CAN MODERN FOOTBALL MATCH DEMANDS BE TRANSLATED INTO NOVEL TRAINING AND TESTING MODES?

FEATURE

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Association football is a complex sport with unpredictable activity patterns during matches[1]. Players regularly transition between short multi-directional high-intensity efforts and longer periods of low-intensity activity[2]. Time-motion analysis has been the data-collection technique of choice to quantify the physical match performance of elite footballers[3]. In the last four decades this technique has quantified the relative or absolute distance covered and time spent along a motion continuum of walking through to sprinting [4-6]. This is accomplished with the aid of validated manual/computerized tracking or global/local positioning technology[7]. Technological advancements in wearables such as tri-axial accelerometers have enabled inertial indices to be progressively introduced alongside traditional time-motion techniques to provide more insight into metabolically taxing activities[8]. This has surely progressed the fields understanding of the physiological, metabolic and mechanical demands of elite football match play. Although more validation work should be conducted that compares inertial indices with physiological and metabolic measures.

The first in-depth match analysis study was published more than 40 years ago by the pioneer Professor Tom Reilly[4] and since then researchers have quantified the physical match performances across a multitude of competitions. These include the English Premier League[9,10], Italian Serie A2,[11], Danish League[5], Spanish La Liga[12], French Ligue 1[13], German Bundesliga[14], in addition to the European Champions League[15,16] and International tournaments[17,18]. The match demands of different populations have also been examined such as male[19], female[20], youth[21] and amputee players[22]. Moreover, this body of literature has been able to reveal the demands of various positions[9,10], competitive standards[2,23,24], formations[25] and the associated match related fatigue patterns[26,27]. Although the use of different speed thresholds, technologies and dwell times for selected movement categories in these studies has limited the ability to generalise and compare between studies[28]. Another fundamental issue very present within the majority of these studies is the lack of contextualisation of the physical data. For instance, authors simply reporting the distances covered and frequency of occurrence of selected physical metrics without any consideration for important performance determinants in football like tactical and technical factors[9,29]. This ultimately leads to one-dimensional view into fluctuations in running performances and a lack of insight to the players and coaches[30]. Another issue experienced by practitioners reading such research is its lack of application into practices such as training and testing.

Thus, this brief review will explore the literature published on the longitudinal trends in match running performance to inform the reader on the current demands of elite football match-play. Moreover, illustrate how data on modern match performance can be applied into everyday practices within the elite environment such as training and testing.

EVOLUTIONARY TRENDS IN FOOTBALL MATCH PERFORMANCE

Sports such as running, team handball and Australian Rules football have evolved significantly in recent years, potentially due to advances in physical and/or tactical preparation[31-34]. In football there is also a commonly held belief amongst the media, coaches and players that the game has evolved exponentially in the last decade. However, despite the popularity of the game, limited reports have been published on this area. The earliest paper published on this subject compared the intensity of English League matches played in the 1991–92 versus the 1997–98 season[35]. The authors concluded that the tempo of the game had increased as evidenced by more dribbling, passing, crossing and running with the ball in the latter season. More recently, Wallace and Norton[36] analysed match performance data from World Cup Final matches across a 44-year period. The data demonstrated that passing rates increased by 40% with concomitant elevation in ball speed. A main limitation of this research was it only provided insight into technical evolution with very limited consideration for the physical performance of players. Football is a multifaceted sport with the physical, tactical and technical factors amalgamating to influence performance with each factor not mutually exclusive of another[30]. Thus, research quantifying the evolution of football match-play should consider multiple factors.

A series of studies exploring the evolution of the English Premier League have recently been published using a duel technical-physical approach [9,37,38]. These studies examined the largest sample of elite players published to date

(14700 player observations) across 7 seasons (2006-07 to 2012-13) whilst equalising the number of players analysed across each year, seasonal period, position and game location. The first study[37] analysed the data in its entirety and demonstrated that total distance covered by players did not differ between the 2006-07 and 2012-13 seasons but high-intensity running and sprinting distances increased by 30-50% (Figure 1). Whilst sprints in the 2012-13 season were much more frequent than that found for the 2006-07 season, they were also shorter and more explosive. From a technical perspective, players performed more passes and successful passes in 2012–13 compared to 2006–07 season. This increase was mainly due to an increase in short and medium distance passes. The data clearly indicate that elite leagues like the English Premier League have evolved substantially.

This first study only examined longitudinal trends in physical and technical match performances in their entirety, so a second study quantified the evolution of playing position to gain an insight into tactical changes[38]. Full-backs demonstrated the most pronounced increase in high-intensity running and sprinting distances with attackers the least pronounced in the 2006-07 versus 2012-13 seasons. While wide players illustrated markedly more physical evolution than other positions, it was the central players like central defenders and midfielders that evolved more in terms of passing metrics. These trends could indicate tactical changes in the English Premier League with teams utilising traditional tactical systems in 2006-07 like 4-4-2, 4-3-3 and 4-5-1 and then moving towards more modern systems such as 4-2-3-1 and 4-1-4-1 formations[38]. These latter tactical systems are extremely compact in the central regions of the pitch (hence central players passing more) and allow wide players (full-backs) to utilise the flanks to add an offensive threat[39].

The third study examined if this physical and technical evolution was partly due to the English Premier League becoming more competitive[9]. Thus, the data was split into four groups based on the final placing (A=1st-4th, B=5th-8th, C=9th-14th, D=15th-20th). Although all groups physical and technical performances increased, it was group B that illustrated the most pronounced elevations in high-intensity running distance and the number of passes from 2006-07 versus 2012-13. The demarcation line between 4th (bottom of group A) and 5th place (top of group B) in the 2006–07 season was 8 points, but this decreased to just a single point in the 2012–13 season. The data demonstrate that physical and technical performances have evolved more in group B than any other group in the EPL and could indicate a narrowing of the performance gap between the top two groups.

A consistent finding from all studies in the literature is that the game is becoming more demanding. Thus, fitness coaches should aim to condition players to cope with multiple intense bouts with minimal recovery while maintain technical and tactical proficiency. A major limitation with the majority of match demands studies is the lack of application into practice[40]. Few studies have translated discrete actions into useable metrics such as angles of

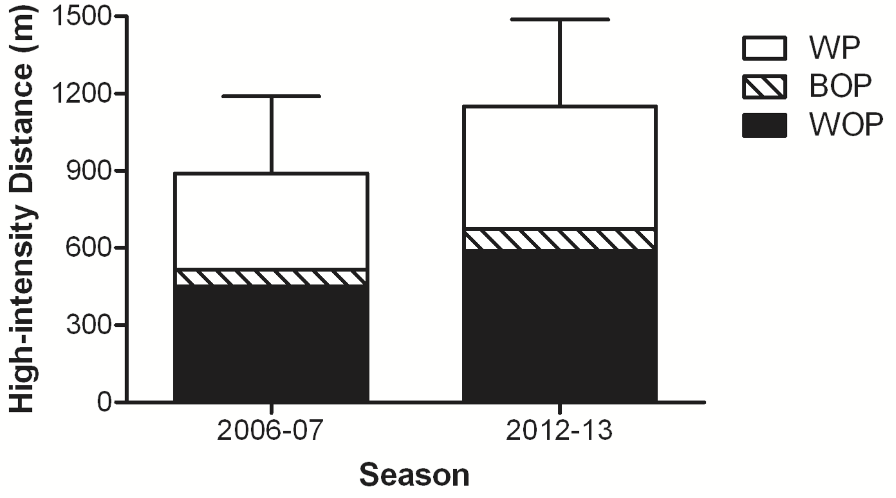

Figure 1. Longitudinal changes in high-intensity running distance in the English Premier League (2006-07 versus 2012-13). WP = with possession, BOP = ball out of play, WOP = without possession. Data modified from Barnes et al.[37].

turns, technical sequences and tactical actions associated with physical data that could be used within the club setting[40,41]. Thus, the next section will detail how match demands data can be applied to design testing and training modalities that have a high degree of specificity.

APPLICATION OF MATCH ANALYSIS INTO TRAINING AND TESTING MODALITIES

A recent study has revealed unique position-specific trends with special reference to movement patterns, pitch location, technical skills, tactical actions and combination play[40]. All of the categorises above were coded using a novel 'High Intensity Movement Programme' which synchronised physical match metrics such as high-intensity running with video recording of each intense action (Table 1). The study was designed to provide additional information for practitioners wishing to design general and position-specific drills. The study demonstrated that high-intensity running distances were greatest for wide midfielders and lowest for centre backs with full-backs, central midfielders and centre forwards falling somewhere in-between. However, as the data was contextualised it provided more insight into purposeful tactical efforts in and out of possession. For instance, in possession, centre forwards carried out more high-intensity efforts in the offensive third of the pitch, whilst driving through the middle, running in behind, and

Categories	Description
Movement Pattern	
Turn 0-90°	Player turns ≤ ¼ circle
Turn 90-180°	Player turns ≥ ¼ circle but ≤ ½ circle
Swerve	Player changes direction at speed without rotating the body
Arc Run	Player (often leaning to one side) moving in a semi-circular direction
Technical Skill	
Long Pass	Player attempts to pass the ball to a team mate over a distance greater than 30 yards
Trick	Player performs ball skill before, during or after dribbling / running with the ball
Cross	Player attempts to cross the ball into the opposition penalty box from either flank in the attacking third of the pitch
Shot	Player attempts to kick the ball into the opposition goal
Header	Player makes contact with the soccer ball using the head
Tackle	Player dispossess the soccer ball from the opponent
Tactical Outcome (In Possession)	
Break into the opposition penalty box	Player enters the opposition penalty box
Run with the ball	Player moves with the ball either dribbling with small touches or running with the ball with bigger touches
Overlapping Run	On the external channel, player runs from behind to in front of, or parallel to the player on the ball
Push up the pitch	Player moves up the pitch to support the play or play offside (defensive and middle third of the pitch only)
Drive through the middle of the pitch	Player runs with or without the ball through the middle of the pitch
Drive inside the pitch	Player runs from external flank with or without the ball into the central area
Run the channel of the pitch	Player runs with or without the ball down one of the external areas of the pitch
Run in behind the opposition defence	Player aims to beat the opposition offside trap to run through onto the opposition goal
Tactical Outcome (Out of Possession)	
Close down opposition player	Player runs directly towards opposition player on the ball
Interception of opposition pass	Player cuts out pass from opposition player
Covering	Player moves to cover space or a player on the pitch whilst remaining goal side
Track runner	Player runs alongside opposition player with or without the ball
Ball passed over the top of player	Opposition plays a long pass over the defence through the center of the pitch
Ball passed down the side of pitch	Opposition plays a ball over the top or down the side of the flank
Recovery run	Player runs back towards own goal when out of position to be goal side

Table 1. 'High Intensity Movement Programme'. Adapted from Ade et al.[40]

breaking into the box. Whilst wide players like full backs and wide midfielders produced more high-intensity efforts overlapping and running the channel than other positions[40]. They also performed more crosses after these runs than other positions due to more efforts finishing in wide attacking pitch areas. Out of possession, positions with a major defensive role in the team like centre backs, full backs and central midfielders produced more high-intensity efforts covering space or team-mates and recovery running whilst all positions performed frequent high-intensity efforts closing down the opposition.

The frequency, duration, distance, angle of turns of these contextualised efforts across positions are valuable prescription metrics when constructing combination or isolated drills, particularly when considered relative to one another[40]. In order for a movement pattern, technical skill, combination play or tactical action to be included in the design of a position specific drill they adhered to one of the following criteria: (1) It occurs in >33% of efforts, (2) There is at least a small effect size difference compared to a minimum of two other positions, (3) In categories with a large number of variables (>3), there is a moderate standardised difference compared to the mean of the other variables. The third criteria allows for actions that may not occur in a high percentage of efforts, but relative to the other variables are the most prominent and should therefore be included (e.g. heading for a centre back). Ade et al. 40 reported the majority of high-intensity efforts do not include any ball contact (~60-75%), however for player enjoyment, technical skill development under fatigue and compliance such actions should be included.

The first drill designed used an appropriate blend of science gathered from the 'High Intensity Movement Programme' and the art of coaching as evidenced by consultation with a UEFA Pro License football coach. This was a combination drill in which all positions are worked in unison with game- and position-specific ball work present. For effective drill design on a full-sized pitch, the start and end location of efforts were replicated to enhance the ecological validity of this drill, thus duplicating position-specific in and out of possession scenarios but with over-load. As speed endurance production and maintenance training typically induces sufficient metabolic overload[42] for aerobic and anaerobic adaptations in players[43], this was the training mode used. The drill started with the full-back producing an effort in the defensive third before overlapping the wide midfielder, to receive a pass in the wide attacking third to perform a cross. Simultaneously, the centre forward breaks into the box to score while being tracked by the centre back both having started in the middle third of the pitch. The central midfielder drives through the middle of the pitch performing an arc run to support the attack ending with a possible shot on goal. At the end, all positions produce a recovery run to individual pitch locations based on match data[44]. Using a speed endurance production work to rest ratio (1:6), all five positions (n=10; English Premier League academy U17-18's) produced 8 repetitions of ~30s with 180s recovery. This elicited an average and peak heart rate response of ~77 and 88% of maximal heart rate and produced blood lactate concentrations following the final repetition of ~5-6 mmol·L-1.[44] This training response is substantially lower than that reported in previous research assessing isolated running drills or 1vs1 small-sided games in football players (~82-84 and 89-90% of maximal heart rate and 10-13 mmol·L-1) albeit using a lower work to rest ratio of 1:4[42]. Using a speed endurance maintenance work to rest ratio (1:2), all five positions (n=10; English Premier League academy U17-18's) produced 8 repetitions of ~30s with 60s recovery. This elicited an average and peak heart rate response of ~80 and 93% of maximal heart rate and produced blood lactate concentrations following the final repetition of ~6-16 mmol·L⁻¹.[44] Video footage revealed the intensity of the drill drops should one player perform a technical skill poorly (pass / touch) as the simultaneous flow of the drill becomes disjointed resulting in some positions having to slow down and alter their runs. Large intra-player variation in time-motion characteristics between repetitions was also evident, especially sprint distance covered (>40%)[44]. This particularly impacted the metabolic responses of the speed endurance production drill. Consequently, the position-specific speed endurance drills were amended to be administered in isolation in the absence of a coach led session during end stage rehabilitation or when additional conditioning is required due to lack of match exposure or poor fitness. Testing data (n=6; English Premier League academy U17-21's) of the isolated speed endurance production and maintenance drills physiological response has revealed average and peak heart rate response of ~76, 85% and ~84, 90% of maximal heart rate with post drill blood lactate concentrations of >13 mmol·L⁻¹.[44] Please see Figure 2 for an example of an isolated positional drill for a full back based on the 'High Intensity Movement Programme'.

Alongside daily training, players are also required to complete physiological testing batteries to monitor physical qualities that are vital for the game[6]. The ability to repeatedly produce intense actions with minimal recovery is an important attribute for elite players to possess[5]. A recent study has revealed a unique Reactive Repeated-Sprint Test that was developed using key variables from the most intense 5-min period in elite football matches[6], 26. The test consists of 8 repetitions of 30 m sprints, with accelerations, decelerations, multi-directional movements

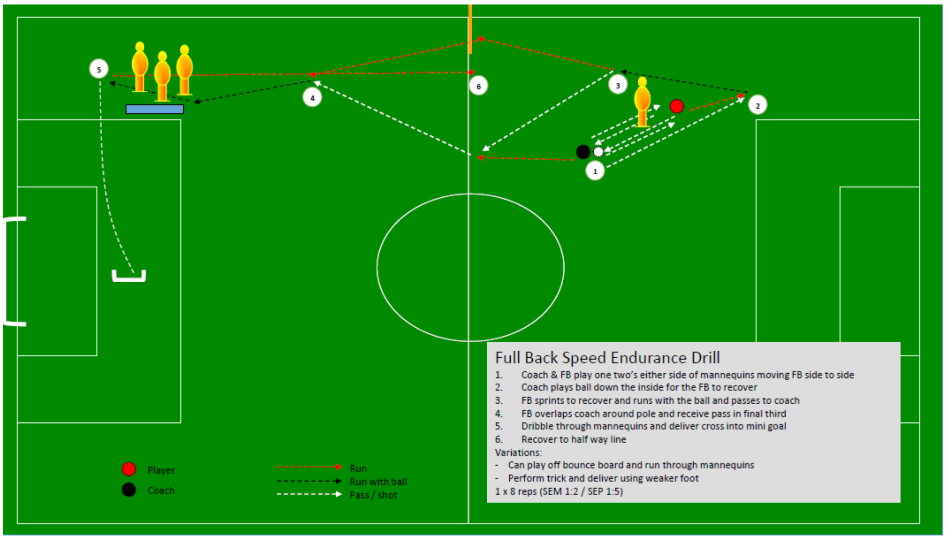

Figure 2. Isolated positional drill for a full back based on the 'High Intensity Movement Programme'. Please note the yellow figures represent mannequins. SEM = speed endurance maintenance, SEP = speed endurance production. Drill configuration from Ade & Bradley[44].

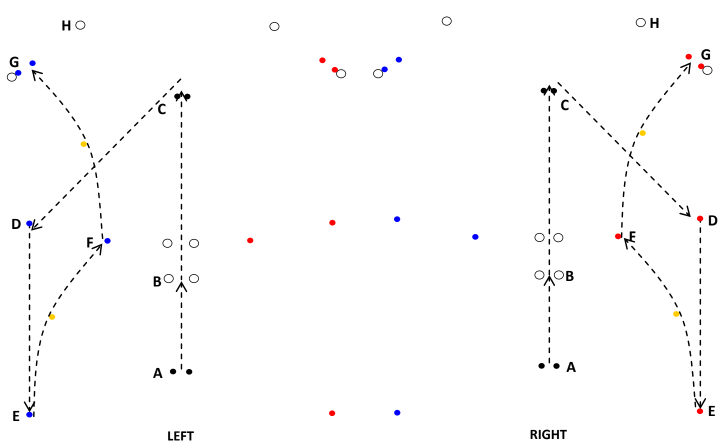

Figure 3. Layout of the reactive repeated sprint test. Test configuration from Di Mascio et al. [6]. All short sprints are 6 m (5 x 6 m = 30 m). Players start at point A, and sprint to the poles at point C. They turn at point C, sprint through to point E via point D, turn and sprint to point F via a curved run to the outside of point E then through the finishing gate shown at point G via a curved run to the inside of the cone. A visual signal at point H determines whether they go right or left, and is initiated when the player runs through the second set of timing gates. Timing starts at the first set of timing gates and is complete at point G. O timing gate

and a reactive element included in the 5 sets of 6 m sprints within the 30 m (Figure 3). The turns during the test were based on those found by Bloomfield et al.45 where the most frequent at high-intensity were directly forward, forward diagonal and arc forward; these were included in this order. Results included total (for 8 repetitions) and best time (fastest repetition), and has so far excluded a fatigue index due to its high variability[46].

English Premier League youth players performing the test on two separate occasions interspersed by 1 week, produce a coefficient of variation of <1%, highlighting excellent reliability. As the test is based on measurements from the most intense 5-min period during competitive matches (logical validity), the validity of the test was assessed by evaluating match running performance (concurrent validity). Large to very large correlations were found between test performance vs high-intensity running in the most intense period (r = -0.55-0.74) and during a match (r = -0.55-0.67) for elite and sub elite youth squads. It was also compared to other tests of a relevant nature (criterion validity) and sensitivity to performance levels (construct validity). An excellent relationship was found between the Arrowhead agility test and the fastest repetition of the test for elite youth players. Test performance differed markedly between levels with elite U18 players outperforming elite U16 and sub-elite players. Furthermore, elite senior female players were outperformed by all male counterparts. The test is similar to intense periods during a match due to its heart rate and blood lactate concentrations throughout. This test elicited peak heart rate responses of ~92-95% of maximal heart rate and produced blood lactate concentrations following the final repetition of ~9-15 $mmol \cdot L^{-1}$ in sub-elite youth players.[6] This was similar to values after intense periods of match-play[47].

CONCLUSIONS

This review details the longitudinal trends in match demands and clearly indicates that elite leagues such as the English Premier League are now more physically and technically demanding than a decade ago. Thus, the need to optimise a player's physical capacity using running and football-based drills is more important than ever to enable players to perform optimally but also make them robust enough to maintain this throughout the season. Moreover, the monitoring and evaluation of elite players needs to use the most reliable, valid and sensitive tests possible. As a result, this review has explored how match performance data can be used to design testing and training modalities that have a high degree of specificity.

PRACTICAL IMPLICATIONS

- Elite football competition has evolved substantially, with large increases in physical and technical demands that are often inter-related. The use of traditional performance metrics that report gross physical output therefore lack the contextual information necessary to fully explain and enhance player performance during training and games.
- The synergy of physical and technical performance metrics allows for the creation of player/position-specific drills and tests, challenging the individual's physical capabilities in relation to their tactical role within the team, in and out of possession.
- Tactical conditioning drills appear to provide the greatest physical and technical challenge when isolated to specific positional demands rather than when incorporated into a multi-positional drill. Such a position-specific approach to conditioning is highly effective in allowing close replication of the most challenging periods of math play, which is a crucial when conditioning players to meet the demands of the modern game.
- Please note that combination drills could still be used other isolated drills especially if the emphasis is on a global performance stimulus rather than just a physical stimulus. Future research should examine acceleration indices to provide a deeper context to this translation.

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