability with a Kappa Coefficient of 0.95 (McHugh, 2012) (Table 3.13) (Appendix 9.4). Following this process of development, the system was deemed acceptable and reliable for quantifying the movements associated with sprinting in football ($k > 0.90$). This could then be applied in a future study by the current researchers, as well as externally.

3.2.6.3 The Sprint Tactical-Context Classification System Protocol

Subsequently, the reliability of the STC was established. The finalised protocol for the system was employed to attain a full set of data from a single match. The previously outlined method was utilised to identify the sprint effort time-stamps for the analysis. The STC (Table 3.9) was then applied to these identified sprint efforts to establish 2 Action data points for each effort, 1 point within each sub-category. Each player within the match was analysed systematically as outlined previously (3.2.6.1). Firstly, the analysis was completed on each sprint effort to ascertain the Phase of Play within which they occurred (Table 3.4). To achieve this, footage of the sprint effort (Sprint Initiation to Sprint Cessation – Table 3.5) was viewed as many times as deemed necessary to match the effort to an Action Descriptions within this Main-Category. Following this, the same process was followed to select an accurate Tactical Outcome. Phase of Play description deemed Attacking were indicative of In Possession Tactical Outcomes and those Defensive, Out of Possession. Table 3.12 provides an example output from the system.

Table 3.12 An example of a single sprint effort classified using the Sprint Tactical-Context Classification System.

Main-Category	**Sub-Category**	**Action**
Phase of Play	Phase of Play	*Attacking Transition*

Tactical Outcome	In Possession	*Run the Channel*
	Out of Possession	-

3.2.6.4 The Sprint Tactical-Context Classification System Reliability

The STC was then tested for inter and intra-reliability by analysing within and between tester. Excellent agreement ($k > 0.90$) was observed for both conditions. ‘Almost perfect’ agreement was seen within tester, through an intra-reliability Kappa Coefficient, $k = 0.97$. Alongside this, an ‘almost perfect’ inter-reliability Kappa Coefficient of $k = 0.97$ was witnessed between testers (McHugh, 2012) (Table 3.13) (Appendix 9.4). The development of the STC was deemed successful. All sprint efforts during the pilot work were comprehensively categorised by the system. The classification was therefore accepted as effective and reliable for the quantification of the tactical-contexts within which sprinting occurs in football.

Table 3.13 Reliability results for the SMC and STC

Classification System	**Intra Reliability (*k*)**	**Inter Reliability (*k*)**
SMC	*0.98*	*0.95*
STC	*0.97*	*0.97*

3.3 DISCUSSION

The current study sought to develop and then test the reliability of two systems aimed at describing sprinting in football. The initial part of the study aimed to develop and test the reliability of a classification system capable of quantifying the specific movements associated with sprinting in EPL football. This process involved the refinement of a previously outlined system aimed at quantifying ‘Gamespeed’ movements in football (Jeffreys et al., 2018). This previously available system was refined to suit the sprinting-specific needs of the current thesis and was deemed acceptable for quantifying these movements associated with sprinting in football. The classification system proved to be reliable between and within testers. Thus, the system was regarded as acceptable for future study and practical application, both by the current researchers and externally.

Additionally, the study sought to develop and test the reliability of a Tactical-Context Classification System. This system was designed to be capable of defining and quantifying the Phase of Play and Tactical Outcome within which sprinting occurs in the Premier League. Similar to the initial part of the study, previous work was used as the basis for the development of this system (Ade et al., 2016). This previous work was developed from a system focused on high-intensity running to one specific to sprinting. Certain categories were deemed unnecessary for the current purposes and an additional category was included. The novel system proved very reliable within and between testers at successfully achieving this aim and is, therefore, a reliable method for defining the tactical-context of why sprinting occurs during football match play.

The Football Sprint Movement Classification System showed ‘near-perfect’ inter-tester reliability. The most similar previous research attempting to classify the ‘purposeful movements’ completed in football saw ‘moderate’ inter-tester reliability across most categories; slightly lower than the current method (Bloomfield et al., 2007; McHugh, 2012). The greater reliability is likely due to the specific nature of the current classification system. Focusing solely on sprint efforts rather than broader ‘purposeful’ movement, likely allows the system to maintain greater reliability within and between testers. (Bloomfield et al., 2007; Faude et al., 2012). Though using slightly differing categories, it is hoped that the current system is an advancement of the available methods for classifying movement in football.

The system is based upon original work outlined previously to act as a general target movement classification in sport, and specifically football (Jeffreys, 2008, 2016; Jeffreys et al., 2018). No known previous study has applied this system to ascertain the number of different movements in sports. Following minor adaptations for sprinting specific movements, the system has proved reliable and valid. This previously outlined classification system may, therefore, prove to be valid and adaptable for other similar team sports such as Rugby and American Football and could prove a useful system for the designing of training programmes in these sports.

The Football Sprint Tactical-Context Classification System saw ‘almost perfect’ agreement when tested for intra-tester reliability, and ‘almost perfect’ reliability when tested for inter-tester reliability (McHugh, 2012). These results are in agreement with the previous study utilising the categories within the system with high-intensity distance rather than sprinting (Ade et al., 2016). Here, intra-reliability was deemed to be ‘almost perfect’ and inter-reliability similarly ‘strong’. It is thus fair to suggest that the system outlined previously is very applicable for defining the tactical-context of sprints in football alongside its originally intended aim of high-intensity distance. The differences observed between the previous study and the current for inter-tester reliability is likely due to the greater sample used previously.

The current study may benefit further from a greater analysis of reliability. An increase in the sample size would increase the accuracy of these measures. 97 and 66 efforts were used to calculate the intra-reliability and inter-reliability scores respectively across the 8 categories, giving total sample sizes of 776 and 528 for SMC and 194 and 132 for STC. Additionally, though none of the categories varied greatly to the others, further analysis could seek to establish reliability within each category individually. Though, larger samples may be required for each category.

In addition to gross sample size, another key further development to ensure the system is sufficiently reliable to be applied by any practitioner is for the study to be repeated utilising various different teams and playing styles. As the current analysis was completed using a single team’s matches, it may be the case that the system lacks validity and reliability when applied to teams who utilise different playing styles and potentially complete sprint efforts that are more difficult to classify. The current reliability scores are therefore their most accurate when used with the current team only.

The five-stage model (Fig. 3.1) employed for the development of the systems proved successful for the needs of the current study. This is ultimately judged by the development of two reliable systems for the classification of movements and tactical-contexts of sprinting in football. The model allowed for the refinement of previous work completed in the area to suit the specific needs of the current study. Whilst previous literature within the area was lacking (Table 3.1), the model dictated the critical evaluation of the available works (Table 3.2) and the subsequent broad categorisation of the sprinting efforts in football. The broad categorisation phase was based strongly on the previously developed systems, whereas the refinement of these categories to sprinting-specific was the key novel development. This phase ensured the system's specificity for the current purposes and it is believed to be the key phase for ensuring the reliability of the systems where the categories are effectively described in detail to guarantee repeatability.

As noted, the cores of the two systems were derived from previous work. However, development was required for novel processes for their application in sprinting. Here application processes were piloted and compared to the aims of the study to ensure successful development. During the system refinement (Stage 4) it was crucial to accurately define the start and end of a sprint effort to allow for the application of the systems. The model employed supported this crucial stage. Success here was key as it would fundamentally affect the results of the systems.

Thus, it was essential that the sprint efforts could be effectively defined. This was achieved through the support of definitions currently available in the literature and previously outlined methodologies (Barr et al., 2013; Nagahara et al., 2014; Sweeting et al., 2017; Moir et al., 2018). Whilst the quantitative threshold of the sprint effort signalled the maximum velocity portion of the sprint, as discussed, it was necessary to define the initiation and cessation of the effort. This stage of the development of the process was key and appears to have been effective through pilot work and the reliability results.

Additionally, the utilisation of a threshold of 7 $m.s^{-1}$ to consider efforts as sprints may present issues (Sweeting et al., 2017). Shorter distance efforts may be omitted due to the inability to reach sufficient velocity (Barr et al., 2013; Moir et al., 2018). Thus, an understanding of the definition of what constitutes a sprint is crucial to their eventual classification. There is potential for misunderstanding if this definition is not explicitly understood. The ultimate results of the movements completed whilst sprinting in football would likely be different for maximal effort runs of <10 m, where a velocity of 7 $m.s^{-1}$ may be difficult to achieve (Barr, 2013). Thus, the limitations of the current study, where these shorter efforts are potentially excluded, must be understood and accepted when observing any results produced by the system.

Also pertinent to the classification of efforts is the accuracy of the measurement system used to ascertain velocity. In the current study, the match velocity data was derived from camera tracking technology, but due to recent changes in the laws of football, other potential options now exist such as GPS and Localised Positioning

Systems (LPS) technology. This hardware may have the potential to provide greater accuracy for instantaneous velocity (Hoppe et al., 2018). LPS, for example, provides the most accurate direct measurement of velocity, however, involves a costly and logistically difficult system set up. GPS, again a direct measure, may lack accuracy in stadiums with high stands due to signal interference. However, neither method was available at the time the study was conducted, but each method should be considered on its own merits for any future work (Hoppe et al., 2018).

The example outputs from the application of the systems showed interesting early results. For example, the Sprint Movement Classification System, Initiation – Starting Position Sub-Category showed sprint efforts were regularly performed from positions that were not Linear (44%) (Figure 3.4). With further study, this type of data could prove very useful for researchers and practitioners seeking to design speed development programmes in football. Similarly, the outputs from the Sprint Tactical-Context were promising (Figure 3.5). Unexpectedly, the majority of sprint efforts occurred during the Defensive Organisation phase. Additionally, an even split was seen between Transition and Organised phases of play. Again, further investigation could prove fruitful in future training programme design.

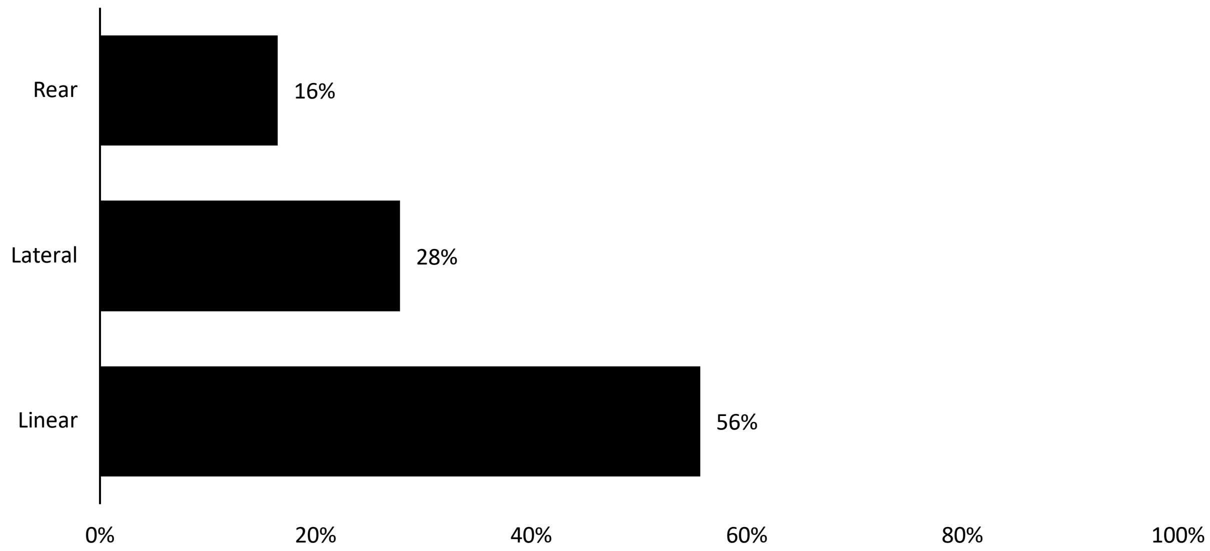

Figure 3.4 Example SMC output (Initiation – Starting Position)

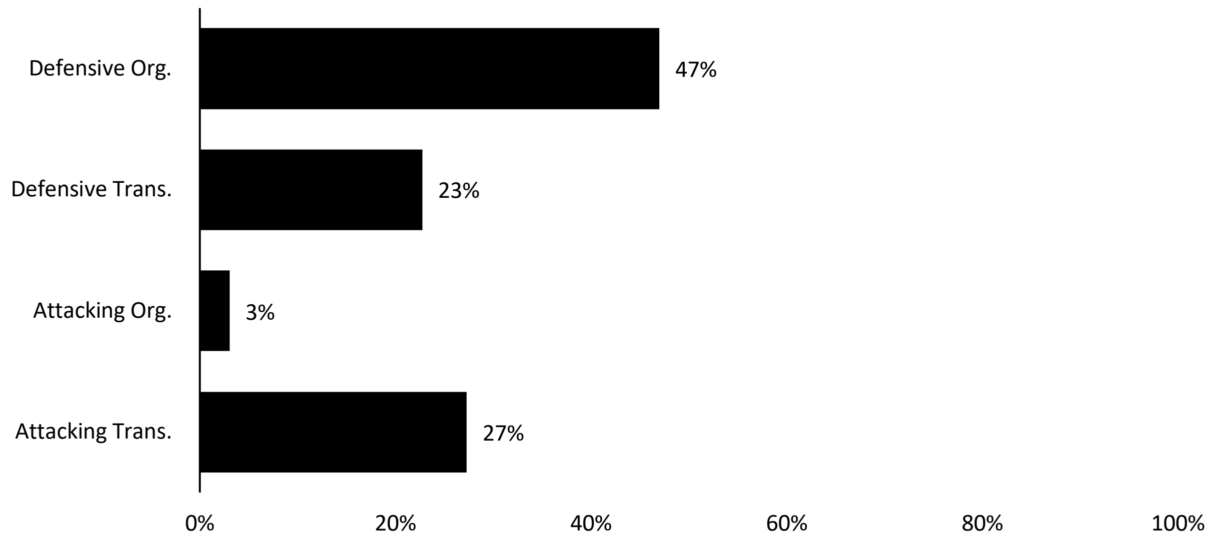

Figure 3.5 Example STC output (Phase of Play)

3.3.1 Conclusions

The development of both classification systems was deemed successful. The model employed to develop the systems was sufficient for current purposes. Each system was observed as satisfactorily reliable to be employed in further research and externally within research and practice. Each will thus be employed in a future study in the current thesis to ascertain firstly the movements associated with sprinting in football, and secondly the tactical-contexts within which these sprints occur.

CHAPTER 4

A CLASSIFICATION OF SPECIFIC MOVEMENT SKILLS

DURING SPRINTING IN PREMIER LEAGUE FOOTBALL.

4.0 PERSONAL REFLECTIONS

During the development of Chapter 3, my role at my current organisation came to an end. This consequently, partly, affected the development of the thesis and the final direction that we decided to take. However, this was never the ultimate driver of the thesis, as beyond increasing the difficulty of the logistics of access to a squad of footballers for a potential intervention, the main aims of the work were not affected. Additionally, this also made the project the sole responsibility of myself and my supervisory team, without any input from within the club. Thus, there was not any particular necessary demand for the seeking of a direct impact upon training practice, the balance between theoretical and practical could be decided upon by the research team.

The systems developed in the study showed me personally a very different side of sprinting in football. I believe most practitioners, similar to myself, assumed sprinting in a match was highly variable but previously we never knew exactly how this looked. I have talked through the systems with many practitioners working in different environments, and I believe that if I was personally still in my previous role this analysis would provide the bedrock of all of my performance enhancement programming; both on an individual player level and as a whole squad of players. This knowledge could inform all interventions from the gym through to the pitch. I also believe that in the future the key is to automate the process to reduce the time-consuming nature of such an analysis. This would take the analysis to another level due to the amount of data that could be collected. In a similar way to how GPS-based load-monitoring systems developed. Marker-less motion detection is currently in very early stages of development but could prove fruitful to such automation.

4.0.1 Research Skills

Whilst collecting data for Chapter 3, it became further apparent that the area was becoming a ‘can of worms’, where the more we dug into the area the further it appeared we needed to dig. The original idea to investigate some of the key movement patterns involved in sprinting in football and attempt to improve performance in them began to seem like jumping ahead of where the understanding in the area truly was. It appeared that much more research was needed to be completed describing sprinting in football. It is from this point onwards that the focus of the thesis became to describe sprinting in football in as much detail as possible. Therefore, the plan for the progression of the studies became:

1. The development of a football Sprint Movement Classification System and a football Sprint Tactical-Context System.
2. The implementation of a football Sprint Movement Classification system.
3. The implementation of a football Sprint Tactical-Outcome Classification System.
4. An investigation into scientific dissemination of these research findings.

It was felt that breaking the studies up accordingly would allow for greater depth to each chapter and better describe sprinting in football. Therefore, the thesis would cover two main questions, of How sprinting is completed in football, and Why sprinting is completed in football. It was hoped that this would provide practitioners with an ability to add further specificity to their training programmes and also begin to develop a better understanding of the exact contexts of sprints, for the future development of assessment and drill design.

Alongside the realisation that the key to progressing the area was to investigate further how sprinting is completed in a match, my change in role, as noted, affected the development of the thesis. Moving on from working within a club full-time, meant that I no longer had guaranteed access to a squad of players for testing. However, this allowed the project to be more independent as it was no longer constrained by the needs of my employer. Thus, this further allowed for the focus to become on describing sprinting broadly rather than any particular intervention-based study that a sponsor may deem required.

Whilst piloting the two systems it became clearer the link that exists between the context of why sprinting occurs, and the movements observed as a result. Ultimately, the context and environment/scenario the athlete is exposed to will dictate the movement patterns they 'select'. At this stage, a large focus of my reading started to be around perception-action coupling and the inherent link between what the athlete observes and the resultant action. The movement patterns quantified in the thesis, and thus seen during a match, are not necessarily the most effective for the given context the athlete faces – they could be successful or unsuccessful in achieving the task outcome. This further increased the importance of understanding why sprinting occurs as this could allow future research to begin to define success in these tasks and potentially assess a player's ability or develop an ultimate performance model. This data would also allow coaches to enhance their players' performance in any common context they may face.

4.0.2 Professional Skills

As discussed, professionally I had always assumed the variable nature of sprinting in football, but there lacked a true quantification to support this assumption. Now with the development of these systems, it is hoped that this is possible and can impact practice at all levels in football. This was supported by discussions I had during the process with elite practitioners in speed development. It was noted how the potential to be able to establish position profiles could directly dictate practice.

During this period my eyes were opened to the area of ecological dynamics and the link between perception and action. This is an area I hadn't previously considered in-depth, and if anything, had disregarded. I previously assumed that this area fell under the remit of the football coaches and that our role as physical performance staff was to enhance the straight-line running speed of players and that the transfer would happen 'organically' during regular football training. However, I now challenge this assumption and believe there is a whole area that performance staff should be looking deeper into. One that is likely a lot more important than improving an athletes' squat strength or maximum velocity capabilities. I hope the next stage of the research further cements this by providing a reliable quantification of these actions.

Further developing these concepts of the specific nature of sprinting in football could potentially improve football coaches understanding of the physical development processes felt important by performance staff. By attempting to contextualise the physical demands of a match better in ‘football language’ it is likely that better buy-in can be achieved. This is opposed to the traditional method of just presenting locomotor distances without any reference as to how this relates to a match. If a coach can better comprehend how sprinting relates to the match, more holistic training practices can be incorporated with the hope of achieving better transfer to match performance.

This area of better contextualising the physical demands within the match is a particularly hot topic at the time of writing the thesis. Thus, from a personal perspective, it provides a great opportunity to develop my own personal brand and become reputable within the subject area. A focus on early dissemination of some of the pilot work completed in Study 1 has allowed me to begin to create interest in contextual sprinting. I believe that employing this strategy has aided me in my understanding of the early findings from the thesis. Disseminating material has certainly encouraged me to develop expertise in the topic.

4.1 INTRODUCTION

When designing training programmes aimed at preparing players for competition or return from injury, it is crucial that a practitioner considers specificity as a fundamental principle of training. The more specific the training activity is, the greater the likelihood of transfer to match performance (Jeffreys, 2011; Brearley and Bishop, 2019). A balance though exists between the amount of overload achievable and the specificity of the training employed (Brearley and Bishop, 2019). However, only by possessing clear knowledge of the contest activities can a practitioner 'reverse engineer' and develop a spectrum of drills and exercises (Ade et al., 2016; Bradley and Ade, 2018; Brearley and Bishop, 2019). These may range from those that are highly specific yet less easily overloaded, to those that lack as high specificity but possess the ability to provide greater overload (Brearley and Bishop, 2019; Jeffreys et al., 2018; Jeffreys, 2011). It is clear that any training intervention should begin with the specific contest activity in mind.

Typical locomotor distances covered whilst sprinting provide a great starting point in designing these programmes for football. However, it stands to reason that a greater understanding of match demands would allow practitioners to be able to further increase the specificity of their practice if required and ultimately enhance subsequent transfer. This distance-based data ultimately lacks the intricate information around how the distance is specifically achieved and as noted can be potentially too reductionist (Bradley and Ade, 2018)

Only by fully understanding the movements associated with sprinting in football can practitioners truly prepare their players for enhanced performance or to prevent injuries. Any assumption that sprinting in football is solely linear (as distance data may suggest), without knowledge of its intricacies, potentially lacks important information. Thus, with increased knowledge, training and injury prevention programmes could be designed accordingly to mitigate these different demands. Different force demands would likely require different strength and plyometric based programming. Thus, there is a need to ensure players are accustomed to tolerating these specific differing demands to reduce the risk of injury (Brearley and Bishop, 2019).

As discussed in Chapter 3 and the review of the literature, by combining standard GPS locomotor distance data, velocity and frequency metrics with a deeper knowledge of the movement patterns associated with these efforts, practitioners can further increase the specificity of the drills they prescribe. These could be 'stand-alone' drills aimed at overloading the physical attributes of the player, or more specific match mimicking drills where the aim is to combine the physical development with highly contextually specific skill development through greater ecological validity (Myszka, 2018; Ade et al., 2016; Jeffreys, 2011).

It is the authors' opinion that information on sprinting to supplement the previously studied high-intensity (Ade et al., 2016) running would prove to be even more valuable for practitioners working in elite football. Due to the increased physical demands, potential performance benefits and inherent injury risks associated with greater velocities, a study looking at the specific movements associated with football sprinting would be of benefit (Faude et al., 2012; Schache et al., 2012; Schuermans et al., 2017). Thus, a Movement Classification System (The Sprint Movement Classification System) outlined previously will be utilised to provide specific detail on how sprints are performed during a football match.

4.1.1 Aims

It is therefore the aim of the current study to provide practitioners with general all position detail around the movements involved in sprinting in football. Thus, allowing the designing of more specific training to further enhance the transfer of skill development to match play, alongside greater physical preparedness.

4.2 METHODS

To ascertain the movements associated with sprinting in football, a previously developed classification system (Chapter 3) was employed. The SMC (Table 4.3) was deemed reliable for its application in research and was thus utilised in the current study with data from Premier League matches. The system allows for match footage to be systematically analysed to comprehensively describe the movements completed whilst sprinting in football. Analysis was completed across the three broad Main Categories of Transition: the movements completed immediately prior to the sprint effort, Initiation: the movements associated with the beginning of the sprint effort, and Actualisation: the movements employed during the sprint effort.

Table 4.1 The detailed Sub-Category descriptions from the Football Sprint Movement Classification System.

Main-Category	Sub-Category	Description
Transition	Transition Movement	*The movements completed immediately prior to the sprint effort.*
Initiation	Starting Position	*The position from which the sprint effort begins.*
	Change of Direction	*The presence of any change of direction from the transition movement to the beginning the sprint effort.*
Actualisation	Acceleration	*The type of acceleration used to complete the sprint effort.*

	Maximum Velocity	*The direction of the sprint effort.*
	Torso Orientation	*The existence of any dissociation of the torso.*
	Action During	*Any possible action completed during the sprint effort.*
	Action End	*Any possible action completed at the end of the sprint effort.*

4.2.1 Sample

All data utilised was secondary data taken from publicly available sources (3.2.6) (Premier League DVMS, ChyronHego). Additional Gatekeeper Consent was obtained from a representative of the club. Each of the analysed team's EPL games from the 2017-18 season were assigned a reference number in ascending order correlating with the chronological order of the matches. 5 home and 5 away matches were then chosen at random from these. These included matches against 9 separate opposition and involved 20 different players. Results of the matches included 3 wins, 4 draws and 3 defeats. The team's formation was classified as 4-5-1 on 5 occasions, 4-4-2 on 3, and 5-3-2 on 2. Whilst primary analysis was focused on all players due to the restriction in sample size, additional analysis was completed between playing positions. Positions were observed via two methods (Table 4.2). Firstly, players were categorised as CB, FB, CM, WM and CF. Additionally, to support the small sample size of these positions, groupings were created based upon the playing positions location on the pitch, Central (CB, CM, CF) and Lateral (FB, WM).

From the 10 matches analysed, 901 total sprint efforts were recorded. These matches averaged 14 players per match and 90 total sprint efforts each. As no sprints were completed by Goalkeepers over the match sample, each match involved 10 outfield players at one time. Thus, inclusive of substitutes, each player averaged 9 sprint efforts per match. An average 1,661 m of Total Sprint Distance was observed per match. Thus, each sprint effort averaged 18.5 m.

Table 4.2 Detail of the sample size for the number of different players within each playing position and the total number of players within each position across the 10-match sample.

	CB	FB	CM	WM	CF	Central	Lateral
Number of different players	*4*	*4*	*8*	*6*	*3*	*15*	*9*
Total number of players across the match sample	*24*	*22*	*34*	*27*	*21*	*79*	*49*

4.2.2 Protocol

The protocol developed in Chapter 3 was systematically employed for all sprint efforts of the analysed team, in each of the 10 matches. This included all sprints completed by all players involved on the analysed team. Sprint efforts of players who did not complete the full match were included, alongside those of players that were substituted into the match. This allowed for analysis of a full team across the whole match, to avoid any skewing of average outputs. Thus, 100% of the match time was analysed for 10 outfield positions. Match sprint time-stamps for each player during each match were ascertained (Chapter 3 – 3.2.6) and these were then systematically analysed according to the protocol outlined in Chapter 3 (3.2.6.1). Thus, each sprint consisted of nine descriptive Action points (Table 4.3).

Table 4.3 An outline of the Football Sprint Movement Classification System, detailing all categories and Action descriptions.

Main-Category	**Sub-Category**	**Action**	**Description**
Transition	Transition Movement	Static	***No movement*** *of the feet*
		Jockeying	*Shuffling and readjustment steps* ***without significant displacement***
		Linear	***Forward*** *direction of travel at any velocity*
		Ball	*Dribbling with the* ***ball***
		Lateral	*Shuffling of the feet to travel in a* ***sideways*** *direction, no crossover*
		Diagonal	*Crossover steps to travel in a* ***diagonal*** *direction*

		Rear	*Travelling directly **backwards** to the direction of facing*
		Rear Plus	*Travelling backwards to the direction of facing with the addition of **shoulder drops** for readjustment*
		Deceleration	*Significant **deceleration mechanics** including landing, passing, tackling and receiving the ball*
Initiation	Starting Position	Linear	*Typical initiation of an acceleration in a **forward** direction*
		Lateral	*The completion of a **hip turn** movement where the foot opposite to the intended sideways direction of travel steps over the other to set up for standard acceleration mechanics*
		Rear	*The completion of a **drop step**, followed by a hip turn to initiate standard acceleration mechanics in the direction opposite to the way the individual is facing*
	Change of Direction	None	***No** alteration to the current direction of travel*
		Lateral	*The completion of a **cutting step**, where the foot opposite to the intended direction change is planted outside the centre of mass to initiate a sideways change of direction. Typically, short contact times*

		Front-Back	*The completion of a **plant step** where momentum in the forwards direction is stopped and a movement in the opposite direction is begun. Typically, longer contact times than cut stepping*
		Back-Front	*The completion of a **plant step** where momentum in the backwards direction is stopped and a movement in the opposite direction is begun. Typically, longer contact times than cut stepping*
Actualisation	Acceleration	Explosive	*A **rapid acceleration** including a sudden increase in leg turn over and overall velocity*
		Rolling	*A **gradual acceleration** where an increase in velocity is achieved over a more prolonged period. Less of a sudden increase in leg turnover.*
	Maximum Velocity	Linear	*The upright running portion of the sprint is completed in a completely **forward** direction*
		Curved	*The upright running portion of the sprint is completed with the presence of any degree of **curvature**. Typically involves a lean of the torso towards the direction of the curve and the placement of the inside foot inside the centre of mass*

	Torso Orientation	No Rotation	*During the upright running portion of the sprint the torso is kept facing directly* ***forwards***
		Rotation	*During the upright running portion of the sprint is completed with the presence of any amount of rotation at the* ***torso away from the direction of travel***
	Action During Sprint	None	***No other action*** *is performed during the sprint*
		Duel	*During the sprint there is presence of a* ***duelling action with another body****. Any action that is not typically of standard sprinting mechanics*
		Ball	*During the sprint there is some* ***ball involvement,*** *including a pass, or dribbling with the ball where the individual kicks the ball and sprints after it*
	Action at the End of Sprint	None	*The sprint* ***does not*** *end with any action*
		Duel	*The sprint ends with a duelling action. Including a* ***tackle, or engagement of another body***
		Ball	*The sprint ends with an action including the* ***ball*** *such as a pass, shot, header or dribble*

4.2.3 Statistical Analysis

Raw data was collected for each sprint and stored anonymously in Microsoft Excel (Microsoft Corporation, Redmond, WA, USA). This data was then processed and formatted for analysis in a common statistical analysis software (SPSS, Chicago, IL, USA). Processing included the establishing of means for each Action category of each match. Following the confirmation of normality utilising Shapiro-Wilk testing, a one-way analysis of Variance (ANOVA) was completed to determine any statistical differences in the mean frequency of each category. Tukey HSD post hoc was utilised for multiple comparison. Significance was set at $P < 0.05$. All data, unless otherwise stated, was presented as mean and standard deviation. Following this, Cohen's *d* effect sizes (ES) were calculated to ascertain the magnitude of these differences. Magnitudes were set, in line with previous work, as Trivial (<0.2), Small (>0.2-0.6), Moderate (>0.6-1.2), Large (>1.2-2.0) and Very Large (>2.0) (Batterham and Hopkins, 2006; Ade et al., 2016).

4.3 RESULTS

Following the statistical analysis, results are presented firstly and primarily across all playing positions. These are presented by the system's Main-Categories of Transition Movements, Initiation Movements and Actualisation Movements. Following this, results are displayed according to playing positions. However, due to a restricted sample size (Table 4.2), these are presented only as percentages of efforts for secondary consideration.

4.3.1 All Positions

4.3.1.1 Transition Movements

Sprinting in football was observed as beginning from a variety of different Transition Movements. All categories of movements were seen across the sample used. Statistically significant differences were observed between the type of Transition Movements utilised ($P < 0.01$) (Fig. 4.2). 68% of all efforts were categorised as Linear or Diagonal (45% & 23%) (Fig. 4.1).

As discussed, two categories (Linear and Diagonal) occurred statistically significantly more often than the remaining categories ($P < 0.01$) (Fig 4.2). The most common transition movement used for all positions during a match was Linear (41 ± 12), occurring significantly more often than all other movements (ES: 2.1-4.3, $P < 0.01$). The second most common was Diagonal (20 ± 4), which occurred significantly more frequently than all other movements except Linear (ES: 3.1-5.7, $P < 0.01$). These two movements can be thought of as predominantly forward-facing and travelling strategies.

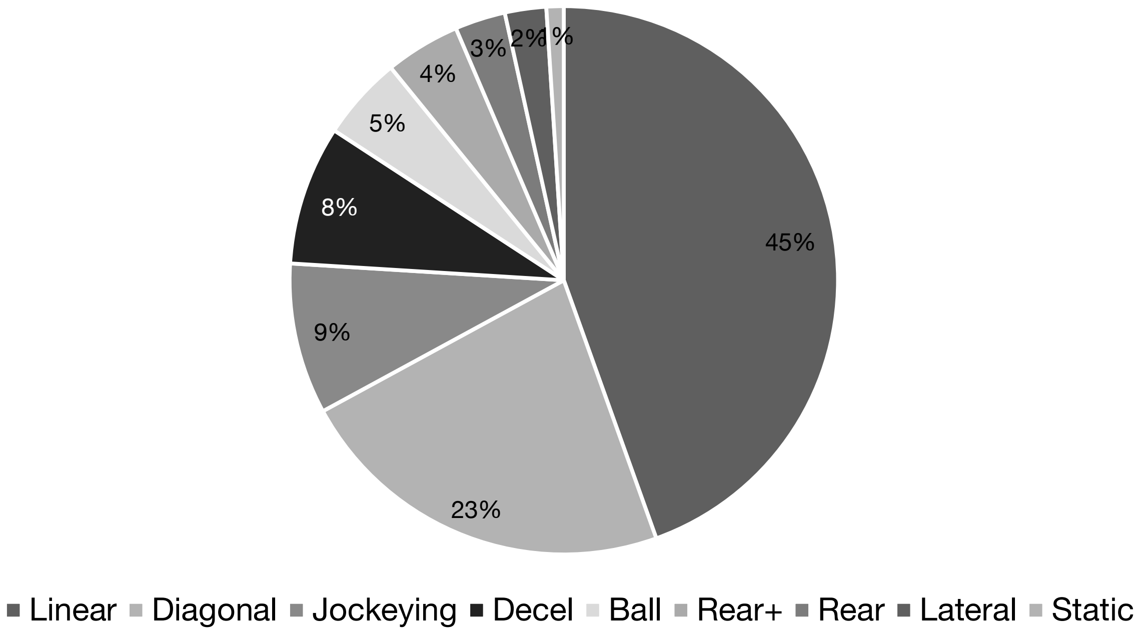

Figure 4.1 Average percentage of Transition Movements utilised.

As noted, all categories were witnessed in the analysis. However, no other statistically significant differences existed between the remaining seven categories. Of these, the least common movement utilised immediately prior to a sprint during a match was Static (1 ± 1), accounting for only 1% of efforts. All remaining categories (other than Linear and Diagonal) occurred during less than 10% of sprint efforts. The largest of these were Jockeying, 8 ± 3 (9%) and Deceleration, 7 ± 3 (8%).

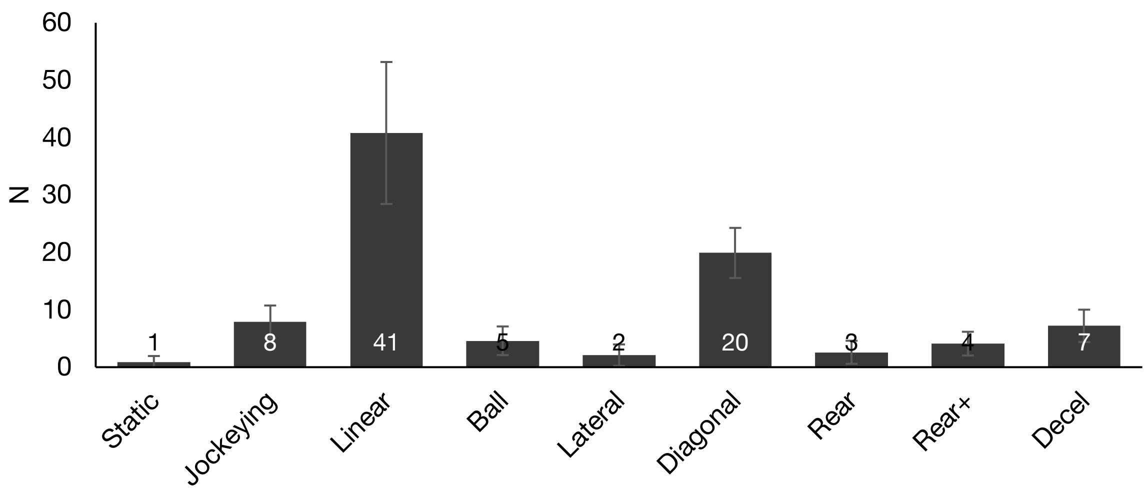

Figure 4.2 Mean and Standard Deviation of the number of sprints completed during a match from different Transition Movements.

4.3.1.2 Initiation Movements

Sprints in football were observed as initiating from a variety of Starting Positions and Changes of Direction. Statistically significant differences were seen across both Sub-Categories ($P < 0.01$). All categories within the classification system were observed in the sample of matches. A Linear Starting Position was clearly the predominant strategy employed in the current study, occurring in 63% of sprint efforts (Fig. 4.3). This was followed by Lateral (21%) and lastly Rear (15%). When observing any Change of Direction used to initiate the sprint effort, no change in direction was the most commonly seen (48%), followed by Lateral (44%), Front-Back (7%) and Back-Front (1%) (Fig. 4.4). Whilst no Change of Direction was the most commonly observed, when categories consisting of a change in direction (Lateral, Front-Back, Back-Front) are combined they appear most frequently (52%) (Fig. 4.5). Thus, most sprints occur following a change in direction.

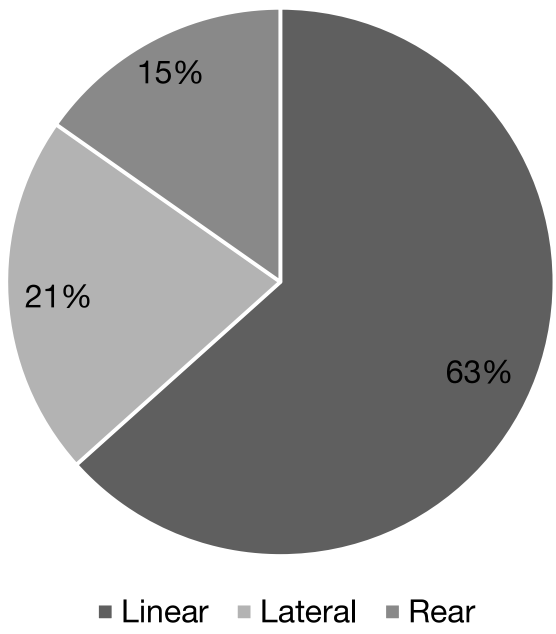

Figure 4.3 Average percentage of the different Starting Positions utilised.

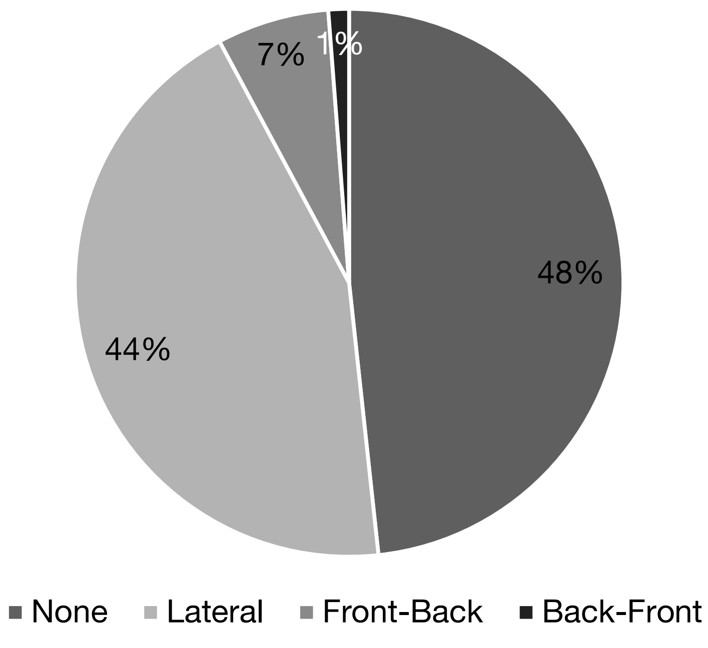

Figure 4.4 Average percentage of the different Changes of Direction utilised

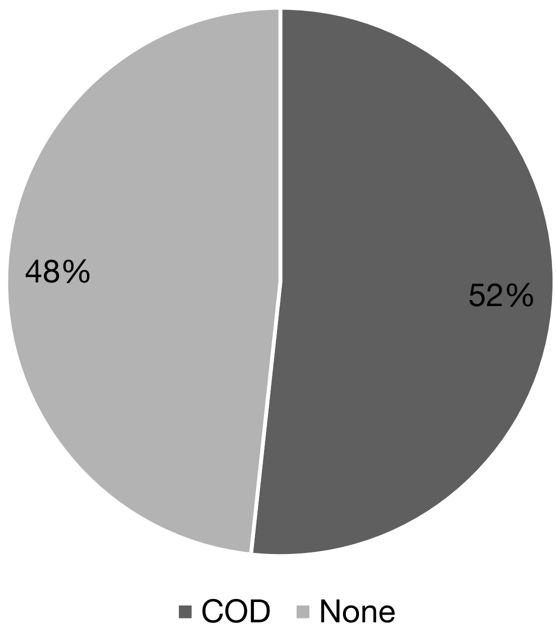

Figure 4.5 Average percentage of Changes of Direction utilised, grouped by COD (Lateral, Front-Back, Back-Front) and None.

As noted, Linear was the most frequently observed Starting Position in football match play (57 ± 10) (Fig. 4.6). This occurred significantly more frequent than Lateral and Rear positions (ES: 5.0-5.3, $P < 0.01$), at least three times more often than both of the other categories. Further, no statistically significant differences were seen between Lateral and Rear Starting Positions (19 ± 3 & 14 ± 5). However, worth consideration, is that over one-third of efforts in the study were not completed from Linear Starting Position.

Most sprints in football occur within the category of no Change of Direction immediately prior to initiation of the effort (44 ± 11) (Fig. 4.6). No Change of Direction (ES: 4.9-5.6, $P < 0.01$), and Lateral Changes of Direction (ES: 4.3-4.9, $P < 0.01$) occurred statistically significantly more frequently than Back-Front and Front-

Back. Of the categories that included a Change of Direction, Lateral was the most frequently occurring (39 ± 11). Players rarely complete sprints from a Back-Front or Front-Back Change of Direction (1 ± 1, 6 ± 2). However, as noted, when combined most sprint efforts in football begin with a type of change of direction (Fig 4.5).

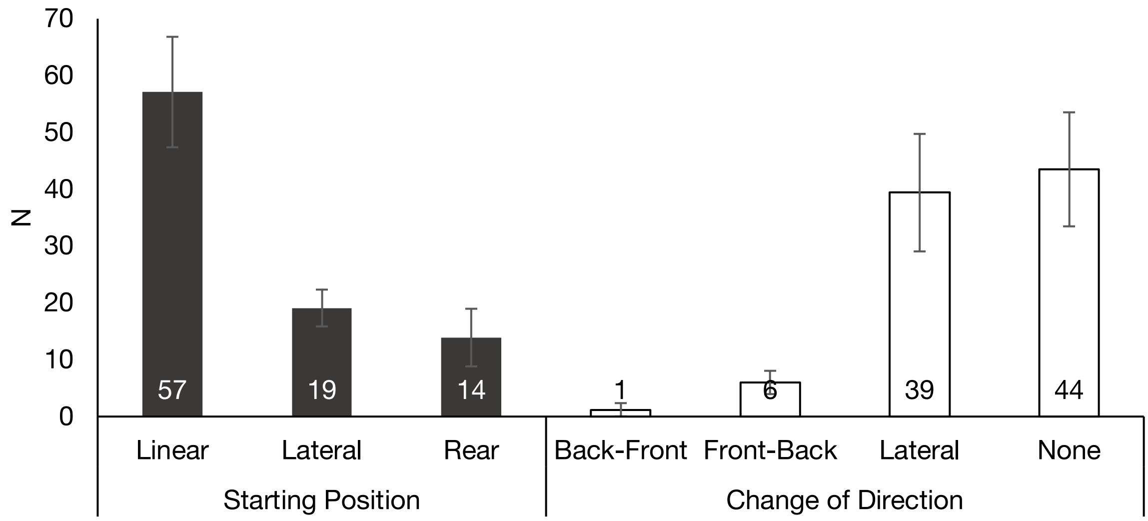

Figure 4.6 Mean and Standard Deviation of the number of sprints completed during a match from different Starting Positions and Changes of Direction.

4.3.1.3 Actualisation Movements

The Actualisation category consisted of five descriptive data points for each sprint effort. Variation was observed across all five of these Sub-Categories and all possible Actions were observed within each (Fig. 4.8). The majority of sprint efforts in football included some degree of curvature (78%) during the Maximum Velocity phase of the sprint (Fig. 4.7). Whilst during Acceleration, 59% of sprints were completed Rolling as opposed to Explosively. Further, both During (81%) and at the End (46%) of these sprint efforts, no skill involvement was the most commonly observed action. The final category observed that the majority of efforts involved a degree of rotation at the Torso (56%).

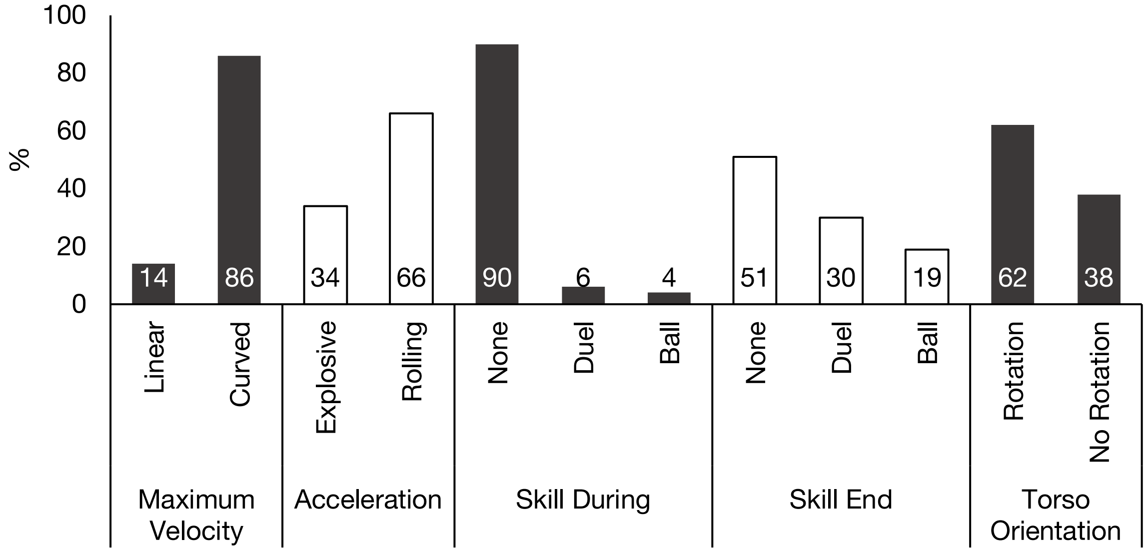

Figure 4.7 Average percentage of movements employed defined by their Actualisation categories.

All Actualisation categories showed statistically significant differences ($P < 0.01$). Sprints consisting of any amount of Curvature (78 ± 13) during their Maximum Velocity phase were statistically more frequent than those categorised as solely Linear (12 ± 3) (ES: 7.2, $P < 0.01$). Alongside this, Rolling Accelerations (59±8) were statistically significantly more frequent than Explosive Accelerations (31 ± 9) (ES: 3.2, $P < 0.01$). During the sprint effort, No Action (81 ± 11) was the most frequently observed, which occurred significantly more frequently than Duel (5 ± 3) and Ball (4 ± 2) (ES: 9.1-9.5, $P < 0.01$). Yet, no significant differences were seen between these final categories. Similar to During, but less pronounced, at the End of the sprint efforts No Action was again the most frequent (46 ± 10), occurring significantly more frequently than both Duel (27 ± 7) and Ball (17 ± 4) (ES: 2.2-3.8, $P < 0.01$). Additionally, Duel was observed to be significantly more frequent than Ball at the End of the efforts (ES: 1.7, $P < 0.05$). However, when combined 49% of sprints in football ended with a type of action (Duel or Ball) (Fig. 4.7). Whilst sprinting, the majority of efforts were completed with Torso Rotation (56 ± 11) away from the direction of travel, statistically significantly greater than No Rotation (34 ± 6) (ES: 2.65, $P < 0.01$)

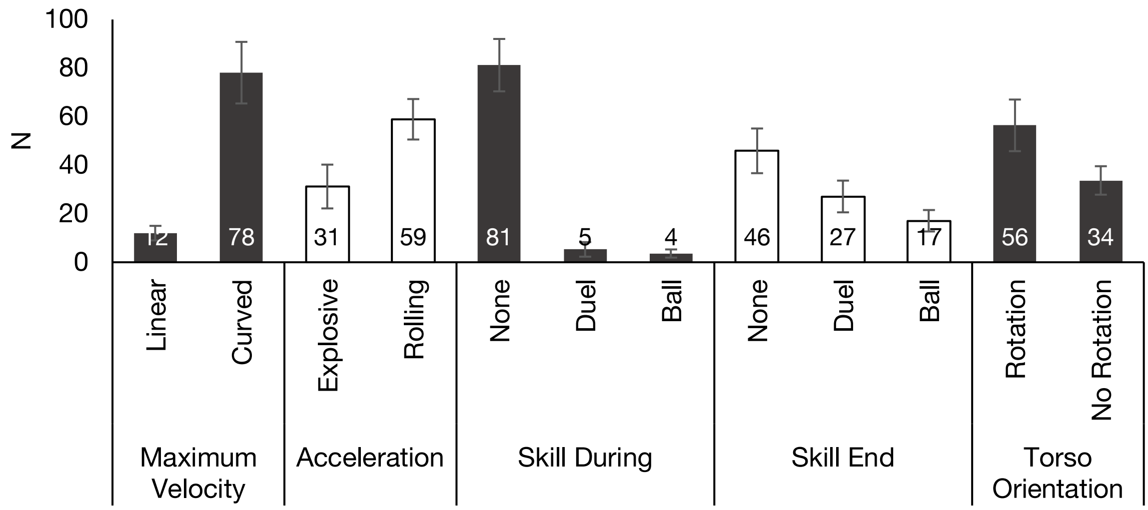

Figure 4.8 Mean and Standard Deviation of the number of sprints completed during a match described by their Actualisation categories.

4.3.2 Summary

Whilst the study focused on Sub-Category analysis, when observing the results combined, the most common sprints completed during a football match can be seen. The most common average Actions within each category are displayed in Table 4.4. The majority of efforts involve linear starts form linear transition movements and with no change in direction. These efforts are most commonly with a rolling acceleration. Whilst sprinting, efforts typically possess some amount of curvature and torso rotation. Alongside this, the majority of efforts are completed without any skill during or after. Whilst clear patterns exist in the most common types of sprint efforts in football, it is important to note that all categories were observed across the analysis and should thus be considered in any conclusions drew.

Table 4.4 List of the most common Action within each Sub-Category.

Transition Movement	Linear	*45%*
Starting Position	Linear	*63%*
Change of Direction	None	*48%*
Maximum Velocity	Curved	*86%*
Acceleration	Rolling	*66%*
Skill During	None	*90%*
Skill End	None	*51%*
Torso Orientation	Rotation	*62%*

4.3.3 Positional Detail

Sprint efforts are presented additionally by playing position. However, due to inherent restrictions in sample size as a result of analysing a single squad from genuine match data, this was completed as a secondary analysis (Table 4.3). Thus, results are solely presented as percentages of efforts completed. As discussed, players were grouped in positions by two methods. Firstly, by reported, typical football playing positions (FB, CB, WM, CM, CF) and additionally by ‘position location' (Central and Lateral). This supplementary grouping allowed for a somewhat larger sample size (Table 4.3).

4.3.3.1 Transition Movements

When observing Transition Movements completed by Playing Position, large differences are seen (Table 4.5). All positions completed the majority of their sprints from Linear movements, followed by Diagonal. As discussed, these are the most 'typical' forward-moving transition movements. When grouped together, CM were seen to complete the greatest proportion of sprints from Linear and Diagonal movements (76%), whereas WM completed the least (55%).

Table 4.5 Average percentage of sprints completed during a match from different Transition Movements, categorised by playing position.

Position	Static	Jockeying	Linear	Ball	Lateral	Diagonal	Rear	Rear+	Decel.
FB	1	7	40	4	2	28	4	7	7
CB	2	7	38	0	5	35	0	9	4
WM	2	14	32	10	2	23	3	4	10
CM	0	4	63	2	4	13	2	4	8
CF	2	11	43	6	0	23	3	4	8
Central	1	7	48	3	3	24	2	6	1
Lateral	2	11	36	7	2	26	4	6	2

Beyond Linear and Diagonal (the most frequent for all positions), the next most common movements utilised were: FB - Jockeying and Rear (7%), CB - Rear+ (9%), WM - Jockeying (14%), CM - Deceleration (8%), and CF - Jockeying (11%). Thus, whilst the most common movements are similar across positions, differences exist beyond this. This could have potential implications for how specific positions are prepared for match play.

Certain positions appear to use more varied Transition Movements than others. As noted, 45% of WM sprints are completed from positions that are not typical forward direction movements (Linear and Diagonal). This is particularly different from CM where only 14% are from non-forward direction movements (Table 4.5). This is further evident by CB recording 0 sprints in two of the categories (Ball and Rear). FB and WM were the only two positions to record sprints within all movement categories. These positions are both categorised as Lateral playing locations.

Lateral categorised positions complete 38% of sprints from non-forward direction Transition Movements, as opposed to only 28% for Centrally located positions. This is predominantly due to 12% less Linear movements for the Lateral positions. Lateral positions notably complete more sprints from Jockeying and Ball Transition Movements (+4% and +4%). These differences are likely due to constraints such as the positions location on the field and the unique tactical demands.

4.3.3.2 Initiation Movements

When observing Initiation Movements by Playing Position, CM was noted as the position completing the greatest proportion of their sprints from a Linear Starting Position (75%), whilst WM the least (54%) (Fig. 4.9). Consequently, WM completed the greatest proportion of sprints from a Lateral Starting Position (28%) and CM the lowest (10%). These findings support the similar results for Transition Movements. CB was the position to complete the greatest proportion of sprints from a Rear Starting Position (20%), with FB the least (11%). It is clear that playing position has an effect on the Starting Position that sprints in football are completed from.

When playing positions are grouped by their location, the major difference observed is more frequent Lateral Starting Positions to sprint efforts for Laterally located positions (+8%). This results in a reduced proportion of sprints from Linear positions (-5%). This may be as a result of Lateral positions typically being located on the sides of the pitch, and the ball likely predominantly featuring in the centre of the field. Players may be observing play building in the centre of the field and sprint in a lateral direction down either side.

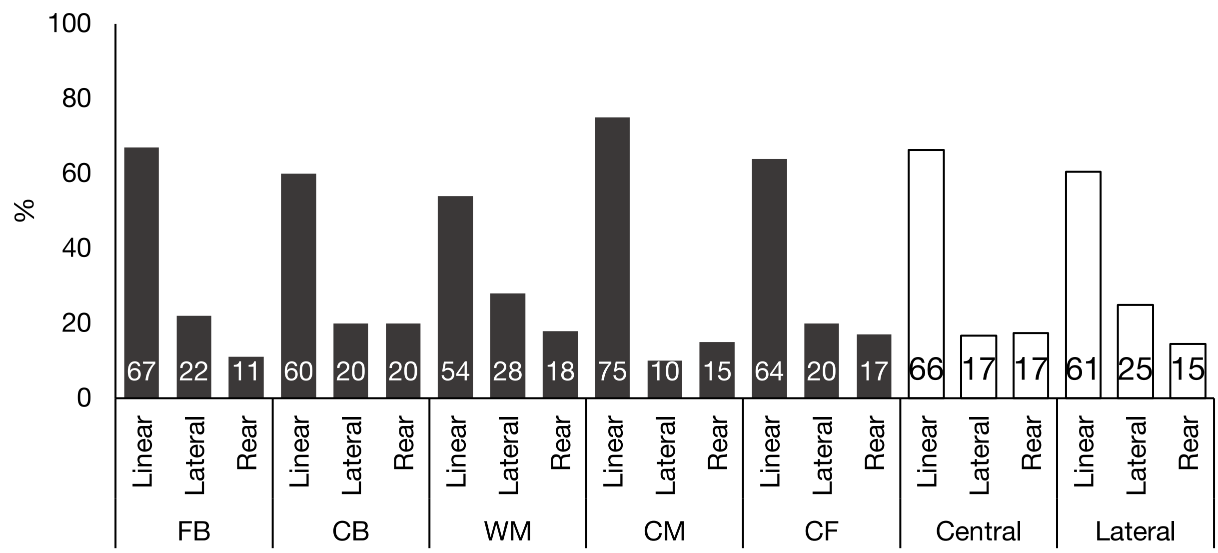

Figure 4.9 Average percentage of sprints completed during a match from different Starting Positions, categorised by playing position and position locations

Of the five Playing Positions, three of these completed the greatest proportion of their sprints from No Change of Direction: FB, 52%; WM, 48%; CM, 61% (Fig. 4.10). Whereas for CB and CF, the most common Change of Direction was Lateral. This suggests differing demands between playing positions. However, CF and CB will typically be in direct competition during a match and may thus complete similar movement patterns as a result. Across positions, CF completed the smallest proportion of sprints with No Change of Direction compared to all others (37%), suggesting demand for sprints completed in multiple different directions. Though Back-Front and Front-Back Changes of Direction were generally rare, 8% of a CB sprints began with a Front-Back direction change, the most of all positions. Due to the profile of the position, these could be key match determining efforts.

Little differences existed when the positions were grouped by location. Lateral positions completed 7% more efforts with No Change of Direction compared to Lateral Change of Direction, contrasted with a 2% difference for Centrally located players. Suggesting, slightly higher demand for changes in direction immediately prior to sprint efforts for these centrally located players. However, broadly the position’s locations are similar with less than 10% of efforts coming from Front-Back and Back-Front. Within the Initiation Movements category, the principal differences due to position location were seen in the Starting Position of sprints.

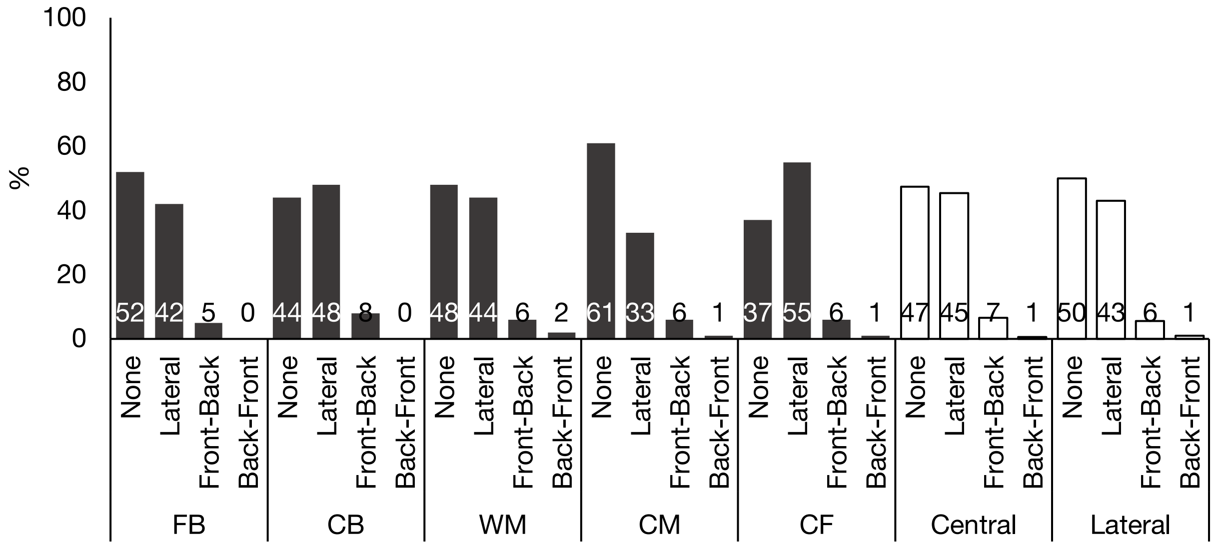

Figure 4.10 Average percentage of sprints completed during a match with or without a Change of Direction, categorised by playing position and position location.

4.3.3.3 Actualisation Movements

All playing positions completed the majority of their sprints with an amount of curvature, rather than strictly Linear. CB completed the greatest proportions of their sprints Linearly (17%), whilst FB, WM, and CM completed the least (12%) (Fig. 4.11). However, no major differences were seen between positions. Only small differences were seen when Playing Positions were grouped by location also. A 3% greater proportion of sprints consisted of curvature for Lateral positions compared to Centrally located positions.

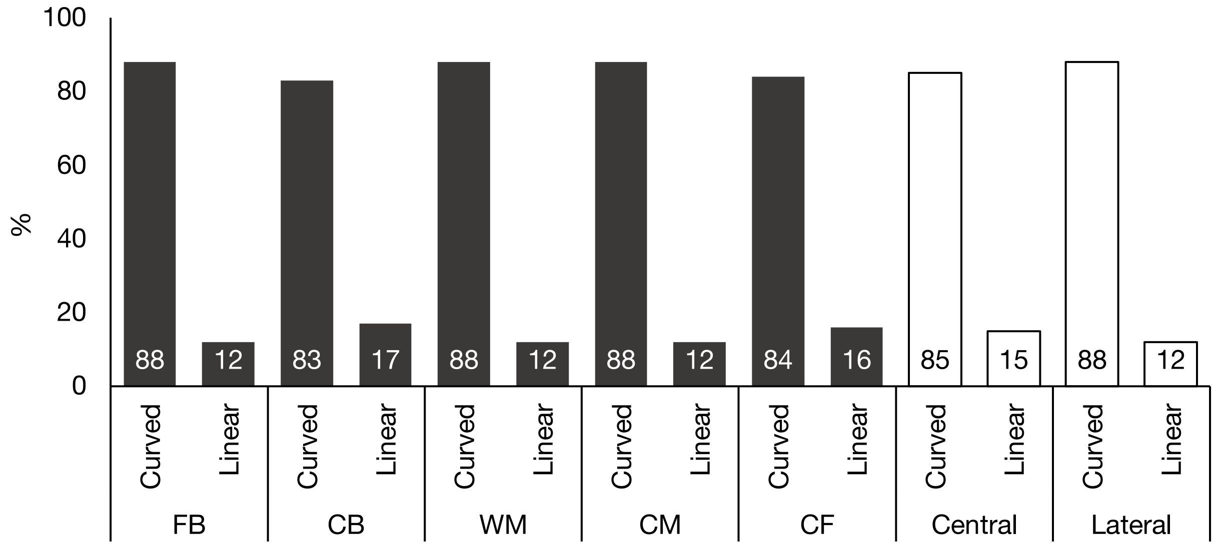

Figure 4.11 Average percentage of sprints completed during a match that consisted of linear or curved Maximum Velocity, categorised by playing position and position location.

All playing positions completed the majority of their sprints with a Rolling Acceleration, rather than Explosive (Fig. 4.12). CM completed the greatest percentage of their sprints with Rolling Accelerations compared to other positions (78%). Conversely, WM exhibited the lowest proportion of Rolling Accelerations (61%) and thus the greatest Explosive (39%). Differences were also seen when players were grouped by their position location. Lateral positions completed 7% less Explosive Accelerations and thus 7% greater Rolling.

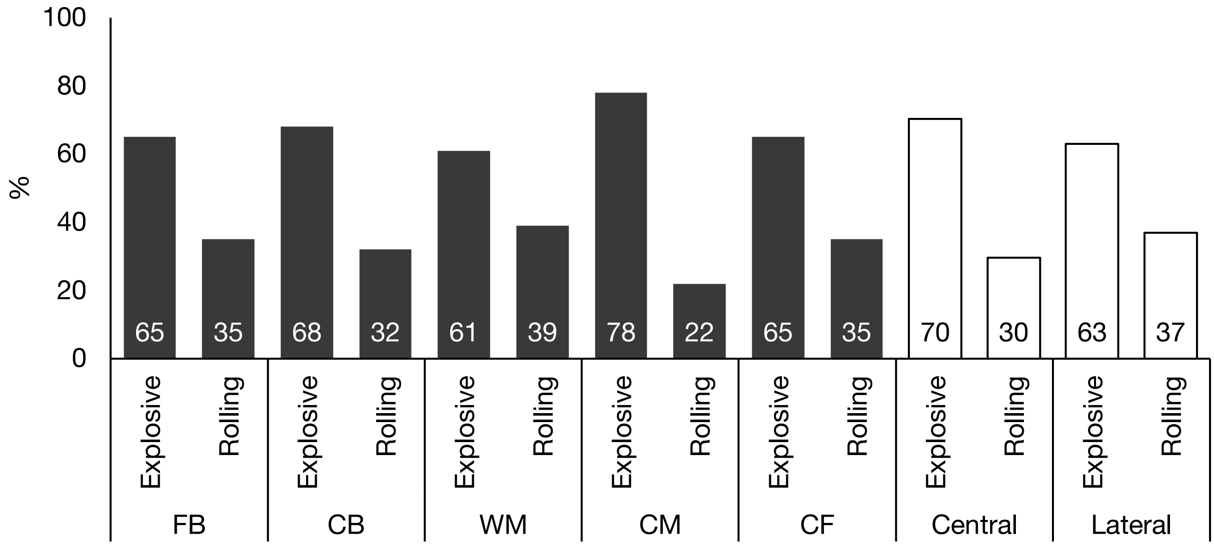

Figure 4.12 Average percentage of sprints completed during a match by Acceleration type, categorised by playing position and position location.

During the sprint effort, all playing positions most common action was None. All positions, except WM, second most common action was Duel, followed by Ball (Fig. 4.13). Whereas WM second most common action was Ball (7%), and lastly Duel (3%). CF completed the greatest amount of actions during their sprint efforts (14% - Duel & Ball), the majority of which were Duelling actions (9%). Conversely, FB and CM completed the least amount of Actions during their sprint efforts (6% - Duel & Ball). The principal difference between Lateral and Central positions appears to be Central positions completing 3% more sprints that required a Duel with the opposition. This is mirrored by Lateral positions completing 3% more efforts with Ball involvement during the sprint. Central-based positions are likely involved in sprints in the more congested centre of the pitch than their Lateral counterparts, leading to more Duelling opportunities.

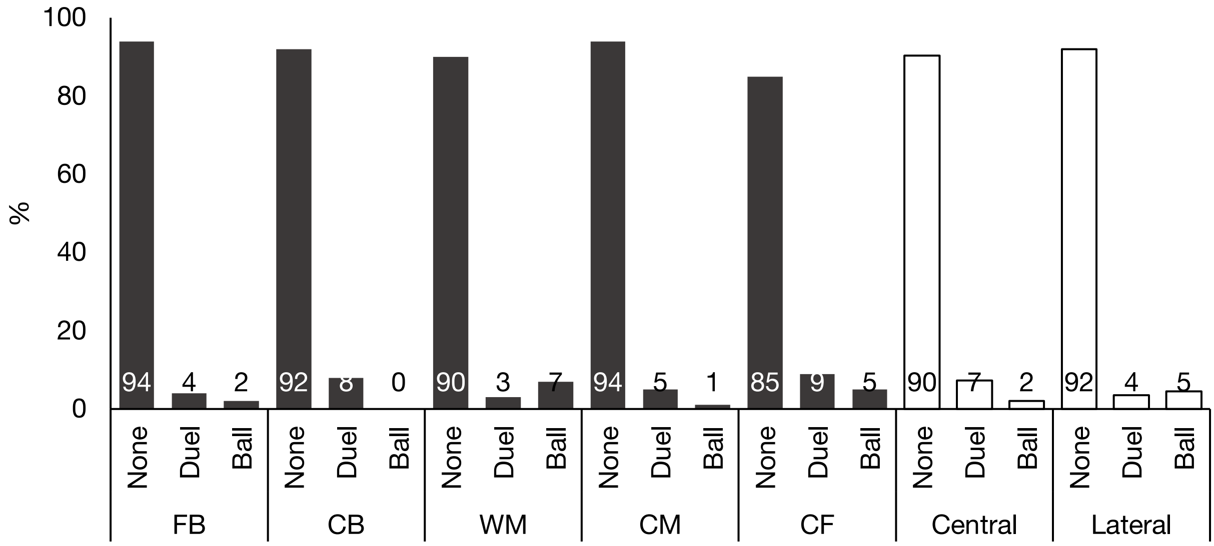

Figure 4.13 Average percentage of sprints completed during a match that consisted of any action during the effort, categorised by playing position and position location.

For all playing positions, the greatest proportion of sprints Ended with No Action (Fig. 4.14). The second greatest proportion of sprints ended with Duel for all positions followed by Ball, except FB whose second most frequent action was Ball (31%), followed by Duel (22%). CM completed the greatest proportion of their sprints without any action at the end (64%), conversely, FB and CF completed the most (53% - Duel & Ball). Within the categories, FB was the position to End the greatest proportion of their sprints with Ball (31%) and CM the lowest (53%). CB was the position to complete the greatest proportion of their sprints ending in Duel (37%) and FB the lowest (22%). Similar to Action During, Central positions are more likely to End their sprint efforts with a Duel (+6%) than their Lateral counterparts. The Lateral positions complete more sprints ending in a Ball skill (+13%), and more likely to complete any type of Action, (+6%).

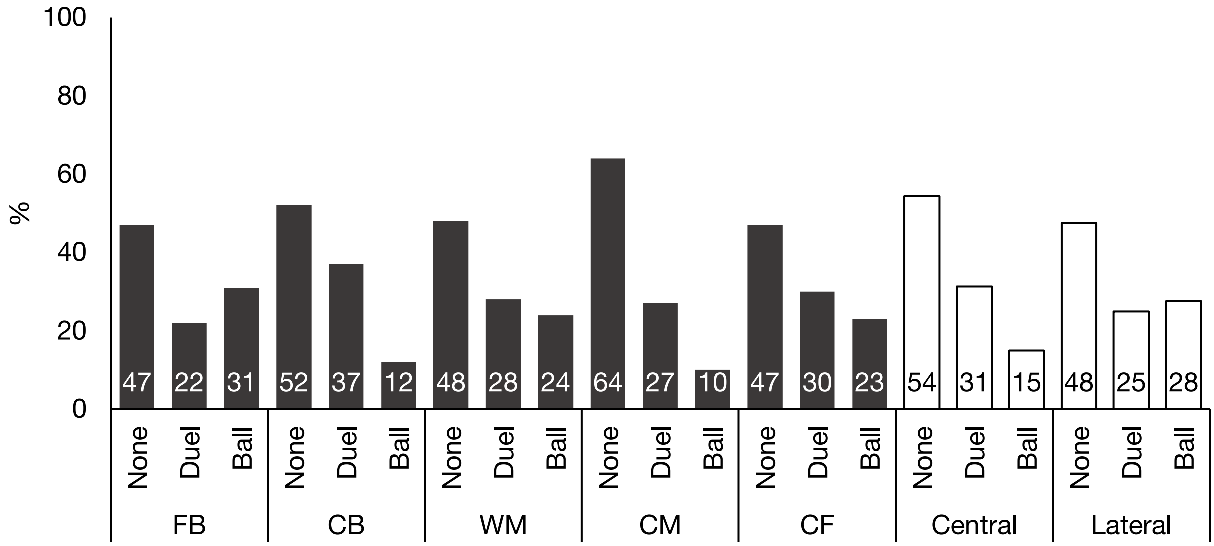

Figure 4.14 Average percentage of sprints completed during a match that consisted of any action at the end of the effort, categorised by playing position and position location.

All positions completed the majority of their sprints with a Rotated Torso (Fig 4.15). WM was the position to complete the smallest proportion of their sprints with a Rotated Torso (57%) and FB the greatest (72%). The two defensive positions (FB & CB) completed a greater proportion of their sprints with a Rotated Torso compared to all other positions (71% & 60%). Possibly as a result of their defensive roles in the team, where they are likely observing attacking players during sprint efforts. Little difference was observed in the position location categories for the frequency of sprints completed with Torso Rotation. Both Central and Lateral position locations completed the majority of their efforts with some degree of Torso Rotation with very little differences between them.

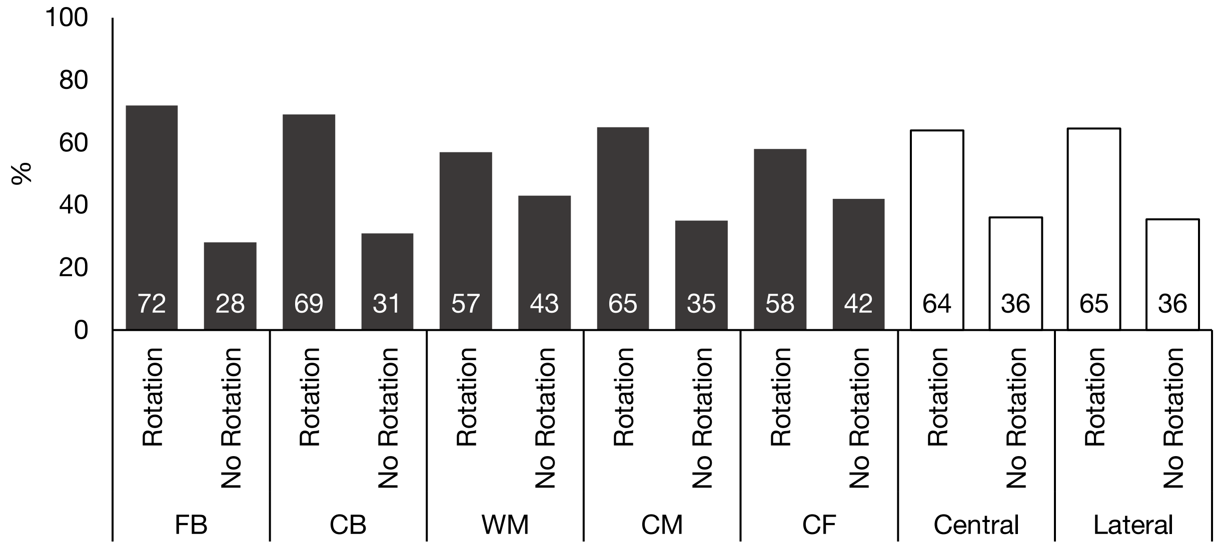

Figure 4.15 Average percentage of sprints completed during a match that consisted of Torso Rotation, categorised by playing position and position location.

4.4 DISCUSSION

The current study aimed to provide practitioners with detail on the specific movements involved in sprinting in football. Sprinting occurs from and with a variety of different movement patterns. Whilst this variation is clear, certain movements occur more frequently than others. The results show sprints in football regularly begin from a linear initiation position, without a change of direction (Fig. 4.6) and from forward travelling (Linear and Diagonal) transition movements (Fig. 4.2). These sprints are often completed with an amount of curvature and an instance of torso rotation (Table 4.4) (Fig. 4.8). Sprinting in football also typically ends with an action such as duelling with an opponent or involvement with the ball and are attained from a gradual acceleration (Fig. 4.8). Additionally, these movements likely differ between positions. This information will provide practitioners with a greater depth of detail to base their conditioning programmes off. Through this enhanced understanding of match-demands, highly specific drills can be designed to replicate these actions.

Observed movement in a sport is thought to be influenced by the interplay between various Task (tactical), Environmental (both physical and socio-cultural variables) and Organismic (the individual performer's characteristics) constraints (Seifert and Davids, 2017; Myszka, 2018). These constraints interact to create the boundaries for the 'perceptual-motor workspace', which dictates the problems faced by the athlete at a given time (Myszka, 2018). The current study shows that whilst sprinting in football appears to consist of a variety of different movements, there is a clear tendency for sprints to occur from what could be classed as 'typical' positions.

These are positions that would resemble more classically defined sprints, such as those seen in Track and Field. Within the categories of Transition, Change of Direction and Initiation, those classed as linear or forwards tend to be the most commonly observed. For example, Linear and Diagonal Transitions (67%), No Change of Direction (48%), and Linear Initiations (63%) (Fig. 4.1, 4.3 & 4.4). This is in line with a previous study on high-intensity efforts, where the majority were preceded by turns of less than 90° (Ade et al., 2016). It would be reasonable to assume that these types of efforts are faster, and more physiologically and biomechanically efficient than efforts requiring greater changes of direction and varying initiation positions (Besier et al., 2003; Osgnach et al., 2010). These 'typical' efforts do not demand that a player performs a hard change in direction prior to the sprint effort, which would likely require more time and energy to complete. The current study is unable to wholly distinguish the cause of this prominence of 'typical' sprinting movements in football. The constraints imposed during the match may dictate this outcome, or the individual's skill level may mean they perceive affordances (opportunities for action) differently which leads to different action outcomes that may have been seen elsewhere.

Previous research has shown that higher level players sprint less during a match than their lower-level counterparts (Bradley et al., 2013). These higher-level players appear to be more selective with their high-intensity efforts, conserving their energy for the most crucial moments of a match. Additionally, it is generally accepted that more skilled performers are able to utilise postural information of an opponent to anticipate intention (Murphy et al., 2018). It could thus be potentially the case that the highly-skilled players in the current study (EPL) attempt to 'default' to these linear-type efforts when possible as a means of efficient movement. The ability to anticipate an upcoming sprint effort and the consequent reorientation of one's direction of travel into the observed 'typical' patterns seen could therefore be a developed skill possessed by players. This would be an efficient strategy for conserving one's energy and ensuring maximal possible effectiveness to each sprint effort. However, further study across playing standards would be required to fully support this theory by comparing more skilled with less skilled footballer players and the movement strategies employed.

Nevertheless, it appears the discussed constraints at times may dictate that these more linear efforts are not possible. Leading to the application of movements that may be thought of as less time and energy-efficient in comparison. Across the categories discussed above, the results show that ~30-50% of efforts do not possess these 'typical' linear movements. These differences become even clearer when broken down by playing position. For example, a WM will Initiate 46% of their sprint efforts from non-linear positions, compared to 25% for CM. It is thus reasonable to assume that the match, a player's position within the match, a team's strategy, and the subsequent tactical demands required of a player dictate the types of movements that present themselves during sprinting (Myszka, 2018). Yet, as noted, it is currently unclear what is the true cause of this variation. Whilst previous study has observed high-intensity efforts, no data currently exist on 'why' a player may be required to complete a sprint during a match (Ade et al., 2016). It is likely that specific match related tasks are the cause of this variation, thus it is a logical progression of the research to next begin to quantify these tasks. A deeper understanding of the reasons for sprinting in football would begin to explain the movements presented in the current study. This would also the allow for more specific conditioning practices and potential for improving a player's ability to perform effectively within these tasks by an ability to replicate the environments within which the currently observed movements present themselves. These representative-task drills would allow the athlete to develop movement degeneracy through repeated exposure to the tasks (repetition without repetition) (Seifert et al., 2016; Myszka, 2018). Thus, allowing for exploration of the most effective movement strategy for the given task demand.

Whilst the Transition into and Initiation of sprint efforts are broadly split between what can be described as typical linear efforts and non-linear, the Actualisation of the sprint effort itself appears to rarely be typical. During the sprint effort, a player regular travels in a non-linear (curved) direction (87%) and consistently performs this with a rotated torso away from the direction of travel (64%). This is supported by the most comprehensive previous study, completed with high-intensity efforts, where the majority of positions completed efforts that mostly consisted of a 'swerve' or 'arc run' (Ade et al., 2016). These movements likely allow for a player to adjust their approach during the sprint effort and generally alter their direction of travel whilst travelling at high velocity. For example, a CF may use a curved sprint as a means of avoiding being caught offside, whilst seeking to sprint in behind a CB. This allows the CF to initiate their sprint and build up velocity as their team's possession of the ball develops. As a pass is then made in behind the opposition's defence, the CF will use the curved path to manipulate their direction of travel from across the width of the pitch to towards the opposition goal. This would be a more effective strategy than walking or jogging across the defensive-line and initiating a sprint effort from little velocity and requiring a more pronounced change in direction. However, the current study merely observed the frequency of these efforts. Though it is clear that the ability to maintain velocity whilst travelling along a curvilinear path (and/or dissociating the torso) appears to be a key skill for football players, further detail is required to elucidate the exact nature of these efforts (Brice et al., 2008).

Thus, it appears that a detailed understanding of the kinetic and kinematic demands of curved sprinting is important for the preparation of footballers for the demands of match-play. However, there exists very little football-specific research currently. One key previous study sought to ascertain the differences between faster and slower footballers over curved efforts. It was noted that, though an overall velocity reduction is accepted as a consequence versus linear sprinting, faster players use a strategy of greater hip flexion of the inside leg, thus reducing their centre of mass when completing curved sprinting in isolation (Brice et al., 2008). Additionally, from research in track-based sprinters, it is known that the outer leg sees increased anteroposterior propulsive impulse demands compared to linear sprinting, and the inside leg is required to generate inward impulse and turning (Churchill et al., 2016). Data from the current study showing that sprinting in football is rarely strictly linear (13%) and that curvilinear sprinting requires different strategies is fundamental for practitioners to understand and warrants further detailed research on how best to prepare players for enhanced performance and resilience to injury. For example, increased anteroposterior propulsive impulse demands are suggestive of a potential injury mechanism. Such an understanding should be considered in the preparation of footballers to meet the demands of match play. Training should focus on improving a player's capacity to cope with such demands. This could be achieved through maximal effort curved sprinting or specific gym-based exercises. This appears a key area for the focus of future study in football, to better understand how these curved efforts truly occur and how best to train accordingly for these demands.

Similar to curvilinear sprinting, as noted, sprinting with dissociation of the torso appears a key skill for footballers to possess (64% of efforts). This likely allows a player to observe the action of the match whilst completing a sprint effort that may require them to travel in a separate direction. This is particularly evident when comparing the quantity of sprints completed with a rotated torso for defensive versus attacking positions (71% vs. 60%). This is likely a result of defensively-focused positions requirement to respond to the actions of attacking players and maintain their own and the team's defensive structure (Jeffreys, 2011). Previous work has shown that Defenders complete more Skipping and Shuffling movements than Strikers. Similarly, these are likely strategies employed as a means of travelling whilst maintaining visual contact with an opposition attacking player (Bloomfield et al., 2007). Thus, it appears important for football players to be able to effectively sprint whilst rotation at the torso occurs. However, to the authors' best knowledge, no published literature currently exists on how this may affect sprinting ability or how to effectively train this skill. Future study should attempt to focus on these areas.

A clear sign of the complexity of sprinting in football, and the key differences from sprinting in track and field, is the Action End category. Here, 48% of sprint efforts ended with a duelling or a ball-based action. Although half of the efforts ended without one of these actions, it is clear that sprinting in football does not occur in isolation from the match. These sprinting efforts seem to occur as a result of a match-related stimulus. The discussed constraints such as Task, Environment and Organism dictate the presented movements. Again, this is further confirmed when comparing this data across positions. For example, 64% of a CM sprints end in no action, whereas for FB and CF this is as low as 47%. This is likely indicative of the nature of each positions' role within in a match, whereby the latter positions are potentially more involved in key match actions such as goal scoring, where a CM may sprint predominantly for other reasons such as maintaining team structure. Sprinting to a duel or ball action would require the manipulation of one's velocity to manage approach speed into the action. The athlete's ability to continuously perceive the environment and decide upon the most effective action appears key to such an effort. Success is unlikely attributed solely to time to complete, such as in Track and Field (Jeffreys et al., 2018; Myszka, 2018). Adjustments to the movement may include direction and velocity as the continuous organism-environment interaction occurs (Seifert and Davids, 2017). However, as noted, currently no data exists as to why sprinting occurs in football.

Whilst it is clear that sprinting in football occurs through various different movements before, during and post effort, the reasoning for why remains unclear. Though it is may be reasonable to assume that the principle driver of these movements is the match and a player's relationship to this through their position and team's strategy. However, the movements that present themselves during match play are not necessarily the most optimal for a given situation, merely those that are 'selected' by the player given the circumstances they are presented. The current study did not assess the effectiveness of efforts. If training practices are to be improved, a more in-depth understanding of the actual tasks completed whilst spiriting is required. Thus, it may be of further benefit to understand the reason sprints occur in a match to truly begin to understand sprinting in football. Further study may then seek to define what a successful outcome in these tasks are and consequently the most effective movement strategy to achieve this.

As discussed, the most logical progression for future research appears to be gaining a better understanding of why sprinting occurs in football; consequently, explaining the current studies results of how sprinting occurs. It is reasonable to assume that these are heavily linked and that a study seeking to understand why sprinting occurs would explain the occurrence of different movements patterns associated with sprinting in football. The tactical scenario faced by the player would dictate the outcome observed. This would further enhance the ability to designed effective training programmes.

The current study was completed using only one team from one Premier League season. Due to this, the ultimate, direct applicability of the results are limited to the team used as key factors such as formation and team strategy are likely to affect the eventual movement outcomes presented (Bradley et al., 2011; Aquino et al., 2017). Whilst the results provide a good starting point for increasing the available knowledge in the area, caution must be taken when extrapolating these out to other teams and playing standards. However, with these limitations accounted for, the results presented will be pertinent to football within the utilised population of English Premier League football. To resolve this potential limitation, future research could seek to replicate the current study using a controlled variety of teams, and potentially seek to draw comparisons across different formations, strategies, and playing level. For example, a team instructed to 'press' often will likely present a different sprint movement profile to a team which remains deeper in their formation.

Additional to a better understanding of how formation and strategy may impact movement outcomes, it would benefit practitioners for research to aim to clarify the most efficient biomechanical strategies for the varying movement profiles presented in the current study. Three further stages of development appear to exist: firstly, to elucidate the exact nature of the demands during match play of the movement patterns observed in the current study, beyond frequency. For example, the exact nature of curvilinear motion (specific angles, distances and the bioenergetic cost of curved sprint efforts), or torso dissociation. Following this, the most efficient strategies to enhance on-pitch performance need to be better understood, such as technical strategies for curvilinear sprinting at these differing angles and distances.

Finally, how these are best trained for performance enhancement and injury prevention. For example, gym-based methods for enhancing force production during curved sprinting.

A greater understanding of how sprinting in football is completed is important for the physical preparation of players. By quantifying the specific movements involved in sprinting during a football it is possible for practitioners to design drills that replicate these movements, thus better-preparing players for the demands of match-play (Ade et al., 2016). For example, the knowledge that 37% of sprint efforts are initiated from a non-linear starting position may dictate practitioners future programming. Here, both gym and field-based training interventions may be specifically directed towards these unique kinetic and kinematic profiles, rather than solely for linear efforts. This could lead to performance enhancement in key match-defining actions (Faude et al., 2012). For example, movements such as curvilinear sprinting and cut steps each have their own unique demands (Besier et al., 2003; Brice et al., 2008). Performance enhancement of these tasks may likely require a different focus with respect to gym-based kinetic development. As discussed, curvilinear sprinting requires increased inward impulse of the inside leg, and unplanned cutting movements rely heavily upon co-contractions. Depending upon a practitioners training philosophy, varying levels of focus may be made to these specific movement patterns within a training programme. This may manifest as a large focus on completing football-based drills that elicit various different curved sprints efforts within them, as standalone curved sprint drills, or, for example, gym-based multidirectional plyometric training.

In training, there exists a balance between necessary specificity and the potential for overload. Where the more specific an activity, typically the less opportunity for overload is present. It has been proposed that the ultimate solution to the paradox is a mixed-methods approach (Brearley and Bishop, 2019). In this approach, both methods are used to provide overload to physiological systems as well as the necessary training of highly-specific activities. This ensures optimum transfer to match activities. However, this method can only be employed with a deep understanding of the match activities themselves. The current study provides an enhanced understanding of the movements employed whilst sprinting in football. Thus, training programmes can be designed to both replicate these activities and also overload the specific physiological systems involved.

As discussed, observed movement is constrained by the interplay between the Task, Environment and the Organism (Seifert and Davids, 2017; Myszka, 2018). Thus, with the present study providing a greater understanding of the movements that are common in football, training drills that seek to mimic these can be designed more effectively. Through a constraints-led approach, drill design can be focused on creating ‘repetition without repetition’, where the athlete is exposed to tasks that allow for exploration and promote movement degeneracy through the seeking of movement solutions (Seifert et al., 2016; Seifert and Davids, 2017; Myszka, 2018). The constraints to these representative drills can be manipulated, for example by reducing or increasing the pitch size to elicit differing responses and learning experiences. The aim being to achieve ultimate movement degeneracy for a given task, where the athlete is capable of finding movement solutions to any given situation. An example of such a drill would be to seek to enhance a player's curved sprinting ability. Rather than merely rote repeating a curvilinear effort, a drill can be designed involving the initiation of the effort to different stimuli such as opponents, teammates and the ball. Or, the adjustment of one's velocity and direction during the effort to similar stimuli or completed on a different surface and within different environments. Finally, the drill can be finished with an attempt to shoot at goal, make a pass or cross, or complete a different movement pattern. This representative task should enhance the athlete's skill acquisition in curvilinear sprinting.

Similarly, practitioners possessing enhanced knowledge of the specific movements associated with sprinting during a match are better placed to successfully rehabilitate players to cope with these demands. Only by understanding these movement demands can a practitioner truly achieve this by exposing a player to these demands in a controlled training environment. These movements can be replicated in training through drills designed in combination with typical locomotor data. Without this awareness, drills may replicate sprinting distances well but lack the true specificity of how this distance is typically achieved during a match. Again, for example, an athlete returning to play may be unequipped to tolerate the specific demands of sprinting along a curve, or with a rotated torso. Previously, where knowledge of only the typical sprint distances existed, a practitioner may have sought to rehabilitate a player to tolerate these distances. With this additional understanding of, for example, the large frequency of curved sprint efforts, and their unique demands, a practitioner can design training programmes accordingly to be more assured of a player's readiness to return to training.

4.4.1 Conclusions

Broadly it is clear that sprinting in football is rarely linear and not necessarily similar in nature to sprinting in track and field. Though the fundamental kinetics and kinematics of running fast are likely similar, there are clear differences in how these are exhibited during a match. The key to this is likely due to the perceptual aspect of playing football as opposed to a linear sprint in track. Sprinting in football is performed as a response to external stimuli of the match itself as opposed to only the starter's orders. Therefore, any movement patterns observed in the current study likely results from the action of the match and how the performer perceives this.

For the first time, the current study presents practitioners with an intricate understanding of how sprinting in football is completed. It is clear that isolated, track-based sprinting programmes may be inadequate in the physical preparation of footballers and that practitioners could now use the current findings to refine their practice to better reflect the physical demands of match play. However, due to the apparent link between how a sprint is performed in a match and the match itself, it is clear that future research should begin to understand 'why' these efforts actually occur. By better understanding this 'why', practitioners can seek to replicate the scenarios within which these sprints occur and thus allow for the ultimate development of perception-action coupling by allowing the athlete to learn to execute the most effective movement solution to each situation; rather than solely mimicking the physical results from the current study. This thought process is an essential outcome of the current study due to the clear contextually dependent nature of sprinting in football.

CHAPTER 5

A CLASSIFICATION OF THE TACTICAL CONTEXT OF SPRINTING IN PREMIER LEAGUE FOOTBALL.

5.0 PERSONAL REFLECTIONS

Chapter 4 involved the detailed quantification of the movements involved in sprinting in football. The decision was made to complete the movement and tactical-context analysis separately over two chapters to allow for greater detail and clarity to each. This was the aim of the overall outcome of the thesis, to be a comprehensive description of sprinting in football.

5.0.1 Research Skills

The implementation of the movement classification system was broadly successful, although could have been improved in certain areas. I was personally, slightly disappointed in the restriction of the conclusions that could be drawn for positional differences. Though the findings were certainly useful and a progression on our current understanding, due to the small sample size caution had to be made when declaring with any certainty the differences across positions. However, a strong positive to the study was the practical nature of the research, and certain small caveats of this nature are accepted as a result of this. Gaining access to other teams' personal player data would have created great difficulties. Another option would have been to qualitatively define the occurrence of a sprint from match footage. This was considered but decided it may cause reliability issues.

The findings from the study, typically, provide more questions than answers and I believe the area is ripe for further study. It is my hope that the thesis acts as almost a seminal piece within the area to spark interest in the various different concepts discussed. In much the same way that the work the system was based on did for me personally. This is certainly the feedback I have received through early dissemination. Much more needs to be understood on what these specific movements actually are, such as curved running and torso dissociation. We currently know very little about the specific demands of these, biomechanically and physiologically. As noted in the discussion, investigating what these actually mean would be a logical first step, followed by how we can look to enhance performance in these.

As discussed in the review of the literature, merely using GPS derived locomotor metrics as a means of defining the demands of a match is too one-dimensional. It is important to contextualise this data and it is surprising how little previous work is available within this area. The results of the study further add to this surprise, as what would be defined as a sprint can vary so much. If we, as researchers, are to better understand the demands of a match then progression in this area appears to be key to future studies.

Throughout the analysis, I began to see that certain players relied on specific movement patterns. As would be expected, this suggests that a player doesn't always necessarily select the most effective movements in a given situation. It became clear that these were learned skills and personally added further credence to the importance of Chapter 6 in defining the context within which the sprint actually occurs rather than just the movements used. If the original thesis plan had been followed this data would not have been collected.

Broadly though the system worked very well, and to my knowledge is the first application of such a system specifically in sprinting. The early attempts at informally disseminating the findings were very successful; practitioners were very receptive to the data. As discussed, I believe this type of analysis should become fundamental to any need's analysis, the previously relied upon GPS data does not paint the full picture and requires this additional knowledge for better-informed practice. This data, to me, seems crucial to a rehab situation as well as performance enhancement. Again, the key to this may be the automation of the process to reduce its time-consuming nature.

With respect to the research itself, this was the first time I have completed this type of analysis utilising video. I found it very useful to discuss the process with others more experienced within the area and, as with most skills, I certainly improved my effectiveness and efficiency the more I completed. The pilot/familiarisation process was crucial to this. This progression certainly altered the way I watch athletes in football and their Gamespeed skills specifically. In sport at the highest levels, victory can be decided by extremely small margins and one error in a movement could lead to conceding a goal or missing an opportunity to score. I definitely have a different view of what is important in physical development following the process.

As discussed, leaving my position at the club partially led to a reorientation of the focus of the study. If my previous ease of access to a squad of professional footballers had remained it may have been the case that the subsequent stage of the research may have focused on biomechanically analysis the movements quantified in the current study. I do now strongly believe that this would have been a mistake as this type of analysis would have been 'jumping the gun'. With our current lack of understanding in the area, I firmly believe that the thesis is enhanced by focusing on describing sprinting in football.

5.0.2 Professional Skills

Throughout my time as a practitioner, when working with footballers, I have regularly utilised methods such as sprints from various starting positions and multi-directional plyometrics. However, with the new-found knowledge from the current study, my eyes have been opened to the variable nature of sprinting in football and the most common of these. From my personal experience, I believe many other practitioners to believe similar. We had an understanding that sprinting wasn't just a linear activity but lacked the tangible data to support this assumption.

A player's ability to effectively start from different positions for example may well be more important than their ability to reach a high maximum velocity. Not only from these starting positions but from the different, prior transition movements into the sprint as they are rarely completed from a dead start. Certain movements are more crucial for particular positions than others. This would be an easy start point for the implementation of these findings, to begin to employ these movements as a part of typical speed-based work. If I was still in my previous role this would be key information that I could easily base my programming upon. This would prepare players more effectively to cope with the actual demands of a match, enhance performance and better rehabilitate a player. However, the natural question arises of what the most effective mechanics are for these positions, which is a key area for future research.

Other areas such as curved sprinting and sprinting with torso dissociation, are, in my experience, less commonly trained. Hopefully, the current findings support the ideas that these are potentially important areas for training and standard football training may not provide enough of a stimulus for enhancement. It is possible to reduce these skills and train accordingly. We know that curved sprinting on a track is biomechanically different from linear track sprinting, so it stands to reason that footballers will have unknown demands placed upon them when sprinting in a curvilinear motion. Similarly, sprinting with torso dissociation is clearly a specific skill that could and should be trained. Additionally, it would be useful to know the types of sprint effort that are typically completed as a part of standard football training.

Often practitioners fall into the reductionist trap of seeking to improve a player's maximum velocity and allowing football training to provide the stimulus to transfer this to match play. However, this simplistic assumption is likely more complex, where even tests of change of direction may not really differentiate players Gamespeed skills. Success in football is much more complex and intricate and as a result of the current study, I believe we are someway off optimal practice for enhancing football sprinting ability.

From a training philosophy perspective, the findings and the concurrent reading made me question my long-held beliefs on enhancing football ability. It is highly unlikely that improving a player's gym-based strength will be carried through much to their on the pitch performance. Though I still believe general strength training to be important, particularly for injury prevention. Gym-based activities are so far removed from the match actions it is unlikely to cause any significant improvements. However, I believe they do fundamentally support athletic performance.

General vs specific training has long been a 'hot topic' in strength and conditioning and the most common opinion is probably that strength training is not intended to be specific and replicate competition but enhance general qualities that support performance. However, form my own observation, it usually the case that a practitioner develops their programme based upon this general training, whereas a more suitable way to perceive this programming is to reverse engineer from the competition task (curved sprint) and develop from most specific to least. This would eventually include general training but also ensure that, via enhanced specificity, optimal transfer exercises are not omitted. If a player is unable to technically sprint a curve, general strength training is unlikely to affect this, and improving this should be a priority.

Even with all this novel data on the specific movement utilised, it is highly unlikely that any physical enhancement will truly impact match performance without an understanding of the perceptual aspect of these movements. No physical action is completed without a cognitive-perceptual aspect and these should be viewed together for optimal training and not reduced to separate concepts. This appears to me personally to be a huge area to improve understanding in, and it is hoped the next study achieves this.

5.1 INTRODUCTION

Whilst Chapter 4 began to show ‘how’ sprinting looks in detail during a football match (movement), it is crucial to understand ‘why’ this may be. An understanding of how sprinting occurs provides a good representation of the physical demands of a football match. However, it cannot be assumed that from a skill perspective an athlete will have necessarily chosen the most effective movement strategy during a match for a given task. By understanding why sprinting occurs during a match, practitioners can begin to recreate these contexts and scenarios during training and more effectively seek to enhance the potential selection of movements (Myszka, 2018).

Movement outcomes are a result of decisions made by the athlete in response to a given set of circumstances that they are presented with, constrained by the environment, the task and the athlete themselves (Seifert and Davids, 2017; Myszka, 2018). These match contexts should provide the starting point for the development of any performance enhancement programme (Jeffreys et al., 2018). Only by truly understanding this context can the perception-action relationship be trained (Mason, 2015; Seifert et al., 2016; Seifert and Davids, 2017; Myszka, 2018). The movements that present themselves during a match are not necessarily always the most efficient for this context. Therefore, if a practitioner is aware of the context within which sprints occur, drill design can reflect this. Consequently, this leads to exploratory learning by the athlete to ascertain the most effective movement strategy in a given context (Ade et al., 2016; Myszka, 2018). Additionally, any traditional physical metrics can be better understood by contextualising their tactical outcome within the match. This can be particularly important in multidisciplinary environments (Bradley and Ade, 2018).

Perception-Action coupling is a result of the interaction between an athlete and their environment (Seifert et al., 2016; Mallek et al., 2017; Myszka, 2018). Only by understanding this interaction can an athlete be trained to achieve a successful task outcome by effectively employing their physical movement skill abilities. Thus, an athlete must practice within an environment specific to that of the match and subsequent tactical scenario. Here, practice can be designed to allow 'repetition without repetition', where learning is achieved through exploration and problem-solving (Myszka, 2018). Consequently, improving the efficiency of the athlete's ability to apply their physical abilities during a match. Only by truly understanding the key tactical-contexts of a match can training be designed accordingly. Allowing for the manipulation of constraints to enhance skill learning through enhanced motor degeneracy (Mason, 2015; Seifert et al., 2016; Myszka, 2018).

In addition to this, it is hoped that the development of a better understanding of the context within which sprinting occurs would potentially allow for 'position profiles' to be established. Thus, theoretically allowing for a system whereby a player can be assessed on their effectiveness of sprinting in a match by whether they are or are not successful at achieving the common task outcomes (Bradley and Ade, 2018). This would be an enhancement on current methods of testing a player for sprinting ability outside of the context of a match, where absolute velocity or time to complete is the outcome measure rather than successful task completion. During a match, the attainment of higher velocity is not necessarily always indicative of success (Jeffreys et al., 2018). However, without a current understanding of these key contexts, such an evaluation model is not possible.

As discussed, attempts have been made previously to attempt to quantify the tactical-contexts within which high-intensity running occurs in football. Though not necessarily a sprint, the research provides a good insight into why running at faster velocities may occur. For example, whist in possession, there is variation across positions for the tactical-context of the effort: CB mostly attempt to Push up the Pitch; whereas, FB and WM Run the Channel. CM and CF typically Drive through the Middle (Ade et al., 2016). It is reasonable to assume that these differences exist when looking at sprint efforts, and are potentially starker due sprinting by its nature being more decisive to match outcome (Faude et al., 2012). Focusing on sprinting, rather than high-intensity running as a whole also allows for the refinement of available data and could reduce the time-consuming nature of the current non-automated process due to less total efforts being recorded (Bradley and Ade, 2018). The results would then allow practitioners to design specific drills to improve performance in these important moments of a match involving sprinting and assist in better returning players from injury.

5.1.1 Aims

It is thus the aims of the current study to quantify all-position detail on the tactical-context within which sprinting occurs in Premier League football. Therefore, creating a greater understanding of the specific nature of sprinting in football.

5.2 METHODS

To ascertain the Tactical-Context within which sprints occur in Premier League football, a classification system was applied to match footage of sprint efforts. The system was applied to 10 matches during the 2017-18 season. Each sprint effort was thus classified accordingly by its Phase of Play and Tactical Outcome. A classification system for the quantification of the Tactical-Context within which sprinting occurs in football was successfully developed in Chapter 3. The system was considered reliable in Premier League football and deemed effective for future study.

5.2.1 Protocol

The general protocol from Chapter 3 (3.2.6) was repeated to isolate the sprint efforts from 10 EPL matches. Once these efforts were attained, the STC could be employed for each effort to quantify which contexts sprinting in football occurs. The systematic protocol outlined in Chapter 3 (3.2.6.3) was then followed to record the data. Details of the sample utilised was previously outlined in Chapter 4 (4.2.1). All data utilised was secondary data taken from publicly available sources (3.2.6) (Premier League DVMS, ChyronHego). Additional Gatekeeper Consent was obtained from a representative of the club.

Analysis for the tactical-contexts consisted of two broad categories, the Phase of Play and the Tactical Outcome. Thus, each sprint effort consisted of two descriptive data points. The Phase of Play category described the football-specific moments of a game. A match can always be described as being in one of these four ‘moments’, or phases. Every action that occurs during a match exist in one of these phases and is thought to consist of a Tactical, Technical, Physical and Psychological element (Delgado-Bordonau and Mendez-Villanueva, 2012). These phases are broadly transition or organisation phases, from both attacking and defensive phases (Table 5.1). Transition phases of play described the recovery or the surrendering of possession and the consequent move into the organised phases. Organisation phases described the structured moments of Attacking or Defensive play. Tactical Outcome described the exact context of the sprint action, either In Possession or Out of Possession (Table 5.2).

Table 5.1 The Football Sprint Tactical-Context System Sub-Category descriptions.

Main-Category	**Sub-Category**	**Description**
Phase of Play	Phase of Play	*The phase of play of the subject's team within which the sprint occurs.*
Tactical Outcome	In Possession	*The subject's team is in possession of the ball when the sprint effort occurs.*
	Out of Possession	*The subject's team is not in possession of the ball when the sprint occurs.*

Table 5.2 The Football Sprint Tactical Context System, detailing all categories and Action descriptions.

Main-Category	Sub-Category	Action	Description
Phase of Play	Phase of Play	Attacking Transition	*In possession: Transition to Attacking Organisation following the* ***recovery of possession.***
		Attacking Organisation	*In possession:* ***Attacking build up*** *aiming to create scoring opportunities by disorganising the opposition defence.*
		Defensive Transition	*Out of possession: Transition to Defensive Organisation following the* ***surrendering of possession.***
		Defensive Organisation	*Out of possession: Assuming of* ***defensive structure*** *to prevent the creation of goal scoring opportunities.*
Tactical Outcome	In Possession	Break into Box	*Player sprints into the opposition* ***penalty box****.*
		Overlap	*Player sprints from* ***behind to in front of or parallel*** *to the player on the ball.*
		Push-Up Pitch	*Player sprints up the pitch to support the play (****defensive and middle third of the pitch*** *only).*

		Run the Channel	*Player sprints with/without the ball down to one of the* ***external areas of the pitch.***
		Run-in Behind	*Player aims to* ***beat the opposition offside trap*** *to sprint through onto the opposition goal.*
		Drive inside	*Player sprints with/without the ball* ***from the external flank into the central area.***
		Drive through the middle	*Player sprints with/without the ball* ***through the middle*** *of the pitch.*
		Run with the Ball	*Player moves* ***with the ball*** *either dribbling with small touches or sprinting with the ball with bigger touches.*
		Other	*All other in possession variables that could not be categorised.*
	Out of Possession	Closing Down	*Player sprints* ***directly towards the opposition player*** *on the ball.*
		Interception	*Player sprints to* ***cut out a pass*** *from an opposition player.*

		Covering	*Player sprints* ***to cover space or a player*** *on the pitch while remaining goal side.*
		Recovery Run	*Player sprints back towards their own goal when* ***out of position*** *to be goal side.*
		Ball over the top	*Player sprints after an opposition pass* ***over the defence through the centre****.*
		Ball down the side	***Player sprints after an opposition pass in behind the defence down the side of the pitch.***
		Track the Runner	*Player runs* ***alongside opposition player*** *with or without the ball*
		Other	*All other out of possession variable that could not be categorised.*

5.2.2 Statistical Analysis

Statistical procedures outlined in Chapter 4 were repeated. Following the completion of the analysis for all sprint efforts, for all players, overall matches, raw data was processed and collected in Microsoft Excel. Following this, results were statistically analysed in SPSS. Shapiro-Wilk testing was utilised to confirm normality. Following this, ANOVA with Tukey HSD was employed to establish any statistically significant differences within the 2 categories. Lastly, Cohen's D effect sizes were established to determine the magnitudes of any differences identified.

5.3 RESULTS

As with Chapter 4, results are analysed and presented primarily across all positions. This will provide an understanding of the common Tactical-Contexts associated with sprinting in football. Secondary to this, results are presented by playing position. Again, in the same manner as Chapter 4, positional differences are solely presented as a percentage of efforts to account for the restricted sample size. These positions are categorised by Playing Position (FB, CB, WM, CM, CF) and Position Location (Central, Lateral).

5.3.1 All Positions

5.3.1.1 Phase of Play

Variation existed for the Phase of Play within which sprints occurred ($P < 0.01$) (Fig. 5.1) and all Phases of Play were seen during analysis. Most sprints in football occurred during Defensive Organisation (30 ± 12). This was followed by Attacking Transition (27 ± 9) and Defensive Transition (24 ± 10). Finally, the least common of the phases was Attacking Organisation (9 ± 5). All phases were statistically significantly more frequent than Attacking Organisation (ES: 2.0-2.6, $P < 0.01$).

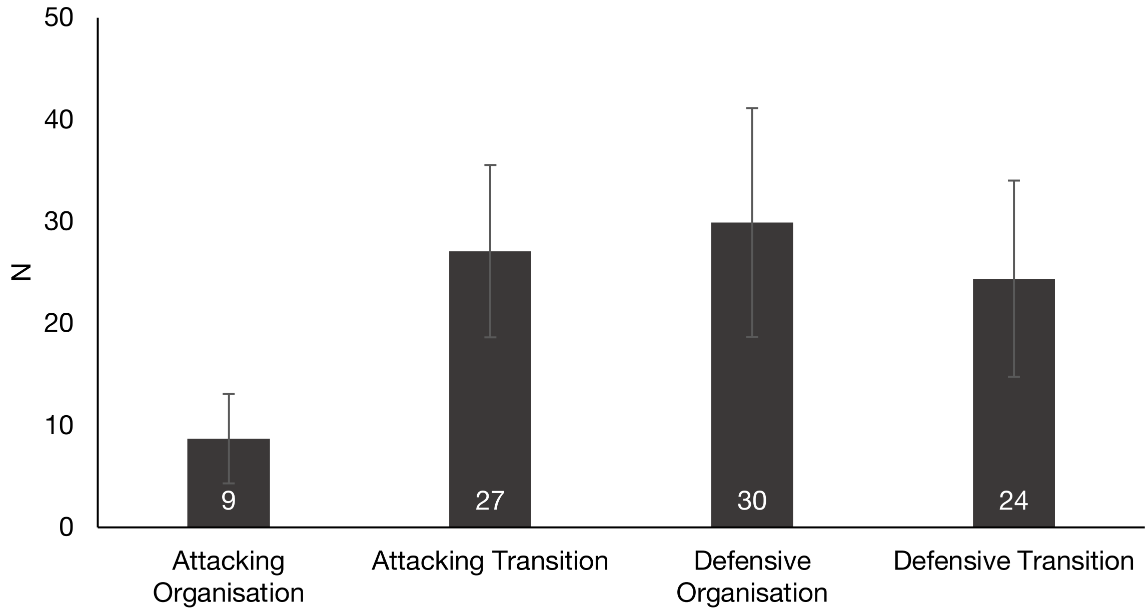

Figure 5.1 The average number of sprints completed during a match according to the Phase of Play within which they occurred.

Whilst the majority of sprint efforts occur during Defensive Organisation (33%) (Fig.5.2) when grouped into Transition and Organisation phases, it is actually the combined Transition phase (57%) which is most common (Fig. 5.3). However, this can mainly be attributed to the Attacking Organisation only accounting for 10% of efforts. Additionally, when phases of play are combined into their Attacking and Defensive categories, 60% of efforts were observed as occurring in the Defensive phases (Fig. 5.4).

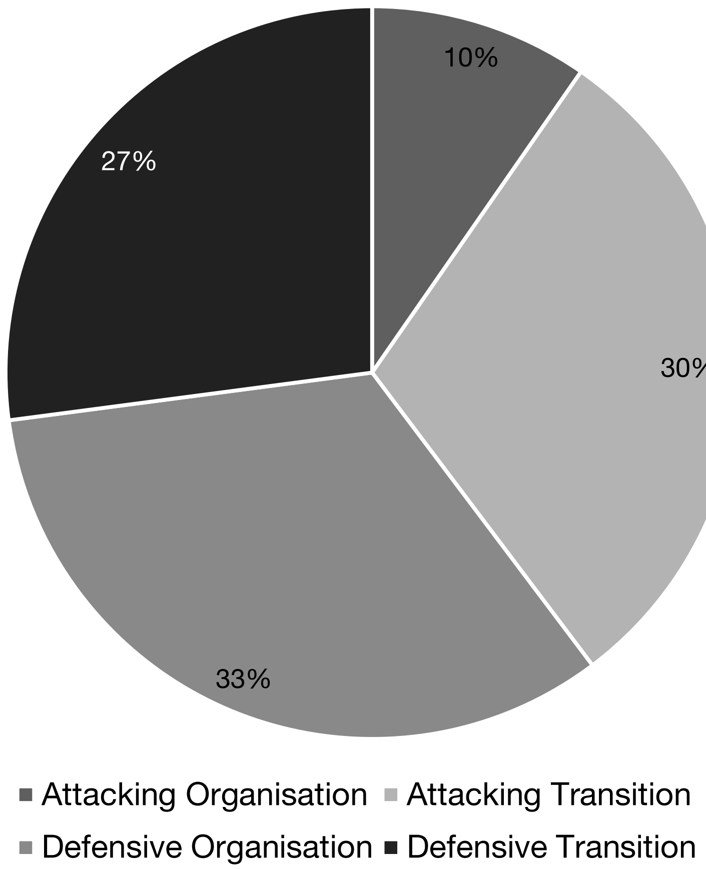

Figure 5.2 The average percentage of sprint efforts completed during each Phase of Play category.

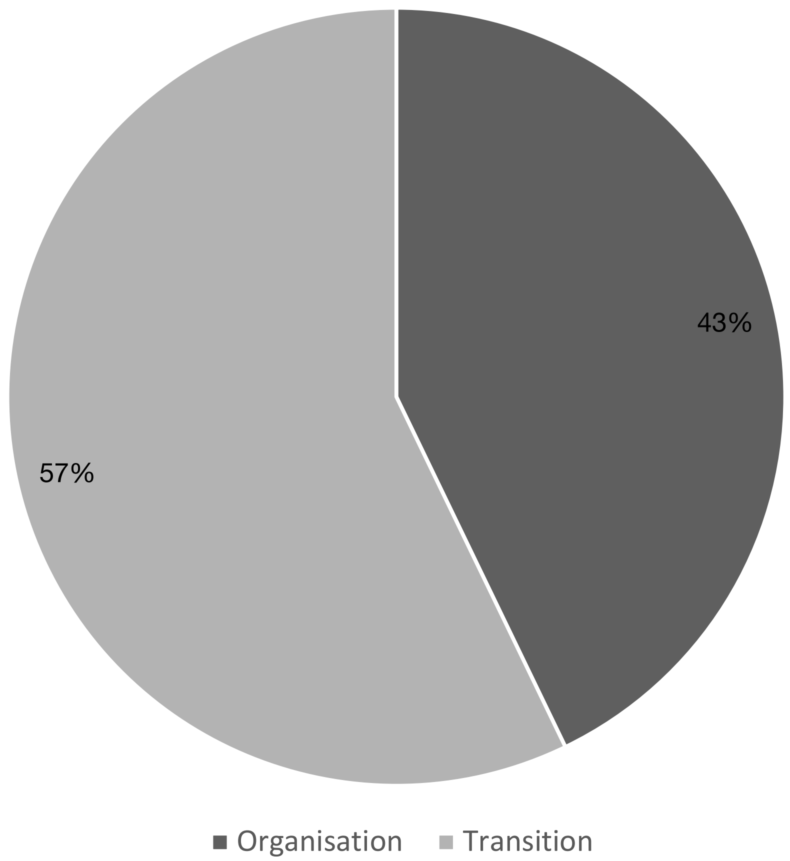

Figure 5.3 The average percentage of sprint efforts completed during each Phase of Play category, presented as Organisation and Transition phases.

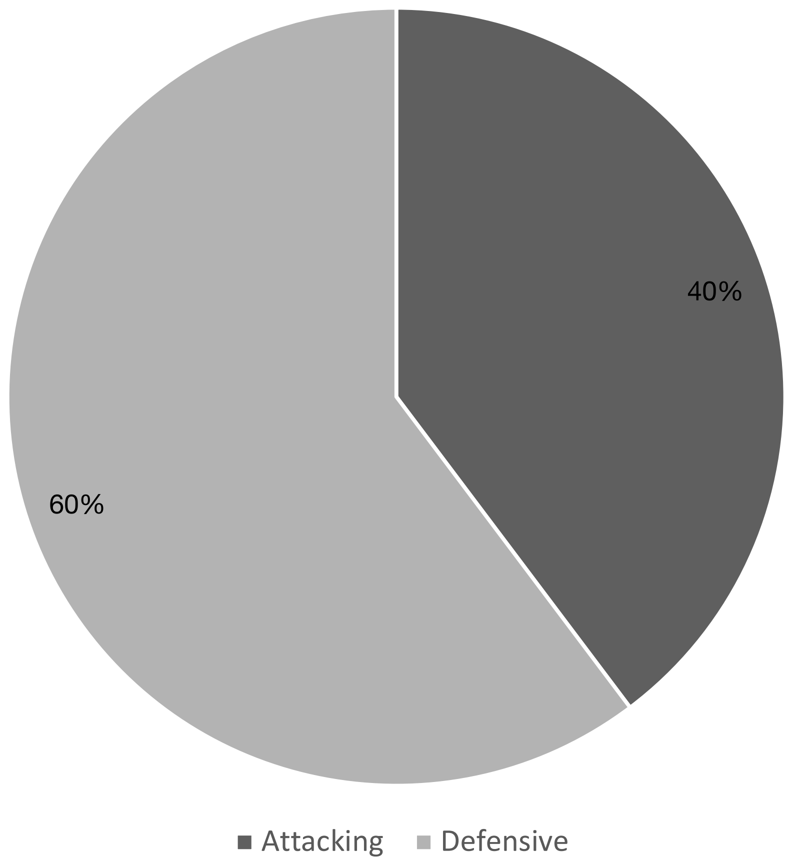

Figure 5.4 The average percentage of sprint efforts completed during each Phase of Play category, presented as Attacking and Defensive phases.

5.3.1.2 Tactical Outcome

Variation existed in the Tactical Outcome within which sprints occurred for all positions ($P < 0.01$) (Fig. 5.5). Closing Down was the most frequent Tactical-Context across both In and Out of Possession categories, occurring 15 ± 4 times during a match. This was significantly more frequent than all other Tactical Outcomes except for the second most frequent, Covering (10 ± 3) (ES: 1.3-4.8, $P < 0.05$). One category was never witnessed during analysis, Out of Possession: Other. This was the least commonly observed of all categories. The least frequent category that was still seen in the results was Interception (1 ± 1).

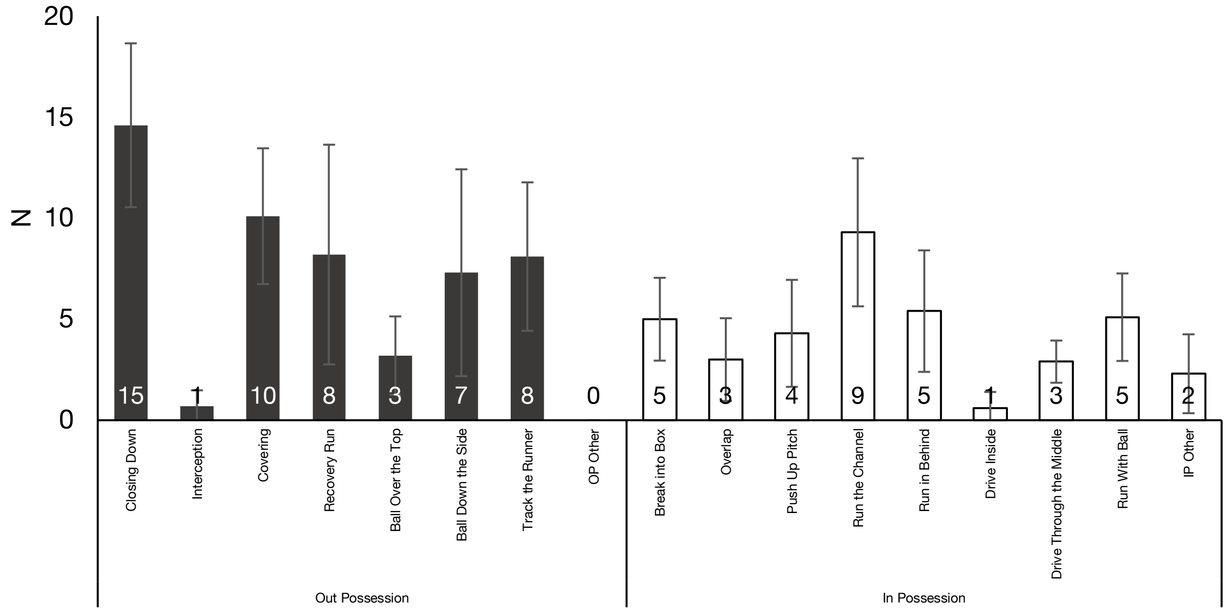

Figure 5.5 The average number of sprints completed during a match according to their Tactical Outcome for In and Out of Possession.

60%of efforts were completed whilst Out of Possession. Of these eight Out of Possession categories, five were commonly seen: Closing Down, Covering, Recovery Run, Ball Down the Side and Track the Runner (14-28%) (Fig. 5.6). Whilst Interception, Ball Over the Top and Other were seen less often (0-6%). As noted, Closing Down was the most commonly observed, accounting for 28% of Out of Possession sprint efforts, 9% more frequent than the second most common, Covering (19%). Covering occurred statistically significantly more often than all categories other than Closing Down, Ball Down the Side, Track the Runner, Run the Channel and Run in Behind (ES: 0.4-4.0, $P < 0.05$).

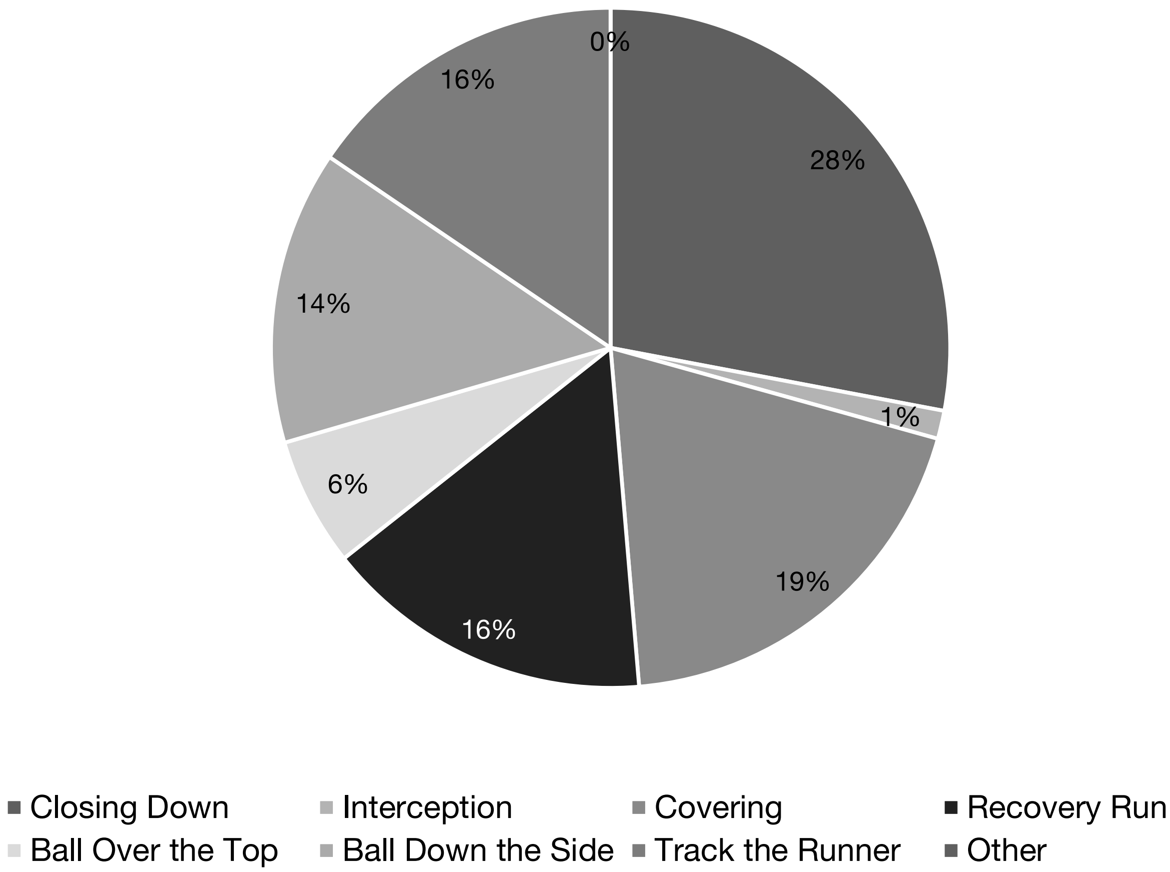

Figure 5.6 The average percentage breakdown of sprints completed in each category whilst Out of Possession.

Similarly, In Possession sprints were variable. Five of the categories occurred most often: Break into Box, Push Up Pitch, Run the Channel, Run in Behind and Run with Ball. (11-25%) (Fig. 5.7). The remaining four categories were observed half as often (2-8%). However, all categories were seen during analysis. When Out of Possession the category labelled Other was never seen (Fig. 5.6), however In Possession this accounted for 6% of efforts (Fig. 5.7). When In Possession, the most frequent context within which sprints occurred was Run the Channel (25%). The least frequent was Drive Inside (2%). This was the least common tactical outcome observed for both In and Out of Possession (1 ± 1).

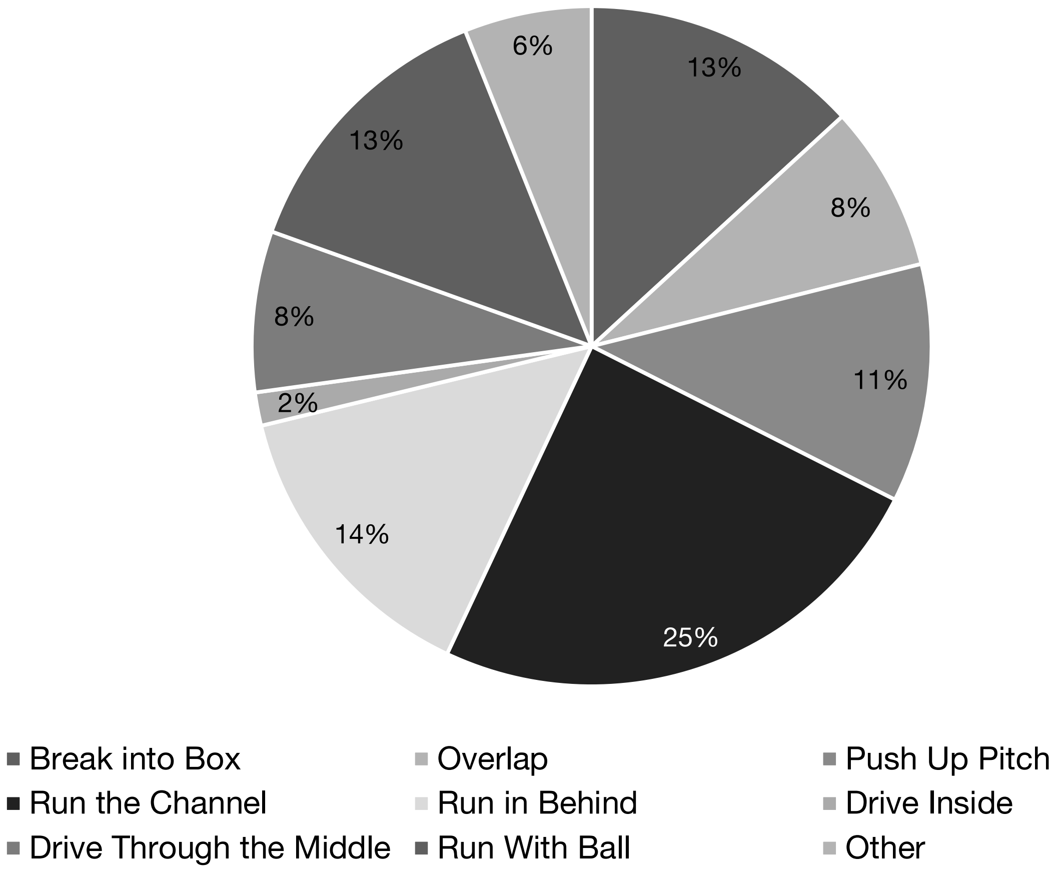

Figure 5.7 The percentage breakdown of sprints completed in each category whilst In Possession.

5.3.2 Summary

Results were observed further by combining the Sub-Categories of Phase of Play and Tactical Outcome. 33% of efforts occur in Defensive Organisation, and the two most common Tactical Outcomes are Closing Down and Covering. These are Tactical Outcomes that are to be expected within this phase where a team reverts to a compact default shape and attempts to defend their goal. Similarly, Run the Channel, Run in Behind, Run with Ball and Break into Box are the most common In Possession categories. These are all efforts that one can expect to be involved in the most common Attacking Phase of Play, Transition. These are contexts where a team can look to 'break' on the opposition quickly.

5.3.3 Positional Detail

Alongside the all position analysis, results were presented by playing position. However, as with Chapter 4, caution was taken during analysis due to restricted sample size (Table 4.3). Thus, results are solely presented as average percentages. Again, two methods were used to categories these positions, playing position (FB, CB, WM, CM, CF) and the position location (Central: CB, CM and CF; Lateral: FB and WM).

5.3.3.1 Phase of Play

Differences were observed across positions for the Phase of Play within which sprints occurred (Fig. 5.8). The greatest proportion of sprints for WM (37%) and CF (52%) occur during Attacking Transitions. Whereas FB (34%) and CB (54%) complete the majority of their sprints during the Defensive Organisation Phase. CM complete the majority of theirs during Defensive Transition (45%). CB complete little to none (1%) of their sprints in the Attacking Phases. All positions except for CB complete the majority of their sprints during the Transition Phases rather than Organisation Phases of Play.

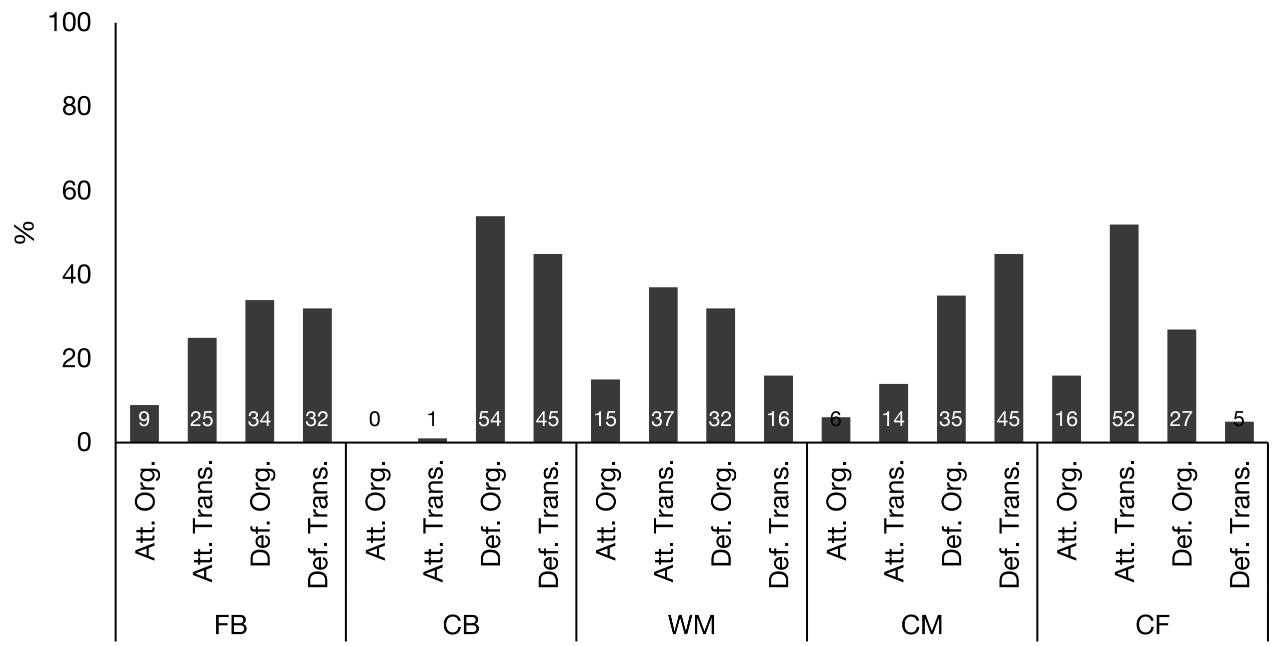

Figure 5.8 The average percentage of sprints completed during a match according to the Phase of Play within which they occurred, categorised by playing position.

When observing differences across position locations (Fig. 5.9), both categories complete the majority of their sprint efforts within Defensive Organisation (Central: 39% and Lateral 33%), however, this is less pronounced as the most common versus the second most for Lateral positions (Central +7% and Lateral +2%). Both categories least common phase to sprint within was Attacking Organisation. This is common across all analysis within the study. The second and third most common phases are both the transition phases, with Lateral positions more likely to sprint in Attacking Transition (31%) and Central positions in Defensive Transition (32%).

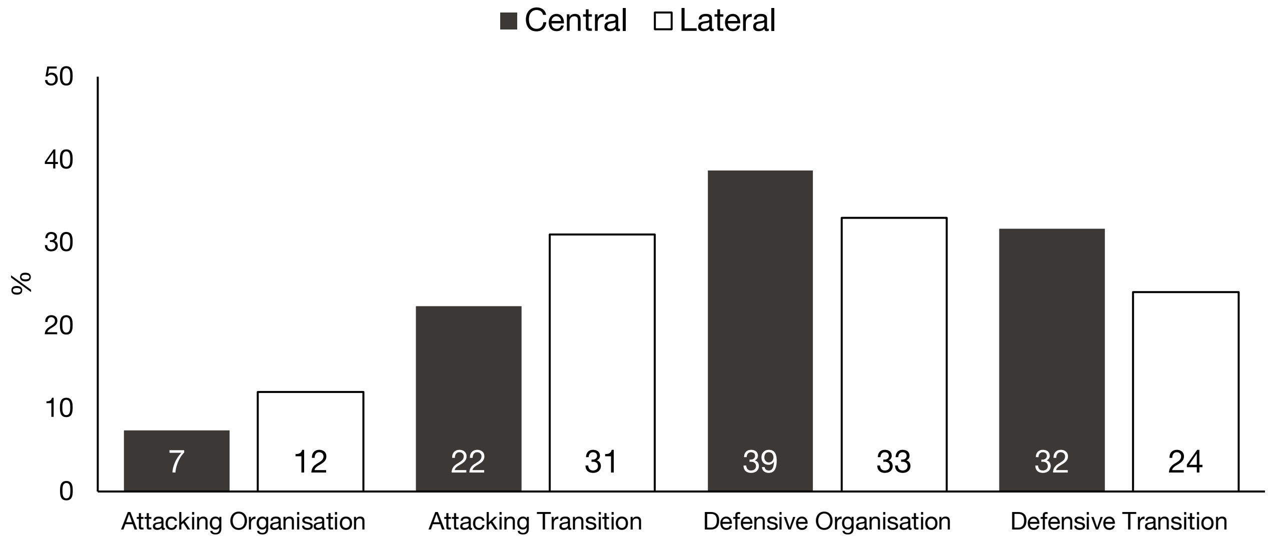

Figure 5.9 The percentage of sprints efforts completed in each Phase of Play category categorised by playing position location.

5.3.3.2 Tactical Outcome

Differences were also observed across positions for the Tactical Outcomes within which sprints occurred (Fig. 5.10 & 5.11). CB sprint predominantly during two Tactical Outcomes. Ball Down the Side and Covering account for 61% of all of their completed sprints. Whilst Out of Possession, WM complete the majority of their sprints Closing Down (21%), three-times as frequent as the next most common. Covering and Track the Runner are the next most common (7%). CF, whilst out of possession predominantly sprint Closing Down the opposition; whilst all other categories occur very infrequently (<6%).

In Possession CB rarely sprint, with only one Tactical Outcome (Other) requiring them to sprint (3% of total efforts). Similarly, for CM only 19% of total sprints occurred whilst In Possession. WM and CF were the positions most likely to sprint whilst In Possession; 58% and 70% of their total sprint efforts respectively. WM predominantly sprinted to Run the Channel (16%) or Run with the Ball (11%); whereas CF mostly sprinted for Run the Channel (23%), Run in Behind (18%) and Through the Middle (10%).

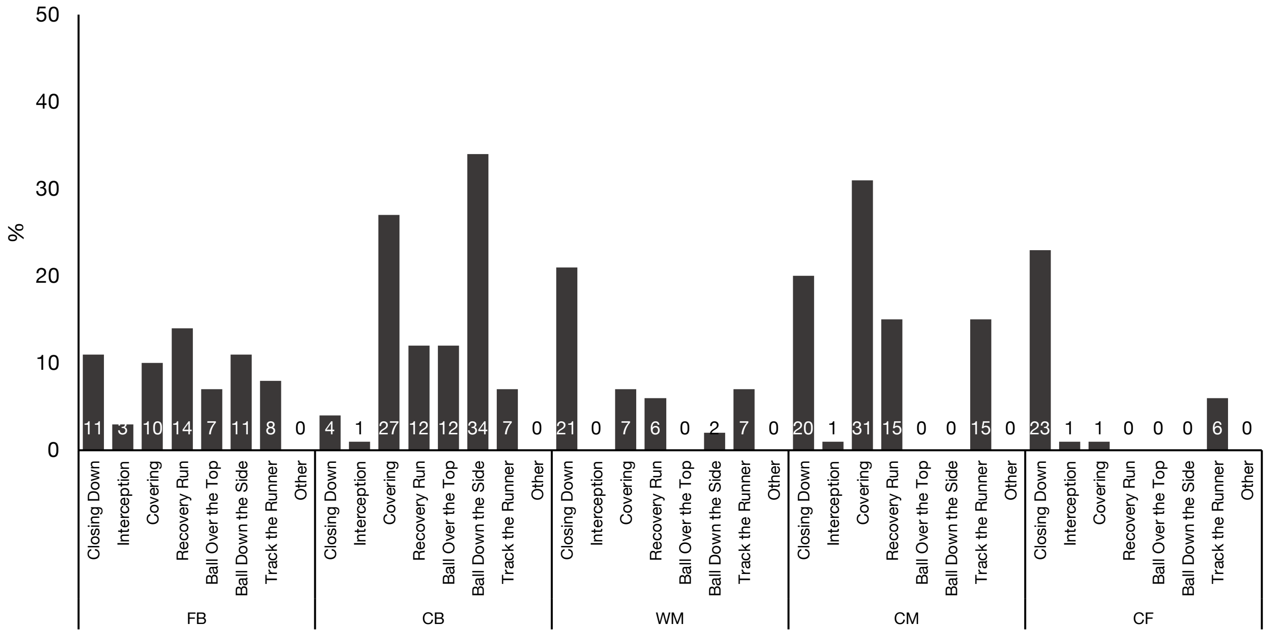

Figure 5.10 The average percentage of sprints completed during a match according to their Tactical Outcome during Out of Possession phases of play, categorised by playing position.

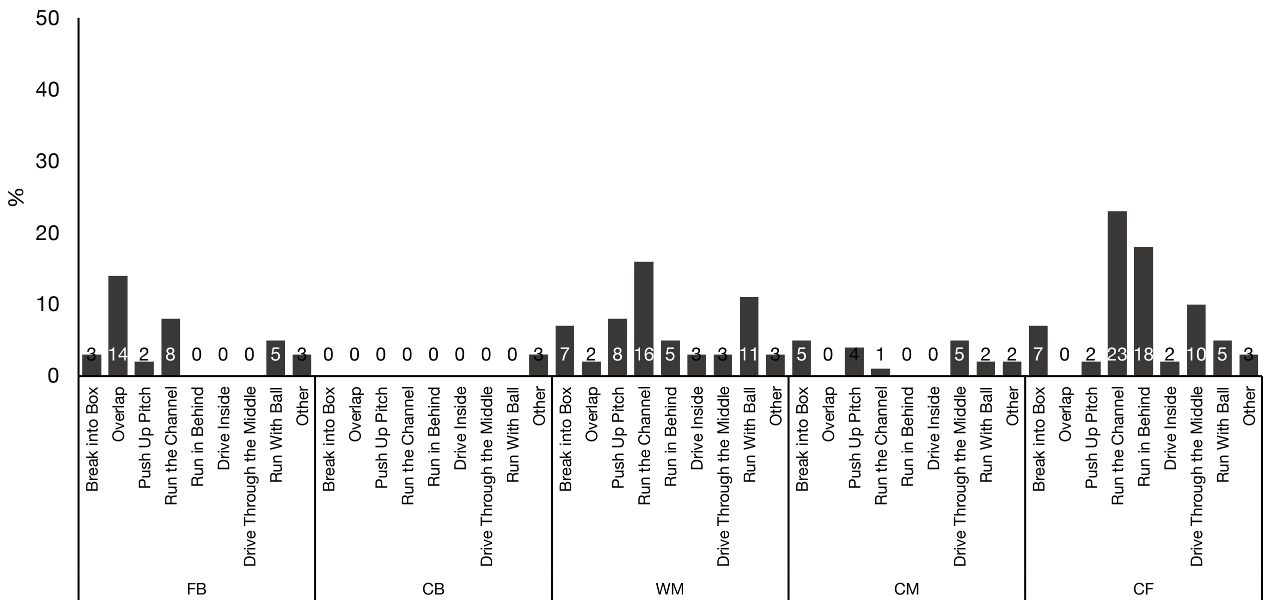

Figure 5.11 The average percentage of sprints completed during a match according to their Tactical Outcome whilst In Possession, categorised by playing position.

Two clear differences exist when comparing Central and Lateral positions and the Tactical Outcome of their Out of Possession sprints (Fig. 5.12). Central players sprint twice as often for a Covering sprint (20% vs. 9%), likely as a result of more often playing in a pair. For example, a pair of CBs. Where one will often sprint to cover their CB partner. Another notable difference is Central players sprinting more often as a result of a Ball Down the Side (11% vs. 7%). Again, this is highly likely as a result of the inherent specifics of the positions' locations.

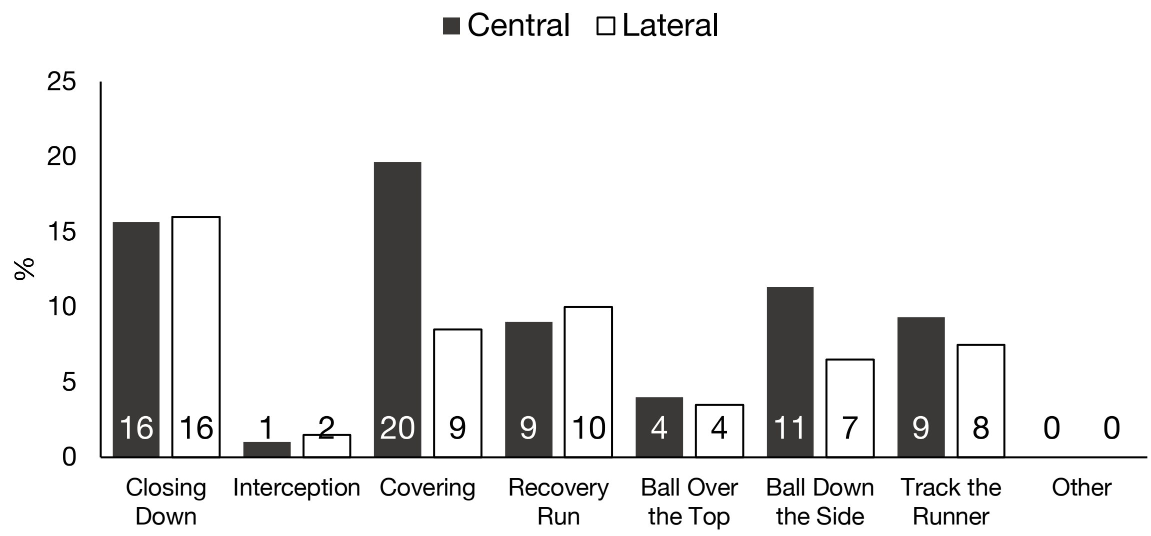

Figure 5.12 The average percentage of sprints completed during a match according to their Tactical Outcome during Out of Possession phases of play, categorised by playing position location.

Whilst In Possession, Central positions appear to sprint less often compared to Lateral positions (Fig. 5.13). The most prominent categories where Lateral positions perform more sprints than Central positions are Overlap (+8%), Run with Ball (+6%) and Run the Channel (+4%). Overlap and Run the Channel are both contexts that would be typically completed in the lateral areas of the pitch and therefore much more favour those positions located Laterally. Run with Ball is often a skill used typically by WM to attempt to cross the ball into the penalty box. Only two categories see Central positions spiriting more frequently than Lateral, Run in Behind (+3%) and Drive Through the Middle (+3%). These are key position-specific contexts, where a CF will often attempt to Run in Behind the opposition defence to create a potential scoring opportunity. Similarly, Drive Through the Middle is a typical context for a CM, where they will attempt to break into the box for scoring opportunity.

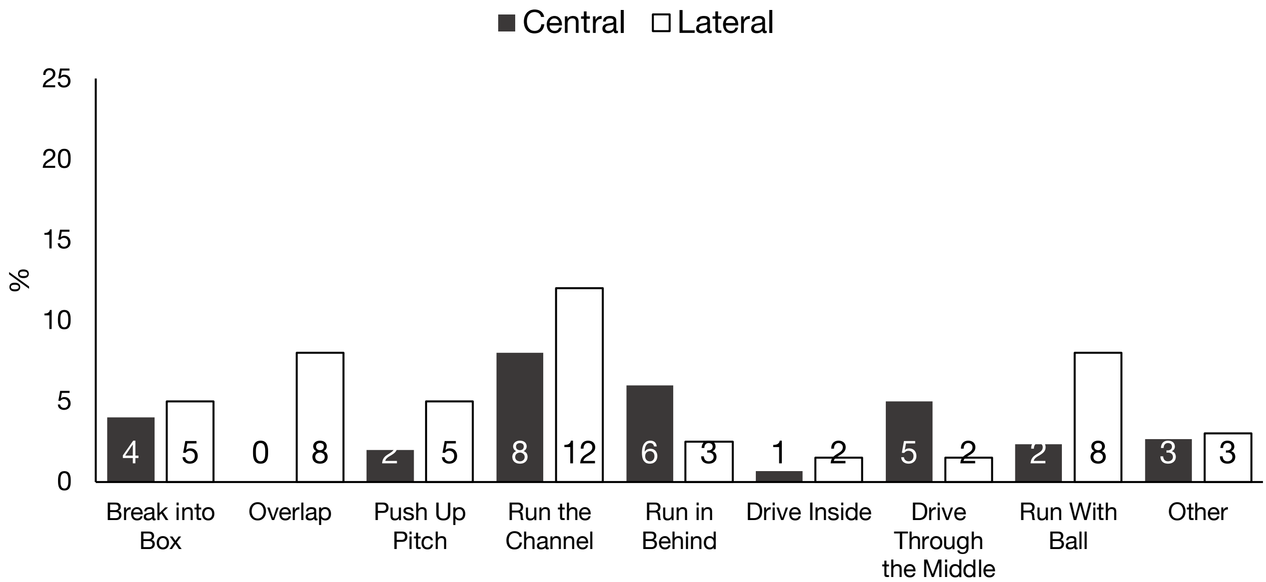

Figure 5.13 The average percentage of sprints completed during a match according to their Tactical Outcome whilst In Possession, categorised by playing position location.

5.4 DISCUSSION

The current study is the first to seek to quantify the football match specific Tactical-Contexts within which sprinting occurs. As seen previously in the most similar research to date, observing high-intensity running, sprints in football occur within a variety of Phases of Play and Tactical-Contexts (Ade et al., 2016). Sprints were observed as occurring in all Phases of Play, however Attacking Organisation was statistically the least frequent of these (Fig. 5.1). The majority of sprints were completed whilst the team was Out of Possession (58%). Closing down was the most common Tactical Outcome within this (17%). It is clear that sprinting in EPL football occurs in many different contexts. The results of the current study could have an impact on the way footballers are prepared for the demands of match play. With the currently presented knowledge on the context within which sprints occur, training drills can be designed accordingly to reflect the exact physical demands of a match (Ade et al., 2016; Myszka, 2018). Additionally, the results may enhance the skill development of footballers by providing practitioners with an ability to develop a player's effectiveness in these key match-defining moments. Through training exposure to representative match contexts, perception and action can be concurrently, and thus optimally, developed (Faude et al., 2012; Myszka, 2018).

5.4.1 Phase of Play

Statistically significant differences were observed across the four phases of play for when sprints occur during football match-play (Fig. 5.1). Attacking Organisation was the statistically least common of these phases of play within which sprints occurred (9 ± 5). Sprinting during Attacking Organisation was ~3 times less common than all other categories. Attacking Organisation describes the phase of play whereby the in-possession team aims to create goal-scoring opportunities by disorganising the oppositions defensive structure. This phase is likely to involve the opposition being set up in a strong organised defensive structure (Delgado-Bordonau and Mendez-Villanueva, 2012). The nature of this phase may reduce the potential for the attainment of adequate velocity to achieve a sprint, as defined by the current methodology. During Defensive Organisation the opposition will attempt to reduce the space available for the team in possession (Attacking Organisation), and consequently, the likelihood of the necessary distance required to achieve the velocity for a sprint effort to be recorded may be limited (Delgado-Bordonau and Mendez-Villanueva, 2012). Nevertheless, those sprints that are performed in this phase are highly likely to be the most crucial due to their direct involvement in goal scoring opportunities – the main focus of the Attacking Organisation phase (Delgado-Bordonau and Mendez-Villanueva, 2012; Faude et al., 2012; Jeffreys et al., 2018).

Though no other statistically significant differences exist across the three remaining phases, the majority of sprinting efforts occur during the two Transition phases of play (57%) (Fig. 5.2). This would be expected due to the nature of transitions where it is common for players to move between defence and attack rapidly in an attempt to develop Attacking or Defensive Organisation in the opposite phase and likely involves greater distances as a result (Delgado-Bordonau and Mendez-Villanueva, 2012; Jeffreys et al., 2018). During the transition between phases, the attacking team will often attempt to exploit the opposition's lack of defensive organisation.

This could lead to fast, extensive sprints into available space in the defensive structure. This is a commonly utilised strategy in football due to the inherent weaknesses of a defending team upon losing possession (Delgado-Bordonau and Mendez-Villanueva, 2012). Transition phases are thus likely to be a key area of focus for practitioners looking to develop effective game speed. Whilst sprints in the current study were not assessed on their effectiveness in relation to the match outcome, previous study has shown sprinting to be key to goal scoring and assisting (Faude et al., 2012). Enhancement of performance in these Transition sprints could therefore potentially see an impact upon match outcome.

Although sprinting is more common during the transition phases, Defensive Organisation was the most common of the four phases overall. The average for this phase, when combined with Attacking Organisation (the least common), is skewed slightly compared to the transition phases and results in a lower overall percentage of efforts during organised phases. Therefore, the majority of efforts occur when the team is settled into a defensive structure and individual players complete defensively-minded, out of possession sprints (Delgado-Bordonau and Mendez-Villanueva, 2012; Jeffreys et al., 2018). Similarly, the majority (60%) of efforts occur in the defensive phases (Organisation and Transition). Closing Down was observed as the most common context for sprinting in the study. This may be indicative of the importance of the phase and the strong impetus placed on not conceding a goal. It would be reasonable to assume that there are strong perceptual differences between defensive and attacking sprints. Where one is in response to the opposition and thus more unknown than those completed in response to teammates where set patterns of play and strategies are employed. Whilst the results appear clear that defensively-minded sprints are more common in football than attacking, caution must be noted due to the limitations of the current study. This outcome may be biased towards the team observed in the study and other teams may see more sprints completed in an attacking context.

When comparing the different phases of play across positions, starker differences can be seen. The two classically defensive positions, Full Back (66%) and Centre Back (99%) naturally complete the majority of their sprint efforts whilst in defensive phases of play (Fig. 5.8). However, whilst Centre Backs rarely sprint during the Attacking phases, Full Backs are much more likely to (34%). This is indicative of the inherent differences in the two positions, which on the surface may appear to have similar demands. This large involvement in the Attacking phases appears to be a modern tactical development of the FB from one solely focused on defending. Modern tactics dictate the involvement of FB in more attacking situations through more fluid formations and strategies such as WM being allowed the freedom to move into the centre of the pitch, freeing up space for the FB to progress further up the field (Barnes et al., 2014; Wallace and Norton, 2014; Bush et al., 2015). Additionally, anecdotally, the team studied possessed a reputation for a defensive style of play. Thus, it is reasonable to assume that teams playing a more attacking style may see even starker differences within the defensive players. The results suggest that FB and CB require specific training programmes, rather than being grouped into a category merely of ‘Defenders’.

Wide Midfielders and Centre Forwards presented similar outcomes to one another. The most frequent phase when sprints occur being Attacking Transitions, followed by Defensive Organisation. The most common of these would be expected, as these highly attacking positions seek to break quickly to catch the opposition's defence out of shape during Attacking Transitions – a potential area of weakness for the defensive team (Delgado-Bordonau and Mendez-Villanueva, 2012). But, surprisingly, a large proportion of efforts are completed during Defensive Organisation for these positions. It appears that once Defensive Organisation is achieved, these typically attacking-minded positions adjust their focus to defending. These are often Closing Down sprints (21% & 23%), where a player sprints directly towards an opposition player to pressure them. Again, though, this could likely vary between teams playing different strategies. Here the team has likely followed a more defensive strategy, relying greatly on these positions to assist in defence.

5.4.2 Tactical Outcome

As discussed, the majority of sprint efforts occur in the defensive Phases of Play (60%), and thus the Out of Possession Tactical Outcomes. Of these Out of Possession categories five of the eight were seen most frequently: Closing Down (28%), Covering (19%), Recovery Run and Track the Runner (16%), and Ball Down the Side (16%). It is likely that this could be specific to the team studied, as discussed previously. Style of play would be a large determinant of this, where certain teams may seek to return to a solid defensive structure upon surrendering possession (Bradley et al., 2011; Wallace and Norton, 2014; Bush et al., 2015). From this, sprints seem to occur to attempt to regain possession such as Closing

Down and those listed above. Teams who play a more attacking style would likely see a greater proportion of sprints whilst in possession as they attempt to 'take the game to the opposition'. Again, this further reiterates the general nature of the current results and the limitations of only studying a single team. Analysis would ideally be completed with a practitioner's own team to ensure results are specific to the population and results are thus directly applicable.

When looking at a breakdown of playing position clear differences exist for Out of Possession sprints and their Tactical Outcome. Though caution is noted due to the restricted sample size (Fig. 5.10 & 5.11). The two most common Tactical Outcomes when Out of Possession for Centre Backs are Ball Down the Side and Covering (61% of all sprints). This appears a key match action for this position. Typically, the team studied played with two Centre Backs, where a ball played by the attacking team down the side of one of the Centre Backs would have elicited a tactical Outcome of Ball Down the Side for that player, and a Covering sprint for their Centre Back partner. Thus, reducing the space in behind the defensive line. The results of the current study suggest this is likely to be a commonly used attacking tactic by Premier League teams, and CB should therefore be trained more effectively to deal with this. By recreating similar scenarios and environments during training practice, a CB ability to perceive and 'read' a potential ball down the side of their defence earlier and more effectively could likely be enhanced to complement their typical physical training. Anticipation and the consequent timing of these efforts would appear to be crucial as the defence attempts to maintain their line before reacting to the attacking opposition. These are skills that can be developed in skilled performers (Murphy et al., 2018, 2019; Runswick et al., 2018).

Whilst In Possession the most commonly occurring tactical outcome was Run the Channel, followed by Run in Behind. These types of sprint efforts by their nature are potentially very impactful on match outcome (Faude et al., 2012). When sprinting to Run the Channel, WM and FB may often be aiming to create separation from a defensive player and provide a cross into the oppositions' penalty box and is, therefore, a strong position to assist a goal from (Ade et al., 2016). Run in Behind would be completed by an attacking player to again achieve separation from a defensive marker and find space in between the defence and their goal for a prime goal-scoring opportunity. Therefore, these tactical outcomes are key to any performance enhancement and could be 'reverse-engineered' to design specific training interventions to improve a player's success during a match. The definition of what success is in each context would be a strong area for future research. Initially though, recreating these scenarios and environments during training to allow a player to learn the key perceptual cues and explore the most effective movement strategy would be a key outcome of the current study.

Again, with a restricted sample size as an accepted caveat, differences are observed when looking at positional breakdowns of the Tactical Outcomes within which sprints occur whilst In Possession. Full Backs for example complete 14% of all their sprints (the most common in possession) whilst performing an Overlap run. This type of effort would have an important timing element, where accelerating up to maximal velocity as fast as possible could be detrimental. The success of the effort could be more related to a ‘controlled’ approach up to the ball rather than absolute velocity. Thus this is likely completed well within a players maximum velocity capacity and is a good example of the difference between ‘game speed’ and maximum sprinting capacity (Jeffreys et al., 2018). The current study clearly demonstrates the specific-nature of sprinting in football and the importance of the contextualised tactical nature of physical demands (Ade et al., 2016; Bradley and Ade, 2018; Jeffreys et al., 2018).

Also, of key consideration, is the link between the Tactical-Context of a sprint effort and its consequent movement profile. Whereby the match, and a players’ relationship to it, dictates the movement outcome. An Overlap sprint, for example, may demand Torso Dissociation, Curved sprinting, and end with a Ball outcome alongside the key perceptual, cognitive ‘reading; of the game. These are all specific skills that would be absent in training following traditional track-based sprinting methods. This overlap effort can be trained along a spectrum of closed-skill drills focused on movement overload, to highly perceptually demanding drills that strongly represent the match-based tasks. As discussed, skilled performers display enhanced anticipation and thus practitioners should seek to ultimately combine this perception and action training to ensure successful transfer to match performance (Murphy et al., 2018, 2019; Runswick et al., 2018).

It is clear that during a football match a player will perform sprints for many different reasons. Each of these Tactical Outcomes has its own unique demands. By now further understanding the Tactical-Context of these efforts, practitioners can improve the specificity of their training programmes through greater specificity. Sprinting is decisive in match outcome and a key mechanism for hamstring injury (Faude et al., 2012; Schuermans et al., 2017). By employing the results of the current study, practitioners can begin to intentionally recreate the most common of these contexts during training to seek to develop a players ability to ‘read’ the environment and make more effective and faster decisions for movement pattern selection through exploratory learning and ‘repetition without repetition’ (Myszka, 2018). As discussed in the Review of the Literature it is believed this approach of training perception and action concurrently will ultimately enhance potential transfer to match performance.

By understanding the key match-based sprinting contexts completed in football, all training interventions can be tailored ultimately towards enhancing performance in these actions. For example, a continuum of drills from highly specific environments, with little physical overload, to less specific but higher overload potential can be employed to repeatedly expose a CB to a sprint in response to a Ball Down the Side (Brearley and Bishop, 2019). By reverse-engineering the match activity, a CB may be trained in the specific task of defending a Ball Down the Side. Firstly, during a specifically designed drill to maintain the perceptual stimulus relevant to the task. Following this, the task-specific movements associated with the context can be trained in their isolated, constituent parts (Chapter 4) such as a sprint performed from a Rear Starting Position. These can be completed with and without a perceptual stimulus. Further to these, more general qualities such as the strength and power required to sprint could be trained through firstly pitch-based interventions and also gym-based activities (Table 7.2). The player will, as a result, develop both the physical and perceptual skills key to a successful outcome in the defined match-specific effort. It would be reasonable to assume that, potentially inadvertently, during typical training practice players would be exposed to some of the key Tactical-Contexts outlined in the current study. Though without the clarity provided by the current data, it is unlikely that any stimulus is adequate enough for true development in the key actions. Nevertheless, the level to which this occurs is currently unknown and to quantify the level of exposure to such position relevant situations would be a logical progression of the current research.

In addition to the performance enhancement possibilities, a deeper understanding of the contexts within which sprinting occurs allows practitioners to enhance the specificity of their rehabilitation programmes. A key factor to returning a player to training, and eventually match play, is to progressively expose the athlete to the stimuli they will likely encounter during day to day football practice. Therefore, by now possessing a greater understanding of sprinting contexts, a practitioner can recreate more specific scenarios that a player will typically encounter in training and match play. It is believed that these will provide the ultimate combination of the physical (Chapter 4) and perceptual stimuli. For example, a CF frequently completes a sprint effort to Run in Behind the opposition defence. Training drills can be constrained to ensure repetitive exposure to these types of efforts and the physical demands which they dictate. Thus, ensuring the athlete is capable of tolerating the demands of training and match-play upon their return to the team.

In addition to this, the development of more specific testing procedures can begin, beyond the typical isolated, time to complete and maximum speed tests currently employed (Jeffreys et al., 2018). By categorising the contexts within which sprints occur by position, researchers could seek to establish 'successful' and 'unsuccessful' outcomes of these efforts and potentially seek to score players on these outcomes. These results could then be used to compare players for scouting purposes. For example, how often does a CB successfully defend a Ball Down the Side? This could then be combined with all other contexts to provide an overall score and a breakdown of each context for potential training of weaknesses. Currently, software exists for practitioners to view match footage of professional players worldwide (Wyscout, Italy). By utilising this, scouting departments and sport science practitioners alike can assess the physical qualities of players from other teams. Similarly, the analysis can be conducted on one's own team to establish areas for improvement.

Within each Sub-Category of Tactical Outcome, there existed a category labelled Other. This was included in the original system that the STC was based upon. Although during the pilot work involved in the system's development (Chapter 3) this category was not seen for either In or Out of Possession, it was decided that maintaining this category would allow for any uncategorisable sprints to be still included in the system. On average 6% of In Possession sprints were labelled Other. These efforts were typically as a result of recovering possession. These often presented themselves as a sprint to retrieve an over hit attacking corner or a wayward pass. This is potentially a limitation of the study in so much as all efforts were not labelled in detail. However, as these were such a small proportion of total efforts it is the authors' opinion that this did not detract from the study's results overall. Future study may look to include a category such as Possession Recovery to the In-Possession Sub-Category.

The current study is mainly limited by the use of only a single team for analysis. Similar to the discussion during Chapter 4, the use of one team may bias results based upon strategy and formation used. It is highly likely the current team analysed could be classified as playing a defensive strategy. Such an approach may mean positions such as Full Back present with fewer attacking sprints. This could also explain the predominance of sprint efforts whilst out of possession, where attacking positions exhibited a significant amount of Closing Down sprints. Thus, to further the research it is necessary to study teams who use different strategies. This is an important caveat for the practical application of the results presented, whereby practitioners should seek to complete the analysis on their team to ensure results transfer.

The classification system employed aims to analyse sprint efforts that attain a velocity of 7 $m.s^{-1}$. However, this method, while common within the literature, may omit maximal effort running that lacks the necessary distance to achieve the required velocity. This is likely to bias efforts selected for analyses to those that are more extensive in nature. This potential limitation was noted in the development of the system (Chapter 3). Nevertheless, it is important to consider this limitation when interpreting any of the presented data for practical purposes. This could be a potential cause of the few sprints observed during Attacking Organisation. Where these efforts may be shorter in nature and thus less frequently achieved the desired threshold for the current study.

5.4.3 Conclusions

The current study is the first known to attempt to define the tactical-context that sprints occur within football. Sprinting occurs as a result of various different tactical outcomes and during all phases of a match. These novel results could have a large impact on the future physical preparation of footballer. Through a deeper understanding of the demands of match play, more specific programming can be designed. Whilst similar previous work has been published on high-intensity running, it is hoped that the current results provide a progression of the area due to the impact that sprinting can potentially have upon match outcome (Faude et al., 2012).

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CHAPTER 6

A PROPOSED MODEL OF SCIENTIFIC DISSEMINATION UTILISING CONTEMPORARY METHODS.

6.0 PERSONAL REFLECTIONS

Study 3 reiterated a lot of the lessons learned from Study 2 with respect to research skills. Both studies were very similar in their design and methodology, even though they focused on slightly different facets of sprinting in football. However, I believe that the additional context data with the previous findings on movements is very important and opens up many different future lines of research and is also hopefully a paradigm shift in the way coaches view sprinting and physical preparation as a whole in football.

6.0.1 Research Skills

As discussed, the method of research for Chapters 4 and 5 are very similar, and consequently the reflection on the processes. However, Chapter 5 certainly creates its own major areas for future thought and study. A key area for me personally, as noted in the discussion, is the potential for the development of more effective game speed assessments for footballers. Whilst typical tests of agility, change of direction and straight-line speed have their place, they are rarely good indicators of success in a football match. I don't believe that there currently exists a suitable test that reflects a player's true match performance – a philosophical debate would be whether this is even possible or necessary. However, if a test can be developed that allows players to be compared on their physical match performance, this would be highly useful for scouting and performance programme assessment. Such a test would require success to be defined in the contexts quantified in the current study and then the development of an appropriate grading system to allow comparison. This would then be much more useful than a typical maximal velocity number.

Whilst a test could be completed manually as in the current study, again automation would be crucial to the feasibility of such a process.

The development of the current study introduced me personally to a new area beyond my typical focus on physical development. This area of ecological dynamics and perception-action coupling is an area I personally, and I believe many other in similar roles, did not understand well enough. The inherent link between how an athlete perceives their environment and the movements they select is key, and I see this as an area that will hopefully progress further within strength and conditioning. Physical abilities are ineffective without the ability to apply them in a game-specific context. I feel this area should a much greater part of any strength and conditioning curriculum.

The current study also made me question my fundamental understanding of science, and whether we may sometimes fall into the trap of being too reductionist. I have certainly seen this be the case in my own personal practice, where certain data points, such as GPS metrics, have been relied on far too heavily when a more holistic view would have been more appropriate. The important things are not always the most tangible or easily measured, and the interaction between these can be as important as the data points themselves. A good example of this would be the reliance on testing time to complete a distance whilst sprinting, or maximum velocity capacities. A study testing the enhancements of these qualities does not indicate that performance in a sport-specific task will be necessarily enhanced accordingly.

The findings and conclusions from Chapters 4 and 5 are highly practical and applicable in elite environments. Thus, the key to the final stages of the thesis is to successfully disseminate these findings. Only in doing so can the studies be useful. It is therefore crucial that Chapter 6 seeks to apply and assess a model capable of doing so. Also, key to these is the means of achieving this dissemination. Any future peer-review submission would take a long period of time and consequently there is a need for the results to be presented through different methods. These more contemporary methods would allow for practitioners and researchers to analyse the results at a more relevant, earlier time.

6.0.2 Professional Skills

As discussed above, the main personal lessons from the study were regarding the perceptual side of sprinting. This certainly made me fundamentally question my own practice. Whereas before, as discussed, I subscribed more to the thought process that this type of transfer occurred during football training I now believe that physical coaches should take a lead role in this area and look to work with football coaches in training these qualities. This could easily be achieved logistically by concerted decision making with drill design.

Whilst there is certainly a place for traditional speed development programming based upon track sprinting, it appears that this type of intervention may ultimately be limited by a lack of perceptual ability training and both should be trained with equal importance. Rote learning of specific skills is limited in its effectiveness beyond the early stages of development and learning and movement dexterity should be sought rather than seeking a perfect technical model. As noted in the discussion, this is likely best achieved following a base level of competency, through ‘repetition without repetition’. Here an athlete is exposed to various different environments, constrained by the coach, and learning is achieved through exploration of the given task. Thus, exposing a footballer to the typical contexts they may face (as gleaned from the current study) repeatedly, but with varying different circumstances, allows them to develop a dexterous response to the context – which, during a match, is never the same.

As noted above, the key to the final stage of the thesis is to effectively disseminate the findings – ideally in a short time frame to ensure the direct applicability of the results. As discussed previously, during the early stages of the programme, I received advice on how to conduct the research focus within the specific area. The aim of this was to view the process as the development of a product and a personal brand. This would aid me in always keeping a focus on the final outcomes of the thesis. Thus, throughout the development of the studies, this is something I have sought to achieve. This has involved consistently disseminating interesting developments via social media and presentation. The final study will be a legitimisation of the process and the model employed.

6.1 INTRODUCTION

Dissemination of research is fundamental to the progression of science, whereby 'research is of no use unless it gets to the people who need to use it' (National Institute for Health Research, n.d.). It can be defined as a planned process where target audiences and the settings in which the research is to be received are considered to lead to the eventual successful uptake and implementation of the findings (Ward et al., 2009). Much scientific research is funded by stakeholders, often ultimately from public funds, therefore it is imperative that results are shared as widely as possible to gain as much value for a project as is feasible. In addition to this, scientific research is often used to develop future studies and create discussion between researchers; ultimately progressing the knowledge within an area. Finally, scientific research is also important for the forming of governmental policies and thus must be accessible (Eagleman, 2013).

Over recent years there has been an increase in the use of more contemporary methods of scientific dissemination such as Social Media, Podcasts and Presentations (Letierce et al., 2010; Robinson-Garcia et al., 2017; Hotez, 2018). Scientists are looking at these modern methods as a means of drawing additional attention to their publications, sharing insights throughout the development of the research, reaching a wider audience, and building their scientific brand (National Institute for Health Research, n.d.; Ward et al., 2009; Letierce et al., 2010; Robinson-Garcia et al., 2017; Hotez, 2018). As noted, it is fundamental to scientific progression that research reaches as wide an audience as is possible (National Institute for Health Research, n.d.).

Alongside the potential enhancement of future publication, it has been suggested that utilising this approach of consistent dissemination during the research process can assist the researcher in developing a 'brand' within their subject area (Hotez, 2018). The development of which has been noted as important for reasons such as how a brand is able to 'move with' a scientist throughout their career, independent of their current employment status (Hotez, 2018). This can facilitate smoother career transitions and even potentially expedite future employment opportunities through the development of one's reputation within an area (Hotez, 2018). Thus, throughout the current thesis, the authors sought to employ these contemporary methods in an attempt to develop such a brand, alongside enhancing the future reception of published research.

As noted in the Review of the Literature, whilst peer-review rightly remains the gold-standard means of disseminating scientific research, it is by no means perfect. Peer-review attempts to ensure scientific rigour through the independent review of manuscripts by respected peers within the discipline (Ferreira et al., 2016). However, the process has been critiqued for such reasons as the decentralised, unstandardised and voluntary nature of the process. These potentially lead to issues such as efficiency, efficacy and quality control (Hochberg, 2010; Lortie, 2012; Ferreira et al., 2016). Similarly, the process can take multiple years between the initiation of the study and eventual publication. For these reasons, many seek to employ contemporary methods as a means of supplementing peer-review publication. However, whilst the current body of literature was reviewed previously, minimal knowledge exists on the direct application of these methods and how they may compare to one another.

As discussed in the Review of the Literature, each method possesses its own areas of strength. However, it is important to formally compare these within a specific context to better understand how these may fit within a broader model of modern scientific dissemination. Only by observing where each is potentially limited can such a model be considered. The current thesis will consequently be disseminated following a model employing contemporary methods such as Social Media, Presentation and Podcast prior to the completion of the thesis and eventually submission for Peer-Review publication (Fig. 6.1). The model was arranged based upon the noted strengths of each method.

Figure 6.1 An outline of the model used in the current study for scientific dissemination.

6.1.1 Aims

Thus, the current study aims to critique the identified contemporary methods of scientific research dissemination in relation to their intended outcomes. These will be employed within a broader described model (Fig. 6.1) and assessed individually and broadly within this model. Through their strategic application, comparisons will be made between the methods to develop recommendations on a plan for successful scientific dissemination utilising the outlined model.

6.2 METHODS

As discussed, three standout contemporary methods exist for scientific dissemination – as adjuncts to traditional peer-review. These being: Social Media, Podcasts and Presentations. The dissemination methods were employed in a strategic process in anticipation of future peer-review submission (Fig. 6.1). Each stage of the model possessed its own specific outcome focus in support of the final outcomes of creating a 'scientist brand', and as impactful as possible future publication (Fig. 6.2). Firstly, the researcher began by sharing information on the development of the study and early pilot results through social media (Twitter). This supported the creation of a 'brand' and early interest in the thesis. The aims of the initial stage (Fig. 6.1 – Social Media) were therefore to create a general awareness of the project. This included both the author's involvement and awareness of the subject of the thesis. It was believed that this would lead to later improved uptake following publication.

Following the development of this early interest, a podcast was completed to discuss the thesis broadly and provide additional context and detail to the proposed studies and future direction. Alongside this podcast, and following the attainment of some early results, a presentation was completed to further the dissemination and explanation of these in anticipation of future peer-review submission. This second stage (Fig. 6.1 – Podcast & Presentation) therefore sought to begin to provide a platform for the effective dissemination of the early findings. These methods allowed for greater detail to be provided. Alongside further enhancement of the reach of the work, it was believed this would solidify the understanding of the research. The final stage (not completed as a part of the current thesis) would then be Peer-Review publication. The aim of this final stage would be the effective dissemination of scientifically rigorous research. Each stage was thus critiqued uniquely in line with its key focus.

Figure 6.2 An outline of the model used according to the aims of each stage.

Attempts were made to assess each stage according to its intended aims (Fig. 6.2). The initial stage of the model sought to raise general awareness of the project and the researchers' profile within the subject area. Consequently, the applications of the stage required consistent, broad, 'attention-grabbing' output to as wide an audience as possible. As a result of this, analysis was predominantly focused upon the quantitative aspects surrounding the reach of the method (Social Media). In contrast, the focus of the second stage was to more effectively disseminate the early findings of the study, furthering the reach and awareness of the project through more scientifically-based means and to a more specific audience. Thus, this stage (Podcast and Presentation), alongside comparative quantitative data pertaining to reach, was assessed through questionnaires completed by practitioners and researchers within the field of sport science. This allowed for a more specific analysis of the methods included in this stage and how they were received by the intended audience. Alongside this formal comparison of methods, a personal reflection was completed by the researchers to provide further context to the analysis.

6.2.1 Social Media

Twitter was utilised as the means of raising general awareness of the thesis and disseminating the study's early findings through social media. A quantitative assessment of its effectiveness was performed by accessing data around the reach of tweets sharing the early research findings and the author's ideas regarding the broad development of the thesis. Focus here was made to the reach of the posts. Due to the discussed restrictions of the method, it was felt that the goal of the initial stage of the model (Fig. 6.2) was to create awareness of the research and the researchers' involvement within the subject area. The time period from the commencement of the doctoral programme to the writing up of the thesis was utilised for analysis. Tweets were published throughout this period whenever points of interest, deemed by the authors, arose (Figure 6.3). These were selected with the aim of creating interest and discussion within the subject and the current research being completed. Particular attention was made towards the development of a 'scientific brand' and the profile of the research. Upon the commencement of the final thesis write-up period, outcome measures were compared from the beginning of the process. The selected outcome measures included those typically provided by the platform such as Followers, Engagements and Impressions (Table 6.1). Due to the inherently transient nature of Social Media, 'Typical' outputs, those that were deemed reflective of the dissemination output as a whole, were selected for analysis. An individual example of these measures is displayed in Figure 6.4.

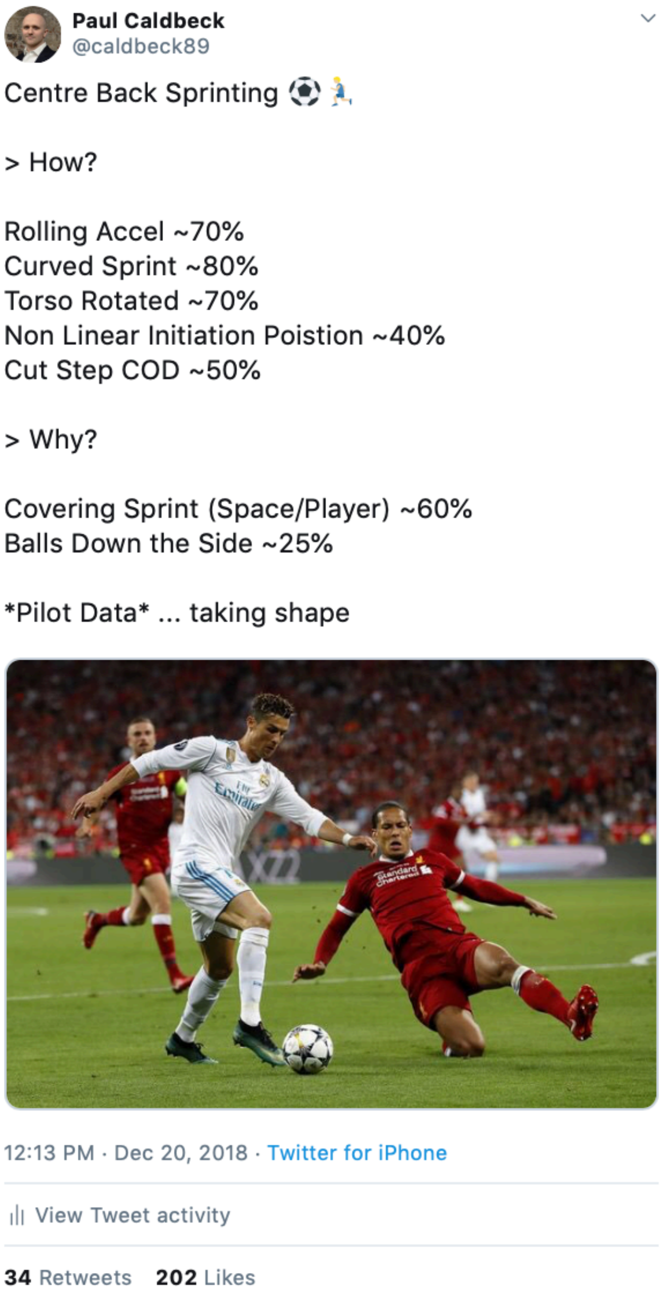

Figure 6.3 Example Social Media post (Twitter) disseminating early findings form the current thesis.

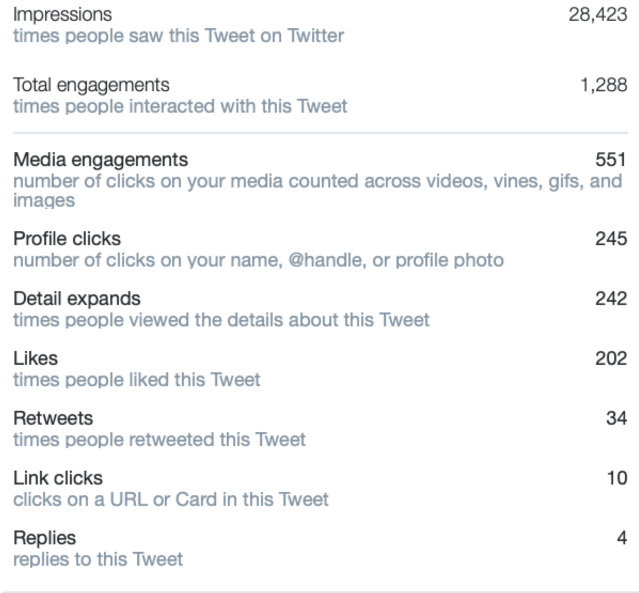

Figure 6.4 Example performance of a Twitter Social Media post disseminating the early findings of the current thesis.

Table 6.1 A table outlining the outcome measures of dissemination through Social Media.

Outcome Measure	**Definition**
Followers	*The number of accounts that have actively selected to view the tweets published by the author's account.*
Engagements	*The number of accounts that have clicked on a specific tweet itself, the publishers account profile, or any links and media as a direct result of a tweet.*
Impressions	*The number of times a tweet has appeared in the timeline of other Twitter accounts.*

6.2.2 Podcast

The second stage of the Model (Fig. 6.1) (Podcast & Presentation) was focused more towards the successful dissemination of the early findings, rather than fundamentally the reach, as with the first stage (Social Media). To ascertain the effectiveness of podcasts as a method of scientific dissemination, the author completed an interview on a popular podcast within the area, the Football Fitness Federation Podcast (Fig. 6.5) (the invite of which was received as a result of the early dissemination through Social Media). From this, an assessment was made on the strengths and weaknesses of podcasts by discussions with active practitioners and additionally quantitative data obtained pertaining to the number of listens. The podcast was completed following data collection for the thesis.

Figure 6.5 An example media output from the studied Podcast disseminating the early findings of the current thesis.

The establishment of strengths and weaknesses of the method consisted of active practitioners listening to the podcast and answering questions produced by the researchers sent through email:

1. What did you feel was good about the podcast?
2. What improvements could have been made to the podcast?
3. What were the key take-home points from the podcast, and how easy do you feel these could be applied in a performance environment?
4. What are your opinions on podcasts as a method of scientific dissemination, particularly when compared to others such as peer-review journal articles, presentations and social media?

The questions were sent out to three active practitioners within football sport science. Two complete responses were received for the final analysis. From these responses, data was refined and processed into tables consisting of the strengths and weaknesses of the method. This was then employed as an outcome measure for the results of the current study. In addition to this qualitative assessment, the number of listens of the podcast was used as a means of quantifying the reach of the method (Table 6.2). These were attained through discussions with the producers of the podcast and totalled from the two main publishing methods of the final podcast: iTunes Podcast (Apple, USA) and SoundCloud (SoundCloud, Germany) (www.soundcloud.com/footballfitnessfederation/4-is-son-heung-min-faster-than-usain-bolt-with-paul-caldbeck). Though not the focus of the stage, this allowed for comparisons to be made with the reach achieved through Social Media.

6.2.3 Presentation

Alongside the Podcast, an external, independent presentation was completed to disseminate the findings of the current thesis (Appendix 9.3) (Fig. 6.6) (again, the invite was received as a result of early Social Media dissemination). This was completed following the attainment of all results for the thesis. The presentation was delivered at a regional event ran by the national governing body of Strength and Conditioning in the United Kingdom, the UKSCA. The content of the presentation sought to introduce delegates to the area of Contextual Sprinting in Football. Following this, the methods utilised in the thesis were outlined, and the consequent results discussed. This then allowed for anecdotal practical implications from the researchers to be presented and discussed with delegates.

Figure 6.6 An example media output form the studied presentation disseminating the early findings of the current thesis.

As with Podcasts, the analysis was completed to assess Presentation as a means of disseminating the early results of the thesis. Thus, a similar qualitative investigation was employed. Delegates were asked to provide feedback on the presentation and their views on its effectiveness for scientific dissemination. Similar questions to those used to assess Podcasts were produced:

1. What did you feel was good about the presentation?
2. What improvements could have been made to the presentation?
3. What were the key take-home points from the presentation, and how easy do you feel these could be applied in a performance environment?
4. What are your opinions on presentations as a method of scientific dissemination, particularly when compared to others such as peer-review journal articles, podcasts and social media?

Four complete responses from the 35 delegates were received and the same data processing protocols as those outlined previously were followed. For the quantitative analysis of the reach of the method, the delegate number was utilised (Table 6.2).

6.3 RESULTS

6.3.1 Social Media

The main outcome focus of the initial stage of the model, Social Media, was to create awareness of the thesis. As discussed, whilst exact figures are difficult to ascertain due to the transient nature of the method, typical outputs were used as a means of gauging effectiveness. From the beginning of the process until the writing-up period of the thesis, the author increased their Twitter 'Following' by ~1500 (150%). Though, as discussed in the Introduction and Review of the Literature, consideration must be made as numbers can be inflated due to fake 'bots' accounts. Typical tweets involving the research attained 'Engagements' of ~1,200 (Table 6.2), with typical 'Impressions' (the featuring on others timeline) of ~12,000 (Figure 6.4). Additionally, both podcast and presentation invites were as a direct result of this social media activity.

As noted, the main aim of the second stage of analysis was to begin to effectively disseminate the thesis' early findings rather than merely increase awareness of the project. However, it is still useful to compare the reach of the contemporary methods employed and contextualise these against more traditional peer-review publication. Though it is difficult to ascertain average 'reads' of a journal article, a key paper used within the current thesis attained 1,791 reads at the time of writing (ResearchGate) and has been formally cited 13 times (Scopus.com) (Ade et al., 2016). It likely though that this figure could be higher than the typical article due to being 'open-access', and it is also unclear whether this would record duplicate views. The presentation of the current thesis results was completed to an audience of 35 delegates - though at a larger event this may be up to around 100. Lastly, the podcast, at the time of writing, attained 513 listens (Table 6.2). It is clear, without considering effectiveness, that peer-review has the possibility of reaching the most people when compared to Presentation and Podcast, however, Social Media may provide a means of reaching a similar audience size.

Table 6.2 A table comparing the reach of different methods of scientific dissemination.

	Peer Review	**Social Media**	**Podcast**	**Presentation**
Views / Engagements / Listens / Delegates	*1,791*	*1,288*	*513*	*35*

6.3.2 Podcast

A key point from the feedback received around the Podcast was the ability for the researcher to provide context and background from their perspective as a practitioner: *'context of the researcher not just the research'*; *'Good real-world information about experiences working with coaches'*. Again, this is an area that is potentially lacking in peer-review articles by following traditional scientific report methods, where anecdotal information should be restricted. This was a key theme noted in the results and a clear strength of the method.

The Podcast was also noted as potentially lacking in intricate, robust detail: '*The podcast format requires a broader context and narrative and, therefore, some assumptions'*; *'more specific information'*. This appears to be a natural issue with these formats as opposed to the scientifically rigorous peer-review (Table 6.3). Time restrictions and logistical factors prevent this being a feature in the podcast format. Also, as noted, during a Podcast the format is typically that of an interview. Whereby the researcher, as the guest, is interviewed by the host. Thus, it may not be possible to discuss the intricate methodological considerations. Similarly, the audio nature of the podcast doesn't allow for a listener to reference back in the same manner as a published article.

Table 6.3 A table outlining the feedback responses relating to the strengths and weaknesses of the dissemination of the current thesis results through a Podcast.

Strengths	Weaknesses
The topic is contemporary and relevant *The researcher articulated knowledge really well* *Getting the context of the researcher not only the research* *The researcher demonstrated a good rationale to the research* *The researcher signposted the application of the research to the applied setting extremely well, giving examples of application across a wide variety of settings/ contexts*	*It would be great to hear the podcast once the researcher had made more progress with other studies e.g. especially in reference to the SSG analogies etc* *The host could have asked more challenging/ relevant questions around the research process to allow the researcher to elaborate on the study itself in addition to the researcher's observations and applications* *At times I think the researcher maybe takes a bit of a leap beyond their research to imply the benefits/ application, which is not a criticism but more a recognition between the difference between traditional and non-traditional dissemination methods. The podcast format*

	requires a broader context and narrative and, therefore, some assumptions.
Clear flow - what you're doing for your research, and then how you can apply those findings into practice *Position specific profiling based on contextual sprinting* *Enjoyed the practical elements - how you feel you can apply the findings into both gym and pitch-based settings, in particular the information regarding how you selected more traditional movements alongside the Frans Bosch type of work* *Good real world information about experiences working with coaches and building relationships*	*Maybe more specific information based on building rehabs around contextual sprinting actions and S&C exercises to complement this.*

6.3.3 Presentation

A key theme that was raised as a strength of a presentation was the ability to integrate significant amounts of visual material alongside the results of the thesis ('*allows me to see how what is being discussed relates to the sport')* (Table 6.4). This is echoed through most comments when discussing the strengths, as well as when compared to other methods. The key being that a presentation allows the presenter to explain concepts in greater depths than may be possible during a journal article and this is further enhanced by the opportunity to supplement with visual material such as videos and images.

In addition to this, another theme of the comments regarding presentations was the opportunity for the presenter to give their own opinions on the practical implementation of the findings of the thesis. When disseminating through peer-review, little in the way of a coach's opinion on research findings can be included due to the experimental nature of the process. However, this more scientifically rigorous data can be presented with practical examples from the coach's experience when presenting. This is evidenced in comments such as: *'directly relevant to my work as an S&C coach'*; '*step-by-step example strategy'* and *'evidence to practice'*. This is particularly pertinent to the aims of the current thesis to be directly applicable in elite environments.

However, similar to Podcasting this same practicality of Presentation as a method is potentially also a negative as it does not always allow for a detailed, rigorous presentation of the methods utilised as would be the case with peer review. This is suggested in comments such as: *'I struggle with lots of information within a slide which is why it is beneficial for me to be able to look back over the slides at a later date'*; '*I got a little lost when you were discussing the 'movement classification section'*. This degree of depth would be available for the reader to constantly peruse over and refer to as they read a journal article. This is an inherent restriction with presenting work.

Table 6.4 A table outlining the feedback responses relating to the strengths and weaknesses of dissemination of the current thesis results though scientific presentation.

Strengths	Weaknesses
The presentation was very visual which works well for me, especially with the inclusion of all the videos as this allows me to see how what is being discussed relates to the sport. I think getting in a bit of humour is really good as it is very engaging. I like the whole theme of the presentation as it clearly relates evidence to practise.	*Personally, I struggle with lots of information within a slide which is why it is beneficial for me to be able to look back over the slides at a later date. This may just be due to the stage in my career or how a process information.*
The presentation provided clear detail that offers application for training. The content was supported by valuable data that was position specific, and offered further insights related to the game (in/out of possession, direction of travel and transition types) which are key for the development of the game in both tech/tact and physical developments. The presentation was also delivered well and laid out clearly, supported by plenty of evidence throughout.	*It would have been nice to see more break-downs of the footwork explanations and changes. There was of course some good use of videos and an instance where there was a great breakdown using photos but would have been good to see more of this throughout if time wasn't limited.*
The presentation was engaging throughout, both visually and for stimulating thoughts / reflections on my current practice. It contained a lot of detail and felt directly relevant to my work as a S&C practitioner in football.	*Probably just a technical fault at the university, but some of the videos were not playing on loop very easily as you wanted them too.*
I thought the presentation flowed very nicely and I enjoyed the informality of it. I specifically liked the step-by-step example strategy you	*I got a little lost when you were discussing the 'movement classification' section and I think you could have taken a little bit more time to*

gave for improving sprinting - relating to Bondarchuk's exercise classification.	*explain the difference between the transition and the initiation part of the movement.*

Table 6.5 A table outlining the feedback responses comparing Presentations and Podcast as a method of scientific dissemination of the current thesis results.

Presentation	**Podcast**
I really like presentations as I feel you can gain a lot through hearing someone speak, and I find it really engaging. It is also a great opportunity to meet people and have discussions. But I do believe that all these methods have their place. For example, podcasts are great for when you are travelling, and social media is great when you have a spare 5 minutes, but all these methods are great opportunities to discover new articles and papers to read. I think you need a good blend	*Provide a fast and accessible method of dissemination* *Allow access to a wide audience, which is often practitioners so, therefore, informs impact* *Should not be at the expense of other methods but may compliment peer-review especially as allows context and application to be shared* *Often lacks quality assurance* *Often influenced by the host's skill set - ability to ask good questions, understanding of the subject area etc* *Develops useful skill set of the researcher that may otherwise go undeveloped e.g. develops researcher's ability to communicate research effectively as they will have to do to maximise implementation* *Can sometimes be a little superficial around the detail of the research or the individual’s knowledge in the area* *Good to get context on the researcher rather than just the research*

Some aspects are better than others. From a perspective of understanding there is more options to inquire for clarity during a presentation. Additionally, with the knowledge that the information has come from practical application and experience. However, with a journal there are finer details specific to the methodology that ensures reliable processes have been used, and finer stats that may be critical to see. Presentations do offer a more 'humanised' journal and delivered in laymen's which makes learning a lot easier and smoothly.	*Very good - easier to work around schedule e.g. listen on the way into work/doing other tasks Prefer getting the same information without having to actually sit down and read a paper*
I like presentations as a method. For me, watching the presentation live and being able to ask questions afterwards is so much more valuable than just reading a presentation on the internet, without having been there to hear the author talk over it / explain different parts of it. I would say that, they are my favourite way of keeping up to date with current research. I think podcasts and social media offer the quickest, most easily accessible way to get a summary of current research / topics related to my field. I regularly use them to browse through what is out there at the moment - then I like to read academic papers / peer-reviewed articles to gain a further insight into any areas that have sparked my interest. Podcasts and social media are probably more time-efficient and convenient	

initially, but from my experience people tend not to share everything on there and go into more detail on things when you actually go to see them present.	
Personally, I enjoy listening to people who know more than me talk about their findings much more than reading an article. Podcasts are also helpful during long car journeys, but I always have questions which cannot be answered. So, for those reasons, I think an informal presentation with an enthusiastic presenter is the best way to get information across.	

Table 6.6 A table outlining the feedback responses comparing the 'Take Home' points of the current thesis results from Presentations and Podcast.

Presentation	Podcast
My big take home message was that we always teach athletes to sprint like sprinters, but they very rarely sprint like that in a game situation so just to coach an athlete "perfect sprinting technique" probably won't cut it. But also, as you mentioned at the end, there is a place for coaching athletes on their technique. If that makes sense?	*We must start with the game to frame the development activities – what are the athletes asked to do?* *Context is a necessity in sprinting* *Easily applied – from gym-based conditioning, to isolated field-based training, to team-based football training – the researcher provided some good insights to each of these areas*
For me, some of the take homes were around the process of development. Teach the fundamental basics of sprinting and running,	*There is need for players to be coached to perform contextual sprinting movements* *Stick to your key, basic principles e.g. squat to*

make it more relatable to the sport (duels) and then make it highly specific (with a ball). The types of runs seem to be critical; linear for max speed, curved, and the ability to transition from lateral facing or rear facing. The final point was around the perception of the game as a key point to out manoeuvre the opposition alongside good movement mechanics.	*improve lower limb force production but add in more sport specific movements to complement this - players will buy in* *Have plenty of time available to impact on athletes e.g. warm ups - you just have to use this time cleverly*
Key take home points were sprinting in a football context is different to sprinting in an isolated context, so even when training 'isolated speed sessions', we can make it relevant to the game / playing position, by thinking about factors such as: Orientation of the sprint, Thoracic / torso dissociation, Movement Patterns preceding the sprint. For me the take home messages were also to look more deeply into football sprinting than just the generic GPS data that is out there, which just tells us a bunch of numbers without really providing context. My own take on this is that a mixture of reading and speaking to players, technical coaches, strength and conditioning coaches like Paul who are researching the topic, plus just watching football intently and making my own observations could all help get a better and deeper understanding of football sprinting - to make my training practices more relevant for my players.	

The key take home points for me were how traditional S&C movements we all love to administer, i.e. squats, cleans etc. do not necessarily translate to creating better sprinters on the pitch. Instead we need to train smarter and more specific to the movement - i.e. plyometrics in different planes. For me, this was a nice conformation that we are emphasising the right methods of training.	

6.3.4 Personal Reflections

From the authors' personal perspective, it was hoped that the process would lead to the creation of a scientist brand within the research area of sprinting in football and improve the potential impact of any future peer-review publication. Throughout the initial stages, where the focus of dissemination was on Social Media (Twitter), the material posted was very well received (Fig. 6.4 & Table 6.2). The constant use of this method led to the invites for the following stages of a Podcast and a Presentation and can thus be thought of as successful on this basis. The second stage where the Podcast and Presentation were completed sought to begin to further the awareness of the thesis and preliminarily disseminate the early findings. Here, the Podcast was well-received (Table 6.2) and the Presentation well attended by active practitioners and researchers within Sport Science. Consequently, the early dissemination of the thesis through the use of contemporary methods was viewed as successful from the author's personal perspectives. Additionally, preliminary findings from the thesis were recently cited in a peer-reviewed, published article (Fílter et al., 2019).

6.4 DISCUSSION

The current study sought to gain an understanding of the application of contemporary methods of dissemination and how they may supplement traditional peer-review publication within a broader model. Findings from the current thesis were disseminated through Social Media, Presentation and Podcast. Feedback was provided by attendees and listeners to provide comparisons and strengths and weaknesses of each method. Whilst these more contemporary methods have particular strengths and were successfully used in the current thesis, it is believed peer-review publication should always remain the 'gold-standard' method of scientific dissemination due to its inherent quality control (Ferreira et al., 2016). However, the contemporary methods outlined can be used in conjunction with peer-review to enhance the future effectiveness due to their ability to create an awareness of projects and assist the research in the development of a brand (Table 6.2).

In the current model, the initial stage employed social media as a means of generating early interest in the thesis. Following the process, this allowed the author the reach of ~2,500 active Followers. This meant that following activities such as retweeting, a typical tweet could reach Impression of up to ~12,00 people. An average tweet thus achieved Engagements of ~1,200 accounts (Table 6.2). Social Media led to the subsequent invites for the Podcast interview and the Presentation, which furthered the dissemination of the thesis. Accordingly, the use of Social Media also supported the development of a 'scientist brand' within the area through this increased awareness and requests to speak on the topic.

Following the initial stage, a Podcast and Presentation were used. The main advantage of these methods appears to be the opportunity for the researcher to provide context to their findings (Table 6.3 & 6.4). When writing a traditional journal article, the researcher is necessarily required to write in a 'cold' scientific report style which is driven by facts and avoids assumption and opinion. Whereas when presenting their research, it is possible to better 'frame' the findings in the context that the research was completed. This is particularly important with work that is highly practical such as the current thesis, as it allows for the context of the research to be better understood. Here, by the nature of the project, a solution was sought to a practical problem from working practice. As seen previously, by disseminating the findings through Podcasting and Presenting, the rationale and potential impact on future practice can be better articulated through a style befitting of the specific audience. This has been shown previously to potentially lead to enhanced uptake of the knowledge (Merzagora, 2004; Johnson et al., 2012; Prakash et al., 2017; Thoma et al., 2018; MacKenzie, 2019). This was clearly raised by the feedback received in the current study (Table 6.3 & 6.4).

Similarly, Podcasting and Presenting allowed the researchers to suggest further practical consideration to the findings (Table 6.3, 6.4 & 6.4). Within these formats assumptions that are not possible in detailed scientific writing can be made. Coaching is often considered a balance between the application of scientific knowledge and anecdotal experience (Ross et al., 2001; Nash et al., 2011). No study can truly replicate the specific parameters and considerations of all specific contexts the research may be applied within. As noted, these contemporary methods better provide a platform for the differentiation of material to suit the receiving audience. This allows the researchers to apply their intricate knowledge of the subject and the research to support its application within different contexts. Such knowledge and opinion cannot be provided with traditional peer-review scientific writing (Ferreira et al., 2016). The feedback received in the current study strongly endorses this, where the majority of responses note this as a strength of the Podcast and Presentation (Table 6.3 & 6.4). With the attending audience in mind, the researcher can shape the output to be as relevant and applicable as possible. For example, the current Presentation was completed at a conference organised by the UK Strength and Conditioning Association. Thus, the material presented (Appendix 9.3) focused on how the findings may be applied by a Strength and Conditioning practitioner. This would differ if the results were presented to Football coaches, an opportunity not afforded when publishing in a scientific journal.

In the same manner, as the opportunity to provide additional context, potential practical implications and anecdotal support, Podcasts and Presentations allow for less obstructed possibilities for the delegates to easily seek clarity from the presenter/researcher through questioning (Table 6.5). This process is much less open, slower and demanding in a peer-review context. This potential for more open 'two-way dialogue' has been noted previously as a strength of these methods. As discussed, Podcasts are typically supported by Social Media and website discussions (MacKenzie, 2019). For example, during the completion of the current

Presentation, questions were asked surrounding the classification of movements during the application of the Sprint Movement Classification System. This allowed the presenter to clarify within a group environment how these specific movements were defined and eventually classified in much greater detail and with visual support. These would not have been possible through a journal article. This was raised in the feedback received in the current study (Table 6.5).

Whilst Podcasts and Presentations excel in their potential for providing additional context to the research, it is likely that they lack the in-depth, technical detail of a journal article as noted in Table 6.5 (Hochberg, 2010; Letierce et al., 2010; Ferreira et al., 2016; Robinson-Garcia et al., 2017). This is particularly pertinent for areas such as a methodology and statistical analyses, where the formats do not necessarily suit this type of information as well as a peer-review publication. For this reason, it is crucial that peer-review remains the gold standard method of scientific dissemination, whereby reports are deemed accurate and acceptable by reviewers pre-publication. These alternative contemporary methods should thus only be used to provide additional context and discussion but may refer to journal publications. In addition to this lack of detail, there is little in the way of quality assurance for scientific rigour outside of peer-review (Hochberg, 2010; Ferreira et al., 2016). Where these methods can be seen as benefitting from an ability for a researcher to provide opinion and anecdote, these again can only ever be viewed as an addition to the traditional scientific method to maintain standards, and it is important for delegates and listeners to understand this process.

Where a presentation is typically researcher-led, a podcast, as is the case with the current study, is often completed in an interview format. This potential weakness was raised in the feedback received (Table 6.3). Here the presenter will question the researcher on the topic and will guide the direction of the discussion. This may mean that certain key facets of the research are missed as an interviewer, likely less knowledgeable on the subject than the reader, will possess an agenda that differs from that of the researcher. It is important that the researcher seeks to guide the presenter either beforehand or during the interview.

Another weakness of presentations is the number of delegates able to attend. Rarely does this exceed ~100 (the current study included 35 delegates), whereas a journal article (1,791) or podcast (513) can be read and listened to internationally at any time. Podcasts were particularly noted for their convenience and ability to be passively listened to whilst driving for example. As discussed previously, the numbers of interactions and impressions of tweets can be inflated due to duplicates and 'Bots'. This may lead to a misrepresentation of the reach of the tweets, however, it is accepted that the analytics provided are generally accurate, even if slightly inflated at times (Robinson-Garcia et al., 2017). The current study saw Impression of ~12,000 and Engagements of ~1000. With a Following audience of ~2,500, these number could be considered reasonably accurate, without too much over inflation due to duplication or bots.

As discussed, the contemporary methods outlined were employed within a broader model (Fig. 6.1). This was deemed to be very successful at generating interest in the current thesis. The author has successfully developed a 'brand' as an active researcher within sprinting in football. This is indicated by the receiving of multiple invitations to speak at presentations for national governing bodies (UKSCA), national independent conferences (Soccer Science), world-leading universities (Loughborough University), and professional sports teams (Paris Saint-Germain FC). Additionally, early findings from the research were also referenced by practitioners in their own presentations and podcast shows (Tom Joel, Leicester City FC: The Need for Speed, Catapult Football Performance Workshop, Birmingham, November 2018; Jonas Dodoo, SpeedWorks: Earn the Right, Football Fitness Federation Podcast, April 2018; Stuart McMillan, Altis: Football Speed, Rangers FC Internal CPD, Glasgow, October 2019) and published research (Fílter et al., 2019). It is hoped that the successful dissemination thus far translates to the eventual peer-review submissions from the thesis.

Each contemporary method has its own strengths and weaknesses which, when employed effectively, complement one another. The current model employed seeks to take advantage of these. Firstly, by reducing the negative effect of the lag time between a studies completion and its eventual peer-review. Here, early dissemination is possible through Social Media, Podcasts and Presentations. This, as noted, allows the researcher to remain visible within their area and continue the development of their personal brand. Additionally, it supports scientific discussion as a greater part of the research process, rather than in retrospection, solely after publication. Another key complementary factor is how Podcast and Presentation are able to support the publication of research by providing the researchers' anecdotal experiences and how they may relate to the study's findings practical implementation. This supports the eventual publication of the research. Regardless of the effectiveness of such a strategy, the final peer-review publication of scientific work remains vital. This ensures scientific rigour and should not be lost within a dissemination model. As discussed, these contemporary methods are less effective at achieving this necessary precision.

6.4.1 Conclusions

The current study successfully employed a contemporary strategy for scientific dissemination. This was judged as successful as a result of invitations to present and discuss the findings that were achieved throughout the process. Additionally, the enhanced social media following supported this. As a result, it is believed that others participating in a similar level of study could employ the model presented to enhance the successful dissemination of their findings and to begin to create a 'scientific brand'.

CHAPTER 7

SYNTHESIS OF FINDINGS

7.0 SYNTHESIS

The current chapter seeks to synthesise the findings of the present thesis in relation to the original stated aims. The chapter will discuss the conclusions from each study as standalone results as well as discussing any potential links between the major findings. These findings will be interpreted based upon the intended goal of informing professional practice in elite football. Suggestions for areas for further research will be made, alongside any potential considerations and limitations to the current thesis.

The current thesis sought to:

1. Develop a reliable system for quantifying the movements associated with sprinting in a football match and an additional system for quantifying the tactical-context within which sprinting occurs
2. Quantify the movements involved in sprinting during a football match and observe any differences across and between positions.
3. Quantify the football-specific tactical-contexts during a match in which sprinting occurs, across and between positions.
4. Outline and compare contemporary methods of scientific dissemination within a broader model.

The aims of Study 1 were met. This was indicated by the development of successful and reliable classification systems for measuring the movements and tactical-contexts of sprinting in a football match. Further, these systems were then successfully applied during Study 2 and Study 3. Thus, both aims of Study 2 and

Study 3 were met by the consequent successful quantification of these sprinting descriptors. The systems were effectively applied to a sample of the team's matches to establish any differences across and between positions. Finally, Study 4 successfully outlined and assessed a model employing contemporary methods of scientific dissemination of the thesis' early results.

7.1 GENERAL DISCUSSION

Sprinting, alongside being a fundamental hamstring injury mechanism, is a key determinant of a football match outcome (Faude et al., 2012; Schache et al., 2012; Schuermans et al., 2017). Recent research has shown that sprinting is becoming more frequent and explosive during match play, particularly in certain positions such as Full Back (Barnes et al., 2014; Bush et al., 2015). For these reasons, it is crucial that practitioners seeking to enhance performance and prepare players for the physical demands of a match possess an in-depth knowledge of sprinting during a game. Previously, little was known about the intricacies of this sprinting beyond the, now common, standard locomotor distances. Practitioners possessed a good knowledge of how much sprinting is completed at various playing standards, between positions, across age groups and between sexes (Bradley et al., 2013; Barnes et al., 2014; Andrzejewski et al., 2015; Bush et al., 2015; Abbott et al., 2018). From technologies such as GPS, LPS and camera tracking systems, total sprint distances, distances per effort, percentage of total distances, maximum velocities, number of accelerations and the type of acceleration were all readily available and applied in working practice. However, little attempt had been made to better understand the exact nature of these efforts. Therefore, the current thesis sought to equip practitioners with an enhanced knowledge of how and why sprinting occurs during a football match and provide them with novel methods for the analysis of their own team.

To complete such an analysis required the development of a novel classification system within each of the areas of how and why sprinting occurs. Both of these systems, The Sprint Movement Classification System and The Sprint Tactical-Context System, were successfully developed utilising similar previous methodologies and outlines (Ade et al., 2016; Jeffreys et al., 2018). Each proved reliable within and between tester (Chapter 3). Therefore, these systems could readily be employed by practitioners to ascertain further knowledge on the types of sprint efforts completed by their own teams – thus supporting any training programme designed to enhance performance and prevent injury. The systems could also be utilised for further research in the area attempting to discover the differences in specific populations such as playing standard. Another key area would be to attempt to add to the current findings between position. As a result of the applied nature of the current thesis, as noted, position-specific population size was inherently restricted. A wider study utilising multiple teams would rectify this limitation.

As discussed previously, no action in sport is completed in isolation. Constraints such as the Organism itself, the Task completed, and the Environment the task is completed within coalesce to create what has been described previously as the 'Perceptual-Motor Workspace' (Travassos et al., 2012; Immonen et al., 2017;

Myszka, 2018). Within this framework, the eventual observed movement, or action, is a result of an athlete's perception of potential Affordances (perceived opportunities for action within a particular set of circumstances) (Williams et al., 2006; Immonen et al., 2017; Mallek et al., 2017). Consequently, training practices should ultimately seek to train this Perception-Action coupling, rather than solely training the action in isolation. Thus increasing potential transfer to match performance through enhanced motor Degeneracy, as opposed to rote learning of a skill (Mason, 2015; Seifert et al., 2016; Immonen et al., 2017; Myszka, 2018). It is the authors' experience that currently in elite football this process is inefficiently employed. Whereby, predominantly, sport science practitioners typically train movement in isolation, assuming transfer to occur during typical football training.

No data currently exists on the specific types of sprint efforts completed during football training. Over the course of a Premier League season, starting players have been observed as completing 10 times greater sprint distance in matches than training (Anderson et al., 2016). If, for example, as the current results show, Wide Midfielders complete 8 sprint efforts during a match that are curved in nature, over a 38-game season, 304 curved efforts will be completed during match-play. Whilst sprint distance is not necessarily indicative of frequency of effort, this previous data could suggest during a 46 week season a Wide Midfielder may only complete 30 curved sprint efforts during training. Less than 1 effort per week. It is unlikely that this low dosage would be sufficient to develop any skill enhancement in curved efforts. Typical football training during the in-season period has been shown to be lacking running efforts at the very highest velocities (Anderson et al., 2016). This is likely due to the prominence of 'small-sided games' during training, where distances are reduced to increase player involvement but may lack the required distance for true sprint efforts. This is thus a key potential area of development for football-specific sprinting ability, where there likely currently exists an unrepresentative stimulus. The results of the current thesis therefore provide a potential for enhancing this sprinting stimulus provided during training through an enhanced understating of demands.

The current study sought to increase the knowledge of the specific nature of sprinting in football, and the contexts within which they were completed. Thus, the observed movements performed whilst sprinting were quantified. Following this, one of the key Constraints to movement in football, the nature of the Task (Tactical-Context) completed to elicit this movement outcome was quantified. The Organismic constraint is specific to the individual and the Environmental Constraints relate to factors such as the pitch dimensions and weather conditions the Task is completed within. Thus, through this enhanced knowledge of the key Task constraints (Chapter 5) practitioners can seek to more effectively design training programmes that develop Perception and Action as a single entity. For example, by using this constraints-based approach, space can be increased to encourage more frequent interactions between a Centre Forward attempting to Run in Behind a Centre Back. Thus, expediting the learning process by increasing the opportunities for the Centre Forward to learn relevant cues for the most effective timing of their runs, alongside the enhancement of physical movement skills.

This Ecological Dynamics framework provides a structure for the interaction of movement with the environment through an on-going exchange of information (Myszka, 2018). By facilitating this learning exploration within a representative environment, it is hoped an athlete will develop enhanced movement degeneracy, where the individual is able to select the best movement solution for any given situation. Expertise is thought to relate more to the ability of an athlete to adapt their movement solutions to any given set of circumstances, as opposed to exhibiting an attuned convergence on a specific strategy (Mason, 2015; Seifert et al., 2016; Myszka, 2018). Whilst Chapter 5 defined the contexts that sprinting occur within, no two contexts such as Run in Behind during Attacking Organisation will be the same. Consequently, whilst the movement observed in Chapter 4 suggest clear themes, the outcome of training practices should be the ability of the athlete to adapt to a plethora of differing circumstances within each Task context.

As noted, however, Perception and consequent Action do not exist in isolation. Thus, similarly to the ability to adapt physically to transient environments, an athlete must develop the ability to process the key perceptual cues present within each context. Through repetitive exposure to a representative context, an athlete can develop enhanced ‘perceptual attunement’ to relevant cues and develop a heightened sense of available affordances. Through a combination of this enhanced perceptual ability and a consequently developed motor degeneracy ability, an athlete can ultimately present improved performance during a match. For example, a CB may perceive the ‘threat’ of a pass played in behind the defensive line earlier and therefore more effectively complete the common task of Ball Down the Side.

This may present itself in a wide variety of observed movements that reflect the various differing conditions this task may occur within.

A previously discussed method of achieving this ultimate transfer of Perception and Action to match performance is utilising ‘Repetition without Repetition. Here an athlete is exposed to a representative task but in a multitude of differing circumstances, through the manipulation of the task constraints. By the increased knowledge provided in the current thesis, practitioners can create better-informed drills to reflect these match-based tasks. Thus, utilising the findings of the current thesis, a practitioner may seek to improve a CF effectiveness at performing a Run in Behind. Training drills may be designed to replicate this specific context such as Attack Vs Defence. These will vary each time they are completed. This could be achieved by manipulating the environment through a variety of sized pitches (thus, the space behind or in front of the defence) or playing surfaces. Or similarly, by manipulating the task itself through altering the starting position of the drill, the starting position of the CF, the number and shape of the defence, or different attacking formations. Through this, the CF will develop enhanced perceptual attunement to the task and thus their ability to ‘read’ the development of the play. This then results in improved motor degeneracy ability through the selection of different movement solutions as a result of the exposure to a multitude of differing tasks and ultimately subsequent transfer to match performance (Table 7.2).

Whilst, as discussed, the observed movements during a match are as a result of the athlete’s perception of the specific task faced and thus may vary, certain themes were seen positionally. The most common tasks completed by each position will therefore dictate the frequent occurrence of common movement patterns that satisfy the task demands. The most frequently observed tactical-contexts that FB sprint within are, whilst in possession, Overlap (14%) and Run the Channel (8%). And whilst out of possession, Recovery Run (14%), Ball Down the Side (11%) and Closing Down (11%). Due to their typical location on the pitch being in the Wide areas, FB complete the greatest proportion of their sprints with a dissociated torso (Ade et al., 2016). This is likely as a result of the majority of play being within the central areas of the pitch. For example, to complete an overlapping run, a FB will usually be observing play build inside of their starting position, they will then complete a sprint around the outside of their teammate, and this will involve running in a different direction to the play they are observing. Similarly, when completing Recovery Runs and responding to Ball Down the Side of their CB. FB also complete the greatest proportion of efforts with No Action During the sprint. Again, this is clearly dictated by the most common tactical-contexts within which they sprint. Recovery Run, Overlap, and Run the Channel are likely to be completed without any duelling action with an opposition player.

WM, similarly, primarily operate in wide areas of the pitch and complete the fewest proportion of sprints with a Linear Starting Position. This would stand to reason if the majority of play occurs in the middle of the pitch and WM start wide and in the midfield. However, conversely to FB, they complete the lowest proportion of sprints with a dissociated torso. This can be attributed the high proportion of efforts that are Closing Down (21%) and Run with the Ball (11%), where to close down an opposition player the WM will sprint directly towards them, and when running with the ball the focus will be mainly on their own direction of travel rather than any other areas of the pitch. They also complete the highest proportion of Explosive efforts, likely again due to Closing Down where a pass to an opposition player 'triggers' a rapid press.

In contrast to their defensive partners (FB), CB very rarely sprint in Attacking Phases of Play. The majority of their efforts occurring due to Ball Down the Side (34%) and Covering sprints (27%). This leads to common movement patterns such as the majority of their sprints occurring from Lateral changes of direction (48%) as a pass is made in behind the defence. Similarly, CB complete the highest percentage of sprints that initiate from a Rear starting position (20%). They also complete the second greatest amounts of efforts with a rotated torso (69%), likely again due to defending a large number of passes played in behind the defence.

CM, potentially surprisingly, sprint overwhelmingly during defensive phases (80%). This could be as a result of the style of play of the team studied and may differ with a team playing a more attacking style where there is a greater onus on them to support attacking play. The most common tactical-context that CM sprint within is Covering (31%) – the second-highest proportion of all sprint efforts across all positions. This type of effort maintains the integrity of the team's formation, whereby the CM sprints, likely to a 'goal-side' position, to cover a teammate. For this reason, 45% of their efforts are completed in Defensive Transition as they attempt to prevent fast breaks on their defensive teammates. They complete the greatest proportion of efforts ending in No action (no duel or ball action) (64%), as well as the least amount of actions during these sprints (6%). These Covering sprint efforts also lead to the greatest amount of Gradual Accelerations (78%), Linear Starting Positions (75%), No Change of Direction (61%) and Linear Transitions (63%). It is clear that these efforts are not the most time-constrained of efforts and allow the CM the opportunity to observe play around them and react accordingly in a controlled manner.

CF most common tactical-contexts that sprints occur within are Closing Down (23%), Run the Channel (23%); and Run in Behind (18%). As a result, their two most common phase are Attacking transition (52%) and Defensive Organisation (27%). Another consequence of these tactical-contexts is that, alongside FB, they End the greatest proportion of their sprints with an Action (53%) and complete the most Action During (14%) – the majority of these being duelling (9%), likely with the opposition CB (8%). Additionally, they are one of only two positions to complete primarily Lateral Changes of Direction (55%), rather than None (37%). These actions are likely due to whilst completing Run the Channel and Run in Behind attempting to avoid being caught ‘offside’ and to also evade the opposition defence. To do this they complete generally forward-facing transition movements (linear and diagonal) and then attempt to create separation by performing a hard-Lateral Cut Step to a Linear Starting Position sprint, in behind the Defence.

In applying the results consideration should be made to the fact that the data presented in the current thesis are averages. A practitioner seeking to enhance performance in these key match-defining moments should be aware of the 'worst-case scenario'. Certain efforts may be more crucial than others, which is a limitation of the current work. Additionally, with the current, more integrated approach of observing sprinting in football, caution should also be made to the trap of being reductionist. As discussed, previous methods of describing the demands of football devoid of context could be suggested as being reductionist, however, by creating averages of movements and context in an attempt to be less reductionist could easily be suggested as replicating this reductionist view. It is the case that all sprinting actions in football are completed within the complexity of the game and any attempt to isolate these actions may begin to create errors and lack certain key complexities and interactions.

Further to the development of improved training practice, by defining the contexts within which sprinting occurs, there is potential for the future development of superior football sprinting ability assessments for scouting and performance perspectives. If it is possible to define success in these sprinting contexts, a system can be developed, whereby using match footage, players can be graded on their football specific sprinting ability rather than solely time to complete a distance or maximum velocity capacity. This would allow a comparison between players and a baseline for training purposes. For such a concept, utilising the current data, key tasks related to positions would need to be set. For example, a CB frequently defending a Ball Down the Side. Utilising available footage, a club that is scouting for a new CB could conceivably rate and compare potential signings based upon their success in this task. Alongside other metrics used this could provide an insight into the key physical skills of the individual.

The final chapter of the thesis sought to employ and compare contemporary methods of scientific dissemination. Social Media, Podcasts and Presentations were compared to one another, and the gold-standard method of traditional peer-review publication. This was completed within a broad model based upon the established strengths, weaknesses and typical aims of each method. These methods, particularly Social Media and Podcasts, have grown in popularity in recent years through advancement in technology such as Smart Phones and platforms such as Twitter. Whilst few would argue the merits of replacing peer-review publication with such methods, there certainly appears a role for their application by scientists. A strong theme of the chapter became the ability for a scientist to be more consistent with their outputs through these methods, rather than infrequently and sporadically through solely publication. This can more effectively support the development of an individual scientist brand within a particular subject area (Hotez, 2018).

Throughout the current programme, the authors employed the model described (Figure 6.1), utilising the contemporary methods of dissemination. This was completed within the current subject area within sport science of contextual sprinting, or Gamespeed. Whilst key researchers lead the area, as discussed in Chapter 6, the authors' have become respected within the topic through the dissemination of the results. This is best exemplified through the invitation to present at local and national conferences and leading academic institutes, visit elite sports teams, and the referencing of the early results by practitioners and researchers within podcasts, presentations and publications. These have been key developments from both a professional and research background of the authors.

7.2 PRACTICAL IMPLICATIONS

For around four decades practitioners have presented the demands of football by utilising the 'traditional' approach of quantifying absolute and relative distances completed along of spectrum of running speeds, from walking to sprinting. It has however been recently suggested that this method is reductionist in nature due to a lack of context around this data. A more integrated approach should be sought to assist coaches in better understanding how these metrics relate to a player's tactical responsibilities and support practitioners in successfully translating these into training and testing practices (Bradley and Ade, 2018). Recent attempts have been made to begin to suggest how this may look with regards to high-intensity running (Ade et al., 2016).

As discussed, the SMC allows practitioners to accurately and reliably ascertain the exact movements completed by their athletes whilst sprinting in football. By performing this analysis performance enhancement programmes can be refined to better reflect the exact movements seen during match-defining actions. Specific on-field interventions could be designed to reflect these observed movements, alongside more general strength and plyometric training being designed to reflect better the expected kinetics of these actions. In addition to performance enhancement, rehabilitation practices would benefit from this greater understanding. Similarly, the STC can be employed by practitioners to understand why their athletes typically perform sprints. Through the use of this data, specific drills can then be designed to reflect these key scenarios from a match, thus allowing a player to learn through exploration of the perceptual cues relevant to success in the scenario and develop enhanced motor degeneracy for the ultimate movement. It is believed that this more refined approach to training sprinting in football, by combining perception-action coupling, could lead to improved transfer to match play and better performance enhancement practices.

The novel findings of the thesis have the potential to alter the nature of current practice within football and potentially other similar field-based invasion sports. Combining the data produced by the two systems allows a practitioner to develop a full spectrum of training focused on enhancing specific match-based sprinting performance (Gamespeed). As noted, training typically exists on a continuum of most specific to least specific. As the interventions lose specificity it is believed that they may possess a greater potential for overload. Thus a mixed method has been noted as likely the most effective philosophy. (Brearley and Bishop, 2019). The acknowledged study attempts to provide an example of how this may look utilising a popular model for considering such an approach– Bondarchuk's Exercise Classification. Here exercises are categorised in relation to their balance between specificity and overload (Table 7.1).

Table 7.1 An adaptation of Bondarchuk's Exercise Classification *(Adapted from Brearley and Bishop, 2019).*

Category	Description
Competitive Exercise (CE)	*Identical, or almost identical to the competition event.*
Specific Development Exercise (SDE)	*Repeat the competitive event but in its separate parts, may include overload.*

Specific Preparatory Exercise (SPE)	*Do not imitate the competition event but train the major muscles and physiology involved.*
General Preparatory Exercise (GPE)	*Do not imitate the competition event and do not directly train the muscles or physiology involved.*

Such a model can be employed through the 'reverse engineering' of the competitive exercise. It is generally accepted that the model was predominantly developed within Olympic sports such as sprinting and throwing. (Brearley and Bishop, 2019) Theses sports are much more simply distilled into their fundamental aspects. But now by combining the results of the two current classification systems (SMC & STC), 'competitive exercises' specific to football can be seen. As an example, a CB may commonly face a Ball Down the Side during a match. Data from the SMC shows that CB, more so than any other positions, initiate sprints from Rear Starting Positions. Alongside this, they also complete the most sprints ending in duelling actions (physical contact with the opposition including jockeying, pressing and tackling). This position-specific data can now be coupled with the more general all position data to allow us to develop a spectrum of training based upon these demands (Table 7.2).

Table 7.2 An example application of an Exercise Classification system employing the results of the current thesis.

Category	Description
Event	- *Defensive Transition/Organisation. Ball Down the Side.* - *Linear/Diagonal Transitions. Rear Starting Positions. Curvilinear Maximum Velocity. Rolling Acceleration. Torso Rotation. End in Duel*

CE	- *Football-specific Drills: Small-Sided Games that seek to create opportunities for the Event to occur.* - *Context-Specific Drills: Drills that specifically seek to mimic the Event such as Attack Vs. Defence drills.* - *Focus: Highly perceptually specific. P-A focus*
SDE	- *Separation Drills: Drills that seek to mimic the constituent parts of the event such as maximal effort Curvilinear Sprinting. Multi-directional Initiation Drills.* - *Overload Drills: Exercises that seek to create overload in key positions such as Resisted Sprinting.* - *Focus: Less focused upon contextual factors. Highly-specific physical overload.*
SPE	- *Specific Gym-based Training: Specific Coordination Overload Exercises such as Unilateral Strength, Multi-directional Plyometrics, Hip Lock and other attractor position training.* - *Focus: No contextual focus. Greater focus upon physical overload maintaining an amount of specificity to the event.*
GPE	- *General Gym-based Training: General exercises such as Bilateral Strength, General Power, Physiotherapy.* - *Focus: Training of broad physical qualities that support more specific training.*

Worth consideration is that the model presented is designed as a spectrum and thus should be interpreted as such. The examples provided could be categorised very differently in different contexts. Another important consideration is how this may be applied within a periodised model. Both from the perspective of defining the competitive event (Ball Down the Side) and the according focused training. Firstly, whilst in the above example a CB most commonly encountered context is a Ball Down the side, as noted, the current study placed no weighting on contexts with respect to their potential importance. Another context could be the most crucial that a CB may face during a match and should thus be trained with the significance it demands. Similarly, all exercises employed concurrently may not be the most effective training strategy. For example, early in a player's career, focus may be made to more general physical qualities and specificity increased following the diminishing of gains.

Through training practices that better reflect a football match, rather than general qualities, it is believed that coaches and athletes may have better 'buy-in' to sport science practices. By being able to observe a specific replication of match-based activities, such as Run the Channel, players and coaches alike will better be able to understand the objectives of the practitioner as opposed to merely training to run fast in a straight line over a given distance. The results of the current thesis enhance the clarity with which performance interventions can be directed towards key match actions, and consequently the athlete's appreciation of this.

7.3 PROJECT LIMITATIONS AND FUTURE RESEARCH

The current thesis consists of the first studies to attempt to quantify ‘how’ and ‘why’ sprinting occurs in a football match, however, caution should be paid to the inherent match to match and team to team variability. Innately a match is a chaotic environment and, though patterns exist, large differences are likely observed between different teams in different environments. Additional, due to the practical nature of the thesis, certain inherent limitations are necessarily accepted. As a result of the programme being completed whilst within professional employment, the sample of a single playing squad was employed.

7.3.1 STUDY 1

In Study 1 two novel classification systems were developed to quantify ‘how’ (Sprint Movement Classification System) and ‘why’ (Sprint Tactical-Context Classification System) sprinting occurs during a football match. Following a testing procedure, these systems were deemed adequately reliable for continued use in the thesis. However, though the testing completed currently was deemed sufficient, the accuracy of these reliability measures could be further enhanced by employing a wider inter-reliability process through the use of more testers from different backgrounds such as sport science, performance analysis and coaching. This would ensure the systems can be utilised across disciplines and that results are transferable within multi-disciplinary departments. Additionally, the systems were tested for reliability as a whole rather than by individual category, the process could be refined in the future, if necessary, by performing such an analysis.

7.3.2 Study 2 & Study 3

The two core experimental studies in the thesis, Study 2 and Study 3 sought to implement the two classification systems developed in Study 1 and separately quantify the movements involved in sprinting in football and the tactical-context within which they occur. Each was completed using only one Premier League team. As discussed previously, the extrapolation of the results to broad environments is consequently limited by this homogeneity and an area for progression of the research area would be to complete similar analysis with more teams. Additionally, controlled studies of teams playing differing styles and formations would be useful to ascertain any potential differences.

Study 2 could be biased to a greater extent by the fact a small sample size of players was used due to the limitation of using one team. For example, if a player has a tendency for performing a certain movement pattern this could alter the final results. Whereas Study 3 is likely more affected by the style of the opposition as the team studied would be dictated to tactically by the opposition and their strategy; particularly whilst out of possession. A greater sample size overall would also allow for greater analysis to be completed between positions. Similarly, attempting to control for the style of play of the studied team and also the opposition would provide greater clarity.

7.3.3 Study 4

Study 4 sought to assess a model of contemporary methods of scientific dissemination. Naturally with this type of analysis, there are limitations with the type of data collected to establish the effectiveness of each method. For example, as discussed during Chapter 4, successful dissemination through social media was assessed through the use of data such as Interactions and Followers. These are particularly difficult variables to control and measure. However, they provide the only real means of assessing the impact of social media outputs. Future study could attempt to compare methods by further quantifying the impact of, for example, social media outputs that consist of different styles. An example may be a title and a link to a published research paper compared to an output detailing the key conclusions of the study. Similarly, but more difficult to control, the citations and 'downloads' of peer review articles disseminated using solely each of the three methods could be compared.

7.4 CONCLUSIONS

Sprinting in football is complex, occurring in many different contexts and through many different movements. The methods developed in the current thesis provide practitioners with systems for ascertaining the exact nature of these sprinting efforts and can be reliably applied in their working practice. These results can then inform future programming and drill design by ensuring intricate knowledge of sprinting exists. These developments have the potential to transform the physical preparation practices of footballers. Future research could focus on developing the ideas presented by firstly further investigating how sprinting may differ between positions, formations and strategies. Alongside this, there is large scope for investigating the biomechanical and physiological nature of these varying movement patterns utilised in sprinting and how they may be optimally performed and trained for.

7.5 PERSONAL REFLECTIONS

Overall, I found the programme very valuable. Though challenging at times, I believe I am a much better researcher and practitioner than before the process. I have developed specific skills from the actual research process itself, as well as more broad skills from the programme as a whole. Over the course of the programme, my aims for my professional career have adjusted significantly, and I left the role that I began the programme within.

7.5.1 Research Skills

In the Training Plan I outlined, in the form of Gantt Chart (Appendix 9.1), a plan of progression to complete the programme. However, this had to develop and be reassessed at the end of Year 1. Mainly this was a result of my role changing. Data collection was set-back due to this, as the focus of the studies changed. This caused an overall delay in the programme. Though the project was finished on time. As discussed in Chapter 3, the original Proposal for the project changed significantly as it developed. The final Thesis was thus very different. The main focus became on describing sprinting rather than developing an intervention study. This is discussed in detail in Chapter 3 and the Training Plan.

Upon beginning the programme, I believe my research skills, as a whole, were some way off the level needed to complete the thesis. Though my undergraduate and postgraduate studies I certainly neglected this part of the process and didn't really 'buy-in' to the writing of the dissertation projects. I merely did the minimum required to pass through. Thus, I believe I was definitely lacking in some areas, particularly my writing style.

Within the Self-Audit (Training Plan) (Appendix 9.1) it was identified through psychological profiling (PDA Report) that due to my personality I may struggle with asking for help. This was noted as being particularly relevant when completing such a large piece of work as a doctoral thesis. This was something I actively sought to improve upon throughout the programme. I believe the plans I put in place at the beginning were beneficial. Though at times, I may have fallen into my old negative habits, I believe that by maintaining consistent contact with my supervisor I made improvements in this area.

In addition to this, the Self-Audit focussed on my research skills. Through the RDF framework assessment, it was identified that a weakness of mine was ‘Engagement and Impact’. I made a concerted effort throughout the project to develop this area. This became the focus of Chapter 6. I believe this area was particularly successful. Through receiving invites to present the early findings of the thesis, speak on podcasts and discuss the thesis with elite clubs this can be judged as effective.

My writing and my ability to create a rational argument were not of a high enough level. This is something I have worked hard on through the process by attempting to gain as much feedback from my supervisor as possible, and then attempt to successfully implement this. Whilst I believe I have improved a lot, I still have some way to go to view myself as a good writer. But this was a good opportunity for me to attempt to improve my ability to work collaboratively and utilise feedback effectively.

Within my professional practice I believe I am very good at completing tasks effectively and efficiently (Training Plan: Appendix 9.1), but maybe lacked the skills to think longer-term and more conceptually. This is obviously a key requirement for being able to complete a programme such as a Professional Doctorate. Again, similar to my basic writing skills, I believe I have improved significantly in this area but still have much room for improvement. This is, naturally, the largest single piece of work I have completed, and I am confident I have learned a lot from the process and would be much better prepared to complete a task of similar magnitude in the future. The necessary adjustments we made during the development of the conceptual plan for the thesis were great lessons for me personally in managing the direction of such a large piece of work.

My default working philosophy is a solitary, single-minded one, whereby I am very susceptible to working through tasks alone without consulting others. This is something I have worked hard at rectifying throughout the programme with my supervisor and although it definitely doesn’t come naturally to me, I again believe I have made significant improvements in this area. A project such as the current thesis could never be possible without collaboration. This is an area I need to continue to focus on through my professional career. The communication aspect of this is key for future management roles.

I plan to submit some of the findings of the current thesis to peer-review, as discussed in Study 4. My current thoughts around this are for two research articles, one pertaining to the movements associated with sprinting in football, and another the tactical-contexts within which they occur. These would include the systems developed form Study 1 and each their own according research findings. These are not yet planned or written and would be a process following completion of the programme. These are additional skills that I would need to develop to achieve the level required.

The area studied in the thesis is a comparatively new one and hopefully, the current work opens this up for future research. As noted in the discussion, for a long time now a lot of the focus for scientific research in football has focused on utilising standard locomotor distance reporting. In addition to this, previous recent work discussing the importance of context to this data, and the need for a more integrated approach, the future of research in this area will likely evolve from this rudimentary reporting to a more holistic, integrated method. This progression will hopefully be an advancement for scientific research in football.

Though my future with respect to research is unknown, I do have a strong interest in the area and I am passionate about seeing it progress. I believe through the focused dissemination of the thesis' findings I have become known as associated with the area. As discussed in Chapter 6, through the programme I received numerous invites to present the work and my opinions, discuss these during podcasts, and write online articles in the area. Similarly, as discussed, preliminary findings from the thesis were cited in a recently published peer-review study (Fílter et al., 2019). As noted previously during my reflections, this is a thought process I held throughout the programme, to create a product out of the thesis and develop my personal brand. I believe I achieved this goal, both as a researcher and practitioner, mainly through actively seeking to disseminate the findings and my associated opinions in the area. This is evidenced in the results of Chapter 6.

7.5.2 Professional Skills

As discussed in the previous section, a main aim from a professional perspective during the programme was to create a product from the thesis and develop my personal brand. Naturally, this carries through my work as both researcher and practitioner, as I sought to become a 'football sprinting guy'. This involved attempting to become a respected opinion within the area that others would seek out as a 'minor expert'. For me personally, I believe this to be one of the greatest successes of the programme. Prior to the start I was certainly not known particularly for my expertise within sprinting in football, yet by the end, I have a large international network due to the findings of the thesis. This was mainly achieved through social media and cemented through podcasts, presentations and online articles, as discussed in Chapter 6.

The psychological assessment completed as a part of the Self-Audit identified that I may require constant challenges to remain motivated. I believe that this became more and more evident during the final stages of my previous employment. This is something I am attempting to take forwards into the next stage of my career. It is important that I identify roles that will suit this personality trait. Throughout the doctorate, I was able to manage this very well by constantly breaking down the larger project into smaller, more easily attainable targets. This is a method that works very well for me personally and something I need to attempt to achieve in my professional life in the future.

At the time of writing, my professional future is unclear. However, whether I pursue employment directly related to the area of focus of the thesis or not, I believe I have developed strongly in this area, as discussed throughout my reflections. Skills such as collaboration and communication, the development and completion of a large project, and my ability to write, both logistically and effectively, have all improved immeasurable thanks to the programme. By the end of the process, I am much more effective due to a greater understanding of my own personal preferences for completing work, from the structure of my day to the periods of time I can be effective for in one stint. I have learnt I am best able to write during the morning and have been structuring my day accordingly; with more menial tasks saved for the afternoon. I additionally only allow a maximum of 3 hours at a time for this creative work, before I break and change location.

Small changes such as those noted have been implemented through trial and error, particularly during the writing up phase of the thesis. These learning experiences will certainly be carried forward as a result of this, beyond the current programme. Though I can improve in many areas, still, I have benefitted greatly from the completion of the programme, both as a researcher and professionally. I believe I will take these skills on in my future endeavours and be a more successful professional as a result.

CHAPTER 8

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CHAPTER 9

APPENDICES

9.1 TRAINING PLAN

Professional Doctorate Training Plan

DSportExSci2017

May 2017

Paul Caldbeck

SELF- AUDIT

An audit is defined as a process of evaluation of something to determine its accuracy, safety or current state. Traditionally performed in the financial industry to ascertain the correctness of accounts, an audit can however be completed on almost anything. A self-audit would therefore be described as an inspection of one's self. These can be completed on different areas and skills of a person's life. For the current purpose of successfully completing a professional doctorate level of study, it is important to look not only at one's professional skills, but also their research and personal skills. By completing a self-audit, it is possible to assess one's strengths and weakness in requisite areas, and subsequently put plans in place to improve upon these identified skills. Only by completing such a process and identifying areas in need of improvement can a practitioner develop.

A professional doctorate programme aims to apply existing theories and knowledge to solve real-world problems. Therefore, aimed at experienced practitioners, they aim to develop 'research-practitioners' who are able to conduct, process and interpret research into their everyday practice. I personally hope that from completing the programme I am able to advance my practice by becoming more analytical in my problem solving. By developing the skills of a researcher, I hope to be better placed to assess the research surrounding a specific problem, develop a solution based upon my knowledge and findings, effectively implement a strategy and then monitor the effectiveness of this intervention.

The three areas identified as key to success through a Professional Doctorate are professional, research and personal skills. As noted previously, the programme aims to develop ‘research-practitioners’ who have a level of mastery in their professional field aided by their understanding of scientific research methods and their ability to apply these to everyday tasks and problems in their working life. Therefore, to become advanced in one’s professional field, it is crucial to understand my current level. Again, similarly as a researcher, it is crucial to understand one’s strength and weaknesses to pursue an advanced level of understanding; only then can limitations be improved upon. A personal assessment is necessary as this underpins all factors that lead to professional and academic success. By identifying psychological characteristic type, a more efficient plan can be implemented to achieve success on a professional doctorate programme.

It is necessary to use different means of auditing these three areas. For my professional audit I used the British Association of Sport and Exercise Science (BASES) competency framework to assess my current level of professional practice. This framework can be tailored to specific domain within the sport science umbrella and is used primarily as criteria for achieving accredited scientist status with the organisation. The process includes ten areas within a person’s practice and they are required to satisfy, with evidence, all of these criteria. Next, I used the Vitae Researcher Development Framework (RDF) to audit my skills as a researcher. The process ‘articulates the knowledge, behaviors and attributes of successful researchers and encourages them to realise their potential’. This will aid me in successfully completing a thesis as part of the Professional Doctorate programme.

The RDF consists of four key areas of practice that form a successful researcher, within these are three sub categories that contain specific actions that can be graded from 1-5 depending on the level of the auditee. Finally, as an audit of my personal skills I completed a Personal Development Analysis questionnaire (PDA) from Cognite; this test produces a behavioural profile report and assess how they affect my abilities as both a practitioner.

After completing the BASES competency framework as an audit of my professional skills, I discovered a few areas where I can improve. Under the area of 'Self Evaluation and Professional Development' I feel I do not meet competency on my ability to 'maintain an appropriate audit trail and work towards continual improvement' and to 'Understand the value of reflection on practice and evidence of engagement in the process'. I believe that self-evaluation and personal professional development are areas of my own practice where I can certainly improve. To develop in these areas, it would be necessary for me to find a way in which I can keep better records of my day to day practice and periodically reflect on these occurrences. For example, when writing strength programmes for my athletes' I rarely take time to reflect fully on their success and failure. Due to the fast-paced nature of my work I often find it difficult to reflect upon my interventions.

Another section of the profile where I believe I do not achieve full competency is 'Management of Self, Others and Practice'. Here I do not believe I successfully 'maintain records appropriately'. Again, due to the fast-paced nature of my work, I often find it difficult to keep adequate records of the interventions I put in place. It would be beneficial for me to find an efficient means of recording strength programmes and other interventions as they occur.

I feel I have broad, general improvements to make as a researcher to be successful at a doctoral level, which I believe I will begin to make by completing a higher-level thesis. However, after completing the RDF framework evaluation there are clear, specific areas where I can seek to develop. For two of the four key domains, I score particularly low. These are ‘Research Governance and Organisation’ and ‘Engagement, Influence and Impact’. The first area is detailed as ‘The knowledge of standards, requirements and professionalism to do research’. Here I believe I score low due to having only previously completed Master's level research, my knowledge of ‘Professional Conduct’ and ‘Research Management’ are where I need to develop the most. However, I do see these as areas where I will ‘naturally’ progress by completing research at a higher level, through meetings with my supervisor and general reading around doctoral level study.

The second domain, where I score my lowest overall, is detailed as ‘The knowledge and skills to work with others and ensure the wider impact of research’. Again, here I score low merely due to my previous level of study. A key part of the Professional Doctorate programme centres on the dissemination of research to the wider public; by the use of peer reviewed journals, conference talks and Twitter, I believe I will vastly improve in this area. Another skill under the area of ‘Engagement and Impact’ is teaching. Over the course of the programme I aim to complete guest lecturing as a way of developing as a researcher and to further enhance my career prospects.

This will aid in developing my knowledge in my study area to a higher level of understanding.

By completing the PDA psychological report, I was able to audit my behaviors. The report provided me with descriptions based on the axes of Risk, Extroversion, Patience, Conformity to Norms, and Self Control. During my working life I am more inclined to be a risk taker, and as part of this I am very confrontational, autocratic, assertive and dominant. I also lack patience with others. These factors coupled with my highly perfectionist nature mean I am a highly task focused individual yet struggle to understand other peoples' needs and feelings. Whist completing research I may also struggle to ask for help as I seek to find a solution by myself. This can be potentially problematic when completing such a large piece of work.

As my career progresses and I begin to take up roles that consist of greater leadership duties it is important that I am able to delegate work as my current perfectionism could stop me doing this successfully. To be effective as a leader it is important to be able to understand other people as well as the tasks that are required to be completed. I must therefore learn to appreciate other peoples' points of view by being less impatient, remaining calm, and allowing others to flourish. Alongside this, when completing a thesis, I must be able to work successfully as a part of a team where it is necessary that I respect the opinions of others to be effective.

Another key area from the assessment was my need to be constantly challenged as my energy and motivation levels can begin to deteriorate if I am not. There is potential that I feel unchallenged in my current role and may need to seek additional challenges to further motivate myself; I hope that by completing the doctorate I am able to do this. The current programme of study will provide me with a framework of tasks and projects that will keep me constantly challenged and consequently motivated.

The behavior set that I exhibit in my working practice, on the whole, is suitable to my current profession, but as I progress, I may need to attempt to alter this. From a research perspective there are certain aspects of my character that I need to be aware of to be successful on the programme. The process has provided me with an awareness of my behaviors and the ability to put in place interventions to adjust these as my working life develops.

PROPOSAL

Background

Association football is a game characterised by periods of low intensity running punctuated by bouts of more intense sprinting efforts (Andrzejewski et al., 2015). It is these sprinting actions which are commonly decisive in the outcome of a match. It has been shown that 45% of goals scored were preceded by a linear sprint, and similar results were also seen for the player assisting the goal scorer (Faude et al., 2012). Sprints are typically over short distances and rarely exceed 20m, or 4s at a time (Andrzejewski et al., 2015).With advancements in sports science provisions, it is commonly accepted that football at the elite level is developing into an ever-faster game. This has been observed over six seasons in the English Premier League (2006/07 – 2012/13), where ‘pronounced’ increases (24-36%) for all playing positions were seen in High-Speed Running (HSR) (>19.8 km/h). During this period, sprinting distance also increased by 50% (>25.1kmh). The number of sprints completed increased by 47%, from 11 – 27.2 for all positions. These increases were particularly prevalent in wide and attacking positions (Bush et al., 2015).

Recently, the seasonal physical load placed upon Premier League players during the 2013/14 season has been quantified (Anderson et al., 2016). It was observed that regular starters completed 11.2km of sprinting (>25.2kmh) over the course of the season; over 80% of which was completed during matches. This is crucial information when designing training programmes as fringe players performed significantly lower sprinting distances than starters due to not participating in a weekly match.

When looking to develop a skill such as sprinting, as a novice, it is important to analyse elite performers in detail. Only by comparing current performance to elites can we develop a programme to achieve a higher level of ability. Commonly used metrics include step mechanics, consisting of: Step Length (SL), Step Frequency (SF) and Ground Contact Time (GCT) which can be measured using video analysis or optical measurement systems (Weyand et al., 2000; Barr et al., 2013; Krzysztof and Mero, 2013; Rabita et al., 2015). Also, stance kinetic data consisting of the direction and magnitude of force application have been used, however expensive multiple force plate systems are required for such an analysis (Lockie et al., 2013). The combination of these will ultimately determine the velocity, and success, of a sprint. Currently, no data exists on SL in elite footballers.

Absolute maximal velocity, the greatest speed achievable by an individual, is commonly a differentiator of elite sprinting performance (Krzysztof and Mero, 2013). During the 2009 World Championships 100m final, the eventual winner Usain Bolt achieved a maximum velocity of $12.26ms^{-1}$, noticeably faster than the rest of the finalist from the race, $11.80ms^{-1}$ (Krzysztof and Mero, 2013). Team sport athletes, international rugby players, however have only been observed as achieving $8.98ms^{-1}$ (Barr et al. 2013). Due to these lower maximum velocities, team sport athletes only require 30-40m their top sprinting speeds, whereas elite level sprinters typical require 50-60m (Barr et al., 2013; Krzysztof and Mero, 2013; Mattes et al., 2014).

SL has been shown to be a key differentiator of elite performance in maximum velocity sprinting (Rabita et al. 2015). Elite sprinters generally have a SL of 2.20 – 2.45m compared to non- elites of 2.15m (Mattes et al., 2014; Rabita et al., 2015; Yu et al., 2016). Analysing international Rugby Union players at maximum velocity, Barr et al (2013) observed SL of 2.06m, 7.8% shorter than the elite sprinters. It is believed that elite sprinters achieve this greater SL by more effectively applying vertical support forces, particularly in the first half of ground contact, to the ground; thus, allowing the individual the necessary time to reposition their limbs with ever shortening GCT (Weyand et al. 2000).

Another key characteristic of maximum velocity sprinting is the amount steps taken per second, SF. Usain Bolt during the 2009 World Championships final, at maximum velocity had a SF of 4.49hz compared to the rest of the fields average of 4.77hz (Krzysztof & Mero. 2013). National level and youth sprinters have been shown to possess maximum velocity SF of 4.54 and 4.12hz (Mattes et al. 2014; Yu et al. 2016); whilst international rugby players have displayed scores of 4.37hz (Barr et al., 2013). It may be therefore reasonable to assume that a high frequency is necessary to achieving fast maximum velocities.

GCT has been regularly cited as being a determinant of maximum velocity sprinting. Faster sprinters are able to apply larger support forces in shorter times than their slower counterparts (Weyand 2000). Rabita et al. (2015) observed GCTs of 0.094s for elite sprinters, which was the same as sub-elites. National and youth level sprinters have displayed times of 0.103 and 0.128s respectively (Mattes et al. 2014;

Yu et al 2016). However, team sport athletes have shown slightly shorter times than the youth sprinters, 0.111s (Barr et al. 2013).

Although sprinting has been shown to be crucial to the outcome of a match (Faude et al. 2012), the vast majority of those within football last for 2-3s and for a distance of less than 30m (Andrzejewski et al. 2015). Therefore, it could be argued that the ability to accelerate to a higher velocity is more important than the capacity to run at a high velocity per se. Again, to ascertain what an ideal acceleration would look like it is useful to analyse the very elite, competitive sprinters, as a model of success.

With regards to SL, when compared to the very elites from the 2009 100m world championship final, team sport athletes show much shorter lengths. Usain Bolts achieved an average SL of 1.78m during the first 20m and the rest of the field averaged 1.66m (Krzysztof and Mero, 2013). Whereas, international rugby union players average 1.36m, a percentage difference of -31% and -22% respectively (Barr et al., 2013).

When analysing SF, interestingly international rugby players achieve greater steps per second during acceleration. During the first 20m, Usain Bolt achieved a lower frequency (3.89hz) than the rest of the field (4.13hz); the team sport athletes however achieved a very high 4.37hz (Barr et al., 2013; Krzysztof and Mero, 2013). It would therefore be reasonable to assume that SF may not be a differentiator of acceleration ability after a certain level. The lower frequencies of the elite sprinters, than the rugby players is likely to be due to their more effective ground contacts (Weyand et al., 2000).

For GCT, moderate level sprinters spend slightly longer on the ground than team sport athletes (0.130 vs. 0.120s) (Yu et al. 2016; Barr et al. 2013). This may be the reason why the team sport athletes achieve a greater frequency. Longer GCT would allow for larger force application during acceleration and consequently greater SL. However, when analysing PE students GCT of 0.150s were observed, suggesting there may be an optimum length of GCT to allow sufficient force to be applied whilst still maintaining adequate acceleration (Morin et al., 2011).

The direction of force application during acceleration appears to be vital to success (Morin et al., 2012). Morin et al. (2011) demonstrated the calculation of an index of the ratio of applied force during instrumented treadmill sprinting and concluded that during acceleration, the orientation of the force applied horizontally to be more important than the total force applied during ground contact. In addition to this, relative horizontal impulse has also been shown to be the biggest predictor of velocity at 16m (Hunter et al., 2005). Therefore, the technical aspects of sprinting, how forces are applied to the ground, appear to be more important than the physical capacity to produce force.

Due to team sport athletes' shorter SL yet similar GCT, there are clear differences in how force is applied to the ground compared to elite sprinters. The effectiveness of force application (Ratio of Force) may be able to measure this missing piece of the puzzle. The quantification of which is simply the amount of horizontal force applied, divided by the total force per step; this can be estimated through mechanical equations derived from split times (Samozino et al., 2015). This simple field-based method has been validated against costly force plate analysis. The ratio decreases with each continuing step as force application becomes more vertical and velocity increases; the ability to delay the decrease in RF is a strong determinant of acceleration ability (Morin et al., 2011). A high RF is thought to be strongly associated with good technical ability in acceleration and therefore useful in football training programmes (Morin et al., 2011). A popular method of training this skill is resisted sprinting (RS), generally through means such as sled towing (Petrakos et al., 2016).

Sled towing works as a RS method by requiring the athlete to produce greater force in a horizontal direction to overcome the mass of the sled (Morin et al., 2016). Previously, much of the research (and coaching practice) into sled running focused on loads of around 10% body mass due to fears of greater loads negatively affecting sprinting kinematics (Petrakos et al., 2016). However, it has been shown recently that pulling a sled load of 30% body mass induced an increase in RF compared to lesser loads, suggesting an insufficient overload of horizontal force when training using lighter loads (Kawamori et al., 2013). Thus, the previously upheld 10% body mass rule may need to be disregarded, especially in acceleration demanding sports such as football.

Cross et al. (2017) sought to ascertain the optimal sled load that induced maximum power (Pmax), loads above which would challenge predominantly force and below velocity. It was concluded that loads ranging from 69-96% of body mass were required to induce Pmax. Morin et al. (2016) applied this during a pilot study with amateur footballers, where unresisted sprint training was compared with heavy RS training using loads of 80% body mass. Only the RS group saw improvements in RF and a tendency for faster 5 and 20m split times.

Alongside the Ratio of Force, researchers have also attempted to gain a better understanding of an individual's Force - Velocity - Power (F-V-P) capabilities during sprinting (Samozino et al., 2015). This information would aid in informing training programmes by establishing an individuals' strengths and weakness. Since the inception of sport science, it has been understood and accepted that there is an inverse linear relationship between Force and Velocity; whereby higher forces are able to be produced only at lower velocities (Cross et al., 2016). This concept has also recently been further proved in a multi-joint, ballistic activity (countermovement jump), as well as the parabolic relationship of Power and Velocity (Samozino et al., 2008). Via a simple assessment it is possible to profile the capabilities of the neuromuscular system and compare this to an 'optimum' profile (derived from mechanical models). This method has been validated during a maximal sprint (Samozino et al. 2015). Through mechanical models using the variables derived from radar speed-time analysis it is possible to ascertain an individual's ability to produce force at increasing velocities, which can then be extrapolated, according to their linear relationship, to give theoretical maximums (F0, V0, Pmax).

Buchheit et al. (2014) aimed to determine which type of F-V-P profile would predict different elements of sprinting performance. In youth football players they observed that those with greater F0 and V0 were better accelerators, whereas those able to achieve faster maximum velocities possessed greater V0 and Pmax scores. Therefore, when designing strength programmes, focus should be given to the relevant component of the F-V-P curve that relates to the specific sprinting quality intending on being developed.

Currently, research looking into the most effective training methods to improve the F-V-P profile closer to the optimal is undeveloped. The effects of optimised and non-optimised training methods on individuals displaying deficits in their profile for countermovement jumps, be they velocity or force, has recently been studied (Jiménez-Reyes et al., 2017). All participants in the optimised training group improved their jump height, whereas results in the non-optimised (general training) group were much more varied. These results were seen without an increase in Pmax, consequently it is concluded that even in the absence of an improvement in power, training to affect the F-V-P profile to more optimal will enhance multi-joint, ballistic abilities. Although yet to be proven it is hoped believed that by training with sleds at lighter or heavier loads, velocity or force capabilities can be specifically developed and thus improving sprinting performance.

AIMS AND OBJECTIVES

Study 1

To quantify the seasonal sprinting demands of Premier League football.

Study 2

To detail the step mechanics, force - velocity relationship and ratio of force of a squad of professional footballers whilst sprinting to maximum velocity.

Study 3

To assess the effect of varying loads of resisted sprints on professional footballers' force-velocity curves and ascertain at what load maximum power occurs, thus informing future training prescriptions.

Study 4

To apply the findings of the previous studies to a case study of a training programme aimed at improving an elite professional footballers sprinting ability during the in-season period.

METHODS

Study 1

Through the use of GPS data from training days and Tracab data from match days, total sprinting distance over the course of a full season for a squad of professional soccer players competing in the English Premier League will be quantified. This will begin from day 1 of the pre-season and end at the final match of the Premier

League season. For analysis of within season differences, 6 periods will be used, consisting of the pre-season period and 5 equal length periods until the final match week of the season. To compare players within the squad, 'starters' will be categorised as those starting 60% or more of Premier league games, and non-starters less than this. A sprint is to be defined as an effort achieving at least 85% of maximum velocity attained during a maximal effort linear sprint over 40m.

Study 2

OptoJump, optical measurement system will be used to analyse the step mechanics (step length step frequency and ground contact time) of a maximal 40m sprint for all individuals within the squad. A full track of units will be connected to cover the length of the sprint. Also, a laser speed gun will be used to produce a speed-time curve of the effort. From this curve, a force-velocity-power profile and ratio of force value, and decrement, will be produced for each individual. The data will then be presented as two groups, 'faster' and 'slower' according to their maximum velocity achieved compared to the group mean, and comparisons and differentiators drawn. Creating a profile of how those in the 'faster' group are able to achieve these greater speeds, future training programmes can be designed more efficiently.

Study 3

Sled towing loads of 20, 40, 60, 80, 100% of an individual's body mass will be used for a maximal sprint over 30m for all squad members. This will be performed through an OptoJump track to detail stride mechanics. Also, a laser speed gun will be used to produce a force-velocity-power profile for each individual, at each load. The optimal load to elicit maximum power production can then be calculated as an average for the group, and recommendations for training given. This would then either support or contradict the traditional belief that only lighter sled towing should be used to enhance acceleration; this was currently observed in a mixed cohort of athletes. A recent study has suggested that very heavy sled towing can improve acceleration ability in youth players, therefore there is potential that this will translate into full time mature professionals.

Study 4

A force-velocity-power profile will be completed for an individual, as well as their ratio of force, and decrement value off of a 40m sprint. This will then be compared to an optimal profile for the individual and a specific 6 weeks, in-season, training programme will be designed to bring about adaptations towards a more optimal profile. The athlete will then be assessed during a 40m sprint as a posttest analysis of the effects of the training intervention. By developing a training programme based resisted, sled towing from the previous findings, an efficient means of enhancing sprinting performance in elite soccer players, during the in season, can be tested.

TRAINING PLAN

For my training plan I have used a Gantt chart to visibly outline how I plan to progress through the programme. I have broken down the two years into quarters. I plan to have weekly contact with my supervisor by sending an update email every Monday where I will review the previous week and set tasks for the following. In addition to this I will organise two face to face or in-depth phone calls every quarter to discuss my progress through the programme.

During year 1, I will submit my Training plan during quarter 2. Following this my focus will become my literature review and the finalising in depth of my 4 studies. Data collection for studies 1 and 2 will occur during quarter 3 of year 1, after which my focus will be on analysing this data. Quarter 4 will then consist of data collection analysis for study 3. By the end of year 1 I plan to have outlined my literature review; collected data for studies 1, 2 and 3; analysed this data; and begun my methods and results section of study 1.

The 1st quarter of year 2 will be mainly focused on finishing writing the content of my literature review. I will also use the quarter period to collect and analyse the data from my training study, 4. Once I have all of my data collected, I can begin to write the introduction sections of my 4 studies, which will take up the final 6 weeks of the quarter.

Quarter 2 is where I will finalise my literature review by completing my referencing and grammar checks. Once this is complete, I will focus on the results sections and complete these. The final 6 weeks will be spent writing up my discussion and conclusions from study 1. Quarter 3 will then consist of the write up of my final three discussion sections. Finally, quarter 4 will be time to check over my completed work and make any necessary adjustments whilst planning for my VIVA.

Although I have outlined in detail my plan for the two years of the programme, these I are highly adaptable, and the Gantt chart will be a live document that I will update constantly. For this reason, I have tried to leave as little planned work as possible for the final quarter, this will allow me the additional time I may need to catch up on any tasks that are not fully completed.

Quarter 1														
		Week												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Task	Days	02-Jan	09-Jan	16-Jan	23-Jan	30-Jan	06-Feb	13-Feb	20-Feb	27-Feb	06-Mar	13-Mar	20-Mar	27-Mar
General Program Development														
LJMU Induction	1			■										
LJMU Contact Days	3					■			■			■		
Superivsor Contact (Call/Face to Face)	2		■										■	
Supervisor Contact (Email)	0.25	■	■	■	■	■	■	■	■	■	■	■	■	■
Development of original idea	5	■	■											
Contact leading researchers in the area	0.25		■											
Literature search	5	■	■	■	■	■								
Organsie literature within software manager	1					■								
Read Literature	13	■	■	■	■	■	■	■	■	■	■	■	■	■
Annotate articles	13	■	■	■	■	■	■	■	■	■	■	■	■	■
Training Plan														
Outline Proposal	4									■	■	■	■	
Read around Reflective Practice	1													■
Read around Gannt Chart planning	1													■
Read around Self Audit methods (RDF, BASES, PDA)	1													■

Quarter 2														
		Week												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Task	Days	03-Apr	10-Apr	17-Apr	24-Apr	01-May	08-May	15-May	22-May	29-May	05-Jun	12-Jun	19-Jun	26-Jun
General Program Development														
LJMU Contact Days	2	■					■							
Superivsor Contact (Call/Face to Face)	2		■					■						
Supervisor Contact (Email)	0.25	■	■	■	■	■	■	■	■	■	■	■	■	■
Reflective Practice	2	■	■	■	■	■	■	■	■	■	■	■	■	■
Training Plan														
RDF - Complete assesment	0.5	■												
RDF - Detail descriptions	0.5						■							
BASES - Complete competency framework	1						■							
PDA - Complete assessment	0.5					■								
PDA - Attend discussion meeting	0.5								■					
Proposal - Build Content	4					■	■	■	■					
Proposal - Write scientific content	2							■	■					
Proposal - In/End text referencing	1								■	■				
Proposal - Grammar check	0.5									■				
GANNT chart - Complete finalised copy	1						■							
Submission	-									■				
Thesis														
Literature Review - Fact Finding	8										■	■	■	■
Literature Review - Outline	4												■	■

Quarter 3														
		Week												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Task	Days	03-Jul	10-Jul	17-Jul	24-Jul	31-Jul	07-Aug	14-Aug	21-Aug	28-Aug	04-Sep	11-Sep	18-Sep	25-Sep
General Program Development														
Superivsor Contact (Call/Face to Face)	2		■					■						
Supervisor Contact (Email)	0.25	■	■	■	■	■	■	■	■	■	■	■	■	■
Reflective Practice	2	■	■	■	■	■	■	■	■	■	■	■	■	■
Thesis														
Literature Review - Outline	2	■	■											
Literature Review - Bullet point information	13	■	■	■	■	■	■	■	■	■	■	■	■	■
Data Collection - Study 1	1	■												
Data Collection - Study 2	1					■								
Data Analysis - Study 1	3	■	■											
Data Analysis - Study 2	3						■	■	■	■				
Methods - Study 1	2												■	■

Quarter 4														
		Week												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Task	Days	02-Oct	09-Oct	16-Oct	23-Oct	30-Oct	06-Nov	13-Nov	20-Nov	27-Nov	04-Dec	11-Dec	18-Dec	25-Dec
General Program Development														
Superivsor Contact (Call/Face to Face)	2		■					■						
Supervisor Contact (Email)	0.25	■	■	■	■	■	■	■	■	■	■	■	■	■
Reflective Practice	2	■	■	■	■	■	■	■	■	■	■	■	■	■
Thesis														
Literature Review - Build content	6.5	■	■	■	■	■	■	■	■	■	■	■	■	■
Data Collection - Study 3	1	■												
Data Anlysis - Study 3	3		■	■	■									
Results - Study 1	2					■	■	■	■					

Figure 9.1 Year 1 – Gantt Chart

Quarter 1

		Week												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Task	Days	*01-Jan*	*08-Jan*	*15-Jan*	*22-Jan*	*29-Jan*	*05-Feb*	*12-Feb*	*19-Feb*	*26-Feb*	*05-Mar*	*12-Mar*	*19-Mar*	*26-Mar*
General Program Development														
Superivsor Contact (Call/Face to Face)	2		■					■						
Supervisor Contact (Email)	0.25	■	■	■	■	■	■	■	■	■	■	■	■	■
Reflective Practice	2	■	■	■	■	■	■	■	■	■	■	■	■	■
Thesis														
Literature Review - Write scientific content	6.5	■	■	■	■	■	■	■	■	■	■	■	■	■
Data Collection - Study 4	6		■	■	■	■	■	■						
Data Analysis - Study 4	3.5		■	■	■	■	■	■	■					
Methods - Study 3	2	■	■											
Methods - Study 4	2								■	■				
Introduction - Study 1	2										■			
Introduction - Study 2	2											■		
Introduction - Study 3	2												■	
Introduction - Study 4	2													■

Quarter 2

		Week												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Task	Days	*02-Apr*	*09-Apr*	*16-Apr*	*23-Apr*	*30-Apr*	*07-May*	*14-May*	*21-May*	*28-May*	*04-Jun*	*11-Jun*	*18-Jun*	*25-Jun*
General Program Development														
Superivsor Contact (Call/Face to Face)	2		■					■						
Supervisor Contact (Email)	0.25	■	■	■	■	■	■	■	■	■	■	■	■	■
Reflective Practice	2	■	■	■	■	■	■	■	■	■	■	■	■	■
Thesis														
Literature Review - In/End text referencing	2	■												
Literature Review - Grammar check	1	■												
Results - Study 2	2		■	■										
Results - Study 3	2				■	■								
Results - Study 4	2						■	■						
Discussion - Study 1	4								■	■	■	■	■	■

Quarter 3

		Week												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Task	Days	*02-Jul*	*09-Jul*	*16-Jul*	*23-Jul*	*30-Jul*	*06-Aug*	*13-Aug*	*20-Aug*	*27-Aug*	*03-Sep*	*10-Sep*	*17-Sep*	*24-Sep*
General Program Development														
Superivsor Contact (Call/Face to Face)	2		■					■						
Supervisor Contact (Email)	0.25	■	■	■	■	■	■	■	■	■	■	■	■	■
Reflective Practice	2	■	■	■	■	■	■	■	■	■	■	■	■	■
Thesis														
Discussion - Study 2	4	■	■	■	■									
Discussion - Study 3	4					■	■	■	■					
Discussion - Study 4	4									■	■	■	■	

Quarter 4

		Week												
		1	2	3	4	5	6	7	8	9	10	11	12	13
Task	Days	*01-Oct*	*08-Oct*	*15-Oct*	*22-Oct*	*29-Oct*	*05-Nov*	*12-Nov*	*19-Nov*	*26-Nov*	*03-Dec*	*10-Dec*	*17-Dec*	*24-Dec*
General Program Development														
Superivsor Contact (Call/Face to Face)	2		■					■						
Supervisor Contact (Email)	0.25	■	■	■	■	■	■	■	■	■	■	■	■	■
Reflective Practice	2	■	■	■	■	■	■	■	■	■	■	■	■	■
Thesis														
Catch up on any remaining work	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Plan for VIVA	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Submission													■	

Figure 9.2 Year 2 – Gantt Chart

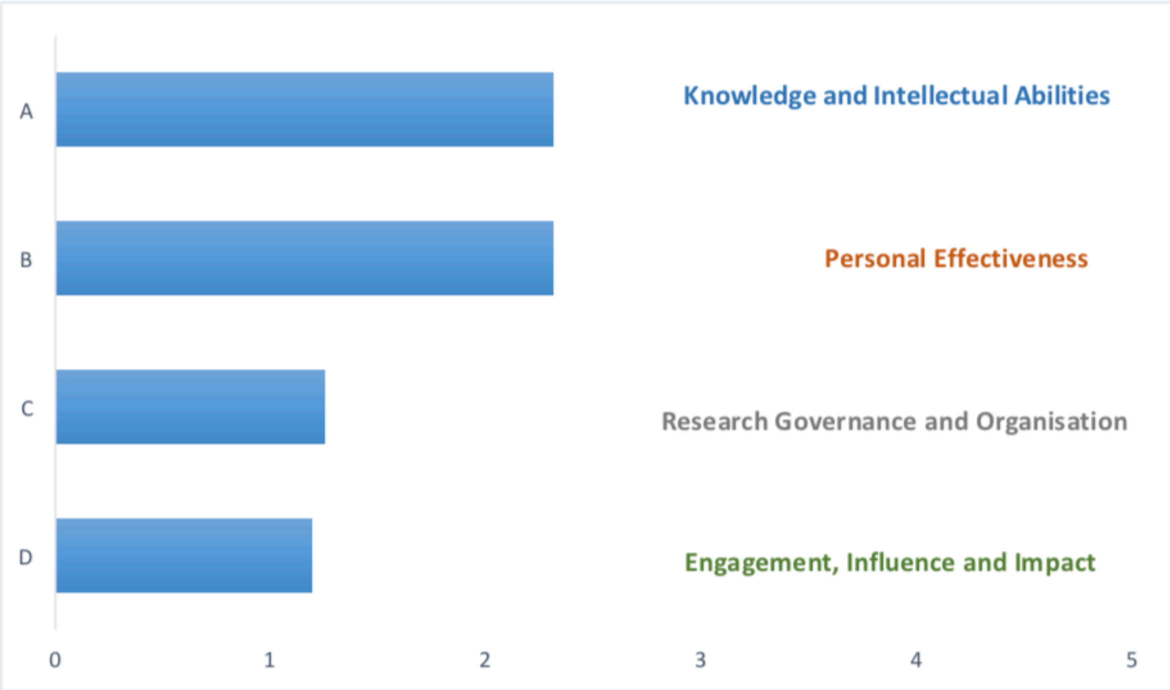


Figure 9.3 Vitae Researcher Development Framework average section outputs.

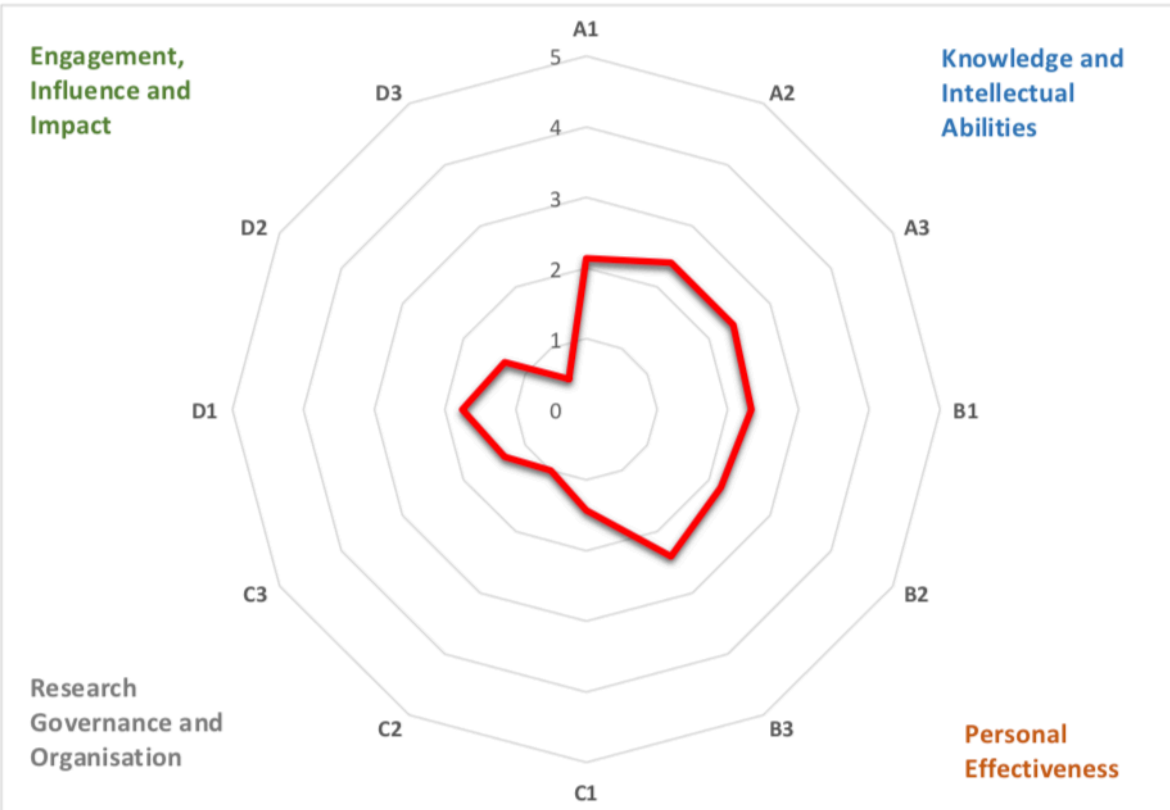


Figure 9.4 Vitae Researcher Development Framework individual section outputs.

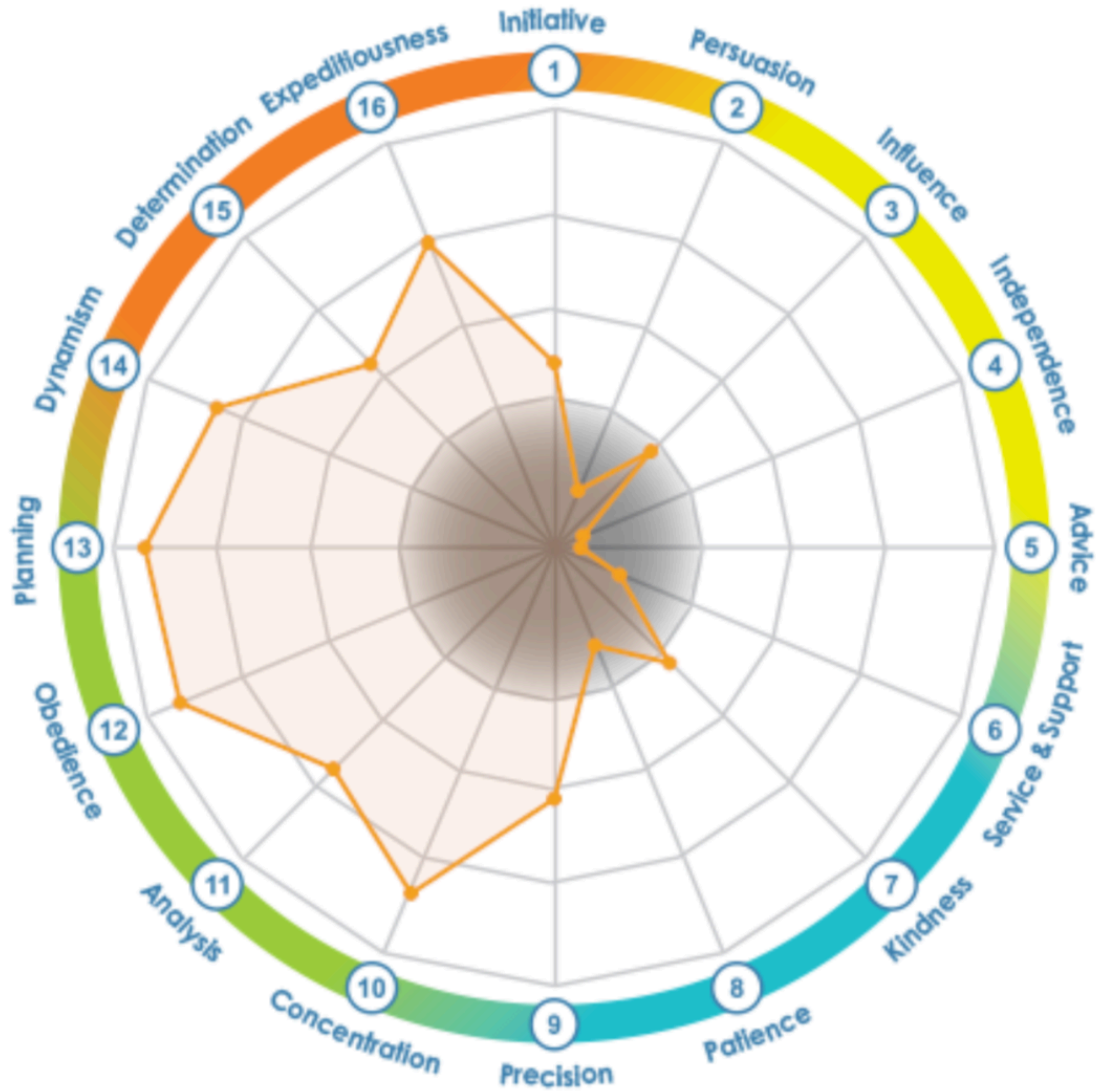


Figure 9.5 Example output from the PDA psychological assessment.

9.2 EFFECT SIZES

Raw Effect Size Data

Table 9.1 Effect size comparisons of each Transition Movement.

	Static	*Jockeying*	*Linear*	*Ball*	*Lateral*	*Diagonal*	*Rear*	*Rear+*	*Decel.*
Static		-3.1[c]	-4.3[c]	-1.8	-0.8[a]	-5.7[c]	-1.0[a]	-1.9[b]	-2.8[c]
Jockeying	3.1[c]		-3.5[c]	1.2[a]	2.3[c]	-3.1[c]	2.0[b]	1.4[b]	0.2
Linear	4.3[c]	3.5[c]		3.8[c]	4.1[c]	2.1[c]	4.1[c]	3.9[c]	3.6[c]
Ball	1.8[b]	-1.2[a]	-3.8[c]		1.1	-4.1[c]	0.8[a]	0.2	-0.9[a]
Lateral	0.8[a]	-2.3[c]	-4.1[c]	-1.1		-5.0[c]	-0.2	-1.0[a]	-2.0[b]
Diagonal	5.7[c]	3.1[c]	-2.1[c]	4.1[c]	5.0[c]		4.8[c]	4.4[c]	3.3[c]
Rear	1.0[a]	-2.0[b]	-4.1[c]	-0.8[a]	0.2	-4.8[c]		-0.7[a]	-1.8[b]
Rear+	1.9[b]	-1.4[b]	-3.9[c]	-0.2	1.0[a]	-4.4[c]	0.7[a]		-1.2[a]
Decel.	2.8[c]	-0.2	-3.6[c]	0.9[a]	2.0[b]	-3.3[c]	1.8[b]	1.2[a]	

[a] *Moderate effect size,* [b] *Large Effect size and* [c] *Very Large effect size*

Table 9.2 Effect size comparisons of each Starting Position Movement.

	Linear	*Lateral*	*Rear*
Linear		5.0[c]	5.3[c]
Lateral	-5.0[c]		1.2[a]
Rear	-5.3[c]	-1.2[a]	

[a] *Moderate effect size,* [b] *Large Effect size and* [c] *Very Large effect size*

Table 9.3 Effect size comparisons of each Change of Direction Movement.

	Back-Front	*Front-Back*	*Lateral*	*None*
Back-Front		-2.7[c]	-4.9[c]	-5.6[c]
Front-Back	2.7[c]		-4.3[c]	-4.9[c]
Lateral	-4.9[c]	4.3[c]		-0.4
None	5.6[c]	4.9[c]	-0.4	

[a] Moderate effect size, [b] Large Effect size and [c] Very Large effect size

Table 9.4 Effect size comparisons of each Acceleration Movement.

	Explosive	*Rolling*
Explosive		-3.2[c]
Rolling	3.2[c]	

[a] Moderate effect size, [b] Large Effect size and [c] Very Large effect size

Table 9.5 Effect size comparisons of each Maximum Velocity Movement.

	Linear	*Curved*
Linear		-7.16[c]
Curved	7.16[c]	

[a] Moderate effect size, [b] Large Effect size and [c] Very Large effect size

Table 9.6 Effect size comparisons of each Action During Movement.

	None	*Duel*	*Ball*
None		9.1[c]	9.5[c]
Duel	-9.1[c]		0.7[a]
Ball	-9.5[c]	-0.7[a]	

[a] Moderate effect size, [b] Large Effect size and [c] Very Large effect size

Table 9.7 Effect size comparisons of each Action End Movement.

	None	*Duel*	*Ball*
None		2.2[c]	3.8[c]
Duel	-2.2[c]		1.7[b]
Ball	-3.8[c]	-1.7[b]	

[a] Moderate effect size, [b] Large Effect size and [c] Very Large effect size

Table 9.8 Effect size comparisons of each Torso Rotation Movement.

	Rotated	*Not Rotated*
Rotated		2.7[c]
Not Rotated	-2.7[c]	

[a] Moderate effect size, [b] Large Effect size and [c] Very Large effect size

Table 9.9 Effect size comparisons of each Phase of Play.

	Attacking Organisation	*Attacking Transition*	*Defensive Organisation*	*Defensive Transition*
Attacking Organisation		-2.6[c]	-2.4[c]	-2.0[c]
Attacking Transition	2.6[c]		-0.3	0.3
Defensive Organisation	2.4[c]	0.3		0.5
Defensive Transition	2.0[c]	-0.3	-0.5	

[a] *Moderate effect size,* [b] *Large Effect size and* [c] *Very Large effect size*

Table 9.10 Effect size comparisons of each Tactical Outcome

	Closing Down	*Interception*	*Covering*	*Recovery Run*	*Ball Over the Top*	*Ball Down the Side*	*Track the Runner*	*OP Other*	*Break into Box*	*Overlap*	*Push Up Pitch*	*Run the Channel*	*Run in Behind*	*Drive Inside*	*Drive Through the Middle*	*Run with Ball*	*IP Other*
Closing Down		4.5[c]	1.1[a]	1.3[b]	3.4[c]	1.5[b]	1.6[b]	4.8[c]	2.8[c]	3.4[c]	2.9[c]	1.3[b]	2.4[c]	4.5[c]	3.8[c]	2.8[c]	3.7[c]
Interception	-4.5[c]		-3.7[c]	-1.8[b]	-1.6[b]	-1.7[b]	-2.6[c]	1.2[a]	-2.6[c]	-1.4[b]	-1.8[b]	-3.1[c]	-2.0[b]	0.1	-2.3[c]	-2.6[c]	-1.0[a]
Covering	-1.1[a]	3.7[c]		0.4	2.4[c]	0.6	0.5	4.0[c]	1.7[b]	2.4[c]	1.8[b]	0.2	1.4[b]	3.7[c]	2.7[c]	1.7[b]	2.7[c]
Recovery Run	-1.3	1.8[b]	-0.4		1.2[a]	0.2	0.0	2.0[b]	0.7[a]	1.2[a]	0.9[a]	-0.2	0.6	1.9[b]	1.3[b]	0.7[a]	1.4[b]
Ball Over the Top	-3.4[c]	1.6[b]	-2.4[c]	-1.2[a]		-1.0[a]	-1.6[b]	2.2[c]	-0.9[a]	0.1	-0.5	-2.0[b]	-0.8[a]	1.7[b]	0.2	-0.9[a]	0.4
Ball Down the Side	-1.5[b]	1.7[b]	-0.6	-0.2	1.0[a]		-0.2	1.9[b]	0.6	1.0[b]	0.7[a]	-0.4	0.4	1.7[b]	1.1[a]	0.5	1.2[a]
Track the Runner	-1.6[b]	2.6[c]	-0.5	0.0	1.6[b]	0.2		3.0[c]	1.0[a]	1.6[b]	1.1[a]	-0.3	0.8[a]	2.7[c]	1.8[b]	0.9[a]	1.9[b]
OP Other	-4.8[c]	-1.2[a]	-4.0[c]	-2.0[b]	-2.2[c]	-1.9[b]	-3.0[c]		-3.3[c]	-2.0[b]	-2.2[c]	-3.4[c]	-2.4[c]	-1.0[a]	-3.7[c]	-3.2[c]	-1.6[b]
Break into Box	-2.8[c]	2.6[c]	-1.7[b]	-0.7[a]	0.9[a]	-0.6	-1.0[a]	3.3[c]		0.9[a]	0.3	-1.4[b]	-0.1	2.7[c]	1.2[a]	0.0	1.3[b]
Overlap	-3.4[c]	1.4[b]	-2.4[c]	-1.2[a]	-0.1	-1.0[a]	-1.6[b]	2.0[b]	-0.9[a]		-0.5	-2.0[b]	-0.9[a]	1.5[b]	0.1	-0.9[a]	0.3
Push Up Pitch	-2.9[c]	1.8[b]	-1.8[b]	-0.9[a]	0.5	-0.7[a]	-1.1[a]	2.2[c]	-0.3	0.5		-1.5[b]	-0.4	1.8[b]	0.7[a]	-0.3	0.8[a]
Run the Channel	-1.3[b]	3.1[c]	-0.2	0.2	2.0	0.4	0.3	3.4[c]	1.4[b]	2.0[b]	1.5[b]		1.1[a]	3.1[c]	2.3[c]	1.3[b]	2.3[c]
Run in Behind	-2.4[c]	2.0[b]	-1.4[b]	-0.6	0.8[a]	-0.4	-0.8[a]	2.4[c]	0.1	0.9[a]	0.4	-1.1[a]		2.1[c]	1.1[a]	0.1	1.2[a]
Drive Inside	-4.5[c]	-0.1	-3.7[c]	-1.9[b]	-1.7[b]	-1.7[b]	-2.7[c]	1.0	-2.7[c]	-1.5[B]	-1.8[B]	-3.1[c]	-2.1[c]		-2.4[c]	-2.6[c]	-1.1
Drive Through the Middle	-3.8[c]	2.3[c]	-2.7[c]	-1.3[b]	-0.2	-1.1	-1.8[B]	3.7[c]	-1.2	-0.1	-0.7	-2.3[c]	-1.1	2.4[c]		-1.2[a]	0.4
Run with Ball	-2.8[c]	2.6[c]	-1.7[b]	-0.7[a]	0.9[a]	-0.5	-0.9[a]	3.2[c]	0.0	0.9[a]	0.3	-1.3[b]	-0.1	2.6[c]	1.2[a]		1.3[b]
IP Other	-3.7[c]	1.0[a]	-2.7[c]	-1.4[b]	-0.4	-1.2[b]	-1.9[b]	1.6[b]	-1.3[b]	-0.3	-0.8[a]	-2.3[c]	-1.2[a]	1.1[a]	-0.4	-1.3[b]	

[a] *Moderate effect size,* [b] *Large Effect size and* [c] *Very Large effect size*

9.3 PRESENTATION

Chapter 6 – Presentation

UKSCA Midlands Regional Event

11th April 2019

Coventry Univeristy

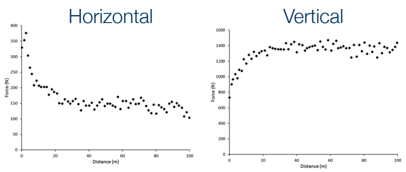
Paul Caldbeck

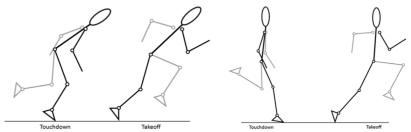

Contextual Sprinting in Football:
Generally Specific
Paul Caldbeck MSc ASCC CSCS

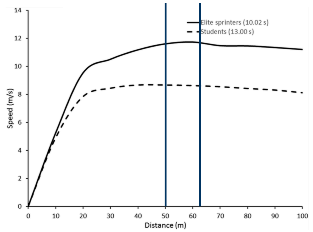

Sprints performed increased for each position between 2006-07 and 2012-13
Performance
Straight sprinting is the most dominant actions when scoring goals
Injury Prevention
The majority of hamstring injuries occur while at or close to maximal speeds
Research Problem
How can we get our players faster?
What is sprinting in football?
(Barnes et al. 2014; Faude et al. 2012; Schache et al. 2012)

What is a Sprint?

*"run at **full speed** over a **short** distance"*







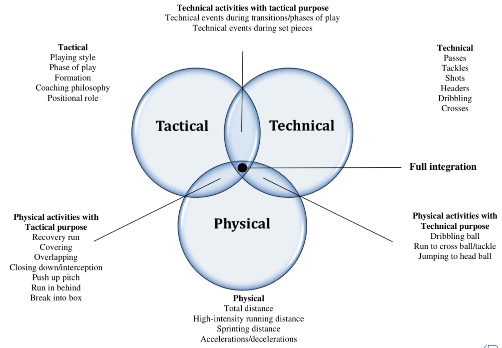
Acceleration

Maximum Velocity

Deceleration

(Moir et al. 2018)

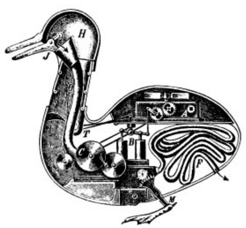
What is Contextual Sprinting?



(Bradley et al. 2018)

Current Understanding

- **Sprint Distance** 6-20m
- **Total Sprint Distance** 250-350m
- **Frequency** 7mins
- **Velocity** 8.8-9.5m/s



Reductionism

'The practice of analysing and describing a complex phenomenon in terms of its simple or fundamental constituents, especially when this is said to provide a sufficient explanation'

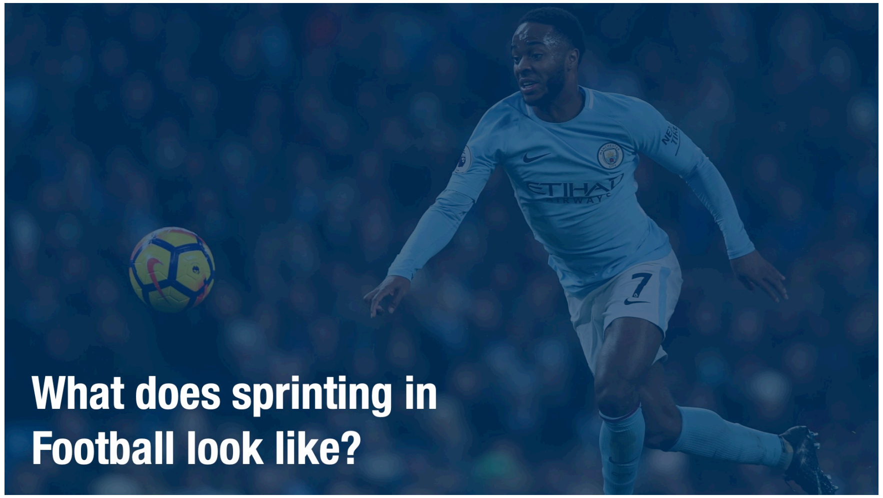
'… the physical metrics are explored without consideration for the technical and tactical indices'

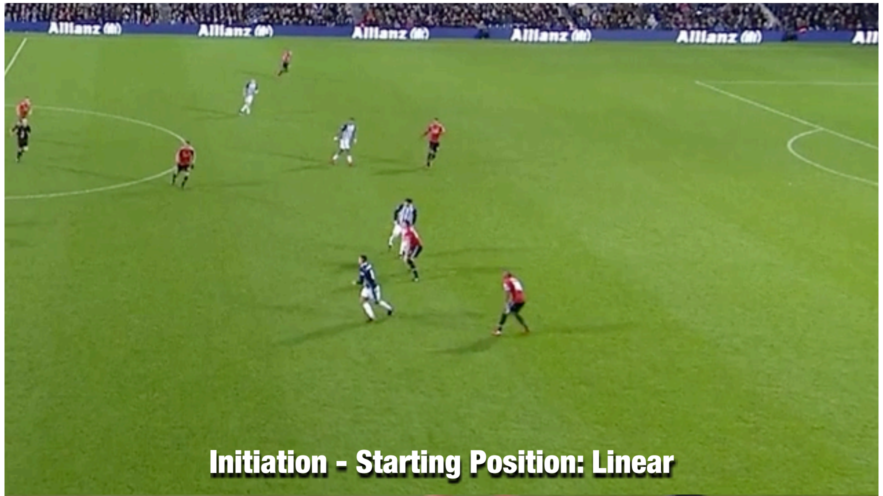
'The search for simple - if not simpleminded - solutions to complex problems is a consequence of the inability to deal effectively with complexity'
Russell L. Ackoff

(Bradley et al. 2018)


Capacity
TDK
TOYOTA
CCM 6 1 CCS 90:12 +3
Capacity
Premier League


Capacity
32-years-old
Retired 2-years
Slow accelerator?
Training for endurance sport
Little Warm Up
Trainers
Sweatpants!!!
Equals fastest time in history for an NFL player
(Dos'Santos et al. 2019; Clarke et al. 2018)
Observe > Orient > Decide > Act
Perception - Action
'Traditionally the approach is to look at these capacities from a definitional point of view and devise means and methods of assessing and developing them based on these definitions'
Capacity
Game Speed
'However, this can often result in practices that do not necessarily reflect the way in which the movements are deployed in a game'
(Jeffreys et al. 2018)





Movement Classification

Transition	Initiation		Actualisation				
Transition Movement	Change of Direction	Starting Position	Acceleration	Maximum Velocity	Torso Orientation	Action During	Action End
- Static - Jockeying - Linear - Ball - Lateral - Diagonal - Rear - Rear+ - Deceleration	- None - Lateral - Front-Back - Back-Front	- Linear - Lateral - Rear	- Explosive - Gradual	- Linear - Curved	- No Rotation - Rotation	- None - Duel - Ball	- None - Duel - Ball

(Jeffreys et al. 2018)

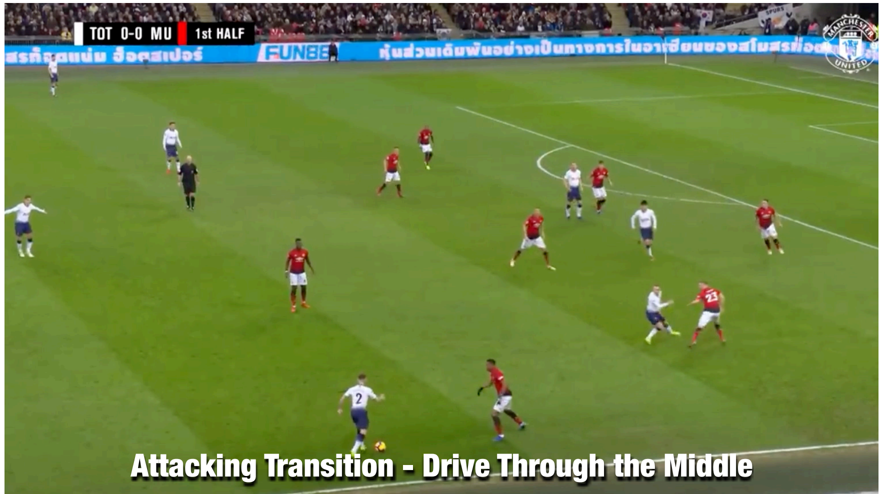

Initiation - Starting Position: Rear
Transition - Transition Movement
Diagonal
Lateral
Deceleration
'Cross Step'
'Side Shuffle'
'Staggered Stance'
Initiation - Starting Position
Linear
Lateral
Rear
'Typical' Acceleration
'Hip Turn'
'Drop Step'
Deceleration Transition
Front - Back COD
Rear Initiation
Gradual Acceleration
Curved Maximum Velocity
Dissociated Torso
No Action During
Ball Action End


Initiation - Change of Direction
None
Lateral
Front-Back
Back-Front
100%
50%
0%
CB
FB
CM
WM
CF
8%
48%
44%
5%
42%
53%
1%
6%
33%
60%
2%
6%
44%
48%
1%
6%
56%
37%
Initiation - Starting Position
Linear
Lateral
Rear
100%
50%
0%
CB
FB
CM
WM
CF
20%
20%
60%
11%
22%
67%
15%
10%
75%
18%
28%
54%
17%
20%
64%
Actualisation - Torso Dissociation
Yes
No
100%
50%
0%
CB
FB
CM
WM
CF
31%
69%
28%
72%
35%
65%
43%
57%
42%
58%
Why does sprinting in
Football occur?

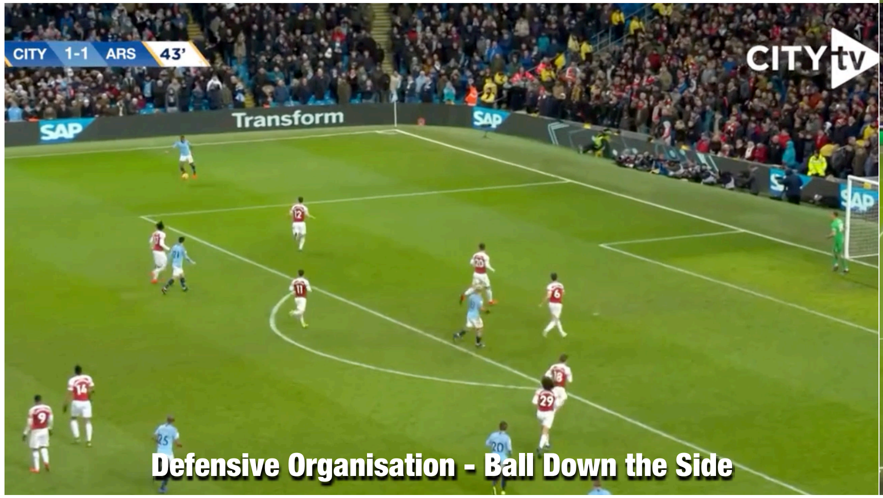
Tactical-Context Classification

Phase of Play	Tactical Outcome	
Phase	In Possesion	Out of Possession
- Attacking Organisation - Attacking Transition - Defensive Organisation - Defensive Transition	- Break into Box - Overlap - Push up the Pitch - Run the Channel - Run-in Behind - Drive Inside - Drive through the Middle - Run with the Ball - Other	- Closing Down - Interception - Covering - Recovery Run - Ball over the Top - Ball down the Side - Track the Runner - Other

(Ade et al. 2016)

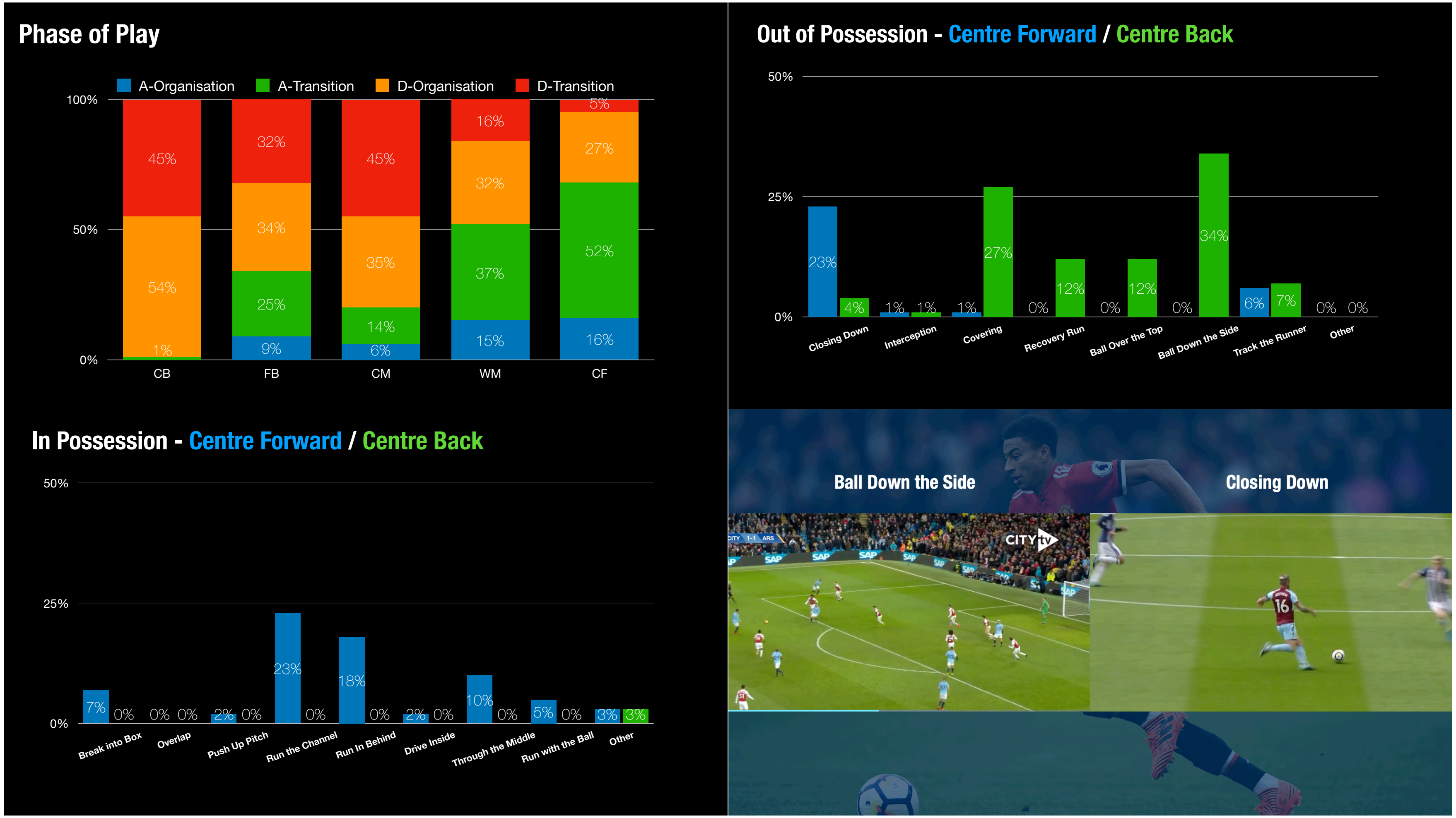


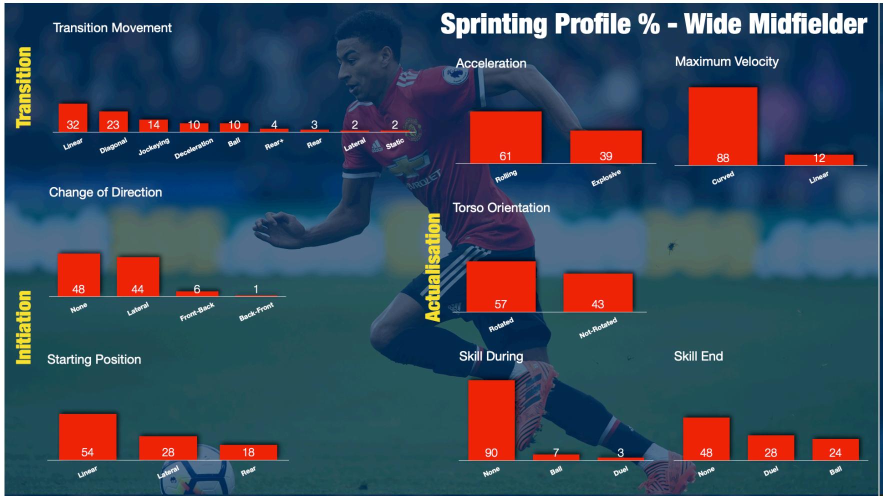
Attacking Transition - Drive Through the Middle



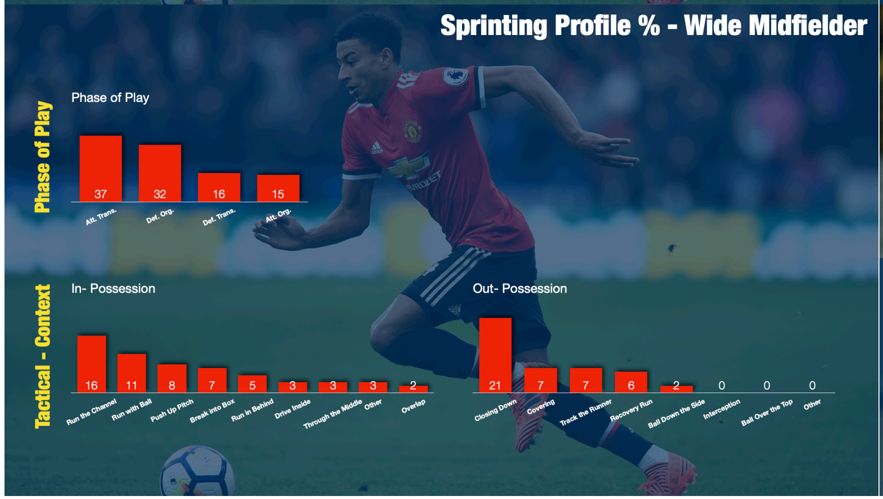
Defensive Organisation - Ball Down the Side

Attacking Organisation - Run in Behind


Phase of Play
A-Organisation
A-Transition
D-Organisation
D-Transition
100%
50%
0%
CB
FB
CM
WM
CF
45%
54%
1%
32%
34%
25%
9%
45%
35%
14%
6%
16%
32%
37%
15%
5%
27%
52%
16%
In Possession - Centre Forward / Centre Back
50%
25%
0%
7%
0%
0%
0%
2%
0%
23%
0%
18%
0%
2%
0%
10%
0%
5%
0%
3%
3%
Break into Box
Overlap
Push Up Pitch
Run the Channel
Run In Behind
Drive Inside
Through the Middle
Run with the Ball
Other
Out of Possession - Centre Forward / Centre Back
50%
25%
0%
23%
4%
1%
1%
1%
27%
0%
12%
0%
12%
0%
34%
6%
7%
0%
0%
Closing Down
Interception
Covering
Recovery Run
Ball Over the Top
Ball Down the Side
Track the Runner
Other
Ball Down the Side
Closing Down
CITY tv


Sprinting Profile % - Wide Midfielder
Transition
Transition Movement
32 23 14 10 10 4 3 2 2
Linear Diagonal Jockeying Deceleration Ball Rear+ Rear Lateral Static
Initiation
Change of Direction
48 44 6 1
None Lateral Front-Back Back-Front
Starting Position
54 28 18
Linear Lateral Rear
Actualisation
Acceleration
61 39
Rolling Explosive
Maximum Velocity
88 12
Curved Linear
Torso Orientation
57 43
Rotated Not-Rotated
Skill During
90 7 3
None Ball Duel
Skill End
48 28 24
None Duel Ball


How can we develop faster Footballers?


Sprinting Profile % - Wide Midfielder
Phase of Play
Phase of Play
37 32 16 15
Att. Trans. Def. Org. Def. Trans. Att. Org.
Tactical - Context
In- Possession
16 11 8 7 5 3 3 3 2
Run the Channel Run with Ball Push Up Pitch Break into Box Run in Behind Drive Inside Through the Middle Other Overlap
Out- Possession
21 7 7 6 2 0 0 0
Closing Down Covering Track the Runner Recovery Run Ball Down the Side Interception Ball Over the Top Other


Learn the rules before you break them
Projection - Produce Force
Reactivity - Transmit it to the ground
Switching - At a high rate
'It seems that the orientation of the total force applied is more important to performance than its amount'
(Morin et al. 2011)

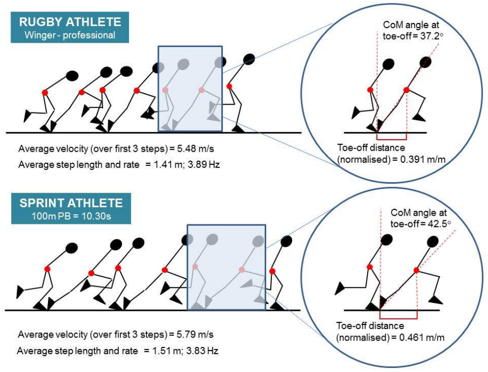
Team Sport Vs Sprinter

Shorter Step Length

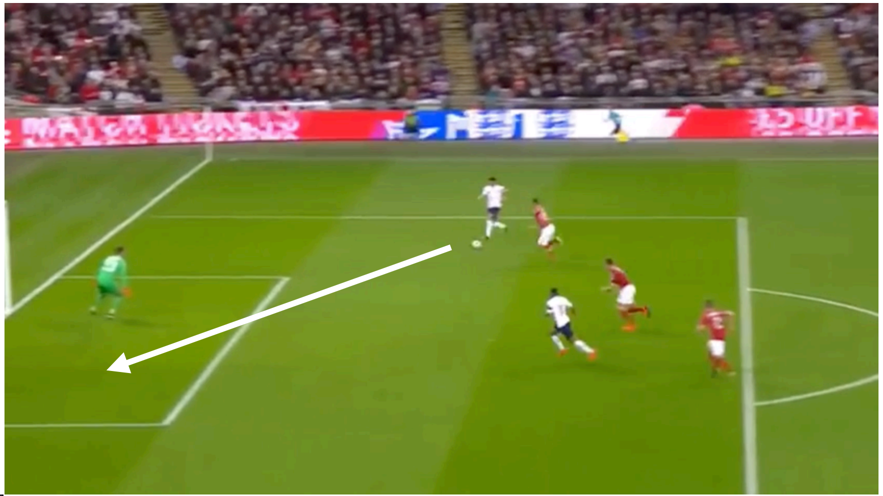
Similar Frequency

More Vertical COM Angle

Reduced Toe-Off Distance

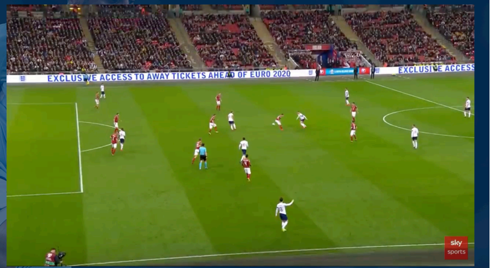


(Wild et al. 2018)



Perception - Action Coupling

*'To ensure **maximal transfer** between training and the game, it is crucial that the **game**, and specifically the **tasks** that the athlete must perform to effectively play the game, provide the **frame of reference** against which speed and agility are judged and developed'*



'Ultimately, speed and agility development needs to look beyond the simple definitions of speed and agility and must reflect the environmental requirements of soccer performance'

(Jeffreys et al. 2018)

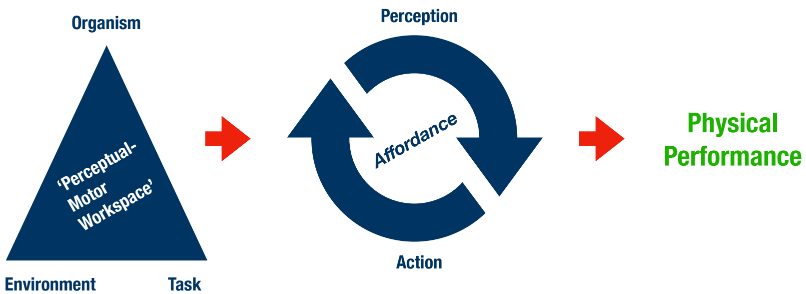
Dynamical Systems Theory

Constraints *'Coalesce to influence the self-organisation of emergent movement behaviours and the ultimate performance that the athlete can achieve'*

- **Organism** 'Individual performers characteristics'
- **Environment** 'Physical and Sociocultural variables in nature'
- **Task** 'The actual activity, such as rules of the game'

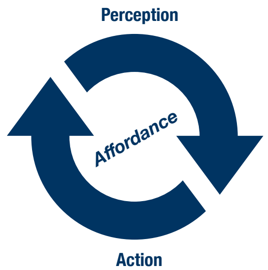
(Myszka, 2018)

Dynamical Systems Theory



(Immonen et al., 2017)

Dynamical Systems Theory



Affordances *'Opportunities for action'*

'To perceive an affordance is to perceive how one can act when confronted with a particular set of environmental conditions'

Perception - Action *'…people perceive their environment and events within it in terms of their ability to act'*

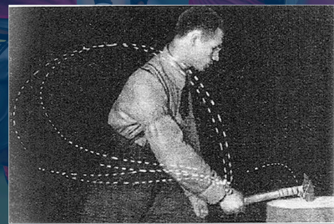
(Fajen et al. 2008)

Dynamical Systems Theory

Attractors *'Within each attractor region, system dynamics are highly ordered and stable, leading to consistent movement patterns for specific tasks'*

Dynamical Systems Theory

Motor Degeneracy *'The human movement system has the ability to vary motor behaviours without compromising function or performance outcomes'*



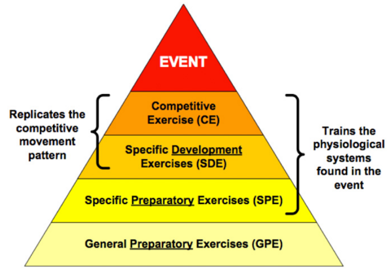
Bondarchuk Exercise Classification

Competitive Exercise
*"**Identical**, or almost, to the competition event"*

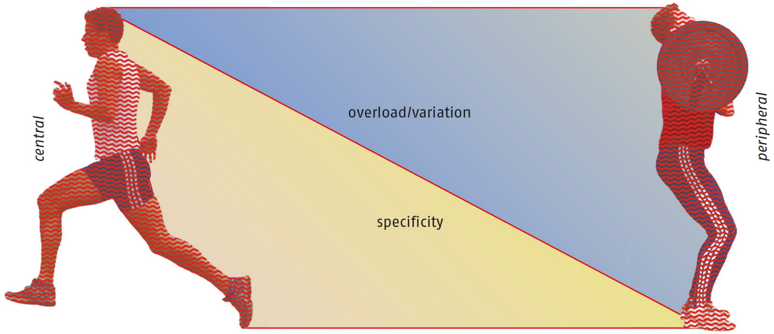
Specific Development Exercise
*"Repeat the competition event, but in its **separate parts** and may include **overload**"*

Specific Preparatory Exercise
*"Do **not** imitate the competition event, but train the **same muscles/physiology**"*

General Preparatory Exercise
*"Do **not** imitate the competition event and do **not** train the specific systems"*



(Bondarchuk Exercise Classification System)



Event	Competitive Exercise	Specific Development Exercise	Specific Preparatory Exercise	General Preparatory Exercise
	"Identical, or almost, to the competition event."	*"Repeat the competition event, but in its separate parts and may include overload"*	*"Do not imitate the competition event, but train the same muscles/ physiology"*	*"Do not imitate the competition event and do not train the specific systems"*
- *Rear Initiation* - *Front-Back COD* - *Explosive Acceleration* - *Curved Sprint* - *Torso Dissociation* - *Up to Duel*	- **SSG etc** - **Att. Vs Def; Crossing & Finishing** - **Repetition without Repetition**	- **Reactive Sprint-start drills, different Starting Positions** - **Torso Dissociation** - **Curved Sprinting** - **Sprints up to a Duel** - **Resisted Sprinting; different Starting Positions**	- **Gym- based Power exercises.** - **Lateral Plyometrics; Hip Turn** - **Torso Dissociation** - **Unilateral.**	- **General Strength** - **Physiotherapy** - **Mobility**

(Bosch, 2015)


Specific Development Exercise
(Taberner & Cohen, 2018)
Specific Preparatory Exercise
(@MethodicalMS)
Specific Development Exercise
(@England; @UK_StrengthLab)
Specific Preparatory Exercise
(Frans Bosch)

LTAD - Individualisation

*'If you move like floppy air man, get stronger. After that, strengthening should be **coordination training with resistance**' Frans Bosch*

*'Overload training without **specificity** usually has very little positive impact on athletic training' Frans Bosch*

*'Because **stronger** individuals display **superior performance** before ballistic power training and have a tendency for **greater improvements** after such training, it would be advantageous for individuals to establish a **solid foundation** for strength before focusing on ballistic power training'*

(Cormie et al. 2010. @JWonCatching. @FLBaseballRanch)

9.4 Reliability Testing

Example Reliability Data

Table 9.11 Example Intra-Reliability data calculation.

		Attacking Tran	ttacking Org	ensive Tran	efensive Or	reak into Ba	Overlap	ush Up Pitc	n the Chann	un In Behin	Drive Inside	Through the	un With Ba	Other	losing Dow	Interception	Covering	ecovery Ru	ll Over the T	Down the S	ack the Run	Other	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Attacking Trans.	1	2.32	1																				17
Attacking Org.	2	1	0.05																				3
Defensive Trans.	3			1.59																			14
Defensive Org.	4			1	7.52																		32
Break into Bax	5					0.07																	3
Overlap	6						0.00																0
Push Up Pitch	7							0.00															0
Run the Channel	8								0.48														8
Run In Behind	9									0.03													2
Drive Inside	10										0.01												1
Drive Through the Middle	11											0.03											2
Run With Ball	12												0.07										3
Other	13													0.01									1
Closing Down	14														3.34								21
Interception	15															0.00							0
Covering	16																0.42						7
Recovery Run	17																	0.19					5
Ball Over the Top	18																		0.07				3
Ball Down the Side	19																1			0.02			2
Track the Runner	20																				0.48		8
Other	21																					0.00	0
		18	2	15	31	3	0	0	8	2	1	2	3	1	21	0	8	5	3	1	8	0	132
																							16.69
																						Inter Reliability CS2	**0.97**