DEVELOPMENTAL, PRACTICE, AND PHYSICAL ACTIVITIES OF ELITE YOUTH SOCCER PLAYERS

NATHAN MICHAEL COBB

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# Abstract

This thesis investigated the developmental activities of elite youth soccer players from a Category One Elite Player Performance Plan academy in relation to their systematic soccer coaching, and the volume of additional physical activity engaged in outside of their formal soccer academy environment. Methodological rigour was ensured through determining the validity, objectivity and reliability of a tool for assessing technical soccer skills. The study demonstrated appropriate levels of objectivity and reliability for technical soccer behaviours specific to the playing philosophy of the academy, and highlighted the importance of following this process to ensure quality data collection. The coaching efficacy of the academy in developing technical soccer skill in under-9 (U9) and under-12 (U12) age cohorts was investigated over a 12-month period. Results suggested that technical skill improvement was negligible over this time period, with the exception of passing frequency and efficiency within the U12 cohort. The final phase of the thesis investigated the habitual physical activity levels of the same cohorts on training- and non-training days to determine whether there is a relationship between physical activity and technical skill development. Results suggested that there is no relationship between the volume of habitual physical activity and the development of technical soccer skills. Additionally, both the U9 and U12 cohorts appeared to follow the early specialisation pathway in soccer. All studies within the thesis focused upon an elite population, and insight into their training activity and skill development is valuable. The thesis has contributed a robust methodological procedure for creating new observational analysis tools when assessing soccer philosophy-specific behaviours. Additionally, a valuable insight into the efficacy of elite soccer coaching and the habitual physical activity patterns of U9 and U12 players has been presented.

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# Publication

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# *Chapter 1:*

# Introduction

# 1.1 Introduction

Developing talented soccer players is a costly and large-scale process which requires scientific support in order to drive evidence-based coaching programmes (Ford et al., 2010; Ward et al., 2005). Professional soccer clubs are now under increasing pressure to develop “home-gown” players within their academies for the senior squad (UEFA, 2010). In response to this, the Premier League’s Elite Player Performance Plan (EPPP) has been introduced in England with the aim of increasing the number of home-grown soccer players gaining professional contracts and competing at the highest level (The Premier League, 2011). With this increased pressure from UEFA, and the lack of consensus regarding what is the ‘optimum’ structure of academy coaching, comes the need for soccer academies to ensure that their coaching programmes are maximising the opportunity to develop the technical proficiency of their players.

Traditional motor learning theory suggests that variability is required in practice in order to develop multiple movement solutions for dealing with similar situations effectively (Schmidt, 1975). However, soccer coaching is typified by training-form, drill-based activities, which are designed to practice one particular technique in isolation (Cushion et al., 2012b; Ford et al., 2010). Although research has highlighted the need for English soccer coaching to move away from this traditional approach based upon empirical evidence (Williams & Hodges, 2005), there is little evidence to quantify the extent to which the traditional approach is successful in developing talented youth soccer players.

If used appropriately, systematic observation tools can provide practitioners and researchers with valuable insights into the technical performance of players, thus assisting the feedback process and longitudinal tracking of performance (O’Donoghue, 2006). Therefore, it could be proposed that systematic observation tools could be utilised to assess the efficacy of soccer coaching. Ensuring that the tool used for collating performance indicator data is both valid, objective and reliable, is essential in ensuring the quality of feedback for coaches and players. Tools should be created against a ‘gold-standard’ example, or involve gold-standard input from appropriate individuals (i.e. qualified coaching staff) to ensure that operational definitions are appropriate (Brewer & Jones, 2002). To ensure objectivity, operational definitions should have sufficient clarity for operators to differentiate between each component, thus ensuring accurate observation (Hughes & Franks, 2002; O’Donoghue, 2007). The reliability of any data collected is at risk due to humans as operators being inherently flawed (James et al., 2002). If implemented correctly, a notational analysis approach to evaluating the efficacy of coaching sessions may provide a method for monitoring player development over time in relation to their systematic coaching hours, therefore ensuring that the optimum approach to coaching is utilised, and that correct decisions are being made in regards to retention and release of players from the academy system.

In regards to existing approaches that can assess technical skill proficiency in youth soccer players, the Loughborough Soccer Passing Test could be useful for coaches in assessing the efficacy of their coaching programme (Ali et al., 2007). However, tests of this nature de-couple perception, cognition, and action), by not replicating the demands of soccer match-play, and only involve one phase in play (Serpiello et al., 2017; Wen et al., 2018). By excluding external variables such as opposition team movements that can influence the execution of soccer-specific actions (i.e. passing, shooting, etc.), tests of this nature are more suited to assessing soccer technique proficiency, rather than skill proficiency (Ali, 2011). Although an advancement on existing approaches, the small-sided game (SSG) format used by van Maarseveen et al. (2017) only accounts for attacking phases of play. Therefore, there is the need to assess technical soccer performance in a setting that closely replicates actual match-play and the dynamic nature of soccer, whereby one team attacks and relies upon the execution of attacking skills (e.g. passing and shooting), while the defending team is reliant upon defensive skills (e.g. tackling and intercepting) (Davids et al., 2005; Grehaigne et al., 1997; McGarry et al., 2002; Vilar et al., 2013).

Utilising activities such as SSGs to assess the efficacy of coaching may be more appropriate. Firstly, due to their game-based nature, which places players under spatio-temporal constraints reflective of competitive attacking and defensive match play (Hill-Haas et al., 2011) and challenges skill rather than technique (Bennett et al., 2018). Moreover, this approach has been adopted for assessing the technical skill of soccer players when combined with observational analysis techniques (Bennett et al., 2018; Fenner, Iga & Unnithan, 2016). Furthermore, utilisation of notational analysis techniques could provide more detailed and robust information regarding the development of soccer-specific skills during systematic coaching programmes rather than subjective scale assessments (Hendry et al., 2018).

Along with the need to assess coaching efficacy as a factor in the development of skilful performance in soccer, factors outside of systematic coaching programmes such as the volume and type of additional habitual physical activity need to be considered. Engaging in physical activity at a moderate-to-vigorous intensity both as an acute bout, and chronic programme, can enhance executive function (EF) performance in children (Best, 2010; Buck et al., 2008; Davis et al., 2007; Fisher et al., 2011; Kamijo et al., 2011). In turn, this can lead to improved soccer performance and the attainment of elite status in the sport (Verberg et al., 2014; Vestberg et al., 2017; 2012).

With the introduction of the EPPP, the volume of systematic coaching hours has subsequently increased from 3 hours per week from U9 to U11, and 5 hours per week from U12 to U16, to 4 (rising to 8), and 12 (rising to 16) respectively (The Premier League, 2011). Therefore, there is a need to investigate the habitual physical activity levels of elite youth soccer players to ascertain whether they have been modified to enable the maintenance of regular participation in these programmes. It has been suggested that children have an innate set-point which acts as a threshold for total physical activity engagement (an “activitystat”) (Gomersall et al., 2013; Rowlands et al., 2008). The ‘ActivityStat hypothesis’ suggests that children who participate in regular sporting activity compensate the volume of moderate-to-vigorous physical activity on days immediately after partaking in structured exercise sessions to ensure that the set-point created by the activitystat is not exceeded (Ridgers et al, 2018; 2015; 2014; Rowland, 1998; Rowlands, 2009).

The studies within this thesis will cover three main areas: methodological rigour in collecting data related to technical soccer performance, the efficacy of elite soccer coaching, and the influence of habitual physical activity. The data collected across these studies will enable greater understanding of the mechanisms underpinning technical skill acquisition and retention in elite youth soccer both in regards to systematic coaching programmes and physical activity behaviour.

# 

# 1.2 Aims and Objectives of the Thesis

The aims and objectives of the thesis were as follows:

*Aim 1:* To develop a robust methodological procedure for assessing the technical soccer behaviour of elite youth soccer players from under-9 and under-12 age cohorts.

Objective 1: To formulate and test a new notational analysis tool in relation to technical soccer performance. The playing philosophy of an elite soccer academy will be used as the basis for technical soccer behaviours within the tool to ensure specificity, and therefore enabling the second aim of evaluating the coaching efficacy of an elite soccer academy.

*Aim 2:* To evaluate the acquisition and retention of technical soccer skills presented in Study 1 over a 12-month period in under-9 and under-12 age cohorts in an elite youth soccer academy, in relation to the coaching programme implemented by the academy.

Objective 2: To observe technical soccer behaviours using the notational analysis tool created in Objective 1 during a series of small-sided games across three time points within a 12-month period (2013/14 pre-season: baseline test; mid-season: post 6-week coaching cycle test; and 2014/15 pre-season: retention test).

*Aim 3*: The primary aim was to evaluate the relationship between physical activity and the development of technical soccer skills. The secondary aim was to evaluate the physical activity levels on training and non-training days in the U9 and U12 cohorts.

Objective 3 (primary aim): To establish physical activity levels of the U9 and U12 cohorts using Tri-axial accelerometers and correlate these data against the technical skill levels of the players.

Objective 3 (secondary aim): To compare the tri-axial accelerometer data on the training and non-training days in the U9 and U12 cohort.

# *Chapter 2:*

# Literature Review

# 2.1 Literature Review

The purpose of this review is to critically appraise the areas of research across the over-arching themes that have influenced the development of the original studies within this thesis. The scope of the review covers the areas of validity and reliability, the structure of practice-based and additional developmental activities, along with the role of habitual physical activity in the development of domain-specific skill and physical fitness.

# 2.2 Validity and reliability

Validity is regarded as the most important consideration for clinical research; a domain where the health and wellbeing of patients can be at stake (George et al., 2003). Therefore, it is logical for observational analysis in soccer to follow the same level of rigour due to the newfound importance of data in enhancing the feedback provided by coaches to their teams and players, along with data being utilised to inform decisions on player recruitment and retention (Wright et al., 2013; Wright, Carling, & Collins, 2014). Validity is generally described as the credibility and accuracy of the study, and is sub-divided into two main types: internal and external. Internal validity is defined as whether the actual observations and measurements of the researcher are truly representative of what is being observed and measured, while external validity is the extent to which the data or ideas generated are applicable to other populations, settings or treatments (George et al., 2003). Reliability is defined as the quality of a measure that possesses reproducibility, and indicates the degree to which a test or measure produces the same scores when applied repeatedly in the same circumstances (Batterham and George, 2003).

The efficacy of analysis tools is dependent upon the inter-relationship of validity, objectivity, and reliability. Humans as observers and operators of analysis tools rely on their reaction time, resistance to fatigue, and observation position when collecting data (O’Donoghue, 2007a), consequently making them susceptible to three types of error when observing performance, thus hindering their reliability (James, Jones, & Hollely, 2002):

1. Operational errors; the observer presses the wrong button (if using a computer-based system),

2. Observational errors; the observer fails to record an event, and

3. Definitional errors; the observer observes and records an event incorrectly.

As such, an analysis tool may have been validated appropriately and be fit for purpose, but the operator of the tool may not be reliable. Conversely, the observer may be reliable in their observation of performance, but their tool could be invalid when compared to a ‘gold-standard’ criterion measure.

Within the observational analysis of soccer domain, ensuring validity and reliability in the collection of technical and tactical soccer behaviours has been a challenge faced by researchers and practitioners alike. In regards to validity in the observational analysis of sporting performance, there is a lack of consensus on how these soccer-specific behaviours should be defined for use by researchers and practitioners (Hughes & Franks, 2004). This leads to a variety of interpretations of the same behaviour between these two domains, thus reducing the applicability of research findings in an applied context. It is only through establishing clear and transferrable definitions for all aspects of soccer performance that the validity of collected data can be ensured (Hughes & Bartlett, 2002).

Reliability testing in observational analysis assesses the consistency of analysis systems in collecting data, and is assessed on two levels; inter-observer reliability, and intra-observer reliability (Hughes et al., 2004; O’Donoghue, 2006). Implementing inter- and intra-observer reliability checks ensures that both the tool (inter-observer) and the operator (intra-observer) are objective in their assessment of performance, thus reducing the chances of the aforementioned errors having a detrimental effect on data collection (Bradley et al., 2007; Brewer & Jones, 2002; Larkin et al., 2016; Tenga et al., 2009; Van Marseveen et al., 2017).

Despite the perceived importance of validity and reliability in observational analysis, Hughes, Cooper & Nevill (2002) reported that prior to 2002, 70% of notational analysis papers in sport, including soccer, failed to report any information regarding the reliability of notational analysis systems used to collect data. Furthermore, an absence of statistical analysis procedures were found in 26% of the aforementioned sample, with 24% of the sample using inappropriate parametric procedures for inherently non-parametric data sets. As such, it could be suggested that the conclusions and implications of research preceding Hughes et al.’s (2002) review are questionable, and potentially unreliable with regards to their practical application in the sporting domain. However, more recent notational analysis research has begun to regularly include validity and reliability checks as part of the methodological procedure (Casal et al., 2015; Gonzalez-Rodenas et al., 2015; Larkin et al., 2016; Pratas et al., 2012; Sarmento et al., 2014; Silva et al., 2014),

# 2.2.1 Establishing the context of analysis tools

A plausible reason for the omission of reliability testing in observational analysis could be the lack of methodological template until Brewer and Jones’ (2002) five-stage process for establishing contextually valid and reliable observation tools in sport. This process includes the previously discussed concepts associated with validity outlined by George et al. (2003); reliability outlined by Batterham and George (2003). Despite issues in regards to establishing these concepts, this process provides a detailed methodological approach that is of particular interest to this thesis, and has been used in previous research to formulate tools of a similar nature (Cushion et al., 2012a).

To be considered contextually valid, tools should encompass all relevant behaviours within the specified context, do not give prominence to any particular behavior, or erroneously omit relevant behaviours (Brewer & Jones, 2002). According to Brewer and Jones (2002), the first phase of creating tools of this nature is to ensure that those involved in using the tool are familiar with the concept of systematic observational analysis. This is achieved through using a contextually similar analysis tool to observe the targeted behaviours of the project, with the phase being complete when inter- and intra-observer reliability reaches 85% (Siedentop, 1976). Brewer and Jones (2002) used the Arizona State University Observation Instrument (ASUOI) to orientate the observer, and after a two-week period found acceptable levels of intra-observer reliability (91% for frequency of behaviours, and 89% for duration).

The ASUOI was contextualised to the sport of Rugby Union to become The Rugby Union Coaches Observation Instrument (RUCOI). This was achieved through three separate observations of three Rugby Union coaches from the top division of the English league, each lasting 90 minutes. It is this stage of the tool creation process that enables a tool to become ecologically valid, whereby the content of the tool is directly representative of the environment in which it is being used (Brewer & Jones, 2002). However, the ASUOI has not been previously formally validated. Therefore, its use as the template for Brewer and Jones’ (2002) RUCOI could be questioned as the behaviours within the tool may be inherently contextually invalid to coaching. A different approach at this stage was taken when developing the Coach Assessment and Intervention System (CAIS). Cushion et al. (2012a) determined that existing coaching tools were insufficient in encompassing all soccer-related coaching behaviours, and consequently consulted with experienced coaches to develop the CAIS. This negates the issues associated with utilising an invalid tool, with similar approaches being implemented by Larkin et al. (2016) and van Maarseveen et al. (2017) in the development of systematic observation tools.

The creation of recent commercially available soccer-specific tools has not followed these initial stages of contextualisation. Prozone MatchViewer (PMV) enables analysts to collate and analyse a large volume of soccer-specific match performance data based on twenty-six independent soccer behaviours. It has been reported that 35.4% of analysts working in English professional soccer clubs utilise this tool to conduct their analyses (Wright et al., 2013). However, within the validation work of Bradley et al. (2007), the process for establishing face validity of the tool was not reported and it does not appear that an existing soccer observation tool was utilised as the framework for PMV. Therefore, the operational definitions included within the tool and their relevance to soccer is assumed.

Tenga et al. (2009) contextualised their soccer-specific tool using ball possession as defined by Pollard and Reep (1997, p. 542). This definition considers possession to be a phase of play commencing at the point of possession being gained, continuing through a series of controlled passes, ending with the ball going out of play, the opposition touching the ball (e.g. a tackle or interception), or an infringement of the rules taking place (e.g. a player is offside, a foul is committed). The element of ‘control’ could be considered as subjective based upon the terminology used by Pollard and Reep (1997), as no limit is placed upon the notion of having ‘enough’ control over the ball. Therefore, the foundation on which the tool is constructed is inherently flawed, which may lead to consistently inaccurate data collection.

The tools presented by Bradley et al. (2007) and Tenga et al. (2009) are match-based and may not be of use to those wishing to assess coaching efficacy. More recent research has moved towards creating tools for the assessment of technical soccer performance in a coaching, rather than competitive match-play, setting using small-sided games (van Maarseveen et al., 2017). Small-sided games (SSGs) are commonly used training modalities for the development of physiological fitness (Hill-Haas et al., 2011), and have recently emerged as a method for assessing the technical soccer ability of soccer players, particularly when identifying talented individuals (Bennett et al., 2018; Fenner, Unnithan, & Iga, 2016; Unnithan et al., 2012). Therefore, formulating valid and reliable observational analysis tools for use in SSGs could be a valuable addition to the analysis process within soccer academies by enabling the tracking of technical and tactical skill development. To date, there is no evidence to suggest that this is commonplace for practitioners in this setting (Wright et al., 2013), nor has this approach been associated with existing talent development models (Vaeyens et al., 2008; Vaeyens et al., 2006; Unnithan et al., 2012).

However, it could be argued that recent SSG-based systems do not truly reflect the demands of soccer match play, and therefore have limited ecological validity (Bennett et al., 2018; van Maarseveen et al., 2017). Van Maarseveen et al. (2017) utilized a trial-based procedure whereby the SSG (3 attackers vs. 2 defenders + 1 goalkeeper) was broken down into independent phases of attacking play. Possession turnovers and technical actions associated with attempting to regain possession were not included in the tool. Soccer is a dynamic goal-striking invasion game that requires the continual interaction between attackers and defenders to give the game its natural ‘flow’ (i.e. both teams have the opportunity to attack and defend) (Hughes & Bartlett, 2015; Robins & Hughes, 2015). This was considered by Bennett et al., (2018) in regards to a more conventional game structure (i.e. both teams needed to attack and defend), but like van Maarseveen et al. (2017), the tool was limited by not including defensive actions.

# 2.2.2 Establishing the validity and reliability of an analysis tool

The third stage of Brewer and Jones’ (2002) five-stage process involved consulting with experienced coaches and practitioners to ensure that the tool measures what it intends to within the specified domain, and if necessary, increasing specificity of the tool by adding further behavior categories. Experienced professional coaches are considered to have a superior knowledge of the game based on the number of years’ experience in the sport. Through consultation with experienced (9 ± 2.3 years experience) Rugby Union coaches and four published observation analysis researchers, Brewer and Jones (2002) concluded that the RUCOI was a suitable tool for observing and recording coach behavior in the chosen domain. Similarly, Bennett et al. (2018), Cushion et al. (2012a), Larkin et al. (2016), and van Maarseveen et al. (2017) all consulted with experienced coaches and practitioners when formulating their respective tools. This process may enhance validity of the tool, but it should be noted that the sample of experts might not be representative of the full population of elite coaches within that particular sport, which could in turn limit the contextual validity of the tool.

Upon establishing face validity, the objectivity of the tool is assessed through testing the tool in the desired context. Experienced (n = 5) and inexperienced (n = 5) observers were recruited to test the functionality of the RUCOI through systematically observing 44 discrete examples of coach behavior (2 of each). The observers were in agreement in excess of 85% when identifying behaviours, thus deeming the tool as reliable when observing coaches. However, observers were given feedback between examples as to which behavior the example represented prior to being shown the next example. While this may have enhanced the observer’s understanding of the behaviours as the test progressed, it could be argued that the process of elimination may have aided the observers in their decision-making. Cushion et al. (2012a) reduced the potential of the process of elimination affecting the judgement of observers by using different frequencies of occurrence for each behavior (at least 1, no more than 3). However, the most appropriate method for assessing objectivity may be the approaches of Bennett et al. (2018) and Larkin et al. (2016), whereby footage of the entire event (in this instance a SSG) is utilised. This provides opportunity for the observer to utilise the tool in its intended context, thus highlighting any potential functionality issues.

A methodological limitation to the existing literature in creating soccer observation analysis tools could be the lack of involvement of experienced performance analysts in the collection of empirical data. Although research has been successful in creating tools that are considered valid and reliable in observing soccer performance, the published research is either ambiguous in stating the experience levels of those recruited for data collection (Larkin et al., 2016; Tenga et al., 2009; van Marseveen et al., 2017), or simply do not provide background information (Bennett et al., 2018; Bradley et al., 2007). A good knowledge of the behaviours included within the tool are more important for ensuring reliability than the wording of definitions (O’Donoghue, 2007). As such, if coaches are considered to have expertise in creating operational definitions for soccer behaviours due to their levels of experience (Brewer & Jones, 2002), performance analysts could be considered as experts in the functionality of these definitions when viewing soccer performance due to the significant proportion of their day-to-day work spent analysing soccer footage (Wright et al., 2013). If the objective of creating these tools is to enhance the day-to-day practice of performance analysts in soccer, then it is logical to suggest that those who work in the industry should be recruited to test the reliability of such tools rather than relative novices in this field (e.g. Observer 2 in Tenga et al., 2009).

Lower levels of inter- and intra-observer reliability were reported by Tenga et al. (2009) for qualitative behaviours, in particular, ‘defensive backup’ (poor), ‘skill level’ (fair) and ‘defensive cover’ (fair). Levels of inter-observer reliability were considerably lower in comparison to intra-observer reliability. This highlights potential issues with the experience levels of the observers as the lead observer was considered to be experienced in the process of observational analysis, while the secondary observer was a novice. This bypasses the first-stage considerations of Brewer and Jones (2002) which suggests that orientation to the process of observational analysis should precede any orientation or training with the use of a ‘new’ tool. Therefore the use of observers with comparable levels of experience in the domain of observational analysis may negate this issue when assessing the objectivity and reliability of similar tools.

Additionally, it is noticeable within the Brewer and Jones (2002) reliability checks that the lead researcher was in agreement with 87% of the original observations after a one-week period when viewing the same video footage. Based on this rate of decline, the lead researcher would not be a reliable user of the RUCOI beyond the first week of use, and could suggest that additional intra-observer checks using the same video footage are required over a longer period of time to ensure that the observer remains within the acceptable 85% threshold of agreement (Siedentop, 1976).

# 2.2.3 Functionality of the analysis tool

With regards to the position of performance analysis within the soccer coaching process (Wright et al., 2014), and the limited time available to produce post-match analysis for coaches and players (Wright et al., 2013), it is unclear as to whether the Prozone MatchViewer system is appropriate for analysts in the industry as Information regarding the time taken to collate data for a full match was not reported. Bradley et al’s (2007) method involved breaking the game into equal segments to be shared between a team of four analysts. Not all soccer clubs will have four performance analysts, and as such, the labour of recording twenty-six discrete events on a 0.1 s frame-by-frame basis may be unfeasible for a small team of one to two analysts when considering the time constraints of performance analysis feedback (Wright et al., 2013). Tenga et al.’s (2009) soccer observation tool contained a total of 22 individual behaviours, 15 of which were based upon qualitative observation. Therefore, it is important to ensure that the tool is contextualised in a user-friendly and time-efficient manner. For example, after initial testing, van Maarseveen et al. (2017) used stepwise analysis to reduce the total number of components within their tool from 21 to 12. Additionally, the tools utilised by Bennett et al. (2018) and Larkin et al. (2016) contain 4 and 13 technical actions respectively, thus demonstrating the ease at which soccer observation tools can be contextualised without containing an excessive amount of actions.

As the EPPP emphasises the development of a soccer playing ‘philosophy’ for each academy, it would be logical to suggest that any observational analysis tools that are to be used by that particular academy should be tailored to measure the efficacy of their specific soccer behaviours (Bennett et al., 2018; Larkin et al., 2016). This would maintain ecological validity and would therefore benefit from being created by using the systematic process outlined by Brewer and Jones (2002). By tailoring analysis tools to soccer behaviours specific to the academy’s playing philosophy, the tool will contain less behaviours than the more ‘general’ soccer tools discussed previously, and therefore negate the reliability issues associated with overly complex analysis tools (Bradley et al., 2007; Tenga et al., 2009; van Marseveen et al., 2017). It is therefore proposed that analysts working within professional soccer utilise the Brewer and Jones’ (2002) method as a framework to create their analysis tools, with their soccer playing philosophy being the ‘context’ in which the tool is utilised.

# 2.2.4 Statistical approaches to determining the reliability of observational analysis tools

Following the establishment of tool validity, inter- and intra-observer reliability checks are required to determine the objectivity of the tool in practice and should receive the same level of attention as the planned analysis of the empirical data collected through use of the tool (Hughes et al., 2002). Altman and Bland (1983) and Bland and Altman (1986) are credited, along with Nevill and Atkinson (1997) and Atkinson and Nevill (1998) as providing the seminal work from which current sports science researchers base their approach to ensuring reliability in data collection. However, prior to 2007, little consideration had been given to how appropriate these methods were for assessing the data collected by observational analysis tools (Cooper et al., 2007).

Data collected through observational analysis is based upon the frequency of occurrence of the variables of interest. This results in inherently non-parametric ratio data, or frequency counts that can be placed into discrete categories (Cooper et al., 2007; James et al., 2007). Two particular methods for quantifying the magnitude of reliability were the levels of percentage agreement and the Pearson’s product-moment correlation coefficient (Hughes et al., 2001; 2002). However, these particular methods are not appropriate for dealing with non-parametric frequency count or categorical data. The level of percentage agreement between observers may be overly conservative in its assessment of reliability due to relying on a substantial sample size to enable effective percentages to be established. Some variables may occur at a far lower frequency than others, thus making the margin for error in agreements far smaller than those that occur at a higher frequency.

The Pearson’s correlation is a test reliant upon the assumption that the data are parametric. However, frequency counts are inherently non-parametric due to the skewed nature of the data and therefore do not follow a normal distribution (Cooper et al., 2007; Hughes et al., 2002). Additionally, these approaches enable the observer to report a single summary statistic of reliability by collapsing all variables. However, this may hide variables that exceed the threshold of reliability. Therefore, the reliability of each variable should be reported independently (Hughes et al., 2002).

Cooper at al. (2007) presented a working example of Nevill et al.’s (2001) proposed ‘limits of practical significance’ method. This approach requires the observer to calculate the proportion of differences between variables for test re-test that exceed a reference value representative of practical importance. In the example presented by Cooper at al. (2007), a reference value of ±1 is suggested, but is acknowledged to be adaptable dependent upon the frequency of occurrence for each variable. Variables that occur more frequently (e.g. a pass in soccer) may require a reference value of ±3 due to the demands placed upon the observer in maintaining concentration and recording the occurrence accurately. Infrequent variables (e.g. a corner kick set play in soccer) require a smaller value (e.g. ±1) as their observation should be relatively simple (Cooper at al., 2007; O’Donoghue, 2007a; James et al., 2007). This approach provides a more practical approach to assessing reliability in observational analysis due to the uncontrollable nature of the potential sources of observer error, and therefore does not excessively penalise the observer (or observers) for minor errors. It is however crucial that the reference value is appropriate to the nature of the variable and the experience level of the observer so an overly-lenient measure of reliability is avoided (Cooper et al., 2007).

While Cooper et al.’s (2007) approach accounts for frequency count based data, James et al. (2007) propose an alternative method to the commonly used percentage agreement and Kappa statistic approaches for assessing the reliability of categorical data. Yule’s Q is presented as a more appropriate measure of observer agreement in comparison to percentage agreement and Kappa. This measure is predicated on the element of luck or chance playing a part in the decision of the observer. Kappa takes luck/chance into account in its calculation and may lead to an overly conservative measure of reliability for the variables involved, potentially leading to the assumption that a variable is unreliable when it is actually reliable (James et al., 2007). This inclusion of chance/luck suggests that an observer may guess when deciding how to categorise the variables during observation. From a practical perspective, trained observers (i.e. Performance Analysts) are unlikely to agree by chance due to their sophisticated comprehension of the variables involved in their analysis. This knowledge can be assumed due to the coaches whom they work with on a regular basis sharing their advanced knowledge of the variables with the analyst during day-to-day work (Wright et al., 2014). Therefore, the use of Kappa in calculating the reliability of observational analysis tools in professional sport could be considered inappropriate.

Several studies which involve the observation of soccer performance using specifically designed analysis tools have measured reliability using Cohen’s Kappa (Bradley et al., 2007; Larkin et al., 2016; Silva et al., 2014; Tenga et al., 2009). κ values of 0.81-1.0 are generally interpreted as very good, 0.61-0.80 as good, 0.41-0.60 as moderate, 0.21-0.40 as fair, and less than 0.21 as poor (Altman, 1991). Expressed as a percentage, this suggests that agreement levels of 41% are moderate. This could imply the lowest level of acceptable agreement is far below the 85% benchmark for acceptable levels of agreement (Brewer & Jones, 2002; Siedentop, 1976), thus suggesting that components of the tools within the aforementioned studies may have been incorrectly accepted as reliable. Conversely, James et al (2007) suggest that a Yule’s Q value of 0.95 (95%) is a more appropriate level of acceptable agreement, particularly when a tool is used by experienced observers.

Low levels of agreement highlighted by the Yule’s Q calculation alerts the observer to a genuine problem with their analysis tool, as opposed to a problem that may be due to chance or luck. Combining the ease of calculation with familiarity of software, the ease of statistical interpretation, removal of chance/luck elements, and higher levels of acceptable agreement, the Yule’s Q statistic could be proposed as a more appropriate approach to determining reliability in the use of observational analysis tools.

# 2.3 The role of deliberate practice in the acquisition of skilful performance

To attain expertise in any practical sport domain, an individual needs to acquire requisite skills to underpin successful performance. Simon and Chase (1973) proposed that ten years worth of experience within any domain is the required amount to attain expertise. However, there is little correlation between experience and skill level, and it is in fact engagement in activities specifically designed to improve aspects of performance that determine expertise (Ericsson, 2006). Theories of skill acquisition suggest that through repetition of a particular skill, a degree of autonomy in reproducing the skill can be established, otherwise knowns as the ‘Power Law of Practice’ (Newell & Rosenbloom, 1981). One of the most prominent studies associated with establishing the relationship between practice and developing expertise, and demystifying the experience-expertise paradigm is the seminal work of Ericsson, Krampe, and Tesch-Römer (1993) in the domain of music. The term ‘Deliberate Practice’ is associated with activities described by Ericsson et al. (1993) as having the following key characteristics:

* High levels of structure, with the sole intention of improving performance by overcoming current weaknesses.
* Performance is monitored closely to provide the individual with appropriate feedback.
* Significant cognitive and physical effort is required to complete deliberate practice activities, and is not inherently enjoyable. Those engaging in deliberate practice activities do so through the motivation to improve performance.
* Deliberate practice does not result in immediate monetary rewards, but does incur a monetary cost in regards to accessing teachers/coaches and the practice environment.

Deliberate practice enables the individual to learn new and develop existing cognitive and motor skills within their chosen domain. By giving the task significant levels of cognitive effort, the process of ‘explicit learning’ is able to take place, which provides the individual with the parameters required to complete a task successfully. The provision of informative and relevant feedback enables the individual to identify and correct any aspects of the movement that result in unsuccessful performance (Williams & Ford, 2008).

Ericsson et al. (1993) suggests that it is through amassing significant time in deliberate practice activities that an individual reaches expertise in their domain, otherwise termed ‘the theory of deliberate practice’. Ericsson et al. (1993) used retrospective recall questionnaires and diaries to estimate the amount of deliberate practice engaged in by musicians of an elite academy over a ten-year period. The results showed that the ‘best’ violinists in the academy had amassed significantly greater amounts of deliberate practice (7,410 hours) compared to their ‘good’ counterparts (5,301 hours) and their teachers (3,420 hours). This was further supported in Ericsson et al.’s (1993) second study on expert pianists. Like the violinists, an average of 7,606 hours was amassed by age 18, significantly higher than the 1,606 accrued by non-expert counterparts. However, it should be noted that this is an average value for each group and the variance in total hours is not reported, therefore masking any individual variance in relation to the amount of deliberate practice hours and attaining expert status. Furthermore, the use of retrospective recall questionnaires requires adjustment to the questions in order to provide cues in assisting participants to overcome memory limitations when recalling past activities (Côte et al., 2007).

Hodges and Starkes (1996) were the first to apply Ericsson et al.’s (1993) theory of deliberate practice to the sporting domain, and focused upon the individual-based sport of wrestling. Current international Olympic-level (*n* = 15) and current provincial club-level wrestlers (*n* = 9) provided retrospective accounts of their practice history. Retired wrestlers from the same levels (Olympic-level: *n* = 10, Provincial club-level: *n* = 8) provided their retrospective practice history accounts as a measure of reliability, with similar amounts of reported practice being considered as reliable. Demographically, the groups were similar, having all commenced participation in wrestling at age 13, moving into systematic coaching at age 14, with a career ‘peak’ at age 25. Data were collected through questionnaires that elicited information regarding the amount of time spend practicing alone, with others, other practice-related activities, and everyday activities, along with rating these activities on a 1-to-10 scale in regards to how relevant the activity was to wrestling, how enjoyable these activities were, the amount of effort required, and how much concentration was required.

The number of average accumulated practice hours after six-years for international standard wrestlers was found to be 5,887, with their club-level counterparts having accumulated 3,571 hours. Although this falls short of the amount reported by Ericsson et al. (1993) for elite musicians, if the amount of deliberate practice hours accumulated are converted to a per-year basis, international wrestlers accumulate more deliberate practice hours than elite musicians (Wrestlers: 981 hours per-year, Musicians: 741 hours per-year). This could imply that either wrestling requires a greater volume of deliberate practice to attain expert status, or the later start age in wrestling results in athletes needing to accrue more deliberate practice hours per year to compensate for the late start. These results seemed to set the trend for future research in team sports, in particular, soccer.

Helsen, Starkes, and Hodges (1998) were the first to investigate this concept to the team sport domain. International (*n* = 17; mean age = 25.6 years), semi-professional (*n* = 21; mean age = 24 years), and amateur (*n* = 35; mean age = 25.4 years) soccer players completed the same questionnaire used by Hodges and Starkes (1996). Results showed that International, National, and Provincial standard soccer players from Belgium accumulated and average of 9,332, 7,449 and 5,079 hours in deliberate practice respectively after 18 years of participation in soccer. Unlike typically individual-based activities such as wrestling or violinist, on a per year basis, based upon the results of Helsen et al. (1998), international standard soccer players accumulated 518.4 hours of deliberate per year on their pathway to expertise. However, the number of individual-based deliberate practice hours was found to be a key discriminant factor between International and Provincial players from six to twelve years into their careers, thus highlighting the importance of engaging in deliberate practice outside of scheduled coaching hours. After this point, team practice became the most important factor.

Support for team practice as a discriminant factor in achieving expert performance is provided by Ward et al. (2007), who found that the amount of time spent in team practice activities differentiated between elite and non-elite players across age cohorts in English youth soccer players aged 8 to 18 years. Elite players were recruited from four English professional soccer academies whose senior team competed in the Premier League. Non-elite players were recruited from local elementary schools, high schools, and universities, and competed at local amateur club/school level. Participants were grouped by age depending upon birth date in the recruitment year (September to September), resulting in an average of 11 players per age group, starting at under-9 (U9), through to U18 (total sample size = 203). An adapted version of the questionnaire administered by Hodges and Starkes (1996) was used to collect data regarding the amount of time spent in practice activities, and player perceptions of activity relevance.

By age 18, where English academy players are either retained with a professional contract, or released to find another club; elite players had accumulated around 4,500 hours of deliberate practice (team practice ≈2,500 hours; individual practice ≈2000 hours). Non-elite players had accumulated ≈2,000 hours (team practice ≈1,000; individual practice ≈1,000 hours). The difference in amount of time spent in deliberate practice activities discriminated between elite and non-elite groups, perhaps due to the systematic nature of elite academy coaching programmes. Like Helsen et al. (1997), elite players accumulated ≈500 hours per year in deliberate practice activities. Only a small percentage of elite youth soccer players in England receive a professional scholarship at age 16, before going on to reach professional status at age 18 (Ford et al., 2009a). It was not known until Ford et al. (2009a) re-visited the sample provided by Ward et al. (2007), how many of the elite players involved in the study went on to attain professional status, and therefore the actual importance of deliberate practice activities in developing expertise during the first six years of engagement with soccer.

A subset of participants from Ward et al. (2007) were used to create three groups: still-elite (*n* = 11), ex-elite (*n* = 11), and recreational (*n* = 11). The still-elite group comprised of all players who had received a professional scholarship at age 16. The ex-elite group had been released from the same academy that the still-elite group had been retained at. The recreational group were recreational-level players from the Ward et al. (2007) study. Where possible, all participants were matched with an equivalent participant across groups based upon start age in playing soccer (and start age in joining the academy program if in the still-elite and ex-elite groups). Data from the Ward et al. (2007) study for the 33 participants was re-examined in regards to the amount of time spent in practice, competition, and play activities between the ages of 6 and 12.

Results showed that the discriminating factor between the still-elite group and their ex-elite counterparts was the amount of soccer-specific play accumulated during ages 6 to 12 outside of formal soccer academy coaching. The amount of soccer-specific practice (both team and individual) did not differentiate between still-elite and ex-elite groups. This advanced the earlier findings of Helsen et al. (1998), by suggesting that deliberate practice activities alone are not sufficient in developing professional players, and that deliberate practice in tandem with soccer-specific play activities is required. Additionally, Ford et al. (2009a) found that an additional 1.5 ±1.3 sports were undertaken by participants across ages 6 to 12, thus suggesting that expertise in soccer is developed through early engagement with the sport through both practice and play activities within the primary sport domain.

To progress this knowledge further, Ford et al. (2012) conducted a global investigation of the developmental activities of elite youth soccer players aged 16. A total of 326 players from Brazil, England, France, Ghana, Mexico, Portugal, and Sweden (*n* = 50 from each country, except Ghana: *n* = 26) completed the Participation History Questionnaire (PHQ) (Ford, Low, McRobert, & Williams, 2010). Based on the previous work of Helsen et al. (1998), Ward et al. (2007), and Ford et al. (2009a), this questionnaire elicited information regarding the start age in soccer and other key milestones (supervised soccer training, soccer competition, and elite academy). Further information regarding the amount of time spent in soccer-specific developmental activities, along with the number of additional sports and the time spent participating in them alongside soccer was also generated from the PHQ.

In keeping with previous research, elite soccer players across all countries engaged in high levels of deliberate practice and deliberate play activities in soccer during early childhood at the expense of partaking in other sports (Ward et al., 2007; Ford et al., 2009a). With the exception of Brazil, this developmental pathway was homogenous across all countries. Compared to other countries (with the exception of Portugal), England recruit players into academies at an earlier age (10.06 ±2.26 years), and the sustained participation in soccer academies results in the gradual decrease of deliberate play activities in favour of more deliberate practice (10 hours per week across a 40 week season). Results from Ford et al. (2012) highlight that deliberate practice is an important factor in the development of elite youth soccer players worldwide.

A limitation to the research of Ward et al. (2007), Ford et al. (2009a) and Ford et al. (2012) is that there is a clear focus on the early years of soccer participation (age <16 years). Recent research by Hendry et al. (2018) addressed this by investigating the importance of deliberate practice on elite soccer players aged ≈15, ≈17 and ≈20. The study tracked a group of 102 elite male soccer players based at professional academies in the UK (recruited at age 14.85 ±0.63 years) over three time points. Participants completed the PHQ (Ford et al., 2010; Ford et al., 2012) at T1 (when first recruited) and at T2 when some players had been offered full-time professional contracts with their academy (*n* = 26; age = 17.34 ±0.69 years). Players who were offered professional contracts at T2 were referred to as the ‘youth-professionals’, while those who did not were termed ‘academy-only’ and subsequently left the study at this point (*n* = 76). Those who were offered professional contracts at T3 were termed ‘adult-professionals’ (*n* = 9), with those not achieving a contract termed ‘youth-professionals only’ (*n* = 17). Along with the PHQ, players and their coaches provided evaluations of their technical, tactical, creative and physical soccer-specific skills based on a 5-point scale (1 = poor, 5 = excellent). This provided novel information regarding the ability of players and was correlated with time spent in developmental activities.

Results showed that the hours accumulated in deliberate practice (from start age to T2) were moderately positively correlated with ratings of technical (*r* = .50, *p* = .01), tactical (*r* = .49, *p* = .01), and creative skills (*r* = .43, *p* = .03) for the whole sample of professional players. Specifically for players who became adult professionals, there was a positive association between the time spent in deliberate practice during childhood and physical skill (*r* = .64, *p* = .05), but a surprising negative association between deliberate practice and technical skill (*r* = -.54, *p* > .05). Based on the amount of deliberate practice across their whole career, there was a strong correlation with physical skill (*r* = .75, *p* = .02). However, no meaningful correlation was found between accumulation of practice hours and technical skill (*r* = .04, *p* > .05). This could suggest that in order to become a professional soccer player, deliberate practice is an important factor in developing the physical skills required to attain a professional contract at age 16. Additionally, this result may suggest that drill-based deliberate practice hours are suitable for developing technique, but not skill (Williams & Hodges, 2005). At present, it is difficult to ascertain the differentiating factors between those who go on to achieve adult-professional status after the youth-professional phase, and is perhaps due to the homogeneity of players at this stage in their development due to the relative parity in accumulation of practice hours (Hendry et al., 2018).

The implications of this research has transferred to the modernisation of developing talented youth soccer players in England. The Premier League’s Elite Player Performance Plan (EPPP) has given prominence to the concept of deliberate practice and the popularised ‘10,000 hour rule’ in formulating guidelines for professional soccer academies (The Premier League, 2011) despite the existing empirical evidence suggesting that expertise can be attained in soccer with considerably less deliberate practice hours.

Despite there being evidence in soccer regarding the amount of deliberate practice required to attain professional status, research has yet to evaluate the efficacy of soccer coaching in developing technical soccer skill as opposed to solely technique. Players within academy programmes are exposed to the same volume of coaching across the group. However, not all players attain professional status (Ford et al., 2009a). Therefore, further proactive approaches to research are required to determine methods for tracking player development while within the academy system in regards to coaching efficacy and additional developmental activities as opposed to retrospectively determining developmental pathways as a reactive measure for future cohorts (Ford et al., 2012; Ford et al., 2009a; Ward et al., 2007).

# 2.3.1 The role of deliberate play in the acquisition of skilful performance

Although deliberate practice is clearly of great importance to developing expertise, there are other varieties of developmental activities that need to be given due attention. For example, the concept of deliberate play. Children’s first experience of sport is often through informal game-based activities for enjoyment. The concept of deliberate practice implies that all activities undertaken within the individual’s chosen domain that contribute to the development of expertise have to be unenjoyable and require significant levels of physical and mental effort. However, this notion has softened with the introduction of the concept of ‘deliberate play’ (Côte, Baker & Abernethy, 2007).

Deliberate play defines activities that are intrinsically motivating, provide immediate gratification, and are specifically designed to maximise enjoyment (Côte, 1999). These activities have been associated with enhanced decision-making (Baker et al., 2003; Berry et al., 2008; Roca, Williams, & Ford, 2012), and the successful transfer of perceptual-cognitive skills between sports that share a similar structure (Baker et al., 2003; Berry et al., 2008; Causer & Ford, 2014).

Roca et al. (2012) investigated the influence of developmental activities on the perceptual-cognitive skills of 48 (age 20.7 ±2.4 years) semi-professional soccer players. A total of 16 (age 22.1 ±2.8 years) amateur/recreational standard players acted as the control group. All players were central defenders or central defensive midfielders. The PHQ (Ford et al., 2009a; Ford et al., 2012) was completed by all participants after undertaking a lab-based simulation protocol. Participants viewed a series of life-size video sequences of attacking play from the central defender’s perspective, with each clip being occluded at the point of a key attacking action (e.g. the player in possession of the ball about to make an attacking pass, shoot at goal, or maintain possession of the ball by dribbling forward). Participants provided verbalised responses to what they felt the player in possession was going to do, along with how the decision the participant themselves made, or were about to make, at the moment of video occlusion. The semi-professional group was sub-divided into high and low performing groups depending upon the accuracy of responses to the video clips.

The high performing group accumulated a significantly higher volume of hours in soccer-specific play during childhood (339.0 ±125.4 h · year-1) than the low-performing (207.6 ±50.6 h · year-1) and recreational groups (142.4 + ±39.5 h · year-1). The same trend was apparent in adolescence, with the high-performing group accumulating 194.8 ±57.6 h · year-1 in soccer-specific play activities, compared to 139.1 ±52.3 h · year-1 forthe recreational group. Compared to the findings of Ford et al. (2009a), the amount of accumulated soccer-specific play activity for equivalent standard players was similar. These findings suggest that soccer-specific play activities are an important component in the development of perceptual-cognitive skills such as, advance cue utilisation, pattern recognition, scanning the environment, anticipation, and strategic decision-making (Williams & Ford, 2008).

Although conducted with semi-professional soccer players, support for the implications of Roca et al. (2012) in regards to the importance of soccer-specific play activities was shown by Hendry et al. (2018), who reported moderate to strong positive correlations between deliberate play and the perceived ratings of tactical and physical skills in players who attained adult-professional status in soccer. However, no association was found between deliberate play and technical skill. Furthermore, in players who attained youth-professional status at age 16, hours in soccer-specific play was negatively related to tactical (*r* = -.55, *p* = .04) and technical skill ratings (*r* = -.52, *p* = .04). Although deliberate play is beneficial in developing anticipatory skills that underpin soccer performance, unless it is used in tandem with systematic deliberate practice, skilled performance is not attainable as the requisite techniques for effective skilled performance will have not been acquired (Ford et al., 2009a; Hendry et al., 2018; Ward et al., 2007).

# 2.3.2 Athlete Development Models

Several conceptual models have been formulated based on the talent development and career transitions of elite athletes, and can help characterise practice and play patterns (Bruner et al., 2010). Bloom (1985) suggested that athletes pass through three sequential stages of development: (1) initiation, (2) development, and (3) perfection, with Salmela (1994) adding a 4th stage (discontinuation) to account for the point at which elite performance is no longer attained, and participation continues at the recreational level. More recent models have considered a broader range of external variables that impact upon talent development. Abbott and Collins (2004) have sought to address the influence of psychological factors (goal setting and self-reinforcement, imagery control, planning and organisation), while Bailey and Morley (2006) have considered the influence of sociological factors such as parental support and social values. However, these models are all limited in their ability to effectively measure and track transitions between phases through the measurement of appropriate variables (Coutinho, Mesquita & Fonseca, 2016).

The Foundations, Talent, Elite, Mastery (FTEM) framework proposed by Gulbin et al. (2013) includes 4 macro phases (Foundations, Talent, Elite, Mastery) sub-divided into 10 micro phases (3 foundation, 4 talent, 3 elite, 1 mastery). A key feature of the FTEM is the absence of age boundaries as a transition point between phases in order to account for the variance in individual development trajectories. However, elite youth soccer programmes are structured around distinct age boundaries (e.g. English EPPP: age 5 – 11 = Foundation, 12 – 16 = Youth Development, 17 – 21 = Professional Development). Based upon existing evidence for the accumulation of practice hours during childhood being a key factor in attaining elite performance levels in soccer (Ford et al., 2009a; Hendry et al., 2018; Ward et al., 2007), it could be suggested that chronological age boundaries are logical and appropriate for talent development models. This enables practitioners to benchmark newly recruited academy players against existing counterparts to determine whether there is a feasible amount of time available for new players to accumulate requisite amounts of practice hours prior to the age of selection for professional contracts.

The Developmental Model of Sports Participation (DMSP) is the most prominent conceptualisation of athlete development from commencing participation, through to attaining elite status (Bruner et al., 2010). The DMSP consists of three athlete development trajectories: (1) recreational participation through early diversification and deliberate play, (2) elite performance through early diversification and deliberate play, and (3) elite performance through early specialisation and deliberate practice (Côte et al., 2007). Attaining elite performance through early specialisation and deliberate practice occurs in individual-based sports such as gymnastics (Law, Côte, & Ericsson, 2007) and figure skating (Starkes, Deakin & Allard, 1996). Conversely, expert performance attainment through early diversification and deliberate play is associated with individual-based sports that are associated with adulthood peak performance such as; triathlon (Baker, Côte & Deakin, 2005; 2006), rowing (Côte, 1999), and tennis (Côte, 1999). This association is prevalent in team sports such as; ice hockey (Soberlak & Côte, 2003; Wall & Côte, 2007), field hockey (Baker, Côte & Abernethy, 2003), netball (Baker, Côte & Abernethy, 2003), basketball (Baker, Côte & Abernethy, 2003; Leite, Baker & Sampaio, 2009; Leite & Sampaio, 2012), baseball (Hill, 1993), cricket (Phillips et al., 2010; Weissensteiner, Abernethy & Farrow, 2009), Australian Rules football (Berry, Abernethy & Côte, 2008), volleyball (Barreiros, Côte & Fonseca, 2013; Countinho, Mesquita & Fonseca, 2014; Leite, Baker & Sampaio, 2009), and soccer (Ford et al., 2009a; Haugaasen, Toering & Jordet, 2014a; 2014b).

Côte et al. (2007) considers age as a mediating factor in moving through the developmental trajectories of the DMSP. Up to age 11, children will ‘sample’ sport through high levels of play activities, before ‘specialising’ in one sport around age 12. The specialisation phase is a transitional phase that results in balanced levels of practice and play activities while the number of sports partaken in reduces. Around age 15, ‘investment’ in the primary sport occurs, resulting in the volume of practice overtaking that of play. Equally, children may choose to not pursue elite performance in sport, but remain recreationally active in a variety of sporting activities after the ‘sampling’ stage (age 12), keeping volumes of play activity high, and practice activities low. The early specialisation trajectory is an exception to the age boundaries within the DMSP, as children specialise within their chosen sport from the age of entry (prior to age 7).

However, with regards to soccer, it could be suggested that elite players do not explicitly follow either of the elite trajectories included in the DMSP. Ford et al. (2009a) proposed the ‘early engagement hypothesis’, which postulates that elite soccer players engage with soccer from an early age and accumulate high levels of soccer-specific play activities, thus combining opposing facets of the DMSP’s pathways. Further support for this notion has been reported by Ford et al. (2012), and Roca et al. (2012).

# 2.3.3 Structuring practice activities

Although there is significant empirical data available supporting the quantity of deliberate practice and the attainment of expertise in soccer, this data does not provide detail regarding the actual structure of these activities (Ford et al., 2009a; For et al., 2012; Hendry et al., 2018; Ward et al., 2007). The Expert-Performance Approach (Ericsson & Smith, 1991) provides a framework to assess the development of talented sports performers. This framework comprises of three stages: 1) Capture Expert Performance, 2) Identify Underlying Mechanisms, and 3) Examine How Expertise Developed.

Deliberate practice can be divided into two broad categories (Ford, Yates, & Williams, 2010). *Training form* activities are those which do not directly replicate the competitive structure of the sport but allow the athlete to repeat specific techniques within a ‘drill-based’ scenario, and is based on the premise that skills should be broken down into parts and practised in isolation (Schmidt et al., 2018). Conversely, *playing form* activities mimic the competitive nature of the sport, and provide opportunity for the athlete to apply a variety of techniques under game-based constraints. Playing form activities (such as SSGs), present an opportunity to capture expert performance for further analysis.

Contextual interference refers to the order in which skills are practised and the amount of external interference placed upon the completion of the skill (Magill & Hall, 1990). Low levels of contextual interference are associated with drill-based training activities, whereby players are able to repeatedly perform the same technique without external stimuli constraining the movement over a prolonged period of time (e.g. passing the ball to a teammate with the same foot, over the same distance). Conversely, high levels of contextual interference is associated with playing-form activities. Players are required to select skills at random as a solution to the problem faced (e.g. playing a SSG).

English soccer coaching is considered traditionalist in nature, and is considered reliant on low contextual interference, training-form activities that are too slow to progress to high contextual interference, playing form activities (Williams & Hodges, 2005). Elite soccer coaches typically use a greater proportion of drill-based training form activities (53 – 65%) compared to game-based playing form (35 – 47%) (Ford et al., 2010; Partington & Cushion, 2013). This appears counter-intuitive based on the premise of playing form training activities being associated with greater skill retention, which is considered the most important factor in learning skills (Schmidt, 1975). However, research has yet to investigate the efficacy of elite soccer coaching in embedding soccer-specific skills.

It has been established that low contextual interference, drill-based activities are beneficial to short-term performance (Williams & Hodges, 2005). However, high contextual interference, game-based activities are superior for the long-term retention of skills, and has been evidenced in a variety of sports, such as badminton (Goode & Magill, 1986), volleyball (Bortoli et al., 1992), baseball (Hall, Domingues, & Cavazos, 1994), and basketball (Landin & Herbert, 1997). With the increased need to produce home-grown players, it is logical to investigate the efficacy of elite soccer academy coaching in the development of technical skills based upon the structure of the coaching programme.

Current attempts to ascertain how expertise in soccer was developed throughout childhood and adolescence has relied on retrospective recall methodologies to obtain practice history data. The depth and quality of this data is therefore reliant upon the memory limitations of the participants, and has so far struggled to create a clear understanding of the structure of practice activities undertaken by expert performers (Ford et al., 2009a; Ford et al., 2012). Therefore, there is a need to conduct research with elite soccer cohorts that are currently engaged in systematic deliberate practice activities. Collecting practice history data in conjunction with tracking changes in soccer performance over time could help investigate the intricacies of deliberate practice, and how it develops expertise.

# 2.4 Physical activity behaviour and skill development

There is a dynamic relationship between engagement in physical activity and the development of fundamental movement skills (FMS), whereby increased levels of structured physical activity present more opportunities to practice and develop FMS. Prevalent in children and adolescents (McKenzie et al., 1998; McKenzie et al., 2002), this relationship leads to an increase in perceived competence and therefore increased adherence to the activity (Stodden et al., 2008). Research has investigated how children who are motor competent are able to maintain physical activity into adolescence (Barnett, 2009; Barnett et al., 2011; Lopes et al., 2011; Lubans et al., 2010; Stodden et al., 2012). However, this relationship has not been reversed to explain whether physical activity influences the rate of skill acquisition, especially if the activity contains elements of soccer-related play.

Soccer is an inherently cognitively challenging activity due to the need to execute multiple FMS while operating at varying exercise intensities, thus forming a natural link between exercise participation and cognition (Best, 2010; Sibley & Etnier, 2003; Tomporowski et al., 2008). Cognitively, soccer requires complex interaction of perceptual-cognitive skills in order to be successful while operating under significant aerobic and anaerobic strain (Best, 2010; Williams & Ford, 2008). The executive function (EF) of an individual is associated with their goal-directed behaviour when performing a given task, and may explain the cognition of children when engaged with exercise activities (Banich, 2009), and can assist in the execution of skills requiring significant attention and anticipation (Verburgh et al., 2014). As EF can be enhanced through participating in physical activity in bouts at a moderate-to-vigorous level (Best, 2010), it warrants attention when investigating the mechanisms behind developing skilful soccer performance.

Greater EF capability has been shown to differentiate highly talented youth soccer players both from their less able counterparts, and from children who do not partake in soccer. This is characterised by superior creativity, response inhibition, cognitive flexibility (Vestberg et al., 2012), reaction time, ability to attain and maintain an alert state (Verburg et al., 2014), and working memory (Vestberg et al., 2017). Vestberg et al. (2017) correlated superior EF with a greater number of goals and assists made throughout the course of a soccer season. However, research has yet to consider the impact of habitual physical activity on enhancing EF, and therefore potentially assisting the development of general technical soccer skills (e.g. passing, dribbling, tackling) as opposed to attacking performance outcomes (i.e. goals and assists).

# 2.5 Physical activity behaviour and health-related benefits

It is well established that there is a dose-response relationship between duration, intensity, and frequency of physical activity levels (particularly bouts of moderate-to-vigorous and vigorous activity) and health-related benefits in relation to adiposity, cardiometabolic biomarkers (e.g. blood pressure), physical fitness (e.g. cardiorespiratory fitness, muscular strength and endurance), and bone health (Janssen and LeBlanc, 2010; Poitras et al., 2016). Although a relationship can be seen between the volume of deliberate practice and play, there is little detail regarding the level of physical/cardiorespiratory fitness required to sustain participation in systematic coaching programmes. Coupled with this, there is very limited information regarding the characteristics of physical activity that occur outside of systematic coaching programmes.

Rowland (1999) proposed that humans have a set point for physical activity energy expenditure, and will adjust habitual physical activity levels in order to maintain energy expenditure at this point. Evidence for this notion has been reported by Frémeaux et al. (2011) in a study of children aged 8 – 10 years, whereby engaging in physical activity at one point (e.g. during school hours), is likely to result in a reduction in physical activity at another point (e.g. outside of school hours). In children and adolescents, it is unclear as to whether regular participation in soccer contributes towards attaining requisite daily levels of moderate to vigorous physical activity (MVPA), and therefore disrupting the set point of energy expenditure, especially in elite populations (Duda et al., 2013; Fenton et al., 2015; Wold et al., 2013). Fenton et al. (2015) reported that 36.7% of recreational youth soccer players (N = 109) aged 11.98 ± 1.75 years, were able to achieve ≥60 minutes of MVPA through weekend participation, while Fenton et al. (2016) reported that only 16% of recreational youth soccer players (N = 118) aged 11.72 ± 1.60 years accrued 60 daily minutes of MVPA. Although there is evidence to suggest that recreational soccer participation results in the accumulation of requisite MVPA levels, it is unclear as to whether this leads to compensatory behaviour on non-training days.

The activitystat hypothesis proposed by Rowland (1999) provides a rationale for the reduction in physical activity to help balance energy expenditure as a result of exercise bouts that include 60 minutes of MVPA. In children age 8 – 11 years, this may explain the reduction of physical activity in response to days involving MVPA (Ridgers et al, 2018; 2015; 2014). It has been reported that a reduction of between 5 and 9.3 minutes of MVPA, coupled with a reduction of approximately 25 minutes light physical activity (LPA) occurs on days after those involving 10 minutes of MVPA (Ridgers et al., 2014; 2018).

Excessive levels of training at a young age may result in physical and psychological burnout. Child athletes may choose to exit formal sport as a result of excessive demands placed upon them (Côte et al., 2007). Conversely, failure to engage in sufficient additional physical activities (e.g. deliberate soccer play) outside of scheduled academy coaching hours may result in reduced development of key technical soccer skills, and subsequent release from the academy system due to insufficient progress (Ford et al., 2009a). Both outcomes may result in the potential loss of perceived competence in sport, and potentially lead to the cessation of regular, structured physical activity, and thus loss of the general health-related benefits (Barnett, 2009; Barnett et al., 2011; Lopes et al., 2011; Lubans et al., 2010; Stodden et al., 2012).

# *Chapter 3:*

# Research Methodology

# 3.1 Design

The thesis contains 3 inter-linked studies that have the general purpose of assessing the efficacy of a ‘Category One’ EPPP Soccer Academy’s coaching programme. The following chapter will provide an overview to the discrete components of the thesis methodology, along with how synthesis between each study was achieved via the methodological approach. Study 1 was designed to establish a valid soccer-specific behaviour measurement tool that could be used objectively and reliably by a single observer. This tool was then carried forward into Study 2, and used as the primary data collection instrument. The data collected using this tool was then used in Study 3 as a dependent variable with objectively measured habitual physical activity. Soccer-specific performance data was obtained through the use of small-sided games (SSGs).

# 3.2 Elite Youth Soccer Players

Participants in the study were recruited from the partaking soccer academy’s under-9 and under-12 age groups. All players within each age group were recruited for potential participation across all three studies. To ensure parity between the two teams involved in the SSGs, the team coach was asked to select two teams of equivalent ability. All players were contracted to the academy, and were considered asymptomatic of illness or injury by the academy’s medical staff prior to participation.

# 3.3 Filming of Soccer Performance

A conventional performance analysis filming approach was used to capture footage of soccer match play. This involved the human-operated use of a digital camcorder positioned on a raised platform, 5 metres from the half-way line of the playing area, thus producing a “wide angle” perspective. This enabled the operator to pan, tilt, and zoom to ensure that all relevant on-the-ball actions, along with all players in close proximity to the ball were captured.

# 3.4 Analysing Soccer Performance

By collecting data associated with the frequency of occurrence, the aims and objectives of this thesis could be realised. Dartfish (Fribourg, Switzerland) is an industry-recognised computer-based software programme that enables the collation of frequency-based performance data (Wright et al., 2013), and was subsequently selected for use in this thesis. Study 1 utilised this approach as a means of testing the newly formulated analysis tool. By collating frequency-based data of soccer-specific behaviours, the objectivity and reliability of the tool was able to be assessed based upon any discrepancies in the frequency of observation between observers. Similarly, Study 2 utilised this approach to establish the changes in technical soccer performance over 6-week and 12-month periods based upon any observed changes in frequency-based data between data collection points. Lastly, Study 3 relied upon the collection of frequency-based technical soccer performance data in order to determine any relationships between changes in performance and the volume of habitual physical activity undertaken on a day-to-day basis.

# 3.5 Sport Participation History

In order to estimate the amount of time spent in soccer-specific and other sporting activities, the Participation History Questionnaire (PHQ) (Appendix I) (Ford et al., 2010; Ford et al., 2012) was administered to all participants within both age groups. The PHQ consists of 3 sections designed to elicit information regarding soccer-specific milestones, engagement in soccer-specific activities, along with engagement with any additional sport and exercise activities away from the academy. This enabled a quantitative estimate of time spent in each section to be established, and the subsequent direct measurement of physical activity using accelerometers to be contextualised.

# 3.6 Habitual Physical Activity

Tri-axial accelerometers (ActiGraph GT3X+; ActiGraph, Pensacola, FL, USA) were distributed to all participants within each age group in order to collect a direct measure of habitual physical activity. To contextualise the data further, participants were asked to complete a daily activity diary (Appendix II). In order to be included in the subsequent analyses, data was required for a minimum of ≥8 hours of wear time on two training and two non-training days. The ActiGraph propriety software (ActiLife v.6.13.2, Pensacola, FL, USA) was used to process accelerometer data. The variables included for the analysis of physical activity were time spent sedentary, along with time spent in light physical activity, and moderate-to-vigorous activity (MVPA). Vector magnitude counts per minute (VM CPM) and steps taken were also included within the analyses.

# 3.7 Statistical Approaches

To assess the reliability of the newly formulated analysis tool in Study 1, guidelines provided by Cooper et al. (2007) and James et al. (2007) were utilised to assess inter-and intra-observer reliability. Percentage agreement with a reference value of ±1 and 95% confidence intervals were calculated for data that could not be placed into distinct categories (Cooper et al., 2007). The median sign test was used to determine any significant differences between observations (*p* < .05). Where data was placed into distinct categories, Yule’s Q was used to determine the level of percentage agreement between observations (James et al., 2007).

With regards to the SSG aspects of studies 2 and 3, data was normalised on a rate per minute basis to account for variation in game duration. This was presented as mean ± standard deviation, with 90% confidence intervals. Hopkins et al.’s (2009) non-clinical inferences approach based upon the smallest worthwhile change (SWC) and odds ratio was used to determine the efficacy of the academy coaching programme. A percentage scale (0 – 4.9 = most unlikely, 0.5 – 5 = very unlikely, 5.1 – 25 = unlikely, 25.1 – 75 = possibly, 75.1 – 95 = very likely, 95.1 – 100 = most likely) was used to express coaching efficacy for each soccer-specific behaviour.

To investigate a potential relationship between technical soccer skill development and habitual physical activity, a ‘performance index’ of arbitrary units was calculated for the degree to which technical performance changed between baseline, post-test, and retention in Study 2 based upon the SWC for each behaviour. Pearson’s product-moment correlation coefficient was utilised to assess the strength of relationship between the ‘performance index’ and physical activity variables (sedentary, light, MVPA, VM CPM, and total steps). Where assumptions of a normal distribution were violated (determined by the Shapiro-Wilk test), Spearman’s rank order correlation coefficient was used.

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# *Chapter 4:*

# Study 1: The Validity, Reliability and Objectivity of a Soccer-specific Observation Analysis Tool

# 4.1 Abstract

The purpose of the study was to assess the validity, objectivity, and reliability of a Soccer-Specific Behaviour Measurement Tool (S-SBMT) in relation to the soccer philosophy of a Category One Premier League soccer academy. A 30 minute, 8 vs. 8 small-sided game (SSG), played by the U12 squad of the participating academy was used for analyses. Validity was ensured through formulating the S-SBMT definitions with experienced soccer coaches from the same soccer academy. Percentage agreement with a reference value of ±1, 95% Confidence Intervals, median sign and Yule’s Q were used to assess objectivity and reliability. High levels of objectivity were found for the number of passes (98.8% agreement), runs with the ball (97.5% agreement), and goal attempts (100%). Reduced objectivity was apparent for forward zonal transitions (75.3%), along with tackles (70.4%), interceptions, (63%), and loose balls (48.1%). Reliability was tested after 1- and 4-weeks, with levels of percentage agreement found to be above the 85% acceptable threshold for most behaviours (passing = 95.1%, runs with the ball = 92.6%, goal attempts = 100%, tackles = 100%). The study demonstrated acceptable objectivity and reliability for S-SBMT behaviours and these findings demonstrate the potential utility of the S-SBMT in monitoring technical actions in a Category One Premier League soccer academy, and a methodological process for other academies to follow in ensuring the quality of performance data.

# 4.2 Introduction

As the most common users of performance analysis, professional soccer clubs across the world hire multiple specialist practitioners, commonly known as Performance Analysts, to perform notational analysis on team and individual performance (Wright, Atkins, Jones, & Todd, 2013; Wright, Carling, & Collins, 2014). By systematically observing soccer performance using valid, objective, and reliable notational analysis tools, Performance Analysts are able to evaluate soccer performance, providing feedback to players and coaching staff to consequently enhance the decision-making process of coaches in relation to players and tactics (Wright et al., 2013). With advancements in modern technology, individual and team performance is captured in digital video format for subsequent use with computer-based systematic observation analysis tools and have become commonplace in professional soccer clubs (Wright et al., 2013).

In English soccer, the recent emergence of the Premier League Elite Player Performance Plan (EPPP) has resulted in academies needing an identity in the form of their soccer playing ‘philosophy’ (The Premier League, 2011). A soccer playing philosophy can be described as a team’s ‘style of play’, and is associated with the general attacking and defensive behaviours of the team during match play. Attacking philosophies are commonly associated with ‘direct’ or ‘possession’ play, while defensive philosophies are represented by ‘high’ or ‘low’ pressure styles (Fernandez-Navarro et al., 2016). As such, it is a common role of performance analysts to establish which aspects (performance indicators) of the playing philosophy are required for analyses (Wright et al., 2013). For example, if analysing a team associated with a ‘direct’ style of play, performance analysts would be interested in the efficiency of longer passes as opposed to passes over a shorter distance (Fernandez-Navarro et al., 2016).

The performance analysis process serves to negate the issues associated with the subjective coach perception of performance, due to memory limitations (Franks & Miller, 1986; Franks, 1993; Laird & Waters, 2008; Nicholls & Worsfold, 2016) and the constraints of the viewing environment (Wright et al., 2014). The use, however, of humans as operators of computer-based notational analysis tools can result in significant measurement error due to the inherent subjective nature of systematic observation, when interpreting performance against predefined criteria (Bradley et al., 2007; O’Donoghue, 2007a). Consequently, it is important to establish content validity, objectivity, and reliability in the formulation of such tools to help reduce these issues.

Content validity of notational analysis tools has previously been established using experienced soccer coaches, due to their contextual expertise in generating applicable operational definitions that logically measure desired performance indicators (Brewer & Jones, 2002). The reliability of any given observational tool can be established through assessment of the same performance across multiple observations of the same event (Batterham & George, 2003). The establishment of validity, objectivity, and reliability when using notational analysis tools in elite youth soccer represents the under-pinning rationale for the present study.

Prior to 2002, 70% of notational analysis papers in sport, including soccer, failed to report any information regarding the reliability of notational analysis systems used to collect data (Hughes, Cooper & Nevill, 2002). Brewer and Jones (2002) produced a five-stage process for establishing contextually valid and reliable observation tools in sport. This includes the key concepts associated with validity outlined by Thomas and Nelson (1990); reliability outlined by Batterham and George (2003), and serves to act as the primary reference point for formulating tools of a similar nature. Consequently, this approach has been used by Ford, Yates, and Williams (2010) and Cushion, Harvey, Muir and Nelson (2012) to create domain-specific behavior assessment tools in an elite soccer coaching setting. However, while these studies provide valuable information regarding coaching behaviours, the behaviours of players within coaching sessions has yet to be explored.

Recent research has moved towards creating tools for the assessment of technical soccer performance in a coaching setting using small-sided games with elite females (age: 16 ± 1.1 years; soccer experience = 9.9 ± 2.3 years) (van Maarseveen, Oudejans & Savelsbergh, 2017). The process by which the analysis system was created ensured validity and reliability using similar principles to those of aforementioned studies (Brewer & Jones, 2002; Cushion et al., 2012a; Ford et al., 2010). Experienced professional coaches were recruited to ensure the validity of the system through checking the content of the tool, while traditional inter- and intra-observer approaches were implemented to ensure reliability.

However, the SSG structure was broken down into independent phases of play, without the inclusion of possession turnovers. This limits the natural ‘flow’ (i.e. both teams have the opportunity to attack and defend) of soccer, thus restricting ecological validity (Hughes & Bartlett, 2015; Robins & Hughes, 2015). With regards to the soccer behaviours included in the system, it is not clear whether they are based upon the specific soccer philosophy of the team from which the players and coaches were recruited. Additionally, by only assessing inter- and intra-observer reliability for 16 and 10% of the total trials respectively, several behaviours within the tool could not be considered reliable due to their infrequency of occurrence.

Without determining validity and reliability in notational analysis tools; performance data stakeholders (e.g. researchers, coaches, players, performance analysts) are unable to guarantee the accuracy of the data. The valid, objective, and reliable use of systematic observation tools is largely dependent upon the accuracy of the operational definitions (Brewer & Jones, 2002; Cushion et al., 2012a; James, Taylor, & Stanley, 2007; Williams, 2012). Should a tool’s definitions lack depth and accuracy with regards to what constitutes the occurrence of a particular event, or be of a length that requires the analyst to think for a significant period of time before making a judgement; data may be collected incorrectly by missing an event’s occurrence, recording an event when it did not occur, or using the functions of the tool incorrectly (Armitage, 2006; James et al., 2007; O’Donghue, 2007b). This has negative implications for professional soccer clubs, as a true reflection of player performance may be skewed either positively, or negatively, thus leading to incorrect player judgements, and a detrimental effect on the burgeoning coach-analyst relationship within soccer clubs (Wright et al., 2013; Wright et al., 2014). By investigating the reliability of Performance Analysts in their use of systematic observation tools, errors of this nature can be reduced or avoided, and establish whether the tool is contextually valid and reliable.

Consequently, the aim of the study was to assess the objectivity and reliability of a contextually valid, club soccer philosophy-specific, behaviour measurement tool (S-SBMT) using two experienced Performance Analysts within a ‘Category One’ Premier League soccer academy. It was hypothesised that there would be good levels of intra and inter-observer reliability of the S-SBMT as a result of following the Brewer and Jones (2002) five-stage process.

# 4.3 Methods

## 4.3.1 Development of the S-SBMT

The purpose of the S-SBMT was to assess the efficacy of a Category One Premier League soccer academy coaching curriculum in the development of soccer-specific behaviours related to the academy soccer playing philosophy. Therefore, the S-SBMT needed to be created in relation to the specific behaviours of the academy playing philosophy rather than including all generic soccer behaviours. An existing observation analysis tool (or combination of multiple existing tools), with established validity and reliability, should be used as a template when formulating new systems (Brewer & Jones, 2002). Two Performance Analysts (PAs) from the same Category One English soccer academy each with an average of 4 years vocational experience were recruited to develop and test the S-SBMT. The PAs had extensive vocational experience in the use of the previously validated Prozone Match Viewer (PMV) observation tool when observing technical soccer performance indicators (e.g. passing, shooting, tackling) (Bradley et al., 2007). Therefore, the behaviours and definitions within PMV were used as the basis for the S-SBMT. The PAs collaboratively compared the PMV definitions to those within the academy soccer philosophy and proposed amendments to existing definitions. A total of 4 behaviours were directly linked to the playing philosophy. Therefore, additional definitions for absent behaviours in the PMV were created to increase specificity of the S-SBMT to the academy soccer philosophy. A total of 12 behaviours required new definitions, and were predominantly associated with the outcome of a behaviour (i.e. successful or unsuccessful attempt at performing the behaviour), as PMV definitions describe the behaviour itself, not the associated outcome (Table 4.1).

|  |  |  |
| --- | --- | --- |
| Table 4.1. Soccer-specific Behaviour Measurement Tool Definitions | | |
| **Behaviour** | **Developed Definition** | **Original Prozone Definition** |
| Passing & Receiving Sequence | A sequence of passes, starting at 1 (the first successful pass), and ending when a player was tackled, fouled, produced a shot or cross, a pass was intercepted, or the ball went out of play. The sequence increased in line with the number of successful passes. |  |
| Pass | Any attempt to move the ball to a teammate which provides the opportunity for the receiving teammate to control the ball. This includes throw-ins and distribution from the goalkeeper. | Any attempt by a player to play the ball to a team-mate. |
| Successful Pass | A pass which is successfully brought under control by the receiving player. |  |
| Unsuccessful Pass | A pass which is not successfully controlled by the receiving player, does not reach the intended receiver, or is intercepted by an opposing player. |  |
| Ball Manipulation | The movement of a player in possession of the ball into available space, or to move past an opposing player into available space in order to attempt a pass, cross, or shot. | Any run with the ball that involves either (I) Multiple touches with a directional change or (II) Beating an opponent. *Originally termed 'Dribble' by Prozone.* |
| **Table 4.1 (continued).** Soccer-specific Behaviour Measurement Tool Definitions | | |
| Forwards Zonal Transition | The moving of the ball via a passing sequence into a zone which is in a forward direction on the playing area in relation to the direction of attack. Examples; Defensive zone to Midfield zone, Defensive zone to Attacking zone, Midfield zone to Attacking zone. |  |
| Backwards Zonal Transition | The moving of the ball via a passing sequence into a zone which is in a backwards direction on the playing area in relation to the direction of attack. Examples; Attacking zone to Midfield zone, Attacking zone to Defensive zone, Midfield zone to Defensive zone. |  |
| No Transition | The ball does not transfer from one zone to another as a result of a passing sequence and/or a player running with the ball. No transition was also recorded if the ball transferred from one zone to another, but the end of the passing sequence was observed to be in the same zone as where the sequence originated. |  |
| Goal Attempt | Any attempt (shot, headed shot) directed towards the opposition goal with the intention of scoring a goal. | Any attempt at goal with any part of the body except the head (Header Shot). *Originally termed 'Shot' by Prozone.* |
| On Target | A shot which is within the posts of the opposition goal and either results in a goal, or a save by the opposition goalkeeper. |  |
| Off Target | A shot which passes the goal line outside of the posts of the opposition goal, or rebounds back into/out of play off the posts. |  |
| Blocked | A shot which is stopped by an opposition player before reaching the goal. |  |
| **Table 4.1 (continued).** Soccer-specific Behaviour Measurement Tool Definitions | | |
| Tackle | Dispossession or attempted dispossession of an opponent by physical challenge or pressure when actual challenge/tackle is attempted. |  |
| Interception | An opposing player, in close proximity, prevents the ball from reaching its intended target. This can take place anywhere on the pitch. *Originally termed 'Block' by Prozone.* A touch by an opposition player which does not stop the ball from reaching the intended target (team-mate via pass or opposition goal via shot). *Originally termed 'Deflection' by Prozone.* | Any pass which is controlled, or deflected by an opposition player as a result of their positioning or defensive pressure on the ball. |
| Loose Ball | The ball is not under the control of any player on the pitch when possession is regained. There is no external influence which leads to the ball becoming 'loose' and available to take by either team. |  |

## 4.3.2 Tagging Procedure

The S-SBMT was constructed using the ‘Tagging’ module within Dartfish 6 (Fribourg, Switzerland) on a laptop computer (Lenovo ThinkPad, Morrisville, United States). The tool was constructed to allow the tagging procedure to begin at the start of a team’s passing and receiving sequence with the relevant selection. At each point within the sequence where the performance analyst felt a behaviour was evident, further selections were completed on the tagging panel. Each selection created a mutually exclusive event within the Dartfish Timeline. The panel was configured to ensure that it was not possible for a single selection to place a behavior in two separate locations along the timeline. Pause, rewind, and variable playback speed functions were accessible to the observer to reduce the risk of behaviours being omitted due to the natural game tempo of the SSG.

## 4.3.3 Establishing S-SBMT Validity

To establish face validity of the S-SBMT, two experienced researchers in the field of notational analysis were consulted regarding the number of behaviours included within the S-SBMT, along with the accuracy of the definitions as per the process outlined by Brewer and Jones (2002). Following this process, content validity was ensured by two UEFA A-licensed coaches with an average of 12 years coaching experience from the same academy as the PAs, viewing 3 video-based examples of each behaviour included in the S-SBMT. Archived match footage of the participating age group was used to determine whether all elements of the S-SBMT were representative of the club playing philosophy in relation to match play, along with whether important technical behaviours of the playing philosophy were omitted from the behaviour categories, or unimportant elements of playing philosophy were erroneously included. The coaches viewed the video-based examples at real-time speed, but were given the option to replay any clips they felt were not initially clear, along with adjusting playback speed when necessary. The only behaviour considered by the coaches to require amendment prior to further use was Ball Manipulation. The original definition presented to the coaches did not include information as to which action ended the behaviour (e.g. pass, cross, shot).

## 4.3.4 Determining Reliability of the S-SBMT

A small-sided game (SSG) was used as the sample of soccer performance in which to test the tool. A SSG was used as opposed to a full 11 vs. 11 game due to the inherent increase in the frequency of technical behaviours observed in SSGs (Dellal et al., 2012). Two Performance Analysts (PA1 and PA2) from the same Category One English soccer academy each with an average of 4 years vocational experience tested the reliability of the S-SBMT. Objectivity of the S-SBMT was established by comparing the frequency of observations for each behaviour between PA1 and PA2 for the SSG. Reliability was established by comparing the results of PA1’s initial observation to subsequent observations of the same SSG by PA1 after periods of 1- and 4-weeks to account for the influence of PA1’s memory on their recognition of behaviours.

## 4.3.4.1 Small-sided game configuration

Sixteen under-12 (U12) players (age: 11.4 ± 0.5 years, stature: 147.3 ± 7.3 cm, mass: 37.4 ± 6.8 kg) contracted to the academy were recruited to take part in the SSG. Participants trained at the academy for an average of 8.5 hours per week, 10 months per year, with an average of 4.2 years previously spent at the academy. The research procedure was conducted in accordance with the ethical guidelines of the academy, with ethical approval obtained from a Local University Ethics Committee. Participants provided written assent, with their parents/guardians providing written informed consent. All players had completed a full health check with the club’s medical staff, along with a medical questionnaire administered by the academy as part of their registration process; thus confirming that all participants were asymptomatic and fit to take part in the study.

The 8 vs. 8 SSG was 30 minutes in duration (2 x 15 minute periods), and took place at the academy on a 60 x 40 m 3rd generation artificial playing surface. The pitch was divided into three equal 20 x 40 m zones along the length of the pitch, with markers placed at 10 m intervals. Both teams were of equal playing ability based on the subjective assessment of the U12 team coaching staff. Both teams were instructed to play in a 1-2-3-2 formation, and follow conventional soccer rules. The SSG was recorded using a Sony video camera (Sony HDR, Tokyo, Japan) with a frame-rate of 30 fps and shutter speed of 1/60th placed on a tripod 1 m in height (Manfrotto, Ashby-de-la-Zouch, United Kingdom). The camera operator was positioned on a platform (Zarges TeleTower, Milton Keynes, United Kingdom) 3 m in height and 5 m from the side of the pitch (Figure 4.1). A ‘wide-angle’ filming perspective was used, with pan, tilt, and zoom functionality available to the camera operator. The zoom function was used when the ball travelled beyond the zones outlined in Figure 1 to enhance the accuracy of coding.

40 m

60 m

Tower:

3 m (height)

5 m

Def zone

20 x 40 m

Mid zone

20 x 40 m

Att zone

20 x 40 m

# Figure 4.1. Pitch dimensions and filming position for obtaining small-sided game video footage. Zones are in relation to attacking from left to right

## 4.3.5 Statistical Analysis

Two types of frequency data are produced by the S-SBMT. Consequently, two different approaches were utilised to determine reliability of the tool. Frequency count-based data for each passing and receiving sequence was concerned solely with the number of passes, and therefore did not need to be placed into distinct categories. Similarly, ball manipulation was concerned with the frequency of players travelling with the ball in their possession. Therefore, percentage agreement with a reference value of ±1 and 95% confidence intervals (CI) were calculated as per Cooper et al.’s (2007) methodology. The median sign test was then used to establish whether any differences between the observers were significant (*p* < .05). Statistically significant differences between observers suggest unreliable use of the systematic observation tool (Cooper et al., 2007). All other behaviours in the S-SBMT could be placed in distinct outcome categories (Table 4.2). Yule’s Q was used to calculate the percentage agreement between observers for each category as opposed to the more conventional use of Cohen’s Kappa. This was due to the calculation for Kappa including the element of luck or chance in finding concordant observations, and therefore producing an overly conservative estimate of agreement (James et al., 2007). Behaviours that exceeded 85% agreement were considered reliable (Siedentop, 1976; Brewer and Jones, 2002).

|  |  |
| --- | --- |
| Table 4.2. Outcome categories of S-SBMT behaviours | |
| **S-SBMT Behaviour** | **Outcome Categories** |
|  | *Positive Zonal Transition* |
| Transition | *No Zonal Transition* |
|  | *Negative Zonal Transition* |
|  | *Tackle* |
| Regain | *Interception* |
|  | *Loose Ball* |
|  | *On Target* |
| Goal Attempt | *Off Target* |
|  | *Blocked* |

# 4.4 Results

## 4.4.1 Objectivity of the S-SBMT

Table 4.3 shows that inter-observer objectivity was 90.1%, 95% CI [83.6, 96.6], for the number of passes per sequence, with proportional agreement calculated at 98.8%, 95% CI [96.4, 100], when the ±1 reference value was applied. Median sign test showed that the absolute difference between PA1 and PA2 was not statistically significant (*p* = .727), therefore suggesting objectivity in the observations. The absolute percentage agreement was 72.8%, 95% CI [63.2, 82.5], between the PA1and PA2 when observing ball manipulation with proportional agreement calculated at 97.5%, 95% [94.2, 100]. The absolute difference between PA1 and PA2 approached statistical significance (*p* = .052). However, the high proportional percentage agreement suggests objectivity in the observations.

Table 4.4 shows objectivity for categories associated with goal attempts were the most reliable in the S-SBMT, with 91.7% agreement for all three categories (*Q* = .917). Backwards zonal transitions were almost in complete agreement (*Q* = .975), but sequences that were recorded as having no transition, or a forward transition, were less reliable (no transition: *Q* = 0.728; forwards transition: *Q* = 0.753). Where a disagreement between observers occurs in relation to zonal transitions, it is likely to be between whether the sequence travelled forwards or did not move between zones. Categories related to possession regains were found to be the most unreliable. Of the three regain categories, tackles were found to have the highest percentage agreement (*Q* = .701). The main source of disagreement between the observers was whether the ball was regained via an interception (*Q* = .63) or loose ball (*Q* = .481).

|  |  |  |
| --- | --- | --- |
| Table 4.3. Inter-observer reliability for passing and ball manipulation between PA1 and PA2 | | |
|  | **Percentage Agreement**  **[95% CI]**  **(median sign)** | **Proportional Agreement (%)**  **[95% CI]** |
| Passing | 90.1 [83.6, 96.6] (*p* = .727) | 98.8 [96.4, 100] |
| Ball Manipulation | 72.8 [63.2, 82.5] (*p* = .052) | 97.5 [94.2, 100] |

|  |  |  |  |
| --- | --- | --- | --- |
| Table 4.4. Inter-observer reliability between PA1 and PA2 for categorical data | | | |
|  | **S-SBMT Behaviour** | **PA1** | **PA2** | | **Yule's Q** |  |
|  | *Forwards Zonal Transition* | 43 | 43 | | 0.753 |  |
| Transition | *No Zonal Transition* | 34 | 35 | | 0.728 |  |
|  | *Backwards Zonal Transition* | 4 | 3 | | 0.975 |  |
|  | *Tackle* | 10 | 6 | | 0.704 |  |
| Regain | *Interception* | 8 | 5 | | 0.630 |  |
|  | *Loose Ball* | 9 | 16 | | 0.481 |  |
|  | *On Target* | 16 | 16 | | 0.917 |  |
| Goal Attempt | *Off Target* | 4 | 4 | | 0.917 |  |
|  | *Blocked* | 3 | 3 | | 0.917 |  |

## 4.4.2 Observer Reliability of PA1

Table 4.5 shows the reliability for the number of passes per sequence was 95.1% (*p* = 1), with proportional agreement calculated at 100%, 95% CI [100, 100] after a period of 1-week. After 4-weeks, absolute percentage agreement drifted to 90.1% (*p* = .363), with proportional agreement calculated at 100%, 95% CI [100, 100]. Ball manipulation was also highly reliable at 92.5% (*p* = .656) after 1-week, before drifting to 87.7% (*p* = .945) after 4-weeks.

Table 4.6 shows levels of reliability between the initial PA1 observation and re-tests after 1- and 4-weeks for categorical data. PA1 coded the 23 goal attempts in the same category after both 1- and 4-weeks (*Q* = .917). PA1 also coded the same frequency of tackles across all three observations (*Q* = .929). Errors in the PA1’s coding in relation to regain behaviours can be attributed to disagreements between interceptions and loose balls. Concordant observations of interception and loose ball regains drifted from 85.2%, week 1 (*Q* = .852) to 77.8% (*Q* = .778) 4-weeks after the original observation.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Table 4.5. Intra-observer reliability of PA1 for passing and running with the ball after 1- and 4-weeks | | | | |
|  | ***1-week*** | | ***4-weeks*** | | |
|  | **Percentage Agreement**  **[95% CI]**  **(median sign)** | **Proportional Agreement [95% CI]** | **Percentage Agreement**  **[95% CI]**  **(median sign)** | **Proportional Agreement [95% CI]** | |
| Passing | 95.1 [92.8, 97.3] (*p* = 1) | 100 [100, 100] | 90.1 [87, 93.3] (*p* = .363) | 100 [100, 100] | |
| Ball Manipulation | 92.6 [89.9, 95.3] (*p* = .656) | 100 [100, 100] | 87.7 [84.1, 91.2] (*p* = .945) | 100 [100, 100] | |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Table 4.6. Intra-observer reliability of PA1 after 1- and 4-weeks for categorical data | | | | | | |
|  | **S-SBMT Behaviour** | **Original** | **1-week** | **Yule's Q** | **4-weeks** | **Yule's Q** |
|  | *Forwards Zonal Transition* | 43 | 45 | 0.901 | 41 | 0.802 |
| Zonal Transition | *No Zonal Transition* | 34 | 32 | 0.877 | 37 | 0.778 |
|  | *Backwards Zonal Transition* | 4 | 4 | 0.976 | 3 | 0.975 |
|  | *Tackle* | 10 | 10 | 0.929 | 10 | 0.929 |
| Regain | *Interception* | 8 | 6 | 0.852 | 7 | 0.778 |
|  | *Loose Ball* | 9 | 11 | 0.852 | 10 | 0.778 |
|  | *On Target* | 16 | 16 | 0.917 | 16 | 0.917 |
| Goal Attempt | *Off Target* | 4 | 4 | 0.917 | 4 | 0.917 |
|  | *Blocked* | 3 | 3 | 0.917 | 3 | 0.917 |

# 4.5 Discussion

The purpose of this study was to create a soccer-specific behaviour measurement tool and assess its reliability when used by two experienced Performance Analysts. It was hypothesised that if the Brewer and Jones (2002) five-stage process was implemented appropriately, good levels of objectivity and observer reliability would be apparent. Results suggested that the S-SBMT could be regarded as having good levels of objectivity and reliability for several behaviours. However, equally, there were unreliable aspects of the S-SBMT despite the coaches and analysts who assisted in the creation of the S-SBMT working within the same academy and possessing similar levels of vocational expertise.

The development of the S-SBMT provides additional support to the notion that following a prescribed method such as that of Brewer and Jones (2002) can result in the production of a notational analysis tool that is logically valid. The use of experienced coaches is crucial to this process due to their sophisticated knowledge of the sport. This ensures that the definitions assigned to each performance variable are logical and appropriately capture relevant performance indicators. Performance analysts often work closely with coaching staff (Wright et al., 2013; Wright et al., 2014). By involving coaches in the process of creating definitions for their notational analysis tool, the analyst can potentially develop a like-minded understanding of the sport, thus ensuring that the data collected is objective between coach and analyst. Additionally, the process outlined by Brewer and Jones (2002) has been shown in this study to be easily transferrable between sports, and as such, could be transferred between soccer clubs with differing playing philosophies to enable club-specific soccer performance data to be collected.

Aspects of the S-SBMT were found to be both objective and reliable in the collection of performance data. Passing and running with the ball behaviours between analysts were found to be at the acceptable 90% agreement level suggested by Cooper et al. (2007) for frequently occurring events. Application of the ±1 reference value resulted in near perfect inter-observer agreement (98.8%). Running with the ball occurred as frequently as passing, with objectivity found to be below the 90% agreement level. However, use of the ±1 reference value increased to a near perfect 97.5%. Additionally, PA1 remained a reliable observer of passing and runs with the ball after a period of 4-weeks. Again, only running with the ball required a ±1 reference value adjustment to exceed the acceptable level of 90%.

Further support for objectivity and reliability was found in the calculation of objectivity and reliability for goal attempts. The same number of goal attempts were observed across observations, with outcomes categorised in the same manner. The high levels of objectivity and reliability may be attributed to the clarity of the definition for goal attempts and the subsequent outcomes (on target, off target, blocked) as the three outcomes differ considerably in their characteristics, therefore eliminating the potential for observer subjectivity to influence the results (Tenga et al., 2009). Therefore, the S-SBMT can be considered a valid tool for assessing the frequency of passing, running the ball, and goal attempt behaviours in youth soccer within a Category One Premier League Academy.

Although it should be noted that high levels of objectivity and reliability were found for backwards zonal transitions; there were discordant observations for both objectivity and reliability (after 4-weeks) in passing sequences that transitioned forwards, or remained in the same zone. Despite a clear definition, zonal transitions were predominantly a subjective assessment of the analyst, whose judgement was only aided by a cone along the side of the pitch as opposed to a pitch with clear markings (e.g. the penalty area) (Tenga et al., 2009). Additionally, the angle at which the game was recorded may have led to perceptual error of the observer in determining pitch location (Bradley et al., 2007). Despite these constraints, there was at least a 72.8% chance of the analysts recording the same zonal transition outcome, and could be as a result of only using 3 different zones rather than the multiple zones found in Tenga et al.’s (2009) system.

The regain behaviours, tackle, interception, and loose ball lacked objectivity. A similar issue was reported by Armitage (2006) in the observation of breaking the gain line in Rugby, whereby observers agreed strongly on going ‘over’ the gain line, but disagreed on whether line breaks were ‘around’ or ‘through’. This suggests that further work is required to investigate why the two analysts view these behaviours differently despite using the same definitions. Disagreements between observers could be attributed to the subjectivity in determining distance between opposing players prior to the behaviour, as it is not practically feasible to measure the distance between players when viewing 2-dimensional video footage. Additionally, as the footage was only 2-dimensional, observers may have been unable to detect a deflection on the ball caused by an opposing player at moments where the camera was fully zoomed out, therefore reducing the chance of an interception being correctly coded (Tenga et al., 2009).

Despite the positive results associated with passing, running with the ball, and goal attempt behaviour, results suggest that the S-SBMT cannot currently be considered a valid and reliable measure of transition and regain behaviours in youth soccer based on its use in a single SSG. The process of creating and developing the S-SBMT followed that of previously valid and reliable observational tools; incorporating the use of highly qualified and experienced soccer coaches, whom are well-versed in the academy soccer curriculum, along with vocationally-experienced performance analysts to ensure validity and reliability in its functionality (Brewer & Jones, 2002; Cushion et al., 2012a; Ford et al., 2010). Therefore, it could be suggested that the relatively low levels of reliability found for defensive behaviours could be attributed to the nature of the behaviours rather than the functionality of the tool (van Marseveen et al., 2017). Using a larger sample of games for analysis may negate this issue, as it may allow the behaviours associated with defensive actions more opportunity to stabilise, and therefore become more recognisable to the observer, due to their reduced frequency in comparison to more reliably observed behaviours (i.e. passing) (van Marseveen et al., 2017). The process of behaviours stabilising over time is known as ‘normative profiling’, and has demonstrated how data sets evolve over time, as the volume of data increases (Hughes, Evans & Wells, 2001; Hughes, Cooper, Nevill & Brown, 2003; O’Donoghue, 2005). Therefore, it may take an analyst a significant period of the competitive season to establish whether behaviours that occur less-frequently than others are objective and reliable. It would be interesting to use the S-SBMT over a prolonged period of time to determine whether defensive behaviours follow the assumptions of normative profiling.

The external validity of the S-SBMT in relation to its use by other soccer academies could be questioned due to the tool only being used with youth soccer players in a single soccer academy, in a single age group, who play to a club-specific philosophy. Further research is required to determine whether the age, playing ability, and soccer curriculum of the participants influences the ease at which common soccer behaviours can be observed. In a wider context, by treating each behaviour as an independent variable, those with poor levels of objectivity and reliability were not masked by acceptable results from other behaviours (Cooper et al., 2007). Therefore, results of this study provide further support for the use of simple statistical approaches; specifically advocating the use of Yule’s Q in assessing observer reliability due to the ability to detect specific behaviours that are not observed reliably. However, the use of this non-parametric statistical approach, combined with the small sample, size gives rise to reduced statistical power compared to parametric analyses (Bland & Altman, 1999).

Future research could look to explore the influence of vocational experience (expert vs. novice analyst paradigm) on an analyst’s ability to use systematic observation tools reliably. This could carry potential implications for best practice, not only in soccer clubs, but other sports where the systematic observation of performance is common. It would be interesting to evaluate how the nature of the sport being analysed influences the process of establishing these key concepts. The results of the present study have highlighted the need to ensure the concepts of validity, objectivity, and reliability when creating notational analysis tools, while accounting for practical issues associated with sample size. Additionally, practitioners are encouraged to utilise this method as a template for ensuring best practice in this vocational setting.

# Chapter 5:

# Study 2: The efficacy of systematic soccer practice in the development of technical skills in elite youth soccer players

# 5.1 Abstract

Soccer academies in the UK are under increased pressure to produce home-grown players of an elite standard for the professional game. Therefore, the aim of this study was to utilise the academy-specific observation tool developed in Chapter 3: Study 1 to assess the efficacy of the coaching curriculum in developing the technical skill of U9 and U12 players. Participants were 8 under-9 (U9) players (age: 8.8 ± 0.4 years, stature: 132.9 ± 3.4 cm, mass: 27.1 ± 2.1 kg) and 14 under-12 (U12) players (age: 11.4 ± 0.5 years, stature: 147.3 ± 7.3 cm, mass: 37.4 ± 6.8 kg). Players engaged with the academy soccer coaching curriculum as per their contracted status at the academy, and participated in a series of 5 vs. 5 (U9) and 8 vs. 8 (U12) small-sided games (SSGs) at baseline, post-test (6-weeks), and retention (12-months) to assess the efficacy of a 6-week coaching block (between baseline and post-test). Magnitude-based inference analysis showed that the most likely possible positive effect from baseline to post-test for the U9 cohort was the frequency of ball manipulation (48.9% possible positive effect), and its success (43.9% possible positive effect). Ball manipulation and goal attempts were the most likely skills to have been retained after the 12-month retention test both in regards to frequency (ball manipulation = 49.5% possibly positive; goal attempts = 43.3% possibly positive) and success (ball manipulation success = 43% possibly positive; goal attempt success = 47.3% possibly positive). For the U12 cohort, passing frequency was the most likely to have been improved by the coaching curriculum from baseline to post-test (68.3% possible positive effect), post-test to retention (77.6% likely positive effect), and baseline to retention (97.4% very likely positive effect). The greater efficacy of the U12 cohort was attributed to superior perception and action skills associated with this age when compared to U9s. However, the SSG configurations used by the academy in this study may be constraining the player’s opportunity to demonstrate their technical soccer skills.

# 5.2 Introduction

Within English youth soccer, a modernised approach towards the development of talented players has been implemented in the form of the Premier League’s Elite Player Performance Plan (EPPP) (The Premier League, 2011), with the aim of producing a greater proportion of ‘home-grown’ players playing at the highest level of the sport in England. A key facet of this approach is the application of the theory of deliberate practice. This requires an individual to engage in domain-specific activities requiring significant cognitive and physical effort, with the aim of improving performance in their chosen domain (Ericsson, Krampe, & Tesch-Romer, 1993; Helsen, Starkes, & Hodges, 1998; Ward, Hodges, Starkes, & Williams, 2007; Ward, Hodges, Williams, & Starkes, 2004).

Elite youth soccer players in England tend to join professional academies at age 10 and accrue 4207 hours in soccer activity by age 16 (Ford et al., 2012), with those attaining professional contracts in soccer at this age considered as ‘experts’ in their domain (Ford, et al., 2009a). Engaging in deliberate practice activities throughout childhood is a key determinant of reaching professional status (Hendry, Williams, & Hodges, 2018), along with being perceived as the most relevant and enjoyable activity for developing soccer-specific expertise (Helsen et al., 1998). Through engaging in these activities, the athlete is able to develop perceptual-cognitive skills that enable the successful application of sport-specific techniques in any given scenario. These skills include; advance cue utilisation (i.e. detecting early visual information from an opponent or teammates ahead of an event); pattern recognition (i.e. recognising common patterns of play as they evolve); visual search behaviour (i.e. searching the environment for the most relevant information and ignore irrelevant information); situational probabilities (i.e. predicting the potential future outcomes of ahead of the event occurring); and strategic decision-making (i.e. deciding upon the course of action in any given scenario) (Williams & Ford, 2008). A key component of the EPPP is the implementation of academy-specific coaching curricula that increase the amount of coaching hours available to players in English soccer academies, thus presenting players with greater opportunity to develop technical skill, game understanding, and decision-making in soccer. English soccer academies are then faced with the challenge of structuring practice within their curriculum to maximise deliberate practice opportunities, to therefore produce skilful soccer players.

Training form (i.e. drill-based repetition of techniques, alone or in small-groups) activities provide the athlete with the opportunity to focus their attention on honing the intricacies of fundamental techniques (e.g. passing and dribbling the ball in soccer) without external interference from opposition players (Ford et al., 2010). The concept of Contextual Interference enables coaches to manipulate training form activities to maximise skill acquisition. Training form activities are often structured in a blocked, constant and massed manner (low contextual interference), while playing form activities enable a random, variable, and distributed practice structure (high contextual interference) (Cushion, Ford, & Williams, 2012; Williams & Hodges, 2005). Soccer coaches typically progress their sessions from low contextual interference training form activities to high contextual interference playing form activities in-line with perceived competency of the player through observation. However, this progression has been criticised for being too slow, often restricting the development of players by limiting their opportunity to practice in a game-based setting (Williams & Hodges, 2005).

In contrast, playing form (i.e. activities structured in a similar manner to competition) activities provide the athlete with a greater opportunity to develop fundamental perceptual, cognitive, and motor skills (e.g. identifying a teammate in open space to receive a pass) in a dynamic environment relevant to competition (e.g. small-sided games) (Williams & Ford, 2008). Soccer coaches are faced with the challenge of creating an ecologically valid training environment that provides the opportunity to refine key techniques in training form activities while transferring them to game-based scenarios (playing form activities) (Ford et al., 2010). Therefore, there is a need to assess the efficacy of soccer coaching at the elite level in relation to the EPPP to determine whether this model is effective when implemented in elite soccer academies.

Existing soccer-specific skill tests, such as the Loughborough Soccer Passing Test, have been used to discriminate skill level in youth soccer. However, these tests lack specificity due to them not fully replicating the actual environment and constraints of soccer match-play by de-coupling perception, cognition and action. Furthermore, these tests are limited in their sensitivity in detecting intra-individual changes in performance over time (Ali, Williams, Hulse, Strudwick, Reddin, Howarth, Eldred, Hirst & McGregor, 2007; Serpiello, Cox, Oppici, Hopkins, and Varley, 2017; Wen, Robertson, Hu, Song & Chen, 2017). Consequently, it could be argued that tests of this nature measure technique proficiency, rather than skill. Utilising playing form activities instead of such tests may be the most appropriate setting to assess soccer skill due to their replication of competitive match scenarios and the subsequent constraints placed upon time and space.

Small-sided games (SSGs) are commonly used by soccer coaches to provide players with the opportunity to apply techniques and tactics in a competitive game and have been shown to be appropriate for assessing the technical skill of soccer players when combined with observational analysis techniques (see Chapter 3: Study 1; Fenner, Iga & Unnithan, 2016). While this approach enables coaches to assess the acquisition of soccer-specific skills in a short-term period, there is little evidence to suggest that soccer coaches consider the retention of these skills after a period without systematic soccer coaching (i.e. returning to coaching after the post-season break) (Williams & Hodges, 2005). Without this information, coaches are unable to determine the efficacy of their previous season’s coaching in developing soccer-specific skills.

The Developmental Model of Sports Participation (DMSP) provides a conceptual framework for assessing the rate of skill acquisition across three age-associated stages, Sampling (6 – 12 years), Specialisation (13 – 15 years), and Investment (16+ years) (Côte, Baker, & Abernethy, 2007). In regards to the sampling stage of the DMSP, elite youth soccer players in England can be recruited into academies at age 8. Therefore, a cohort of under-9 (U9) soccer players from within a professional academy are of particular interest due to their limited exposure to systematic soccer training of an elite standard, and therefore potentially greater capacity to experience gains in technical soccer performance (Côte et al., 2007; Ford et al., 2012). In contrast, aside from the differences in physical development (Malina & Bouchard, 1991), by the end of the sampling stage (age 12), young athletes are expected to have reached a plateau in the rate of technical skill development (Côte et al., 2007). At this point, developing tactical game-based understanding becomes the focus of training, thus enabling researchers to investigate whether technical skill development does indeed plateau, or continues to develop at this stage (Ford et al., 2010; Williams & Hodges, 2005). Therefore, a cohort of U12 elite soccer players provides a further group of interest in assessing the efficacy of elite soccer coaching.

The aim of the study was to assess the efficacy of systematic soccer coaching on the acquisition and retention of technical soccer skills across age-divided cohorts (U9 & U12) within the game-based setting of SSGs. It was hypothesised that after a period of systematic soccer training, both the U9 and U12 cohorts would experience an improvement in technical soccer skill both in the acquisition, and retention phases. However, a direct statistical comparison is not formed due to the difference in current accumulation of deliberate practice hours and associated stage of the DMSP (Côte et al., 2007).

# 5.3 Methods

## 5.3.1 Participants

Eighteen under-9 (U9) players (age: 8.8 ± 0.4 years, stature: 132.9 ± 3.4 cm, mass: 27.1 ± 2.1 kg) contracted to a Category 1, EPL academy volunteered to participate in the study. The players trained at the academy for an average of 6.9 hours per week, 10 months per year, with an average of 1.5 years previously spent at the academy. Twenty under-12 (U12) players (age: 11.4 ± 0.5 years, stature: 147.3 ± 7.3 cm, mass: 37.4 ± 6.8 kg) contracted to the same academy volunteered to participate in the study. The players trained at the academy for an average of 8.3 hours per week, 10 months per year, with an average of 4.2 years previously spent at the academy.

The research was conducted in accordance with the ethical guidelines of the club, with ethical approval obtained from a local University Ethics Committee. Participants provided written assent, with their parents/guardians providing written informed consent. Participants had completed a full health check with the club’s medical staff, along with a medical questionnaire administered by the academy as part of their registration process. Thus, all participants were asymptomatic and fit to take part in the study.

## 5.3.3 Study Design

## 5.3.3.1 Coaching Curriculum

The coaching curriculum used by the academy was created and implemented in-line with EPPP guidelines. The curriculum was designed to improve the following technical behaviours: passing and receiving the ball, manipulating the ball into available space and away from opponents, shooting at goal, intercepting opposition passes, and tackling. The U9 group completed 56 sessions (4 per-week) between baseline and post-test phases, equating to 6.9 hours of soccer-specific coaching per week, of which 5.1 hours were dedicated to technical practice (74% of total coaching time). The U12 group completed 65 coaching sessions (5 per week) between baseline and post-test (acquisition), equating to 8.3 hours of soccer-specific coaching per week, of which 5.25 hours were dedicated to technical practice (67% of total coaching time). The remaining coaching hours were spent in tactical practice, individual position-specific practice, or injury prevention activities. Following the same structure, between post-test and retention phases, the U9 cohort completed a further 56 sessions (4 per-week), while the U12 cohort completed a further 70 sessions (5 per-week) in the 2013/14 soccer season. There was a post-season break of 10 weeks between the end of the 2013/14 season and the 2014/15 season for both cohorts, where no soccer coaching at the academy took place. Both cohorts completed 14 sessions (2 per-week) in the 2014/15 soccer pre-season period prior to the retention phase, and remained with the same coaching staff throughout the data collection process. Figure 1 represents the data collection process for the U9 and U12 cohorts.

## 5.3.3.2 Evaluation of Coaching Efficacy

The study comprised of three phases: baseline, post-test (acquisition phase: the degree to which technical soccer skills improved from Baseline levels), and retention (the degree to which technical soccer skills were retained from the post-test/acquisition phase). Baseline performance was collected in August of the 2013/14 English soccer season, and again in January 2014 after the post-test (acquisition) phase, followed by a 12-month retention test in August 2014. The study comprised of seven small-sided games (SSGs) per group: three at baseline, three at post-test, and one retention. Games at the start (baseline) and end of the acquisition phase were conducted within a 7-day period. Each SSG was filmed and coded using notational analysis to collate technical performance data for comparison between phases.

Pre-season

Post-season

In-season

Pre-season

12-month retention test

(1 SSG)

Baseline

(3 SSGs)

Post-test

(3 SSGs)

56 sessions

(4 per-week)

56 sessions

(4 per-week)

Post-season break

(10-weeks)

14 sessions

(2 per-week)

65 sessions

(5 per-week)

65 sessions

(5 per-week)

**U9**

**U9**

**U12**

**U12**

# Figure 5.1. Data collection timeline for U9 and U12 cohorts

## 5.3.3.3 Small-sided Game Configuration

Coaches were instructed to select two teams (Team A vs. Team B) of perceived equal ability from the pool of recruited participants. The U9 group played 5 vs. 5 (1 goalkeeper, 2 defenders, 1 midfielder, 1 attacker) for 2 x 15 minute periods using conventional soccer rules on a 40 x 30 m pitch, resulting in an individual playing area of 150 m2 (Fradua, Zubillaga, Caro, Fernández-García, Ruiz-Ruiz, & Tenga, 2013). All eight outfield players participated in the seven SSGs. The average duration of the SSGs was 28.3 ± 1.7 minutes (1st period = 13.9 ± 0.74 minutes, 2nd period = 14.4 ± 1.2 minutes). The U12 group played 8 vs. 8 (1 goalkeeper, 2 defenders, 3 midfielders, 2 attackers) for 2 x 15 minute periods using conventional soccer rules on a 60 x 40 m pitch, resulting in an individual playing area of 171.4 m2 (Fradua et al., 2013). Ten of the fourteen outfield players took part in the seven SSGs. Four players were unable to partake in all SSGs due to injury, and were consequently removed from subsequent data analysis. The average duration of the SSGs was 29.8 ± 0.54 minutes (1st period = 14.9 ± 0.34 minutes, 2nd period = 14.9 ± 0.23 minutes). All SSGs took place at the club’s training ground on a 3rd generation artificial playing surface with pitch size based on English Football Association (FA) recommendations for mini-soccer (U9) and youth soccer (U12).

## 5.3.3.4 Filming and Analysis

All SSGs were recorded using a ‘wide-angle’ perspective on a video camera (Samsung HMX-H300, Seoul, South Korea) with a frame-rate of 30 fps and shutter speed of 1/60th. The camera was mounted on a tripod (Manfrotto, Leicester, UK) from a telescopic tower (Teletower, Essex, UK); at a distance of 1 m from the side of the pitch, on the half way line. Technical performance data was collated for each SSG using the Soccer-Specific Behaviour Measurement Tool (S-SBMT) within Dartfish 6 software (Fribourg, Switzerland). Chapter 4: Study 1, outlines the process of determining this tool’s validity, objectivity and reliability, with Table 3.1 showing the definitions for each behaviour within the tool.

One observer, with 4 years professional experience as a performance analyst was recruited to code all SSGs. The first SSG of both groups was used to check intra-observer reliability after a period of 7-days. All technical behaviours were found to be above the 85% agreement level (Siedentop, 1976), thus ensuring the consistency of the observer in using the S-SBMT.

## 5.3.4 Statistical Analysis

To account for variation in SSG duration, frequency of performance indicators were converted to rate per minute to normalise the data for further analysis. Descriptive statistics (mean ± standard deviation) and 90% Confidence Intervals were calculated to express the likely true value of the mean. The smallest worthwhile change (SWC) for each variable was calculated as 0.2 multiplied by the between-subject standard deviation according to Cohen’s effect size thresholds (Hopkins et al., 2009).

A magnitude based inferences (MBI) approach was used to evaluate the true effects of the coaching curriculum in relation to the SWC, presenting a percentage chance of positive, trivial, or negative effects on technical performance (Hopkins et al., 2009). Standardised thresholds of 0.2 (small), 0.6 (moderate), 1.2 (large), 2.0 (very large) and 4.0 (extremely large) multiplied by the pooled between-subject SD were used to determine the magnitude of the effect. Chances were expressed with the percentage scale: 0 – 0.49 = most unlikely, 0.5 – 5 = very unlikely, 5.1 – 25 = unlikely, 25.1 – 75 = possibly, 75.1 – 95 = very likely, 95.1 – 100 = most likely. An effect was deemed unclear if the confidence interval overlapped the thresholds set by an odds ratio of 66. This ensured that >25% chance of positive and <0.5% of negative constituted a decisively useful effect. All MBI calculations were completed using a Microsoft Excel spreadsheet formulated by Hopkins (2007).

# 5.4 Results

## 5.4.1 U9

Table 5.1 shows from Baseline to Post-test that the average rate per minute for most variables was found to decrease, with the largest decrease being observed for the number of successful passes (0.07, *d* = 0.32). Only the number of ball manipulations remained unchanged. From Post-test to Retention, the average rate per minute increased for ball manipulations (0.02, *d* = 0.18), goal attempts (0.03, *d* = 0.25), and successful goal attempts (0.04, *d* = 0.51). Decreases were observed for the number of passes (0.03, *d* = 0.10), successful passes (0.04, *d* = 0.20), and defensive actions (0.04, *d* = 0.30). Successful ball manipulations remained unchanged. From Baseline to Retention, the average rate per minute for most variables was found to decrease, with the largest decrease (0.07) being observed for the number of passes (*d* = 0.24) and defensive actions (*d* = 0.37). Only the number of ball manipulation attempts were found to increase (0.02, *d* = 0.12).

Based upon the SWC for each variable, the coaching curriculum elicited performance changes in the U9 group ranging from no effect, to approaching a moderate effect, for all variables across all three phases of data collection (Table 5.1). Possible positive effects were observed for all variables with the exception of Goal Attempt Success (19.2% = unlikely positive effect) (Figure 5.4) over the 6-week period from baseline to post-test. The most likely possible positive effect was associated with the frequency of ball manipulation (48.9% possible positive effect), and its success (43.9% possible positive effect) (Figure 5.3). A possible positive effect was observed for all variables from post-test to retention, with Goal Attempt Success the most likely variable to have improved during this phase (63.2% possibly positive) (Figure 5.4). Over the 12-month period from baseline to retention, there was a possible positive effect for all variables (23.4% = unlikely positive effect). Ball manipulation and goal attempts were the most likely skills to have been retained after the 12-month retention test both in regards to frequency (ball manipulation = 49.5% possibly positive; goal attempts = 43.3% possibly positive) and success (ball manipulation success = 43% possibly positive; goal attempt success = 47.3% possibly positive). The overall non-clinical inference for all variables across all phases of data collection was unclear due to the limited sample size.

# Table 5.1. Changes in technical performance of the U9 cohort across all data collection phases (average rate per minute)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ***Pre-test*** | ***Post- test*** | ***Retention*** | ***Baseline to Post-test*** | | | ***Post-test to Retention*** | | | ***Baseline to Retention*** | | |
|  | **Mean ± SD [90% CI]** | **Mean ± SD [90% CI]** | **Mean ± SD [90% CI]** | **SWC** | **Mean Difference** | **Effect Size** | **SWC** | **Mean Difference** | **Effect Size** | **SWC** | **Mean Difference** | **Effect Size** |
| Number of Passes | 1 ± 0.24  [1.16, 0.83] | 0.95 ± 0.16  [1.06, 0.84] | 0.92 ± 0.34  [1.16, 0.69] | 0.05 | -0.05 | 0.22 | 0.03 | -0.03 | 0.10 | 0.07 | -0.07 | 0.24 |
| Successful Passes | 0.74 ± 0.26  [0.92, 0.57] | 0.68 ± 0.14  [0.77, 0.58] | 0.64 ± 0.24  [0.8, 0.47] | 0.05 | -0.07 | 0.32 | 0.03 | -0.04 | 0.20 | 0.05 | -0.10 | 0.42 |
| Ball Manipulation | 0.19 ± 0.18  [0.31, 0.07] | 0.19 ± 0.08  [0.24, 0.14] | 0.21 ± 0.10  [0.28, 0.13] | 0.04 | 0 | 0.00 | 0.02 | 0.02 | 0.18 | 0.02 | 0.02 | 0.12 |
| Successful Ball Manipulation | 0.12 ± 0.06  [0.17, 0.08] | 0.11 ± 0.06  [0.15, 0.07] | 0.11 ± 0.06  [0.15, 0.07] | 0.01 | -0.01 | 0.18 | 0.01 | 0 | 0.01 | 0.01 | -0.01 | 0.19 |
| Goal Attempts | 0.26 ± 0.12  [0.34, 0.18] | 0.21 ± 0.11  [0.28, 0.14] | 0.24 ± 0.11  [0.31, 0.16] | 0.02 | -0.05 | 0.45 | 0.02 | 0.03 | 0.25 | 0.02 | -0.02 | 0.21 |
| Successful Goal Attempts | 0.15 ± 0.09  [0.21, 0.09] | 0.11 ± 0.07  [0.15, 0.06] | 0.14 ± 0.08  [0.2, 0.09] | 0.02 | -0.04 | 0.55 | 0.01 | 0.04 | 0.51 | 0.02 | -0.01 | 0.06 |
| Defensive Actions | 0.34 ± 0.14  [0.43, 0.24] | 0.31 ± 0.16  [0.42, 0.2] | 0.27 ± 0.10  [0.34, 0.2] | 0.03 | -0.03 | 0.19 | 0.03 | -0.04 | 0.30 | 0.02 | -0.07 | 0.37 |

Figure 5.2. Percentage chance of the coaching curriculum inducing positive, trivial, or negative effects for passing frequency and success in the U9 cohort

Passing

Success

Passing

Figure 5.3. Percentage chance of the coaching curriculum inducing positive, trivial, or negative effects for ball manipulation and success in the U9 cohort

Ball

Manipulation

Ball

Manipulation

Success

Figure 5.4. Percentage chance of the coaching curriculum inducing positive, trivial, or negative effects for goal attempts and success in the U9 cohort

Goal Attempt

Success

Goal Attempts

Defensive

Actions

# Figure 5.5. Percentage chance of the coaching curriculum inducing positive, trivial, or negative effects for defensive actions in the U9 cohort

## 5.4.2 U12

Table 5.2 shows from Baseline to Post-test that the average rate per minute for the number of passes and successful passes increased (increase: number of passes = 0.11, *d* = 0.57; successful passes = 0.08, *d* = 0.52). The number of ball manipulations and successful ball manipulations decreased, along with defensive actions (decrease: number of ball manipulations = 0.02, *d* = 0.28; successful ball manipulations = 0.02, *d* = 0.54; defensive actions = 0.07, *d* = 0.35). The number of goal attempts and successful goal attempts remained unchanged. From Post-test to Retention, most variables increased, with the largest increase being observed for the number of passes (0.13, *d* = 0.67). Only the number of successful goal attempts remained unchanged. From Baseline to Retention, most variables increased, with the largest increase being observed for the number of passes (0.24, *d* = 1.12). Only the number of defensive actions decreased (0.04, *d* = 0.18).

Based upon the SWC for each variable, the coaching curriculum elicited performance changes in the U12 group ranging from small effects, to approaching a large effect, for all variables across all three phases of data collection (Table 5.2). Possible positive effects were observed for all variables across the 6-week period from baseline to post-test. The largest possible positive effect was for passing frequency (68.3% possible positive effect), closely followed by passing success (65% possible positive effect) (Figure 5.6). From post-test to retention, likely positive effects were observed for passing frequency (77.6% likely positive effect) (Figure 5.6) and ball manipulation success (86.5% likely positive effect) (Figure 5.7). Over the 12-month period from baseline to retention, a very likely positive effect was found for passing frequency (97.4% very likely positive effect), with a likely positive effect for passing success (92.9% likely positive effect) (Figure 5.6). The overall non-clinical inference for all variables across all phases of data collection was unclear due to the limited sample size.

# Table 5.2. Changes in technical performance of the U12 cohort across all data collection phases (average rate per minute)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ***Pre-test*** | ***Post- test*** | ***Retention*** | ***Baseline to Post-test*** | | | ***Post-test to Retention*** | | | ***Baseline to Retention*** | | |
|  | **Mean ± SD [90% CI]** | **Mean ± SD [90% CI]** | **Mean ± SD [90% CI]** | **SWC** | **Mean Difference** | **Effect Size** | **SWC** | **Mean Difference** | **Effect Size** | **SWC** | **Mean Difference** | **Effect Size** |
| Number of Passes | 0.56 ± 0.21  [0.67, 0.45] | 0.67 ± 0.17  [0.76, 0.58] | 0.81 ± 0.23  [0.93, 0.69] | 0.04 | 0.11 | 0.57 | 0.03 | 0.13 | 0.67 | 0.05 | 0.24 | 1.12 |
| Successful Passes | 0.44 ± 0.16  [0.53, 0.36] | 0.52 ± 0.16  [0.61, 0.44] | 0.61 ± 0.19  [0.71, 0.51] | 0.03 | 0.08 | 0.52 | 0.03 | 0.08 | 0.48 | 0.04 | 0.17 | 0.93 |
| Ball Manipulation | 0.12 ± 0.08  [0.16, 0.08] | 0.10 ± 0.08  [0.14, 0.06] | 0.13 ± 0.08  [0.17, 0.08] | 0.02 | -0.02 | 0.28 | 0.02 | 0.03 | 0.36 | 0.02 | 0.01 | 0.08 |
| Successful Ball Manipulation | 0.08 ± 0.04  [0.10, 0.07] | 0.06 ± 0.04  [0.09, 0.04] | 0.11 ± 0.08  [0.15, 0.07] | 0.01 | -0.02 | 0.54 | 0.01 | 0.05 | 0.74 | 0.02 | 0.03 | 0.41 |
| Goal Attempts | 0.09 ± 0.08  [0.13, 0.05] | 0.09 ± 0.08  [0.13, 0.05] | 0.10 ± 0.08  [0.14, 0.05] | 0.02 | 0 | 0.02 | 0.02 | 0.01 | 0.07 | 0.02 | 0.01 | 0.08 |
| Successful Goal Attempts | 0.05 ± 0.05  [0.07, 0.02] | 0.05 ± 0.04  [0.07, 0.03] | 0.05 ± 0.07  [0.09, 0.02] | 0.01 | 0 | 0.09 | 0.01 | 0 | 0.06 | 0.01 | 0.01 | 0.13 |
| Defensive Actions | 0.27 ± 0.22  [0.39, 0.16] | 0.21 ± 0.14  [0.28, 0.13] | 0.24 ± 0.17  [0.33, 0.15] | 0.03 | -0.07 | 0.35 | 0.03 | 0.03 | 0.19 | 0.04 | -0.04 | 0.18 |

Figure 5.6. Percentage chance of the coaching curriculum inducing positive, trivial, or negative effects for passing frequency and success in the U12 cohort

Passing

Passing

Success

Figure 5.7. Percentage chance of the coaching curriculum inducing positive, trivial, or negative effects for ball manipulation and success in the U12 cohort

Ball

Manipulation

Ball

Manipulation

Success

Figure 5.8. Percentage chance of the coaching curriculum inducing positive, trivial, or negative effects for goal attempts and success in the U12 cohort

Goal Attempts

Goal Attempt

Success

Defensive

Actions

# Figure 5.9. Percentage chance of the coaching curriculum inducing positive, trivial, or negative effects for defensive actions in the U12 cohort

# 5.5 Discussion

The aim of the study was to assess the efficacy of a ‘Category One’ English Premier League soccer academy’s coaching programme in improving the technical skills of U9 and U12 cohorts based on the academy soccer playing philosophy. It was predicted that both the U9 and U12 cohorts would experience improvements in the acquisition and retention of technical soccer ability. The two groups were assessed independent of one another, with no comparison being formed due to their differences in accumulated hours in soccer-specific practice, the focus of their respective coaching programmes, and associated stage of the DMSP (Côte et al., 2007).

The U9 cohort were expected to significantly increase their technical ability over the course of the training programme due to their early engagement with soccer and previous limited accumulation of soccer-specific practice hours; thus providing greater capacity for improvement (Côté et al., 2007; Ford et al., 2009a; Ford et al., 2012). However, performance remained relatively unchanged, even after a 12-month retention period, and this could be due to the limited perception and action ability of players at this age. At ages 8 and 9, players will be continuing to develop their technique, and may well show a good level of proficiency and rapid improvement in drill-based activities, where decision-making is relatively simple (Baker & Côte, 2006). However, in a SSG, there are multiple solutions to the same problem due to the inherent variability of this type of activity (Williams & Hodges, 2005). It could be that the problem representation skills of U9 cohort are still developing. Their ability to utilise strategic planning to effectively predict probable outcomes and anticipate the movements of opponents and teammates could be underdeveloped, and may not emerge until age 15/16 (French & McPherson, 1999), or develop fully until early adulthood (Chase & Simon, 1973; Ericsson et al., 1993; McPherson, 1999; Ward & Williams, 2003).

The SSG configuration used may be too cognitively challenging for U9 players, who are unable to make effective decisions regarding which players are the best option for ball retention or chance creation, along with the best method for getting the ball to the correct player. Additional support for this notion can be seen when comparing the two age groups in regards to frequency and success rates of passing and ball manipulation. The U12s attempted fewer passes and ball manipulations per minute than the U9s, but were on average 5.5% (±1.6%) more successful at passing, and 14.2% (±15.9%) more successful at manipulating the ball compared to the U9s. Furthermore, this may suggest that the current configuration for SSGs at this age group within this particular academy may be masking any potential improvements gained through the soccer coaching curriculum. In regards to the challenge point framework (Guadagnoli & Lee, 2004), reducing the number of players involved in the SSG, along with increasing the playing area size, will increase individual player participation while reducing the number of external stimuli. This would provide players with greater opportunity to utilise technical skills in a less challenging environment, thus making any gains in technical performance easier (Clemente et al., 2014; Fenner, Iga, & Unnithan, 2016; Fradua, et al., 2013; Jones & Drust, 2007).

The U12 group appeared to improve their ability to pass the ball both in the 6-week acquisition and 12-month retention phases in regards to the number of passes attempted, and the number that successfully reached the intended team mate. Additionally, although the frequency of ball manipulation remained relatively unchanged across all three phases, the ability of the group to travel with the ball into available space successfully appeared to enhance over the 12-month data collection period. This could suggest that these players are consolidating their technical proficiency from previous years training and beginning to develop knowledge of how to effectively utilise these skills in game-based scenarios (Vaeyens et al., 2007; Ward & Williams, 2003). Additionally, the U12 cohort having an additional 21.4 m2 of individual playing area during their SSGs compared to the U9s may also explain these improvements. The additional space may have resulted in more time to make decisions, and therefore better passing and ball manipulation decisions being made (Olthof et al., 2018).

Another factor that may explain the improvement of the U12 cohort is the accumulation of soccer-specific practice activity. The U12 players are likely to have accrued more time than their U9 counterparts in this type of activity, therefore enhancing their decision-making ability when faced with a dynamic environment – in this case, when to pass the ball, and who to pass the ball to (Ford et al., 2012; Ford et al., 2009a; Hendry et al., 2018). Results from this study could suggest that one of the first skills to undergo perception-action coupling in soccer is passing. The data may suggest that the U12 cohort are able to effectively execute the skill of passing the ball, and may suggest an improved ability to make correct decisions regarding the intended recipient of the pass in a match-play scenario. Additionally, the observed improvements may be due to implicit tactical learning through game-based activities, as the U12 coaching curriculum included a higher proportion of this type of activity compared to the U9s (Berry & Abernethy, 2003; Cote at al., 2007; Williams & Ford, 2008).

However, not all skills increased to the same extent. Attempts on goal and defensive actions remained relatively unchanged. Game-based activities help develop problem solving abilities (Ford et al., 2010; Williams & Hodges, 2005). Due to the nature of invasion games like soccer, skills such as shooting at goal, or electing to stand or slide tackle, require the player to continually assess their environment and anticipate the actions of their own team-mates and opposition players (Aquino et al., 2016). Therefore, the structure of the SSG may be constraining the players due to limited time and space, thus preventing these skills from being demonstrated successfully (Olthof et al., 2018), or at a frequency that enables reliable observation (Hughes et al., 2001; O’Donoghue, 2005).

This highlights the need for clubs to effectively monitor the efficacy of their training programmes in developing talented youth soccer players. By age 12, players will have established a successful array of techniques for effectively playing the sport and will begin to develop their decision-making ability, in-turn enhancing skillful performance. Therefore, SSGs present a game-relevant context in which to evaluate the technical skill of players at this age in relation to the club’s coaching programme. However, from a practical implication standpoint, the 5v5 SSG configuration used by the academy for the U9 cohort in this study may not provide enough individual playing area for technical skill to be demonstrated effectively (Fradua et al., 2016; Olthof et al., 2018). Coaches could reduce the number of players involved and increase the space available, along with implementing conditions to restrict the number of potential decisions facing the player in possession of the ball (Fradua et al., 2016; Guadagnoli & Lee, 2004). For example, the SSG pilot scheme conducted by Manchester United FC places less emphasis on the match result through scoring goals, and more on the frequency of opportunities to pass, dribble and shoot (Fenoglio, 2003). This highlights the importance of configuring SSGs to allow for sufficient opportunity for the targeted technical skills to occur at a stable frequency. This would reduce the impact of game-to-game variance, thus resulting in a more reliable data set from which assessments of player performance can be made (Bush et al., 2015; Hughes et al., 2001; O’Donoghue, 2005).

The amount of time spent in drill- and game-based activities within the U9 coaching programme may be limiting the development of technical skills due to fewer opportunities to practice techniques under game-based constraints. Ford et al. (2010) reported that 13 and 9 year old youth soccer players spend 59 and 69% of deliberate practice time in drill-based practice respectively. Similar observations were found in this study, with the U12 and U9 groups spending 67 and 74% of practice in technical practice activities, which are inherently low in contextual interference, and therefore reduce successful learning of skills (Williams & Hodges, 2005). Thus, it could be suggested that the U9 group would benefit from reducing the volume of technical practice in favour of more game-based activities, thus providing a greater opportunity to practice skills under game-based constraints. However, the amount of individual playing space, manipulated through pitch size and number of players, should be considered when implementing SSGs to ensure that players have adequate opportunity to utilise their technical skills rather than utilising the English FA guidelines for SSG configuration (Fradua et al., 2016).

The present study was able to gain access to two cohorts from within an elite soccer population and provide insight into how systematic soccer coaching affects the development of technical soccer skills within a game-specific context. This was a departure from the traditional video-based simulation or closed-drill type data collection methods found in previous research, thus increasing ecological validity as perception and action are not de-coupled. Despite the highly variable nature of SSGs, results from this study may suggest that passing occurs at a frequency that is stable enough to assess skillful performance during SSGs using these particular configurations. However, not all skills appeared with the same frequency, and it may be that different SSG configurations are more appropriate for assessing other technical skills (Fenoglio, 2003). The approach used by Manchester United FC may enable the frequency of technical soccer skills to stabilise through its larger sample size, thus increasing the chances of actual performance changes being observable (Hughes et al., 2001; O’Donoghue, 2005).

Only the soccer coaching curriculum has been considered when discussing changes in technical skill. In light of the support for a multi-sport approach to skill acquisition, a wider range of activities need to be explored in order to develop a holistic view of the environment that fosters talented youth soccer players. For example, does a greater volume of habitual physical activity through unstructured play provide a superior stimulus for developing skillful performance in youth soccer players? This may enable the inter-player variability in performance to be explained, and is a potential avenue for future research.

To summarise the limitations of the present study, it is acknowledged that the SSG configuration may have resulted in constraining the execution of technical soccer skill due to a challenge point that was too high as a result of the amount of available individual playing area, particularly for the U9 cohort (Guadagnoli & Lee, 2004). Additionally, the number of SSGs may have prevented the stabilisation of technical skills, therefore potentially preventing the accurate assessment of some skills across both cohorts. Furthermore, growth and maturation data for the U12 cohort would have been useful in explaining the development of technical skills. Around age 10-11 years, the growth rate of boys begins to accelerate, which in turn may have a detrimental effect on the ability to perform fundamental movement skills (Malina, 2014). However, it is not known in this study whether this was a contributing factor to any changes in the U12 cohort.

In conclusion, results may suggest that small-sided games based upon English FA recommendations for U9 cohorts may not allow us to fully capture and assess technical skill acquisition and retention. However, the U12 configuration may enable the assessment of passing frequency and success to be measured in a reliable manner. An appropriate method for assessing technical skill is required in order to determine the efficacy of soccer coaching curricula, particularly in the EPPP context where developing elite standard players is a primary objective. While Chapter 3: Study 1 demonstrated that the tool used to collect data in this study is objective and reliable, the use of SSGs as a vehicle for assessing technical skill development may be constraining player’s opportunity to demonstrate their skills if not configured to provide suitable individual playing area for each player.

# *Chapter 6:*

# Study 3: The effect of habitual physical activity levels on the development of technical soccer behaviours in elite youth soccer players

# 6.1 Abstract

Research has suggested that engaging in appropriate levels of moderate-to-vigorous physical activity (MVPA) can enhance executive functions (EF) within the brain, and thus the ability to perform complex movement patterns in a sporting context. Therefore, the aim of this study was to investigate whether levels of habitual physical activity were linked to the development of technical soccer skill. Participants were the same U9 and U12 cohorts from Chapter 5: Study 2. Both groups wore an ActiGraph GT3X+ triaxial accelerometer for a 7-day period to collate physical activity data across sedentary, light, MVPA, vector magnitude counts per minute (VM CPM), and total steps taken on a daily basis. These data were then correlated with the technical skill acquisition and retention data from Study 2. Average wear-time was 12.9 ±1.3 (U9) and 11.9 ±2.1 (U12) hours per day. Results showed that the U9 group engaged in an average of 4.6 ±2.5 (*t*(7) = -5.1, *p* = .001, *d* = 1.9) MVPA minutes per hour, 492.4 ±345.3 (*t*(7) = -4.0, *p* = .005, *d* = 1.9) VM CPM, and 4953.7 ±2177.7 (*t*(7) = -6.4, *p* = .000, *d* = 2.7) steps per day more on training days compared to non-training days. Sedentary time was 4.1 ±2.9 minutes per hour (*t*(7) = 3.9, *p* = .006, *d* = 1.3) higher on non-training days compared to training days. There were no statistically significant differences between the training and non-training days across all measures for the U12 group. Very weak, statistically insignificant correlations were found between physical activity variables and the development of technical soccer skills for both groups. Overall, results from the study suggest that additional physical activity habits are not related to the development of technical soccer skill. Systematic soccer training may be constraining the volume of physical activity engaged with on non-training days for U9, but not U12 players. Past and current engagement with other sporting activities in both groups support the early specialisation pathway.

# 6.2 Introduction

Engaging in structured physical activity and the development of fundamental movement skills (FMS) (e.g. throwing, catching, kicking) share a reciprocal relationship in children (McKenzie et al., 1998) and adolescents (McKenzie et al., 2002). This dynamic relationship postulates that increased levels of structured physical activity present more opportunities to practice and develop FMS, in turn leading to an increase in perceived competence and therefore increased adherence to the activity (Stodden et al., 2008).

Soccer is an activity that requires the application of several FMS while performing exercise bouts of varying intensities and in a dynamic, complex environment. Pre-pubescent soccer players have been shown to operate at heart rates in excess of 170 bpm, and have to balance this high intensity exercise with effectively performing key technical actions in order to produce effective performance (Capranica et al., 2001). The stimulus that non-soccer specific levels of physical activity can bring to FMS has not been evaluated in either recreational or highly trained youth soccer players.

The evidence is unequivocal that regular participation in soccer during childhood and adolescence (age 9 to 16 years) can contribute towards requisite daily levels of moderate to vigorous physical activity (MVPA) (Duda et al., 2013; Fenton et al., 2015; Wold et al., 2013). Furthermore, Fenton et al. (2015) reported that in a sample of 109 recreational youth soccer players (Mean age: 11.98 ± 1.75 years), 36.7% were able to achieve ≥60 daily minutes of MVPA through weekend participation. Additionally, Fenton et al. (2016) reported that only 16% of recreational youth soccer players (N = 118; Mean age: 11.72 ± 1.60 years) accrued 60 daily minutes of MVPA. While the benefit of participating in recreational soccer is clear, the evidence of whether this leads to compensatory behaviour (down regulation of physical activity) on the non-training days is not clear. In children age 8 – 11 years, the ActivityStat hypothesis, whereby higher levels of MVPA on one day, are compensated for on the next, may explain the down regulation of physical activity in response to days involving MVPA (Ridgers et al, 2018; 2015; 2014). Accruing 10 minutes of MVPA on any given day results in a reduction of between 5 (Ridgers et al., 2014) and 9.3 (Ridgers at al., 2018) minutes MVPA on the following day, along with a reduction of approximately 25 minutes light physical activity (LPA). Moreover, the impact of systematic soccer participation on skill acquisition also remains unanswered.

While these issues remain interesting but unresolved in recreational soccer, they both have meaningful impacts at the elite youth soccer level. With the introduction of the Premier League’s Elite Player Performance Plan (EPPP), it is proposed that the entry age into the academy system changes from U9 to U5, resulting in an increase in the number of systematic coaching hours from 3,760 to 8,500 by the time they reach the age of 21 (The Premier League, 2011). The impact that the exposure to high levels of training may have on both compensatory physical activity behaviour on non-training days and skill acquisition remains unanswered. These findings will have implications for both sustaining the physical capacity of the elite youth soccer player and their skill acquisition.

While physical activity levels have been investigated within recreationally active paediatric populations who partake in regular soccer activity to demonstrate the health benefits that can occur (Fenton et al., 2015; Wold et al., 2013), this paradigm has not been implemented within specific sporting populations who are engaged in elite systematic coaching programmes, in this instance: elite youth soccer players. Research has established the physical activity history of elite soccer players throughout childhood and adolescence, and suggests that elite youth soccer players in the United Kingdom specialise in the sport from an early age, with those who go on to attain professional status engaging with higher levels of soccer-specific play activities away from their systematic academy coaching programmes (Ford et al., 2009a; Ford et al., 2012; Hendry & Hodges, 2018; Hendry et al., 2018; Ward et al., 2007). However, research has yet to investigate the physical activity characteristics of these activities, or any other additional physical activity, outside of the academy environment as a potential mediating factor in technical soccer skill development.

Executive functions (EFs) are associated with the control of thought and action, and can be sub-divided into ‘Core’ and ‘Higher’ functions. Core EFs are associated with working memory, cognitive flexibility and inhibitory control, while Higher EFs control the use of information to effectively solve problems (Diamond, 2013, Luciana et al., 2005). Both Core and Higher EFs facilitate the adaptation of soccer players to the dynamic playing environment by enabling attentional focus to be directed towards appropriate environmental cues (i.e. a teammate), before processing the information and selecting an appropriate movement response (i.e. passing to a teammate who is in a suitable amount of free space). Superior EF performance in relation to soccer can be identified in elite youth soccer players and is a predictor of future success in the sport (Verburgh et al., 2014; Vestberg et al., 2017; 2012). There is evidence to suggest that engaging in aerobic physical activity can enhance EF performance in children, both as an acute bout, and as a chronic programme (Best, 2010; Buck et al., 2008; Davis et al., 2007; Fisher et al., 2011; Kamijo et al., 2011). Therefore, it could be suggested that MVPA is an important factor in enabling children to develop techniques and skills required to be successful in soccer through enhancing EF.

While Chapter 5: Study 2 provided evidence related to the efficacy of coaching in regards to the development of such techniques and skills, no information was provided in relation to the player’s habitual physical activity levels, and how this may have affected their technical skill development during a 6-week block of soccer coaching. Thus, the primary aim of the study was to determine whether there were differences in physical activity levels between non-training and training days in the same U9 and U12 cohorts investigated in Chapter 5: Study 2. The secondary aim was to determine whether there is a non-causal relationship between physical activity and the development of technical soccer skills. It was hypothesised that levels of physical activity would be higher on training days than non-training days, and those who engage in higher levels of physical activity will acquire and retain technical soccer skills to a greater extent than their less active counterparts.

# 6.3 Methods

## 6.3.1 Participants

Eight under-9 (U9) players (age: 8.8 ±0.3 years, stature: 132.4 ±3.2 cm, mass: 27.7 ±1.8 kg) and ten under-12 (U12) players (age: 11.6 ±0.4 years, stature: 148.5 ±5.2 cm, mass: 38.1 ±4.9 kg) contracted to the academy were invited to take part in this phase of the study based on their participation in Chapter 5: Study 2. The research was conducted in accordance with the ethical guidelines of the club, with ethical approval obtained from a local University Ethics Committee. Participants provided written assent, with their parents/guardians providing written informed consent. Participants had completed a full health check with the club’s medical staff, along with a medical questionnaire administered by the academy as part of their registration process. Thus, all participants were asymptomatic and fit to take part in the study.

## 6.3.2 Procedure

## 6.3.2.1 Technical Soccer Behaviour

Both cohorts completed a series of three baseline (pre-test) small-sided games (SSGs) prior to a 6-week systematic coaching cycle before completing a series of three post-test SSGs. This was followed by a 12-month retention SSG. The configuration of these SSGs along with the associated soccer coaching curricula for each cohort is detailed in Chapter 5: Study 2.

## 6.3.2.2 Habitual Physical Activity

Data collection took place during the 2013/14 soccer season. To ensure that both cohorts were engaged with their systematic soccer coaching programme, data were collected across both October and November for both cohorts. Participants wore an ActiGraph GT3X+ triaxial accelerometer (ActiGraph, Pensacola, FL, USA) on the right midaxillary line, level with the iliac crest, underneath their clothing for seven consecutive days (Monday to Sunday inclusive). Participants were asked to wear the accelerometer at all times except for sleeping and water-based activities. To prevent potential participant discomfort and damage to the accelerometer, goalkeepers were omitted from the data collection process. During the week of data collection, the U9 group took part in systematic soccer training at the football club on Monday, Wednesday, Friday, and Saturday of the data collection week. The U12 group took part in systematic soccer training at the football club on Monday, Tuesday, Thursday, and Saturday. At the request of the participating soccer academy, participants from both cohorts did not wear the activity monitor during their scheduled competitive matches at the end of the data collection week (Sunday).

The ActiGraph GT3X+ measures and records time-stamped accelerations over a dynamic range of ±6g, and is a widely used, validated accelerometer to assess sedentary time and physical activity in children and adolescents (Evenson et al. 2008; Robusto & Trost, 2012; Santos-Lozano et al. 2013). Data were sampled at 15-s epochs, and downloaded and processed by the ActiGraph propriety software (ActiLife v.6.13.2, Pensacola, FL, USA). To evaluate the time spent sedentary and in light physical activity (LPA) and MVPA, count thresholds based on the vector magnitude, developed by Hänggi et al. (2013), were used, due to having demonstrated acceptable validity in similarly aged cohorts. Steps taken and vector magnitude counts per minute (VM CPM) were also derived from ActiLife. To be included in the analyses, ≥8 hr of accelerometer wear time on ≥2 training days and ≥2 non-training/non-match days was required. A ≥8 hr wear criteria demonstrates acceptable reliability in children (Cain et al., 2013). No adjustment in requisite wear time for weekend days was made due to the cohorts’ academy training and competitive match schedule commencing at similar times to the normal school day (Ridgers et al., 2018). Non-wear was determined using vector magnitude data, as 90-consecutive minutes of 0 CPM, with a 2-minute spike tolerance if accompanied by a 30-consecutive minute small window length of 0 CPM (Choi et al. 2011).

## 6.3.2.3 Technical Soccer Performance Index

Technical soccer skill performance data from Chapter 5 (Study 2) were used to create a *Technical* Soccer *Performance Index* (TSPI)based upon the increase or decrease in performance between acquisition and retention phases. The smallest worthwhile change (SWC) was calculated for each technical behaviour by multiplying 0.2 by the between-participant standard deviation as per Cohen’s effect principle (Hopkins et al., 2009). Each player’s increase or decrease for the acquisition and retention phases was transformed into points depending upon the extent to which performance changed in regards to the SWC (Table 6.1). Points were then summed to result in an overall TSPI (example data in Table 6.2).

## 6.3.2.4 Physical Activity Questionnaire and Diaries

The Participation History Questionnaire (PHQ) was used to collect information regarding the developmental activities engaged in throughout childhood (Ford et al., 2010; Ford et al., 2012). The PHQ comprised of three sections: soccer-specific milestones (start age in: soccer, supervised practice, soccer competition, & participation in an elite soccer academy), engagement in soccer-specific activities (competition, team practice, individual-led practice, & play), along with engagement in other sporting activities (minimum of 3 months participation). Engagement in other sporting activities did not include activities experienced through school physical education lessons.

Participants completed the PHQ in a quiet room under the supervision of the lead researcher, with parents/guardians present to assist their child where required. Verbal instructions were provided regarding the purpose of the questionnaire. Instructions on how to complete each section were provided prior to each section being completed. To aid in memory recall when completing the second section, participants were instructed to provide details regarding the team played for and their coach (Ford et al., 2012). All questionnaires were completed within 45-minutes. To contextualise the accelerometer data, participants completed a daily diary that elicited information regarding the amount of time spent in soccer match-play, team practice, and soccer-specific play. Additionally, information regarding the time spent in any additional sporting or physical activity was recorded. Participants indicated whether the activity was recreational, part of a club, or part of their school physical education programme.

# Table 6.1. Technical Soccer Performance Index scoring system

|  |  |  |  |
| --- | --- | --- | --- |
| ***Player increased performance by (or equal to):*** | **Points** | ***Player decreased performance by (or equal to):*** | **Points** |
| The smallest worthwhile change (SWC) | 1 | The smallest worthwhile change (SWC) | -1 |
| 2 x SWC | 2 | 2 x SWC | -2 |
| 3 x SWC | 3 | 3 x SWC | -3 |
| 4 x SWC | 4 | 4 x SWC | -4 |
| 5 x SWC | 5 | 5 x SWC | -5 |
| 6 x SWC | 6 | 6 x SWC | -6 |
| 7 x SWC | 7 | 7 x SWC | -7 |
| 8 x SWC | 8 | 8 x SWC | -8 |
| 9 x SWC | 9 | 9 x SWC | -9 |
| 10 x SWC | 10 | 10 x SWC | -10 |

Where the player exceeded 10x the SWC, the scoring system continued in the same manner.

# Table 6.2. Exemplar Technical Soccer Performance Index data for the acquisition phase

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Player A*** | **Baseline**  **(rate per minute)** | **Acquisition**  **(rate per minute)** | **SWC**  **(rate per minute)** | **Magnitude of SWC** | **Points** |
| Passing | 0.68 | 0.9 | 0.042 | x6 | 6 |
| Passing Success | 0.53 | 0.68 | 0.033 | x5 | 5 |
| Ball Manipulation | 0.03 | 0.07 | 0.017 | x3 | 3 |
| Ball Manipulation Success | 0.03 | 0.07 | 0.007 | x6 | 6 |
| Goal Attempts | 0.02 | 0.02 | 0.016 | 0 | 0 |
| Goal Attempt Success | 0 | 0.02 | 0.010 | x2 | 2 |
| Defensive Actions | 0.23 | 0.27 | 0.023 | x2 | 2 |
|  |  |  | Acquisition phase points total | | 24 |

## 6.3.2.5 Data Analysis

Physical activity data were normalised to total wear time per day to account for individual variation. Mean ± standard deviation with 95% confidence intervals expressed the average amount of time spent in sedentary, light, MVPA zones, VM CPM and total steps taken per day. The Shapiro-Wilk test established normality prior to paired samples t-test examining the difference between training and non-training days. Data were pooled where there were no significant differences between training and non-training days for each physical activity variable. Cohen’s *d* (Cohen, 1988) was used to determine any meaningful differences between training and non-training days.

Pearson’s product-moment correlation coefficient was utilised to determine any relationship between the physical activity variables on training and non-training days and technical soccer performance index. Where assumptions of a normal distribution were violated, Spearman’s rank order correlation coefficient replaced Pearson’s. Statistical analyses were performed using SPSS v.23 (SPSS, IBM, USA), with an alpha level of *p*<.05 was used to determine the statistical significance of correlations.

Data from the PHQ and daily diaries were combined for each cohort. Additional sporting activities were categorised as individual sports, team sports, or fitness activities, with descriptive statistics expressing the frequency of participation in these activities within the cohort. Incomplete or partially complete diaries were removed from the sample.

# 6.4 Results

## 6.4.1 U9 Physical Activity Data

All participants met the inclusion criteria based on daily wear time. Average wear time for the cohort was 12.9 ±1.3 hours per day. Mean levels of MVPA, VM CPM, and total steps were statistically significantly higher on training days, while sedentary time was statistically significantly higher on non-training days, with all differences observed as meaningful (Table 6.3). The U9 group engaged in an average of 4.6 ±2.5 (*t*(7) = -5.1, *p* = .001, *d* = 1.9) MVPA minutes per hour, 492.4 ±345.3 (*t*(7) = -4.0, *p* = .005, *d* = 1.9) VM CPM, and 4953.7 ±2177.7 (*t*(7) = -6.4, *p* = .000, *d* = 2.7) steps more on training days compared to non-training days. Conversely, sedentary time was 4.1 ±2.9 minutes per hour (*t*(7) = 3.9, *p* = .006, *d* = 1.3) higher on non-training days compared to training days. Therefore, correlation analysis was conducted with the variables split by training and non-training day. Time spent in light physical activity was relatively unchanged and not statistically significantly different between training and non-training days, and therefore pooled for correlation analysis. All correlations observed between physical activity variables and the acquisition and retention of technical soccer skills were considered weak and statistically insignificant, with no clear trend emerging in regards to developing technical skills (Table 6.4).

## 6.4.2 U9 PHQ and Daily Diary Data

All of the U9 participants completed the PHQ (100% response rate), with only one failing to complete the daily diary (87.5% response rate). Rugby was the most common team sport, with 2 (25%) participants indicating involvement both in the PHQ and the accelerometer diary. Three of the 8 players indicated participation in snooker/pool while at home in the PHQ (Table 6.5). However, this was not evident during the week of accelerometer data collection. Half of the group indicated participation in recreational cycling activity while at home in the PHQ, but only 1 of the group reported any cycling activity during the week of accelerometer data collection (Table 6.5).

# Table 6.3. Training and non-training day physical activity levels for the U9 cohort

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Sedentary\***  **(average mins per hour)** | **Light**  **(average mins per hour)** | **MVPA\***  **(average mins per hour)** | **VM CPM\***  **(average mins per hour)** | **Steps\***  **(average daily total)** |
| Training day | 30.9 ±2.1  [29.2, 32.7] | 7.1 ±1.0  [6.3, 7.9] | 22.0 ±1.7  [20.5, 23.4] | 1933 ±119  [1834, 2033] | 17515 ±1414  [10799, 14324] |
| Non-training day | 35.0 ±3.9  [31.7, 38.2] | 7.6 ±1.3  [6.6, 8.7] | 17.4 ±2.9  [14.9, 19.8] | 1441 ±343  [1154, 1728] | 12561.3 ±2108.3  [11100.4, 14022.3] |
| Mean Difference  (mins per hour) | 4.1 ±2.9  [1.6, 6.5]  *p* = .006  *d* = 1.3 | 0.5 ±0.9  [-0.2, 1.3]  *p* = .13  *d* = 0.43 | -4.6 ±2.5  [-6.7, 2.5]  *p* = .001  *d* = 1.9 | -492 ±345  [-781, 204]  *p* = .005  *d* = 1.9 | -4954 ±2178  [-6774, 3133]  *p* = .000  *d* = 2.8 |

\* Difference significant at the *p* < .05 level

# Table 6.4. Correlations between U9 technical skill acquisition, retention, and physical activity levels

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *Training Day* | |  | | | | |
| Sedentary | Light | MVPA | VM CPM | Steps |
| Performance Index  (Acquisition Phase) | *rs* | 0.24 |  | 0.02 | 0.31 | -0.48 |
| *p* | .57 |  | .96 | .45 | .23 |
| Performance Index  (Retention Phase) | *r* | 0.26 |  | -0.20 | 0.10 | -0.19 |
| *p* | .53 |  | .63 | .81 | .65 |
| *Non-training Day* | |  | | | | |
| Performance Index  (Acquisition Phase) | *rs* | -0.18 |  | 0.01 | 0.23 | 0.10 |
| *p* | .67 |  | .98 | .59 | .82 |
| Performance Index  (Retention Phase) | *r* | 0.17 |  | -0.12 | -0.01 | 0.12 |
| *p* | .69 |  | .59 | .99 | .79 |
| *Pooled* | |  | | | | |
| Performance Index  (Acquisition Phase) | *rs* |  | -0.12 |  |  |  |
| *p* |  | .78 |  |  |  |
| Performance Index  (Retention Phase) | *r* |  | -0.28 |  |  |  |
| *p* |  | 0.50 |  |  |  |

# Table 6.5. Additional sporting and physical activities undertaken by the U9 cohort

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Team-based*** | **Total** | ***Individual-based*** | **Total** | ***Fitness-based*** | **Total** |
| Rugby | 2 | Athletics | 4 | Swimming | 7 |
| Basketball | 1 | Cross country | 4 | Cycling | 4 |
| Cricket | 1 | Snooker/Pool | 3 | Running or jogging | 3 |
| Handball | 1 | Gymnastics | 2 |  |  |
|  |  | Table tennis | 2 |  |  |
|  |  | Tennis | 2 |  |  |
|  |  | Boxing/Kick boxing | 1 |  |  |
|  |  | Darts | 1 |  |  |

## 6.4.3 U12 Physical Activity Data

All participants met the inclusion criteria based on daily wear time. Average wear time for the group was 11.9 ±2.1 hours per day. There were no statistically significant differences between training and non-training days for any physical activity variable (Table 6.6). Therefore, all physical activity data from training and non-training days was pooled for correlation analysis. All correlations observed between physical activity variables and the acquisition and retention of technical soccer skills were considered weak and statistically insignificant, with no clear trend emerging in regards to developing technical skills (Table 6.7).

## 6.4.4 U12 PHQ and Daily Diary Data

Eight of the 10 U12 participants completed the PHQ (80% response rate), with 6 out of 10 completing the daily diary (60% response rate). Five of the 8 PHQ responders indicated participation in Cricket, with three of the 5 participating through a local competitive club (Table 6.8). However, no Cricket activity was reported during the week of accelerometer data collection for any participant. No individual-based sport activity was evident within the group. Cycling and running/jogging were the most prevalent fitness-based activities, with 3 participants indicating that they participated in these activities while at home through the PHQ (Table 6.8). However, these activities were not reported during the week of accelerometer data collection.

# Table 6.6. Training and non-training day physical activity levels for the U12 cohort (pooled)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Sedentary**  **(average mins per hour)** | **Light**  **(average mins per hour)** | **MVPA**  **(average mins per hour)** | **VM CPM**  **(average mins per hour)** | **Steps**  **(average daily total)** |
| Training day | 36.5 ±3.1  [34.3, 38.7] | 7.1 ±1.1  [6.3, 8.0] | 16.2 ±3.1  [14.0, 18.4] | 1249 ±226  [1088, 1411] | 1201 ±2309  [10363, 13667] |
| Non-training day | 38.1 ±4.4  [34.9, 41.2] | 7.2 ±1.6  [6.0, 8.3] | 14.8 ±3.4  [12.3, 17.2] | 1212 ±299  [998, 1426] | 10556 ±3282  [8208, 12903] |
| Mean Difference  (mins per hour) | 1.6 ±6.2  [-2.8, 6.0]  *p* = .43  *d* = 0.42 | 0.1 ±1.9  [-1.4, 1.4]  *p* = .99  *d* = 0.07 | -1.4 ±5.5  [-5.3, 2.5]  *p* = .44  *d* = 0.43 | -37 ±333  [-275, 201]  *p* = .73  *d* = 0.14 | -1460 ±4055  [-4360, 1005]  *p* = .28  *d* = 0.51 |
| Pooled days | 37.0 ±3.2  [24.7, 39.4] | 7.2 ±1.2  [6.2, 8.0] | 15.7 ±2.8  [13.7, 17.7] | 1237 ±119  [1106, 1368] | 11519 ±2265  [9899, 13139] |

# Table 6.7. Correlations between U12 technical skill acquisition, retention, and physical activity levels

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | *Training and non-training days (pooled)* | | | | |
| Sedentary | Light | MVPA | VM CPM | Steps |
| Performance Index  (Acquisition Phase) | *r* | -0.25 | 0.52 | 0.09 | 0.10 | -0.49 |
| *p* | .49 | .12 | .80 | .78 | .15 |
| Performance Index  (Retention Phase) | *r* | 0.21 | -0.11 | -0.09 | -0.12 | -0.47 |
| *p* | .56 | .76 | .81 | .74 | .17 |

# Table 6.8. Additional sporting and physical activities undertaken by the U12 cohort

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Team-based*** | **Total** | ***Individual-based*** | **Total** | ***Fitness-based*** | **Total** |
| Cricket | 5 | Athletics | 5 | Running or jogging | 4 |
| Rugby | 3 | Cross country | 3 | Swimming | 4 |
| Basketball | 1 | Badminton | 2 | Cycling | 3 |
|  |  | Snooker/Pool | 2 | Stretching/Yoga/Pilates | 1 |
|  |  | Boxing/Kick boxing | 1 |  |  |
|  |  | Judo/Karate | 1 |  |  |
|  |  | Skiing/Snowboarding | 1 |  |  |
|  |  | Table tennis | 1 |  |  |
|  |  | Tennis | 1 |  |  |
|  |  | Squash | 1 |  |  |

# 6.5 Discussion

The primary aim of the study was to determine differences in physical activity levels between non-training and training days in the same U9 and U12 cohorts investigated in Chapter 5: Study 2, with the secondary aim of determining whether there was a relationship between physical activity and the development of technical soccer behaviours. It was hypothesised that physical activity levels would be higher on training days compared to non-training days, with those who engaged in higher levels of physical activity developing their technical soccer performance to a greater extent than their less active counterparts. Partial support was found for a difference between training and non-training days, with the U9 group accruing significantly higher levels of physical activity on training days. However, no difference was observed between training days and non-training days for the U12s. There were no meaningful relationships observed between levels of physical activity and the acquisition and retention of technical soccer skills for both groups.

On non-training days, the U9 cohort may have been self-regulating their physical activity levels as a strategy for conserving energy to cope with forthcoming training sessions. Results from this cohort may be explained by the ActivityStat hypothesis, whereby higher levels of MVPA on one day, are compensated for on the next in children of a similar age (Ridgers et al, 2018; 2015; 2014). On non-training days, the amount of time spent in MVPA decreased by an average of 4.6 minutes per hour. Based on the cohort average accelerometer wear-time of 12.9 hours, this may equate to a total daily reduction in MVPA of 51.6 minutes on non-training days. As MVPA decreased on non-training days, sedentary time increased by a similar amount. Therefore, it could be suggested that the U9 cohort directly replaced MVPA time with periods of complete rest on non-training days. Combined with the PHQ and physical activity diaries obtained during the week of data collection, it could be suggested that the academy training programme is the primary reason for this compensation strategy in the U9 cohort.

Additionally, research in physical education settings has shown that children of a similar age may not be able to perceive exercise intensity correctly due to the dynamic, rather than non-linear, changes in exercise intensity that are seen in SSGs (Cowden & Plowman, 1999; Lagally et al., 2016). This could suggest that the U9 cohort in this particular study were mis-judging their physical exertion during training sessions and compensating this with limited physical activity on non-training days. Support for self-regulation was found in the indirect physical activity assessment of the U9 group. During the week of accelerometer data collection, no additional sporting activity was reported other than those engaged with during physical education lessons, with PHQ data suggesting that any additional sports were experienced through recreational involvement at home. This supports the early-specialisation pathway associated with the practice histories of UK-based elite soccer players (Ford et al., 2010; 2012; Hendry & Hodges, 2018).

Conversely, U12 physical activity levels were relatively unchanged between training and non-training days, with no significant differences between any physical activity behaviours, thus not supporting the activitystat hypothesis (Ridgers et al., 2018; 2015; 2014). This could suggest that the cohort had developed a level of fitness that could tolerate the demands of their academy coaching programme. Small-sided games (SSGs) are a common training modality of academy programmes, and have been shown to be an effective training method for eliciting improvements in physiological performance (Hill-Haas et al., 2009; Impellizzeri et al., 2006; Reilly & White, 2004). Therefore, in the instance of this particular academy, the U12 cohort could have developed a physiological resilience to the training demands placed upon them, whereas this resilience is not evident at the U9 age group. Conversely, the intensity of U12 coaching sessions may be lower than the U9s, thus enabling a consistent daily physical activity pattern to be maintained.

With regards to additional sporting activity, like the U9s, the U12 cohort did not participate in a variety of additional sporting activities, thus demonstrating the early specialisation pathway (Ford et al., 2010; Ford et al., 2012). According to the DMSP, at this age, individuals develop a tactical understanding of their sport (Cote et al, 2007), which is underpinned by the parallel development of Core and Higher EFs (Best & Miller, 2010; Crone et al., 2006; Luciana et al., 2005). Diversified participation across a range of sports with similar characteristics (e.g. invasion games) may result in an element of transfer between sports in regards to recognising patterns of play and thus being able to solve performance-based problems (Abernethy et al.,2005; Smeeton et al. 2004). Therefore, a potential factor in the lack of relationship between physical activity levels and skill development may be a lack of diversification in additional similar sporting activities and subsequent limited opportunity to further develop EFs. Furthermore, the additional activity undertaken by the U12 cohort appeared to be focused on the development of physical attributes (e.g. aerobic and anaerobic capacity). However, accumulation of activities of this type do not appear to predict future success in the sport (Hendry et al., 2018).

Although conducted with an elite sample of youth soccer players, the measures of physical activity are taken from a one-week period within the soccer season and are not truly representative of season-long physical activity behaviour. While the PHQ data goes some way towards suggesting that these levels may be consistent over the soccer season, response rate from within the cohorts was not maximised, thus making robust inferences difficult. However, the study provides insights into the habitual physical activity levels of elite youth soccer players and their potential influence on developing technical soccer skills. Further research is required to determine the extent to which types of physical activity may promote technical skill development in elite sporting populations (fitness-based vs. sporting-based). It would also be interesting to monitor the habitual physical activity levels of elite youth soccer players over a longer period of time, along with outside of their competitive season to determine whether their high levels of activity are maintained in the absence of their systematic soccer training. Furthermore, investigations into a wider range of academies is recommended so that the EPPP model can move towards a set of general guidelines for optimum physical activity levels across age groups to ensure that the model is successful in its aim of producing more home-grown talented soccer players.

In conclusion, results from the study suggest that habitual physical activity levels are not related to the development of technical soccer skill. The systematic soccer training programme implemented by the academy may have led to a restriction of the volume of physical activity engaged with on non-training days for the U9 cohort, but not for the U12s. With regards to engagement with additional sporting activities, both groups appeared to support the early specialisation pathway, with limited engagement in both individual and team sports being reported.

# *Chapter 7:*

# Synthesis of Findings

# 7.1 Aims and Realisation of Aims

The aims and realisation of these aims are articulated in the following section.

## 7.1.1 Aim 1: Develop a robust methodological procedure for assessing the technical soccer behaviour of elite youth soccer players

The first study of the thesis aimed to formulate and test a notational analysis tool that could be used to accurately record technical soccer behaviours in relation to the Youth academy’s playing philosophy. The Soccer-Specific Behaviour Measurement Tool (S-SBMT) was formulated and tested by elite practitioners within the recruited academy and was considered to be valid, objective, and reliable. This aim was successfully achieved. The S-SBMT was then taken forward for use in the second study.

## 7.1.2 Aim 2: Investigate the acquisition and retention of technical soccer skills over a 12-month period in under-9 and under-12 age cohorts

The second study utilised the S-SBMT to investigate the acquisition and retention of academy-specific technical soccer skills in U9 and U12 cohorts. Results from the study showed no changes in observed performance for the U9 cohort. However, the S-SBMT was able to track behaviour change in the U12 cohort in relation to their passing frequency and success. The results enabled the theoretical concepts underpinning technical skill acquisition and retention to be explored in relation to age, along with the configuration of SSGs as a vehicle for assessing technical skill development.

## 7.1.3 Aim 3: The primary aim was to evaluate the relationship between physical activity and the development of technical soccer skills. The secondary aim was to evaluate the physical activity levels on training and non-training days in the U9 and U12 cohorts.

Study 3 had 2 independent aims. Firstly, the primary aim was to evaluate the relationship between physical activity and the development of technical soccer skills. Results did not suggest a link between habitual physical activity levels and the rate of technical skill development for both the U9 and U12 cohorts. The secondary aim was to evaluate the physical activity levels on training and non-training days for both cohorts. Results showed that the habitual physical activity levels of U9 elite youth soccer players involved a compensation strategy on non-training days, while the U12 cohort’s activity profiles remained relatively unchanged between training and non-training days.

# 7.2 Summary of Key Findings

## 7.2.1 Methodological rigour in academy-specific systematic observation tools

Chapter 3: Study 1 sought to address the limitations of large generic soccer observation tools, and was relatively successful in doing so. Technical soccer behaviours associated with being in-possession of the ball (passing and ball manipulation), along with attacking actions (shots on goal), demonstrated good reliability between two independent observers of equivalent vocational experience. Defensive actions associated with regaining possession of the ball (tackles, interceptions, and loose balls) were less reliable, and this could be attributed to their frequency of occurrence.

## 7.2.2 The efficacy of elite academy coaching in embedding technical soccer skills

Chapter 4: Study 2 investigated the efficacy of systematic elite soccer coaching over a 12-month period by evaluating the acquisition and retention of technical soccer skills. Results showed that the U9s’ technical skills remained relatively unchanged over the data collection period both in regards to acquisition and retention (passing, ball manipulation, goal attempts, and defensive actions). The U12s acquired and retained technical skill in relation to the frequency of passes and their success. Other technical actions remained relatively unchanged (ball manipulation frequency, goal attempts, and defensive actions), with the exception of ball manipulation success, which improved between the post-acquisition phase and retention.

## 7.2.3 Habitual physical activity levels and the development of technical soccer skill

Chapter 5: Study 3 evaluated the potential relationship between habitual physical activity levels and the development of technical soccer skill. No relationship between the volume of physical activity during a typical in-season week and technical skill development was found for both the U9 and U12 cohorts. The U9 cohort appeared to compensate for the volume of hours in soccer coaching by reducing their physical activity volumes on non-training days. The physical activity levels of the U12 cohort were relatively unchanged between training and non-training days. Data from the PHQ showed that both cohorts took part in a limited number of additional sport and exercise activities.

# 7.3 Overarching Issues and Implications

The inception of the studies within this thesis was based upon the collaboration between academic institution and professional soccer academy, and resulted in the researcher becoming part of the full-time staff in the academy for the duration of the data collection process. The aim of the academy was to ascertain whether their playing philosophy was being successfully ingrained within their academy age groups, and the studies within this thesis represent the cumulative efforts of the researcher and academy in achieving this overall aim. The following section will address the practical implications of this thesis in relation to the collaborating academy, and youth soccer as a whole. Furthermore, a considered reflection on how each study could be improved if undertaken again will also be provided.

## 7.3.1 Specificity of systematic observation tools

At the time of conception of this thesis, notational analysis tools were generic in relation to the technical and tactical aspects of performance and designed for match-play use. This resulted in tools that were large and time consuming to use, along with not necessarily being relevant to all practitioners based on the inclusion of every soccer match-play event (e.g. Bradley et al., 2007; Tenga et al., 2009). The tool formulated by van Maarseveen et al. (2017) was applicable to SSGs in a coaching context. However, this format was disconnected from actual match play by only using attacking phases of play. Furthermore, there is an under-utilisation of expert observers (Performance Analysts working in the industry) in empirical research. To develop the existing body of research, in particular the work of van Maarseveen et al. (2017), the Soccer-Specific Behaviour Measurement Tool (S-SBMT) from Chapter 3: Study 1 was designed to be used in a SSG setting without any disconnect between phases of play, while enabling the reliable observation of technical soccer behaviours specific to the partaking academy. Experienced practitioners within the domain of observational analysis in soccer helped develop the objectivity of the S-SBMT, thus enhancing rigour when compared to existing tools (van Maarseveen et al., 2017).

A key strength of Study 1 was the tailoring of the tool to the academy playing philosophy, ensuring that only club-specific relevant technical skills were included, and demonstrating that analysts from within the academy can identify these skills. Therefore, in regards to practical application, it could be suggested that English EPPP academies (and others worldwide) can utilise the methodological procedure presented in Study 1 to formulate their own academy-specific notational analysis tools. Furthermore, the validity of the tool, along with the objectivity and reliability of the observers paved the way for the academy playing philosophy to be investigated in regards to existing coaching programmes in Chapter 5: Study 2. The outcome of Study 1 has left the collaborating soccer academy with a functional tool from which future player assessments can be made.

On reflection, Study 1 could have been strengthened by including a tactical aspect to the tool. Despite specificity being a focal point of the S-SBMT in relation to the academy philosophy, only technical behaviours were included. Although the tool could prove useful in assessing technical performance, this could be considered an incomplete picture of the player’s performance due to the absence of decision-making while off-the-ball. Furthermore, any adjustments to SSG pitch size could produce changes in the tactical behaviour of players that may also be missed (Olthof et al., 2018). Consequently, coaches would be unable to assess the progression of tactical behaviours of this nature when using the S-SBMT, on any SSG pitch size.

Recent research has utilised GPS tracking systems to assess off-the-ball actions associated with tactical performance (e.g. defensive coverage). However, use of this particular methodology to assess off-the-ball actions is still developing, particularly in regards to the influence of task constraints on spatiotemporal behaviour (Ric et al., 2017). From a broader perspective, the inclusion of psychological aspects could be considered. Research by Musculus and Lobinger (2018) has highlighted that psychological characteristics of soccer performance could potentially be observed with accuracy should the same stages of ensuring validity, objectivity, and reliability be followed when formulating an analysis tool.

## 7.3.2 Assessing the efficacy of elite youth soccer coaching

The traditionalist nature of soccer coaching in England has led to limited knowledge regarding the efficacy of coaching programmes (Williams & Hodges, 2005). Chapter 4: Study 2 provided an insight into the efficacy of an English Premier League ‘Category One’ soccer academy by utilising the S-SBMT created in Chapter 3: Study 1, and demonstrated that systematic observation through SSGs can elicit data that shows the development of technical soccer skill over time.

The methodological approach implemented in Chapter 4: Study 2 enabled the assessment of technical soccer skills to occur in a dynamic match-related environment that ensured perception and action remained coupled throughout. Previous research regarding the assessment of technical soccer skills has involved the use of controlled drill-based or phase-of-play scenarios (e.g. The Loughborough soccer passing and shooting tests; Ali, 2007). These tests remove or restrict the number of external variables that may influence the decision-making process of the player in possession of the ball (e.g. the number of opposition players trying to regain possession, the number of available teammates to pass the ball to, etc.). Chapter 4: Study 2 showed that SSGs can be useful for assessing certain technical skills (e.g. passing) under a game-based condition that provides a better representation of technical skill as opposed to simply an assessment of technique proficiency seen in closed drill-type activities (Ali, 2011). However, not all technical skills developed in the manner anticipated, and could call into question the efficacy of SSGs as a modality for assessing technical skill. Therefore, it would be logical to suggest that a balance needs to be struck between controlled drill-based games and open SSGs to ensure an accurate assessment of technical performance.

Small-sided games are conditioned in a manner that places constraints upon players in regards to available playing space and time on the ball. This may place excessive perceptual-cognitive demands upon young soccer players (particularly U9), and may explain the lack of improvement shown in the results of Study 2. Therefore, it could be suggested that coaches should consider utilising SSG configurations that provide a larger individual playing area (Fradua et al., 2013), or a SSG design that is non-traditional (e.g. the use of multiple goals) (Bennett et al., 2018). Conversely, the improvement in passing frequency and efficiency of the U12 group may lend support to the notion that at the specialisation stage (age 12 – 13) of the DMSP, players begin to develop a tactical understanding of their sport. The U12 group demonstrated better decision making when in possession of the ball, and could suggest to coaches that it takes until this age for meaningful gains in technical performance to become visible.

Research has highlighted the requisite volumes of soccer-specific practice required to attain elite status (see Chapter 2), therefore it could be suggested that the U9 cohort have not accumulated enough hours in soccer-specific coaching to demonstrate significant increases in most technical skills. It may be that the development of technical skills is a longitudinal process, which has implications for coaches in the tracking and monitoring of player development in regards to retention or release from the academy programme. In regards to the structure of the academy coaching programme, it is possible that the programme used for the development of technical on-the-ball actions is eliciting positive changes in passing frequency and success, along with the ability to manipulate the ball successfully (but not necessarily at a higher frequency) in the U12 cohort. These technical skills were retained after a 10-month period post the initial 6-week coaching cycle, thus suggesting that the coaching sessions comprise of activities structured with the optimum contextual interference (Williams & Hodges, 2005).

From a practical application standpoint, the results of Study 2 indicate that the tracking of technical soccer performance is a feasible and important procedure for soccer academies in regards to assessing the efficacy of their coaching programme. Small-sided games are a common training modality in soccer. Therefore, assessing technical performance within SSGs does not require major adaptation to already programmed coaching cycles within soccer academies, thus presenting coaches with greater opportunity to be provided with valid and reliable performance data regarding the efficacy of their coaching programme without needing to accommodate additional sessions or activities for performance analysis.

On reflection, Study 2 could have been improved by utilising a more regular data collection process. Although the methodological approach enabled data to be captured either side of a 6-week coaching programme, there was potentially too much time without additional assessments of performance to rule out the changes in performance that were observed after 12-months being as a result of the accumulation of coaching hours, or retention from the first coaching cycle. Additionally, the use of SSGs may have masked any potential changes in performance due to inter-game variability. To enable the data to normalise, a greater number of SSGs could have been utilised, potentially resulting in a clearer profile of changes in technical performance over the 12-month period. Furthermore, the lack of change in performance for the U9 cohort could suggest that the technical performance indicators are not appropriate for this age group, and a modified set of outcome metrics that better represent changes in performance could be explored.

## 7.3.3.1 Physical activity and skill development

Regular participation in structured physical activity that reaches moderate to vigorous levels of intensity can increase the executive function of participants (Best, 2010). Therefore, further research into the cohorts’ habitual physical activity levels was appropriate in order to ascertain whether these levels were contributing to the development of technical soccer skills. It was anticipated that increased levels of physical activity would provide greater opportunity to train and develop Executive Functions (EFs), which in turn, underpin successful soccer performance (Verberg et al., 2014; Vestberg et al., 2017; 2012). However, results from Chapter 6: Study 3 suggested that habitual physical activity levels were not associated with the development of technical soccer skills. PHQ data suggested that both the U9 and U12 cohorts did not engage with a wide variety of additional sporting activities, and therefore specialised in soccer from an early age (Côte et al, 2007; Ford et al., 2009a; Ford et al., 2012). Consequently, both cohorts may be constraining their development of technical soccer skills due to an absence of physical activity that promotes the development of EFs, and provides a valuable insight into the habitual physical activity behaviour of two age-independent cohorts within an elite soccer academy.

Alternatively, both cohorts appear to be limiting their opportunities to partake in deliberate play activities outside of their academy coaching hours. The volume of accumulated deliberate play has been shown to differentiate players who go on to attain professional status and those who are released (Ford et al., 2009a; Roca et al., 2012). This may be having the greatest effect on the U9 cohort, whose technical skill development was relatively unchanged throughout the data collection period. However, the U12 cohort were found to enhance passing and ball manipulation skills with a similar limited engagement in deliberate play. A plausible explanation for this could be that the U12 cohort engaged in deliberate play activities during the foundation phase of their time in the academy (U9 – U11), but have begun to specialise in soccer upon reaching the Youth Development phase of the academy programme (U12 – U16) (Ford et al., 2012; The Premier League, 2011).

Chapter 6: Study 3 may highlight that the current programming of coaching is too intense for the U9 cohort due to the apparent compensation strategy on non-training days. The Academy philosophy for this notion is that players were encouraged to engage with as many different sports and activities as possible at the Foundation stage (U9 – U11); yet empirical results from both the accelerometry and PHQ protocols suggest that this advice is not being followed. It is beyond the scope of Study 3 to establish whether this was as a result of excessive training load at the academy, or other external factors such as parental control and advice. Overall, habitual physical activity was not related to technical soccer skill development in both U9 and U12 cohorts. From a practical application perspective, the academy may be able to use accelerometry to monitor the habitual physical activity and sedentary behaviour of particular age groups to assess whether the existing coaching programme is too physically demanding, and therefore constraining opportunities for players to engage with additional sport and exercise outside of the academy that may benefit their soccer development.

A wider perspective in regards to physical and psychological burnout for these groups could be considered. Soccer academies in England recruit players into academies earlier than other countries (Ford et al., 2012). It could be suggested that engaging with a systematic soccer coaching programme in addition to other physical activities may be excessive for children of these ages, and care should be taken with training intensities and lifestyle recommendations for children in soccer academies. On reflection, Study 3 could have been improved by collecting data throughout the coaching programme that was the focus of Study 2. This would have enabled a more accurate profile of the habitual physical activity for each age group to be developed, and greater inferences to be made between the potential impact of physical activity and the development of technical soccer ability.

## 7.3.3.2 Physical activity and health in elite youth soccer players

A broader issue associated with the aforementioned limited engagement with additional sporting activities is that of physical and psychological health. Partaking in increased levels of physical activity presents more opportunities to develop the key techniques and skills required for success in the child or adolescents’ primary sport, in turn increasing competence and adherence (McKenzie et al., 1998; 2002; Stodden et al., 2008). However, the compensation strategy shown by the U9 cohort, and the limited engagement in additional physical activity by both cohorts, may have implications for competence and adherence.

English soccer academies are under increasing pressure to produce players of an elite standard, with those who are not considered to be of the requisite standard at any given age being released from their contract with the academy. The results of Chapter 6: Study 3 may lend some support to the dynamic relationship between habitual physical activity and skill development. The increase in systematic coaching hours brought about by the introduction of the EPPP may be too challenging for the U9 cohort to sustain. Young English athletes partaking in sport at the elite level are at risk of overtraining, and have been shown to reduce their activity outside of their elite coaching programme (Matos et al., 2011). However, the U12 cohort may have developed a physical resilience to the demands of their coaching programme. Therefore, it could be proposed that the U9 coaching structure in this particular academy potentially needs revising in regards to both structure and intensity to prevent the ActivityStat hypothesis pattern observed in Study 3 becoming a sustained pattern throughout this cohort’s time in the academy.

By reducing physical activity levels on non-training days, the U9 cohort are restricting their opportunity to engage in other activities that may supplement their soccer skill development, which could result in release from the academy due to the insufficient development of key skills. Early engagement with soccer through deliberate play has been highlighted as a key determinant of successful retention within the academy system (Ford et al., 2009a). Therefore, it could be suggested that deliberate play within the domain of soccer should be encouraged outside of the formal coaching hours spent at the academy to optimise skill acquisition. Furthermore, release from the academy system may lead to a lack of perceived competence in soccer and cessation of this particular activity, or physical activity in general (Stodden, 2008). However, any increase in physical activity in the U9 cohort should be monitored to prevent maintenance of an ActivityStat hypothesis pattern, as highlighted by the data in Study 3.

Cessation of participation in soccer is likely to have negative implications for an individual’s health should it not be replaced by another sport or physical activity (Barnett, 2009; Barnett et al., 2011; Lopes et al., 2011; Lubans et al., 2010; Stodden et al., 2012). In particular, the loss of moderate-to-vigorous physical activity elicited through soccer participation may result in individuals failing to reach national guidelines for this exercise intensity (Fenton et al., 2015; Wold et al., 2013).

Conversely, the U12 cohort were able to sustain similar physical activity levels between training and non-training days. It could be suggested that this cohort have developed the physical resilience and fitness characteristics to cope with the demands of their academy coaching programme over the years spent within the academy (Hendry et al., 2018; Janssen & LeBlanc, 2010). It is worth noting that this particular cohort first entered the academy prior to the EPPP being introduced, and therefore developed their fitness levels through fewer systematic coaching hours, and thus has potential implications for the optimum number of coaching hours for soccer players during the Foundation phase (U9 – U11). However, it is not known whether additional physical activity during this time supplemented these coaching hours. Furthermore, as the U12 cohort approach their peak height velocity (PHV), it would be interesting to see whether they are able to sustain their current physical activity patterns due to the challenges faced by rapid changes in height and weight. It could be a recommendation for the academy to monitor individual PHV and tailor training intensity, along with recommendations for physical activity outside of the academy coaching programme (Philippaerts et al., 2006).

Lastly, the results of Study 3 may highlight a psychological issue with regards to psychological burnout. The lack of engagement in additional physical activities may be due to the workload of elite systematic soccer coaching being excessive for children of the ages included in this study, therefore resulting in restricted physical activity participation to prevent physical and psychological burnout, especially if the child participates in another sport at the elite youth level (Côte et al., 2007). It is important to note that these suggestions are generally speculative and are a general indicator of potential future studies based on Study 3. The data within Study 3 is limited in size and scope due to being from a specific cohort of young soccer players. It would be inappropriate at this stage to suggest that all youth soccer players are susceptible to these issues, and a research project spanning a broader range of soccer academies in regards to habitual physical activity is warranted.

## 7.4 Limitations

Conducting research of this nature within a dynamic professional soccer environment is a considerable strength in regards to the standard of participants and the level of ecological validity. However, with this strength comes the limitation of a restricted sample size through the number of contracted players within each age cohort, the availability of the participants at the proposed time of data collection, and injuries experienced through training and match-play. This resulted in a small sample size across the course of the thesis and may have contributed to the lack of statistical power when making inferences.

## 7.5 Future Research

There are several potential directions for future research based on the outcomes of the experimental chapters of this thesis:

## 7.5.1 An expert-novice paradigm for testing notational analysis tools

As discussed, previous research validating the use of customised notational analysis tools have either used novice observers, or not declared the observer’s level of experience. In order for Performance Analysts working in the industry to maintain a productive working relationship with coaches and players, the quality of data presented needs to be of a high quality (Wright et al., 2013). The observers who took part in Chapter 3: Study 1 worked at the same soccer academy, had an average of 4 years vocational experience, and had worked alongside one another for two full soccer seasons. However, the level of agreement for some technical soccer behaviours (which should be relatively easy to identify for experienced analysts) fell below acceptable levels. Comparing experienced analysts to one another along with inexperienced counterparts will aid soccer clubs with valuable data and protocols for determining that their analysis staff are competent at observing soccer behaviour and collating performance data. Furthermore, certain aspects of performance may be too difficult to reliably identify, due to infrequency of occurrence, or constraints associated with conventional filming positions. Therefore, further research of this nature may enable unstable measures of performance to be identified and thus removed from the analysis process. In turn, this will enhance the quality of data available to coaching staff for making decisions on players in regards to being retained or released from the academy programme.

## 7.5.2 Conditioned games for technical skill assessment

Based on the findings of Chapter 4: Study 2 and the continued need to formulate a robust procedure for assessing the efficacy of elite soccer coaching, it could be suggested that a range of conditioned games may enable a more accurate assessment of technical skills than SSGs. Due to the variance in occurrence between technical skills during SSGs, and the de-coupled nature of drill-based activities, a balance between these two approaches needs to be developed. By formulating games that emphasise the use of a particular technical skill, the frequency at which it occurs will increase, thus providing greater opportunity to observe each player with greater accuracy than in a conventional SSG due to greater frequency of occurrence under game-related constraints. Additionally, the amount of individual playing area available to players during these games needs to be considered in order to ensure that all players have sufficient opportunity to demonstrate their skill level.

## 7.5.3 Longitudinal physical activity tracking post-release from the elite youth soccer environment

It has been highlighted that children with high levels of motor competency, and perceived motor competency, go on to be habitually active in later life. It would be interesting to investigate the impact of being released from the professional academy system during childhood and adolescence, as players may become demotivated and no longer feel competent in the sport. This may lead to pursuit of another sporting activity, recreational participation in sport, or complete cessation of sporting participation. All three of these pathways may result in significant alterations to the habitual physical activity of these children/adolescents, which could carry negative physical and mental health implications.

# 7.6 Conclusions

This thesis has yielded some interesting and valuable results in relation to the stated aims and objectives. In study 1, a novel soccer-specific observational analysis tool was formulated based on the playing philosophy of a Category One English Premier League soccer academy, and was found to be a valid, objective, and reliable tool for assessing coaching efficacy. Study 2 showed that the academy’s systematic soccer coaching programme was effective in embedding the skill of passing within an U12 cohort, but may not be as effective for other technical soccer behaviours. Study 3 showed that there was no relationship between technical skill acquisition and habitual physical activity levels, but systematic elite academy soccer coaching results in a compensation strategy for managing physical activity in elite U9 soccer players. Therefore, with regards to studies 2 and 3; rather than producing findings that present new phenomena, these studies have presented results that may rule-out the influence of factors that theoretically have an impact on the development of expertise in the sporting domain.

# References

Abbott, A., and Collins, D. (2004). Eliminating the dichotomy between theory and practice in talent identification and development: considering the role of psychology. *Journal of Sports Sciences*, 22(5), 395-408.

Abernethy, B., Baker, J., & Côté, J. (2005). Transfer of pattern recall skills may contribute to the development of sport expertise. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition*, 19(6), 705-718.

Ali, A. (2011). Measuring soccer skill performance: A review. *Scandinavian Journal of Science and Medicine in Sports*, 21(2), 170-183.

Ali, A., Williams, C., Hulse, M., Strudwick, A., Reddin, J., Howarth, L., Eldred, J., Hirst, M. & McGregor, S. (2007) Reliability and validity of two tests of soccer skill, *Journal of Sports Sciences*, 25(13), 1461-1470.

Altman, D. G. and Bland, J. M. (1983). Measurement in medicine: the analysis of method comparison studies. *Statistician*, 32, 307-317.

Aquino, R., Marques, R. F. R., Petiot, G. H., Goncalves, L. G. C., Moraes, C., Santiago, P. R. P. & Puggina, E. F. (2016). Relationship between Procedural Tactical Knowledge and Specific Motor Skills in Young Soccer Players. *Sports*, 4(4), 52-62.

Armitage, P. (2006). *Analysis of the knockout stages of the 2003 rugby world cup*, B.Sc Dissertation, School of Sport, University of Wales Institute Cardiff, Cyncoed Campus, Cardiff, UK.

Atkinson, G. and Nevill, A. (1998). Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. *Sports Medicine*, 26, 217-238.

Bailey, R., and Morley, D. (2006). Towards a model of talent development in physical education. *Sport, Education and Society*, 11(3), 211-230.

Baker, J. and Cote, J. (2006). Shifting training requirements during athlete development: The relationship among deliberate practice, deliberate play and other sport involvement in the acquisition of sport expertise. In D. Hackfort and G. Tenebaum (Eds.), *Essential Processes for Attaining Peak Performance* (pp. 93 – 110). Oxford: Meyer and Meyer.

Baker, J., Côté, J., and Abernethy, B. (2003). Sport-specific practice and the development of expert decision-making in team ball sports. *Journal of Applied Sport Psychology*, 15(1), 12-25.

Baker, J., Côté, J., and Deakin, J. (2006). Patterns of early involvement in expert and nonexpert masters triathletes. *Research Quarterly for Exercise and Sport*, 77(3), 401-407.

Baker, J., Côté, J., and Deakin, J. (2005). Expertise in ultra-endurance triathletes early sport involvement, training structure, and the theory of deliberate practice. *Journal of Applied Sport Psychology*, 17(1), 64-78.

Banich, M. T. (2009). Executive Function: The search for an integrated account. *Current Directions in Psychological Science*, 18, 89-94.

Barnett, L. M., Morgan, P. J., Van Beurden, E., Ball, K., and Lubans, D. R. (2011). A reverse pathway? Actual and perceived skill proficiency and physical activity. *Medicine & Sciences in Sports & Exercise*, 43(5), 898-904.

Barnett, L. M., Van Beurden, E., Morgan, P. J., Brooks, L. O., and Beard, J. R. (2009). Childhood motor skill proficiency as a predictor of adolescent physical activity. *Journal of Adolescent Health*, 44(3), 252-259.

Barreiros, A., Côté, J., and Fonseca, A. M. (2013). Training and psychosocial patterns during the early development of Portuguese national team athletes. *High Ability Studies*, 24(1), 49-61.

Batterham, A. M. and George, K. P. (2003). Reliability in evidence-based clinical practice: a primer for allied health professionals. *Physical Therapy in Sport*, 4, 122-128.

Bennett, K. J. M., Novak, A. R., Pluss, M. A., Stevens, C. J., Coutts, A. J. and Fransen, J. (2018). The use of small-sided games to assess skill proficiency in youth soccer players: a talent identification tool. *Science and Medicine in Football*, 2(3), 231-236.

Berry, J. and Abernethy, B. (2003). *Expert game-based decision-making in Australian football: How is it developed and how can it be trained?* Brisbane, Australia: University of Queensland, School of Human Movement Studies.

Berry, J., Abernethy, B., and Côté, J. (2008). The contribution of structured activity and deliberate play to the development of expert perceptual and decision-making skill. *Journal of Sport and Exercise Psychology*, 30(6), 685-708.

Best, J. R. (2010). Effects of Physical Activity on Children’s Executive Function: Contributions of Experimental Research on Aerobic Exercise. *Developmental Review* , 30(4), 331–551.

Best, J. R., and Miller, P. H. (2010). A developmental perspective on executive function. *Child Development*, 81(6), 1641-1660.

Bland, J. M. and Altman, D. G. (1986). Statistical methods for assessing agreement between two methods of clinical measurement. *The Lancet*, i, 307-310.

Bortoli, L., Robazza, C., Durigon, V., and Carra, C. (1992). Effects of contextual interference on learning technical sports skills. *Perceptual and Motor Skills*, 75(2), 555-562.

Bradley, P. S., O'Donogue, P., Wooster, B. and Tordoff, P. (2007). The reliability of Prozone Match Viewer: a video-based technical performance analysis system. *International Journal of Performance Analysis of Sport*, 7, 117-129.

Brewer, C., and Jones, R. L. (2002). A five-stage process for establishing contextually valid systematic observation instruments: The case of rugby union. *The Sport Psychologist*, 16, 138-159.

Bruner, M. W., Erickson, K., Wilson, B., and Côté, J. (2010). An appraisal of athlete development models through citation network analysis. *Psychology of Sport and Exercise*, 11(2), 133-139.

Buck, S. M., Hillman, C. H., and Castelli, D. M. (2008). The relation of aerobic fitness to stroop task performance in preadolescent children. *Medicine and Science in Sports and Exercise*, 40(1), 166-172.

Cain, K. L., Sallis, J. F., Conway, T. L., Van Dyck, D., and Calhoon, L. (2013). Using accelerometers in youth physical activity studies: a review of methods. *Journal of Physical Activity and Health*, 10(3), 437-450.

Capranica, L., Tessitore, A., Guidetti, L., & Figura, F. (2001). Heart rate and match analysis in pre-pubescent soccer players. *Journal of Sports Science*, 19, 379-84.

Casal, C. A., Maneiro, R., Ardá, T., Losada, J. L., and Rial, A. (2015). Analysis of corner kick success in elite football. *International Journal of Performance Analysis in Sport*, 15(2), 430-451.

Choi, L., Liu, Z. W., Matthews, C. E. and Buchowski, M. S. (2011). Validation of accelerometer wear and nonwear time classification algorithm. *Medicine and Science in Sports and Exercise*, 43, 357–364.

Clemente, F. M., Wong, D. P., Martins, F. M. L. and Mendes, R. S. (2014). Acute Effects of the Number of Players and Scoring Method on Physiological, Physical, and Technical Performance in Small-sided Soccer Games. *Research in Sports Medicine*, 22, 380-397.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.

Cooper, S-M., Hughes, M., O’Donoghue, P. and Nevill, A. M. (2007). A simple statistical method for assessing the reliability of data entered into sport performance analysis systems. *International Journal of Performance Analysis in Sport*, 7, 87-109.

Côté, J., Baker, J., and Abernethy, B. (2007). Practice and play in the development of sport expertise. In R.C. Eklund & G. Tenenbaum (Eds.), *Handbook of Sport Psychology* (3rd ed., pp. 184–202). Hoboken, NJ: Wiley.

Côté, J. (1999). The influence of the family in the development of talent in sport. *The Sport Psychologist*, 13(4), 395-417.

Coutinho, P., Mesquita, I., and Fonseca, A. M. (2016). Talent development in sport: a critical review of pathways to expert performance. *International Journal of Sports Science & Coaching*, 11(2), 279-293.

Coutinho, P., Mesquita, I., Fonseca, A. M., and De Martin-Silva, L. (2014). Patterns of sport participation in Portuguese volleyball players according to expertise level and gender. *International Journal of Sports Science & Coaching*, 9(4), 579-592.

Cowden, R. D., and Plowman, S. A. (1999). The self-regulation and perception of exercise intensity in children in a field setting. *Pediatric Exercise Science*, 11(1), 32-43.

Crone E. A., Wendelken, C., Donohue, S., van Leijenhorst, L., and Bunge, S. A. (2006). Neurocognitive development of the ability to manipulate information in working memory. *Proceedings of the National Academy of Sciences of the United States of America*, 103(24), 9315–20.

Cushion, C., Harvey, S., Muir, B., and Nelson, L. (2012a). Developing the Coach Analysis and Intervention System (CAIS): Establishing validity and reliability of a computerised systematic observation instrument. *Journal of Sports Sciences*, 30(2), 213-218.

Cushion, C., Ford, P. R., and Williams, A. M. (2012b). Coach behaviours and practice structures in youth soccer: Implications for talent development. *Journal of Sports Sciences*, 30, 1-11.

Davids, K., Araújo, D., and Shuttleworth, R. (2005). Applications of dynamical systems theory to football. *Science and Football V*, 537, 550.

Davis, C. L., Tomporowski, P. D., Boyle, C. A., Waller, J. L., Miller, P. H., Naglieri, J. A., and Gregoski, M. (2007). Effects of aerobic exercise on overweight children's cognitive functioning: a randomized controlled trial. *Research Quarterly for Exercise and Sport*, 78(5), 510-519.

Dellal, A., Owen, A., Wong, D. P., Krustrup, P., van Exsel, M. and Mallo, J. (2012). Technical and physical demands of small vs. large sided games in relation to playing position in elite soccer. *Human Movement Science*, 31, 4, 957-969.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*. 64, 135-168.

Duda, J. L., Quested, E., Haug, E., Samdal, O., Wold, B., Balaguer, I., Castillo, I., Sarrazin, P., Papaioannou, A., Ronglan, L. T., Hall, H. and Cruz, J. (2013). Promoting Adolescent health through an intervention aimed at improving the quality of their participation in Physical Activity (PAPA): Background to the project and main trial protocol. *International Journal of Sport and Exercise Psychology*, 11(4), 319-327.

Ericsson, K. A., Krampe, R. T. H. and Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance, *Psychological Review*, 100, 363-406.

Ericsson, K. A. and Smith, J. (1991). *Prospects and Limits of the Empirical Study of Expertise: An Introduction*. In Ericsson, K. A. and Smith, J. (eds.), Toward a General Theory of Expertise: Prospects and Limits, New York: Cambridge University Press, 1-38.

Evenson, K. R., Catellier, D. J., Gill K., Ondrak, K. S. and McMurray, R. G. (2008). Calibration of two objective measures of physical activity for children. *Journal of Sports Science*, 26, 1557–1565.

Fenner, J. S., Iga, J. and Unnithan, V. (2016). The evaluation of small-sided games as a talent identification tool in highly trained prepubertal soccer players. *Journal of Sports Science*, 34(20), 1983-1990.

Fenoglio, R. (2003). The Manchester United 4 v 4 Pilot Scheme for U9s, *Insight*, 22-23.

Fenton, S. A., Duda, J. L., and Barrett, T. (2016). Inter-participant variability in daily physical activity and sedentary time among male youth sport footballers: independent associations with indicators of adiposity and cardiorespiratory fitness. *Journal of Sports Sciences*, 34(3), 239-251.

Fenton, S. A. M., Duda, J. L., and Barrett, T. (2015). The contribution of youth sport football to weekend physical activity for males aged 9 to 16 years: variability related to age and playing position. *Pediatric Exercise Science*, 27(2), 208-218.

Fisher, A., Boyle, J. M., Paton, J. Y., Tomporowski, P., Watson, C., McColl, J. H., and Reilly, J. J. (2011). Effects of a physical education intervention on cognitive function in young children: randomized controlled pilot study. *BMC pediatrics*, 11(1), 97.

Ford, P., Carling, C., Garces, M., Marques, M., Miguel, C., Farrant, A., Stenling, A., Moreno, J., le Gall, F., Holmström, S., Salmela, J. H., and Williams, A. M. (2012). The developmental activities of elite soccer players aged under-16 years from Brazil, England, France, Ghana, Mexico, Portugal and Sweden. *Journal of Sports Sciences*, 1, 1-11.

Ford, P. R., Yates, I., and Williams, A. M. (2010). An analysis of practice activities and instructional behaviours used by youth soccer coaches during practice: Exploring the link between science and application. *Journal of Sports Sciences*, 28(5), 483-495.

Ford, P. R., Ward, P., Hodges, N. J. and Williams, A. M. (2009a). The role of deliberate practice and play in career progression in sport: the early engagement hypothesis. *High Ability Studies*, 20, 65-75.

Ford, P., Coughlan, E., and Williams, M. (2009b). The expert-performance approach as a framework for understanding and enhancing coaching performance, expertise and learning. *International Journal of Sports Science & Coaching*, 4(3), 451-463.

Fradua, L., Zubillaga, A., Caro, Ó., Iván Fernández-García, Á., Ruiz-Ruiz, C., and Tenga, A. (2013). Designing small-sided games for training tactical aspects in soccer: Extrapolating pitch sizes from full-size professional matches. *Journal of Sports Sciences*, 31(6), 573-581.

Franks, I. (1993). The effects of experience on the detection and location of performance differences in a gymnastic technique. *Research Quarterly for Exercise and Sport*, 64, 2, 227-231.

Franks, I., and Miller, G. (1986). Eyewitness testimony in sport. *Journal of sport behaviour*, 9, 39-45.

French, K. E., and McPherson, S. L. (1999) Adaptions in response selection processes used during sport competition with increasing age and expertise. *International Journal of Sport Psychology*, 30, 173-193.

George, K., Batterham, A., and Sullivan, I. (2003). Validity in clinical research: a review of basic concepts and definitions. *Physical Therapy in Sport*, 4, 155-121.

Gomersall, S. R., Rowlands, A. V., English, C., Maher, C., and Olds, T. S. (2013). The activitystat hypothesis: The concept, the evidence and the methodologies. *Sports Medicine*, 43, 135-149.

Gonzalez-Rodenas, J., Lopez-Bondia, I., Calabuig, F., James, N., and Aranda, R. (2015). Association between playing tactics and creating scoring opportunities in elite football. A case study in Spanish Football National Team. *Journal of Human Sport and Exercise*, 10(1), 65-80.

Grehaigne, J. F., Bouthier, D., and David, B. (1997). Dynamic-system analysis of opponent relationships in collective actions in soccer. *Journal of Sports Sciences*, *15*(2), 137-149.

Guadagnoli, M. A., and Lee, T. D. (2004). Challenge point: a framework for conceptualizing the effects of various practice conditions in motor learning. *Journal of Motor Behavior*, 36(2), 212-224.

Gulbin, J. P., Croser, M. J., Morley, E. J., and Weissensteiner, J. R. (2013). An integrated framework for the optimisation of sport and athlete development: A practitioner approach. *Journal of Sports Sciences*, 31(12), 1319-1331.

Hänggi, J. M., Phillips, L. R. S. and Rowlands, A. V. (2013). Validation of the GT3X ActiGraph in children and comparison with the GT1M ActiGraph. *Journal of Science and Medicine in Sport*, 16, 40-44.

Haugaasen, M., Toering, T., and Jordet, G. (2014a). From childhood to senior professional football: A multi-level approach to elite youth football players’ engagement in football-specific activities. *Psychology of Sport and Exercise*, 15(4), 336-344.

Haugaasen, M., Toering, T., and Jordet, G. (2014). From childhood to senior professional football: elite youth players’ engagement in non-football activities. *Journal of Sports Sciences*, 32(20), 1940-1949.

Helsen, W. F., Starkes, J. L., and Hodges, N. J. (1998). Team sports and the theory of deliberate practice. *Journal of Sport and Exercise Psychology*, 20, 12-34.

Hendry, D. T., Williams, A. M. and Hodges, N. J. (2018). Coach ratings of skills and their relations to practice, play and successful transitions from youth-elite to adult-professional status in soccer, *Journal of Sports Sciences*, 36(17), 2009-2017.

Hendry, D. T., and Hodges, N. J. (2018). Early majority engagement pathway best defines transitions from youth to adult elite men’s soccer in the UK: A three time-point retrospective and prospective study. *Psychology of Sport & Exercise*, 36, 81-89.

Hill, G. M. (1993). Youth sport participation of professional baseball players. *Sociology of Sport Journal*, 10(1), 107-114.

Hill-Haas, S., Dawson, B., Impellizzeri, F. M. and Coutts, A. J. (2011). Physiology of small-sided games training in football: A systematic review. *Sports Medicine*, 41(3), 199-220.

Hopkins, W. G., Marshall, S. W., Batterham, A. M. and Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise*, 41, 3-12.

Hopkins, W. G. (2007). A spreadsheet for deriving a confidence interval, mechanistic inference and clinical inference from a *p* value, *Sportscience*, 11, 16-20.

Hughes, M. and Bartlett, R. (2015). The use of performance indicators in performance analysis. In Hughes, M. and Franks, I. (eds.), *Essentials of Performance Analysis in Sport*. 2nd ed. London: Routledge. pp. 89-112.

Hughes, M., Evans, S., and Wells, J. (2001). Establishing normative profiles in performance analysis. *International Journal of Performance Analysis in Sport*, 1, 4-26.

Hughes, M., Cooper, S-M., and Nevill, A. M. (2002). Analysis procedures for non-parametric data from performance analysis. *International Journal of Performance Analysis in Sport*, 2, 6-20.

Hughes, M., Cooper, S-M., Nevill, A., and Brown, S. (2003). An Example of Reliability Testing and Establishing Performance Profiles for Non-Parametric Data from Performance Analysts. *International Journal of Computer Science in Sport*, 2(1), 34-56.

Impellizzeri F. M., Marcora, S., Castagna, C., Reilly, T., Sassi, A., Iaia, F. M., and Rampinini, E. (2006). Physiological and performance effects of generic versus specific aerobic Small-Sided Games Training Physiology in Football. *International Journal of Sports Medicine*, 27(6), 483-492.

James, N., Taylor, J., and Stanley, S. (2007). Reliability procedures for categorical data in Performance Analysis. *International Journal of Performance Analysis in Sport*, 7, 1-11.

Janssen, I. and LeBlanc, A. G. (2010). Review Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, 7(40), 1-16.

Jones, S., and Drust, B. (2007). Physiological and technical demands of 4 v 4 and 8 v 8 games in elite youth soccer players. *Kinesiology*, 39, 2, 150-156.

Kamijo, K., Pontifex, M. B., O'Leary, K. C., Scudder, M. R., Wu, C. T., Castelli, D. M., and Hillman, C. H. (2011). The effects of an afterschool physical activity program on working memory in preadolescent children. *Developmental Science*, 14, 1046-1058.

Lagally, K. M., Walker-Smith, K., Henninger, M. L., Williams, S. M. and Coleman, M. (2016). Acute and Session Ratings of Perceived Exertion in a Physical Education Setting. *Perceptual and Motor Skills*, 122(1), 76-87.

Laird, P., and Waters, L. (2008). Eyewitness Recollection of Sports Coaches. *International Journal of Performance Analysis*, 8, 76-84.

Larkin, P., O’Connor, D., and Williams, A. M. (2016). Establishing validity and reliability of a movement awareness and technical skill (MATS) analysis instrument in soccer. *International Journal of Performance Analysis in Sport*, 16(1), 191-202.

Law, M. P., Côté, J., and Ericsson, K. A. (2007). Characteristics of expert development in rhythmic gymnastics: A retrospective study. *International Journal of Sport and Exercise Psychology*, *5*(1), 82-103.

Leite, N., Baker, J., and Sampaio, J. (2009). Paths to expertise in Portuguese national team athletes. *Journal of Sports Science & Medicine*, 8(4), 560-566.

Leite, N. M., and Sampaio, J. E. (2012). Long-term athletic development across different age groups and gender from Portuguese basketball players. *International Journal of Sports Science & Coaching*, 7(2), 285-300.

Lopes, V. P., Rodrigues, L. P., Maia, J. A., and Malina, R. M. (2011). Motor coordination as predictor of physical activity in childhood. *Scandinavian Journal of Medicine & Science in Sports*, 21(5), 663-669.

Lubans, D. R., Morgan, P. J., Cliff, D. P., Barnett, L. M., and Okely, A. D. (2010). Fundamental movement skills in children and adolescents. *Sports Medicine*, 40(12), 1019-1035.

Luciana, M., Conklin, H. M., Hooper, C. J., and Yarger, R. S. (2005). The development of nonverbal working memory and executive control processes in adolescents. *Child Development*, 76(3), 697-712.

Mackenzie, R. and Cushion, C. (2013). Performance analysis in football: A critical review and implications for future research. *Journal of Sports Sciences*, 31, 639-676.

Magill, R. A., and Hall, K. G. (1990). A review of the contextual interference effect in motor skill acquisition. *Human Movement Science*, 9(3-5), 241-289.

Malina, R. (2014). Top 10 research questions related to growth and maturation of relevance to physical activity, performance, and fitness. *Research Quarterly for Exercise and Sport*, 85, 157-173.

Malina, R. M., and Bouchard, C. (1991). *Growth, Maturation, and Physical Activity*. Champaign, IL: Human Kinetics.

Matos, N. F., Winsley, R. J., and Williams, C. A. (2011). Prevalence of Nonfunctional Overreaching/Overtraining in Young English Athletes. *Medicine & Science in Sport and Exercise*, 43(7), 1287-1294

McDermott, G., Burnett, A. F., and Robertson, S. J. (2015). Reliability and validity of the Loughborough soccer passing test in adolescent males: Implications for talent identification. *International Journal of Sports Science & Coaching*, 10(2-3), 515-527

McGarry, T., Anderson, D. I., Wallace, S. A., Hughes, M. D., and Franks, I. M. (2002). Sport competition as a dynamical self-organizing system. *Journal of sports sciences*, 20(10), 771-781.

McKenzie, T. L., Alcaraz, J. E., Sallis J. F. and Nell Faucette, F. (1998). Effects of a Physical Education Training Program on Children’s Manipulative Skills. *Journal of Teaching in Physical Education*, 17, 327-341.

McKenzie, T. L., Sallis, J. F., Broyles, S. L., Zive, M. M., Nader, P. R., Berry, C. C., and Brennan, J. J. (2002). Childhood movement skills: Predictors of physical activity in Anglo American and Mexican American adolescents?. *Research quarterly for exercise and sport,* 73(3), 238-244.

McPherson, S. L. (1999). Expert-novice differences in performance skills and problem representations of youth and adults during tennis competition. *Research Quarterly for Exercise and Sport*, 70(3), 233-251.

Musculus, L. and Lobinger, B. H. (2018). Psychological Characteristics in Talented Soccer Players - Recommendations on How to Improve Coaches' Assessment. *Frontiers in psychology*, *9* (41), 1-6.

Nevill, A. M., Lane, A. M., Kilgour, L. J., Bowes, N. and Whyte, G. P. (2001). Stability of psychometric questionnaires. *Journal of Sports Sciences*, 19, 273-278.

Nevill, A. M. and Atkinson, G. (1997). Assessing agreement between measurements recorded on a ratio scale in sports medicine and sports science. *British Journal of Sports Medicine*, 31, 314-318.

Nicholls, S. B. and Worsfold, P. (2016). The observational analysis of elite coaches within youth soccer: The importance of performance analysis. *International Journal of Sports Science and Coaching*, 11 (6), 825-831.

O’Donoghue, P. (2005). Normative Profiles of Sports Performance. *International Journal of Performance Analysis in Sport*, 5, 105-119.

O’Donoghue, P. (2007a). Editoral: Special Issue on Reliability. *Journal of Performance Analysis in Sport*, 7, i-ii.

O’Donoghue, P. (2007b). Reliability Issues in Performance Analysis. *International Journal of Performance Analysis in Sport*, 7, 35-48.

Olthof, S. B. H., Frencken, W. G. P. and Lemmink, K. A. P. M. (2018). Match-derived relative pitch area changes the physical and team tactical performance of elite soccer players in small-sided soccer games, *Journal of Sports Sciences*, 36(14), 1557-1563.

Partington, M., and Cushion, C. (2013). An investigation of the practice activities and coaching behaviors of professional top‐level youth soccer coaches. *Scandinavian Journal of Medicine & Science in Sports*, 23(3), 374-382.

Philippaerts, R. M., Vaeyens, R., Janssens, M., Van Renterghem, B., Matthys, D., Craen, R., Bourgois, J., Vrijens, J., Beunen, G., and Malina, R. M. (2006). The relationship between peak height velocity and physical performance in youth soccer players. *Journal of Sports Sciences*, 24(3), 221-230.

Poitras, V. J., Gray, C. E., Borghese, M. M., Carson, V., Chaput, J. P., Janssen, I., Katzmarzyk, P. T., Pate, R. R., Connor Gorber, S., Kho, M. E. and Sampson, M. (2016). Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Applied Physiology, Nutrition, and Metabolism*, 41(6), S197-S239.

Pratas, J., Volossovitch, A., and Ferreira, P. A. (2012). The Effect of Situational Variables on Teams' Performance in Offensive Sequences Ending in a Shot on Goal. A Case Study. *The Open Sports Science Journal*, 5(1), 193-199.

The Premier League (2011). Elite Player Performance Plan. Available at: http://www.premierleague.com/en-gb/youth/elite-player-performance-plan.html (Accessed: 11th September 2018).

Reilly, T., and White, C. (2004). Small-sided games as an alternative to interval-training for soccer players [abstract]. *Journal of Sports Sciences*, 22(6), 559.

Ric, A., Torrents, C., Gonçalves, B., Torres-Ronda, L., Sampaio, J., and Hristovski, R. (2017). Dynamics of tactical behaviour in association football when manipulating players' space of interaction. *PLoS ONE*, 12(7), e0180773.

Ridgers, N. D., Barnett, L. M., Lubans, D. R., Timperio, A., Cerin, E., and Salmon, J. (2018). Potential moderators of day-to-day variability in children’s physical activity patterns. *Journal of Sports Sciences*, 36(6), 637-644.

Ridgers, N. D., Timperio, A., Cerin, E., and Salmon, J. (2014). Compensation of physical activity and sedentary time in primary school children. *Medicine and Science in Sports and Exercise*, 46, 1564-1569.

Ridgers, N. D., Timperio, A., Cerin, E., and Salmon, J. (2015). Within- and between-day associations between children’s sitting and physical activity time. *BMC Public Health*, 15, 950.

Robins, M. and Hughes, M. (2015). Dynamic Systems and ‘Perturbations’. In: Hughes, M. and Franks, I. (eds.) *Essentials of Performance Analysis in Sport*. 2nd ed. London: Routledge. pp. 239-269.

Robusto, K. M. and Trost, S. G. (2012). Comparison of three generations of ActigraphTM activity monitors in children and adolescents. *Journal of Sports Science*, 30,1429-1435.

Rowland, T. W. (1998). The biological basis of physical activity. *Medicine and Science in Sports and Exercise*, 30, 392-399.

Rowlands, A. V. (2009). Methodological approaches for investigating the biological basis for physical activity in children. *Pediatric Exercise* *Science*, 21, 273-278.

Rowlands, A. V., Pilgrim, E. L., and Eston, R. G. (2008). Patterns of habitual activity across weekdays and weekend days in 9-11-year-old children. *Preventive Medicine*, 46, 317-324.

Salmela, J. H. (1994). *Phases and transitions across sports career*. In D. Hackfort (Ed.), Psycho-social issues and interventions in elite sport (pp. 11-28). Frankfurt: Lang.

Santos-lozano, A., Santín-Medeiros, F., Cardon, G., Torres-luque, G., Bailón, R., Bergmeir, C., Ruiz, J. R., Lucia, A., and Garatachea, N. (2013). Actigraph GT3X: Validation and determination of physical activity intensity cut points. *International Journal of Sports Medicine*, 34,975-982.

Sarmento, H., Anguera, M. T., Pereira, A., Marques, A., Campaniço, J., and Leitão, J. (2014). Patterns of play in the counterattack of elite football teams-A mixed method approach. *International Journal of Performance Analysis in Sport*, 14(2), 411-427.

Schmidt, R. A., Lee, T., Winstein, C., Wulf, G., and Zelaznik, H. (2018). *Motor Control and Learning.* (6th Edn.). Champaign, IL: Human Kinetics. pp. 303-339.

Schmidt, R. A. (1975). A schema theory of discrete motor skill learning*. Psychological Review*, 82, 225-260.

Serpiello, F. R., Cox, A., Oppici, L., Hopkins, W. G., and Varley, M. C. (2017). The Loughborough Soccer Passing Test has impractical criterion validity in elite youth football. *Science and Medicine in Football*, 1(1), 60-64.

Sibley, B. A., and Etnier, J. L. (2003). The relationship between physical activity and cognition in children: a meta-analysis. *Pediatric Exercise Science*, 15(3), 243-256.

Siedentop, D. (1976). *Developing teaching skills in physical education*. Boston: Houghton-Mifflin.

Silva, B., Garganta, J., Santos, R., and Teoldo, I. (2014). Comparing tactical behaviour of soccer players in 3 vs. 3 and 6 vs. 6 small-sided games. *Journal of Human Kinetics*, 41(1), 191-202.

Simon, H. A., and Chase, W. G. (1973). Skill in chess. *American Scientist*, 61, 394-403.

Smeeton, N. J., Ward, P., and Williams, A. M. (2004). Do pattern recognition skills transfer across sports? A preliminary analysis. *Journal of Sports Sciences*, 22(2), 205-213.

Soberlak, P., and Cote, J. (2003). The developmental activities of elite ice hockey players. *Journal of Applied Sport Psychology*, 15(1), 41-49.

Starkes, J. L., Deakin, J. M., Allard, F., Hodges, N. J., and Hayes, A. (1996). Deliberate practice in sports: What is it anyway? In K. A. Ericsson (Ed.), The road to excellence: The acquisition of expert performance in the arts and sciences, sports, and games, (pp. 81-106). Hillsdale, NJ: Erlbaum.

Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Roberton, M. A., Rudisill, M. E., Garcia, C., and Garcia, L. E. (2008). A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. *Quest*, 60(2), 290-306.

Stodden, D., Langendorfer, S., Goodway, J., Ferkel, R., and Gao, Z. (2012). Examining the dynamic relationship between motor competence, perceived motor competence, and physical fitness in children: The relationships among motor skill competence and health-related fitness across childhood. *Journal of Sport and Exercise Psychology*, 34, S13-S13.

Tenga, A., Kanstad, D., Ronglan, L.T. and Bahr, R. (2009). Developing a new method for team match performance analysis in professional soccer and testing its reliability. *Journal of Performance Analysis in Sport*, 9, 8-25.

Tomporowski, P. D., Davis, C. L., Miller, P. H., and Naglieri, J. A. (2008). Exercise and children’s intelligence, cognition, and academic achievement. *Educational Psychology Review*, 20(2), 111-131.

Unnithan, V., White, J., Georgiou, A., Iga, J., & Drust, B. (2012). Talent identification in youth soccer. *Journal of Sports Sciences*, 30(15), 1719-1726.

Van Maarseveen, M. J. J., Oudejans, R. R. D., and Savelsbergh, G. J. P. (2017). System for notational analysis in small-sided soccer games. *International Journal of Sports Science and Coaching*, 12(2), 194-206.

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

Vaeyens, R., Lenoir, M., Williams, A. M., and Philippaerts, R. M. (2007). Mechanisms underpinning successful decision making in skilled youth soccer players: An analysis of visual search behaviors. *Journal of Motor Behavior*, 39(5), 395-408.

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

Verburgh, L., Scherder, E. J. A., van Lange, P. A. and Oosterlaan, J. (2014). Executive Functioning in Highly Talented Soccer Players. *PLoS ONE,* 9(3), e91254.

Vestberg, T., Gustafson, R., Maurex, L., Ingvar, M. and Petrovic, P. (2012). Executive Functions Predict the Success of Top-Soccer Players. *PLoS ONE*, 7(4), e34731.

Vestberg, T., Reinebo, G., Maurex, L., Ingvar, M. and Petrovic, P. (2017). Core executive functions are associated with success in young elite soccer players. *PLoS ONE*, 12(2), e0170845.

Vilar, L., Araújo, D., Davids, K., and Bar-Yam, Y. (2013). Science of winning soccer: Emergent pattern-forming dynamics in association football. *Journal of systems science and complexity*, *26*(1), 73-84.

Wall, M., and Côté, J. (2007). Developmental activities that lead to dropout and investment in sport. *Physical Education and Sport Pedagogy*, 12(1), 77-87.

Ward, P., Hodges, N. J., Williams, A. M., and Starkes, J. L. (2004). *Deliberate practice and expert performance: Defining the path to excellence*. In A. M. Williams and N. J. Hodges (Eds.), Skill acquisition in sport: Research, theory and practice (pp. 231 – 258) London: Routledge.

Ward, P., Hodges, N.J., Williams, A.M., and Starkes, J. L. (2007). The road to excellence: deliberate practice and the development of expertise. *High Ability Studies*, 18, 119-153.

Ward, P., and Williams, A. M. (2003). Perceptual and cognitive skill development in soccer: The multidimensional nature of expert performance. *Journal of Sport and Exercise Psychology*, 25(1), 93-111.

Weissensteiner, J., Abernethy, B., and Farrow, D. (2009). Towards the development of a conceptual model of expertise in cricket batting: A grounded theory approach. *Journal of Applied Sport Psychology*, 21(3), 276-292.

Wen, D., Robertson, S., Hu, G., Song, B., and Chen, H. (2018). Measurement properties and feasibility of the Loughborough soccer passing test: A systematic review. *Journal of Sports Sciences*, 36(15), 1682-1694.

Williams, J. J. (2002). Operational definitions in performance Analysis and the need for consensus. *International Journal of Performance Analysis in Sport*, 12, 52-63.

Williams, A. M. and Hodges, N. J. (2005). Practice, instruction and skill acquisition in soccer: Challenging tradition. *Journal of Sports Sciences*, 23, 637-650.

Williams, A. M. and Ford, P. R. (2008). Expertise and expert performance in sport, *International Review of Sport and Exercise Psychology*, 1(1), 4-18.

Wold, B., Duda, J. L., Balaguer, I., Smith, O. R. F., Ommundsen, Y., Hall, H. K., and Castillo, I. (2013). Comparing self-reported leisure-time physical activity, subjective health, and life satisfaction among youth soccer players and adolescents in a reference sample. *International Journal of Sport and Exercise Psychology*, 11(4), 328-340.

Wright, C., Atkins, S., Jones, B., and Todd, J. (2013). The role of performance analysts within the coaching process: Performance Analysts Survey. *International Journal of Performance Analysis in Sport*, 13, 240-261.

Wright, C., Carling, C., and Collins, D. (2014). The wider context of performance analysis and its application in the football coaching process. *International Journal of Performance Analysis in Sport*, 14, 709-733.

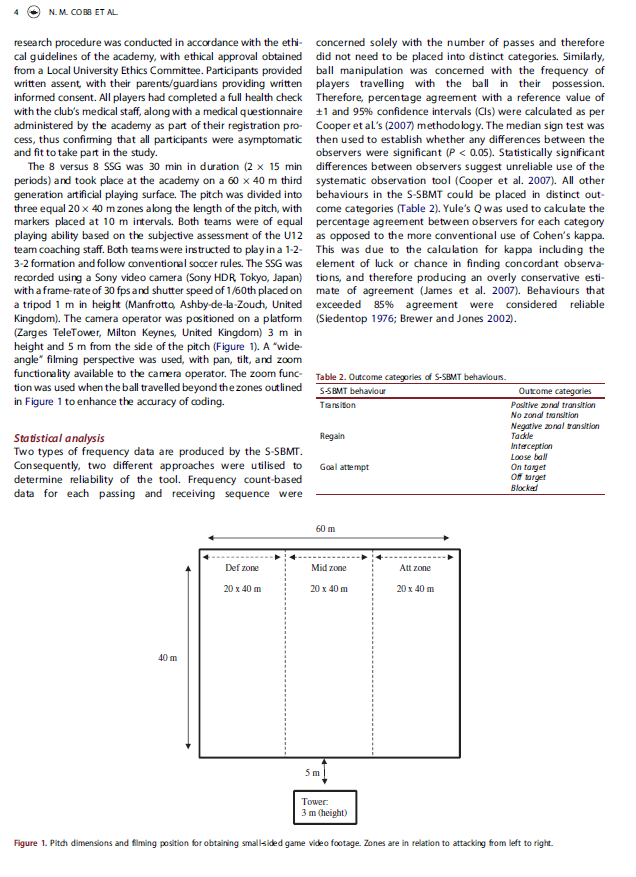
# Appendix A:

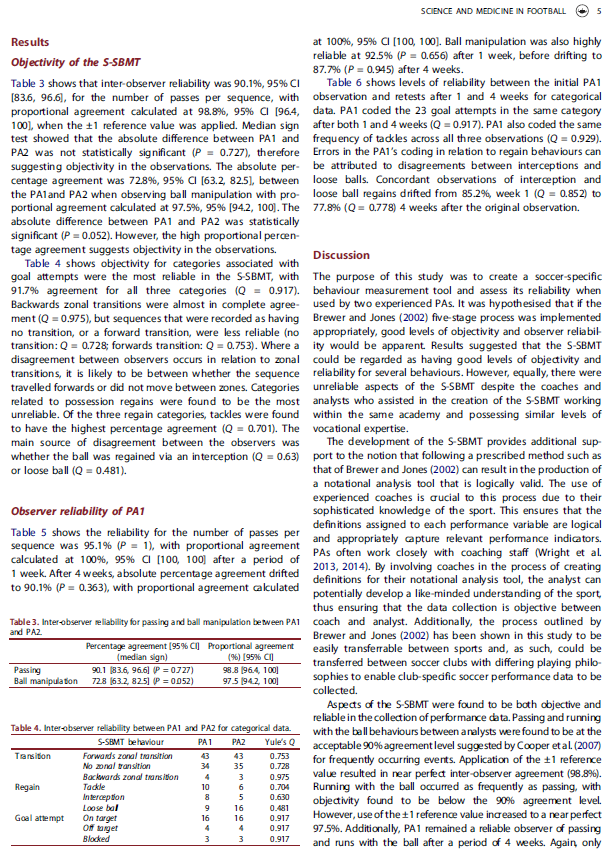
# Cobb, N. M., Unnithan, V. and McRobert, A. P. (2018). The validity, objectivity, and reliability of a soccer-specific behaviour measurement tool, *Science and Medicine in Football*, 2(3), 196-202. DOI: [10.1080/24733938.2017.1423176](https://doi.org/10.1080/24733938.2017.1423176)

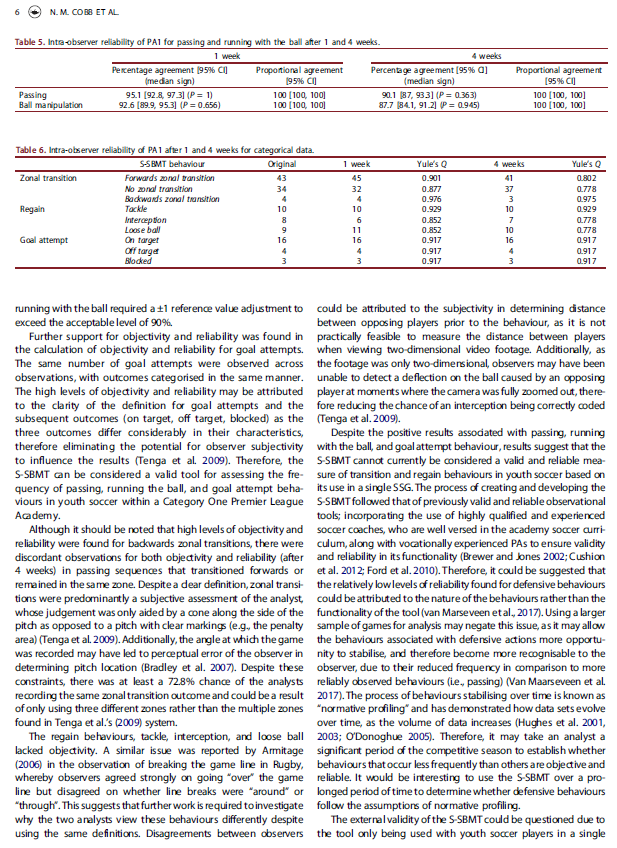


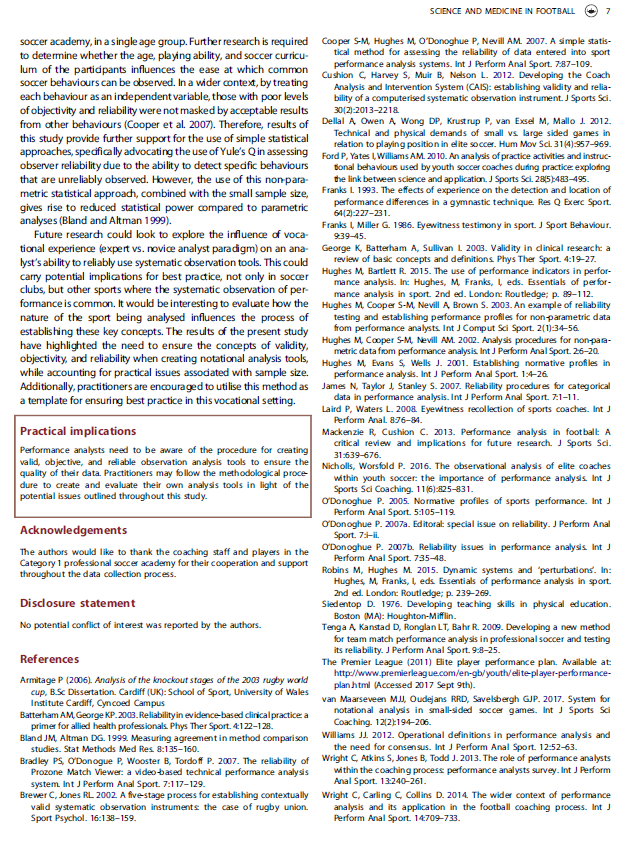












# Appendix B:

# The Participation History Questionnaire (PHQ)

**Participation History Questionnaire**

**1. ‘Milestones’**

What is your name?

What is your date of birth?

What is your town/city of birth? ­­­­­

Which town/city did you go to:

(i) primary school in?

(i) secondary school in?

*School milestones*

\_\_\_ years old when you first started full-time primary school \_\_\_\_ have never done it

\_\_\_ years old when you first started full-time secondary school \_\_\_\_ have never done it

*Sports specific milestones*

\_\_\_ years old when you first started playing football (not in an organised league)

\_\_\_\_ have never done it

\_\_\_ years old for first took part in supervised training by an adult in football

\_\_\_\_ have never done it

\_\_\_ years old when first began football training regularly

\_\_\_\_ have never done it

\_\_\_ years old when first played in an organized football league

\_\_\_\_ have never done it

\_\_\_ years old when first began non-football training (e.g. running, strength, etc)

regularly \_\_\_\_ have never done it

years old when first took part at School of Excellence level

\_\_\_\_ have never done it

years old when first took part at Academy level

\_\_\_\_ have never done it

years old when first took part at international level

\_\_\_\_ have never done it

**2. Engagement in football-related activities**

The following section focuses on the football-related activities you have participated from when you began playing to the present day, the number of hours spent in these activities per week, and the number of months per year you spent in each of the activities. This will be done foreach year you have participated.

Please group the activities you have participated in into the categories listed below:

**1.** **Match-play:** organised competition in a group engaged in with the intention of winning and supervised by adult(s), e.g. league games.

**2. Coach-led group practice:** organised group practice engaged in with the intention of performance improvement and supervised by coach(es) or adult(s), e.g. practice with team.

**3. Individual practice:** practice alone engaged in with the intention of performance improvement, e.g. practicing dribbling skills alone.

**4.** **Peer-led play:** play-type games with rules supervised by yourself/peers and engaged in with the intention of fun and enjoyment, e.g. game of football in park with friends.

Overleaf there is ‘participation history’ log, which lists these four categories and groups them into years. Please fill this in as accurately as possible, starting from this year (i.e., U12 or U9, 2013/2014) and working downwards until you have completed the first year you played football. Please do not fill in shaded areas.

For each year, please complete:

**1**a. The total number of hours spent taking part in activities related to each category.

**1b**. The number of months of the year that you spent taking part in activities related to each category.

**2.** The number of weeks from the relevant year that you were injured and unable to take part in the football activity. Leave blank if no injury.

NB. Please first write the name of the coach and team you played for in each season in the space provided

NB. A football season equals 9 months, whereas a year equals 12 months.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Age group | Team and coach | Activities | # of hrs/wk | Months  /yr | Injury  wks/yr |
| **e.g.** |  | 1. Match-play | 2 | 9 | 3 |
|  | John Smith | 2. Coach-led practice | 5 | 9 |  |
|  | Stoke Rovers FC | 3. Individual practice - self | 2 | 12 |  |
|  |  | 4. Peer-led play | 5 | 12 |  |
| **U12** |  | 1. Match-play |  |  |  |
|  |  | 2. Coach-led practice |  |  |  |
|  |  | 3. Individual practice - self |  |  |  |
|  |  | 4. Peer-led play |  |  |  |
| **U9** |  | 1. Match-play |  |  |  |
|  |  | 2. Coach-led practice |  |  |  |
|  |  | 3. Individual practice - self |  |  |  |
|  |  | 4. Peer-led play |  |  |  |

|  |  |
| --- | --- |
| **Categories:** |  |
| **1.** **Match-play:** | organised competition in a group engaged in with the intention of winning and supervised by adult(s), e.g. league games. |
| **2. Coach-led group practice:** | organised group practice engaged in with the intention of performance improvement and supervised by coach(es) or adult(s), e.g. practice with team. |
| **3. Individual practice:** | practice alone engaged in with the intention of performance improvement, e.g. practicing dribbling skills alone. |
| **4.** **Peer-led play:** | play-type games with rules supervised by yourself/peers and engaged in with the intention of fun and enjoyment, e.g. game of football in park with friends. |

**3. Engagement in other sport activities**

The following section focuses on the other sporting activities you have engaged in, the period of your life in which you took part in this activity, the number of hours per week, and months per year spent in these activities, and the standard of this activity. For each activity, please complete:

**1.** Please place a tick next to the other sports that you have participated in during your life, outside of timetabled school physical education classes.

**2a.** The age you started taking part in each activity.

2b. The age you finished taking part in each activity (if you are still participating in an activity then leave this section blank).

**3.** The total number of hours per week spent taking part in each activity.

**4.** The number of months of the year in which you took part in each activity.

**5.** The standard of the activity that you took part in for that sport (e.g., school, club, national, international).

NB. Please only record other sport activity that has lasted a total of three months of activity.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Other sport activities. | Please tick  if yes | Please cross  if no | Start age | Finish  age | Total # of hrs/wk | Months  /yr | Standard participated at |
| e.g. Cross country | / | x | 7 | 12 | 2 | 8 | School |
| Athletics |  |  |  |  |  |  |  |
| Badminton |  |  |  |  |  |  |  |
| Basketball |  |  |  |  |  |  |  |
| Boxing/Kick boxing |  |  |  |  |  |  |  |
| Canoeing |  |  |  |  |  |  |  |
| Cricket |  |  |  |  |  |  |  |
| Cycling |  |  |  |  |  |  |  |
| Cross country |  |  |  |  |  |  |  |
| Gymnastics |  |  |  |  |  |  |  |
| Golf |  |  |  |  |  |  |  |
| Handball |  |  |  |  |  |  |  |
| Hockey |  |  |  |  |  |  |  |
| Judo/Karate |  |  |  |  |  |  |  |
| Rugby/Gaelic |  |  |  |  |  |  |  |
| Running or jogging |  |  |  |  |  |  |  |
| Snooker/Pool |  |  |  |  |  |  |  |
| Swimming |  |  |  |  |  |  |  |
| Skiing/Snowboarding |  |  |  |  |  |  |  |
| Stretching/Yoga/Pilates |  |  |  |  |  |  |  |
| Table tennis |  |  |  |  |  |  |  |
| Tennis |  |  |  |  |  |  |  |
| Volleyball |  |  |  |  |  |  |  |
| Weights |  |  |  |  |  |  |  |
| Other: |  |  |  |  |  |  |  |
| Other: |  |  |  |  |  |  |  |
| Other: |  |  |  |  |  |  |  |
| Other: |  |  |  |  |  |  |  |
| Other: |  |  |  |  |  |  |  |

# Appendix C:

# Daily Physical activity Diary

|  |  |
| --- | --- |
| Accelerometer Number\_\_\_\_\_\_\_\_\_\_\_\_\_    Please use this diary to fill in the number of hours you spent in each football activity on each day this week, as well as the number of hours you spent in other sport/s activity on each day and the name of the other sport/s. Please include the start and end time of each activity. *Thank you.* | |
| ***Day*** | **Example** (e.g. 1. Match \_\_\_*2*\_\_\_hours) & (e.g., \_\_\_\_\_Tennis\_\_\_\_\_\_\_ \_\_\_\_\_2\_\_\_\_\_\_\_hours) |
| **Monday** | Time started: Time Finished: Please list other sports: Time started: Time Finished:  or Physical Activities  1. Match hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  2. Team hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  Practice    3. Play hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours |
| **Tuesday** | Time started: Time Finished: Please list other sports: Time started: Time Finished:  or Physical Activities  1. Match hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  2. Team hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  Practice    3. Play hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours |
| **Wednesday** | Time started: Time Finished: Please list other sports: Time started: Time Finished:  or Physical Activities  1. Match hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  2. Team hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  Practice    3. Play hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours |

**Football activities: 1.** **Match:** against other teams in which the intention is to win, led by coach(es), e.g. 8 v 8 Sunday matches.

**2. Team practice:** is activity in a group led by coach(es) that you take part in to improve performance, e.g. team practice.

**3.** **Play:** is activity that is engaged in for fun and is led by you or your friends with no coach(es), e.g. game of football in park with friends.

|  |  |
| --- | --- |
| **Thursday** | Time started: Time Finished: Please list other sports: Time started: Time Finished:  or Physical Activities  1. Match hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  2. Team hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  Practice    3. Play hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours |
| **Friday** | Time started: Time Finished: Please list other sports: Time started: Time Finished:  or Physical Activities  1. Match hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  2. Team hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  Practice    3. Play hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours |
| **Saturday** | Time started: Time Finished: Please list other sports: Time started: Time Finished:  or Physical Activities  1. Match hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  2. Team hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  Practice    3. Play hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours |
| **Sunday** | Time started: Time Finished: Please list other sports: Time started: Time Finished:  or Physical Activities  1. Match hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  2. Team hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours  Practice    3. Play hours \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_ hours |

Thank you for taking the time to fill out this diary.