**Kronos** 2014: 13(1)
ISSN: 1579-5225 - e-ISSN: 2603-9052
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Sport Performance

# Breve Reseña de Investigación y de las Aplicaciones que Utilizan con Datos Posicionales de Futbolistas

## Brief Overview of Research and Applications Using Football Players' Positional Data

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Fecha de recepción: 26 de Septiembre 2013
Fecha de aceptación: 10 de Octubre de 2013

## RESUMEN

Los últimos avances tecnológicos han permitido mejorar la validez de los datos disponibles sobre las necesidades fisiológicas y físicas del fútbol y revelan nuevas posibilidades para la comprensión del rendimiento táctico en entrenamiento y competición. Este trabajo presenta una breve descripción de la investigación y las aplicaciones que utilizan los datos de posición de los futbolistas. Hoy en día, los principales avances tecnológicos se basan en sistemas de radiofrecuencia, sistemas semi-automáticos de rastreo de video, o unidades de GPS. Cada uno de estos sistemas puede registrar los datos de posición de los jugadores en el campo con un mayor grado de precisión. Sin embargo, la mayoría de los estudios disponibles utilizan esta información para cuantificar las demandas físicas y fisiológicas de los jugadores. Pero, dada la naturaleza del fútbol, estas demandas parecen estar dependientes del comportamiento táctico de equipo. Las investigaciones actuales han identificado nuevos indicadores de rendimiento, ayudando a mejorar la validez de los análisis tácticos. Al final, el estudio mutuo de las variables multidimensionales puede ser un nuevo avance para perfeccionar la representatividad de las prácticas y de los diseños de tareas y para mejorar el feedback de los entrenadores a los jugadores.

**Palabras Clave:** datos de posición, indicadores de desempeño, sistemas, fútbol

## ABSTRACT

The recent technological advances have allowed improving the validity of available data on physiological and physical requirements of football and revealed new possibilities for understanding the tactical performance in practice and competition. This paper presents a brief overview of research and applications using football players’ positional data. Nowadays, the main technological advances are based in radio frequency systems, semi-automated video tracking systems or GPS units. Each of these systems aims to capture the players’ in-field positional data with a higher degree of accuracy and minor demands for the data analysis and interpretation. However, the majority of the available studies are using this information to quantify the physical and physiological demands of the players. Yet, given the nature of the game, these demands seem to be dependent on the team tactical behaviour. In this sense, current researches have been identifying new performance indicators, helping to improve the validity of tactical analysis. At the end, the study of multi-dimensional variables can be a further advance to refine representativeness of practice task designs and to improve the coaches’ feedback to the players.

**Keywords:** positional data, performance indicators, systems, football

## INTRODUCTION

Contemporary football training is a multifactorial process requiring high accuracy in physiological, technical and tactical workload prescriptions that, ultimately, determines the players' and teams' performances. The elite level players experience significant loads during competition (Bangsbo, Mohr, & Krustrup, 2006), which demand for specific adaptations during training. For these reasons, the identification of key performance indicators that may improve the training process is a main issue for coaching staffs. The football activity profile can be described as intermittent with great variability of stimulus and intensities (Rebelo, Brito, Seabra, Oliveira, & Krustrup, 2012) when struggling for the ball possession, sprinting and changing direction, merged with technical skills and tactical decisions (Gonçalves, Figueira, Maçãs, & Sampaio, 2013). In fact, players are required to repeatedly produce high-speed actions with brief recovery periods (Buchheit, Mendez-Villanueva, Simpson, & Bourdon, 2010b) and perform high-intensity directional changes with minimal recovery bouts (Dellal, Keller, Carling, Chaouachi, Wong, & Chamari, 2010). Thus, the ability to recover and to reproduce performance in subsequent high intensity actions is considered an important fitness requirement to achieve elite level performances (Girard, Mendez-Villanueva, & Bishop, 2011).

Monitoring these holistic performances requires to measure variables such as heart rate (Buchheit, Simpson, Al Haddad, Bourdon, & Mendez-Villanueva, 2012), ratings of perceived exertion (Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004), repeated sprint and change of direction abilities (Wong, Chan, & Smith, 2012) and time motion related (Casamichana & Castellano, 2010). In addition, technical performances are measured by using game related statistics such as passing, tackling or shooting (Ali, 2011; Rampinini, Impellizzeri, Castagna, Coutts, & Wisloff, 2009) and tactical performances by players' positioning-derived variables (Sampaio, Lago, Gonçalves, Victor, & Leite, 2013; Sampaio & Maçãs, 2012).

## TECHNOLOGICAL ADVANCES IN DATA COLLECTION

Recent technological advances in positional, computational and imaging tools have allowed the collection of players' in-field positional data, either in competition or training scenarios, with a higher degree of accuracy and minor demands for the data analysis and interpretation. These technological advances are mostly based in radio frequency systems (Frencken et al., 2010), semi-automated video tracking systems (Di Salvo, Collins, McNeill, & Cardinale, 2006) or GPS units (Johnston, Watsford, Pine, Spurrs, Murphy, & Pruyn, 2012; Varley, Fairweather, & Aughey, 2012).

One example of radio frequency systems is the LPS system, which is based on the frequency-modulated continuous wave principle, measuring the distance between fixed base stations and mobile tags placed on the players (Leser, Baca, & Ogris, 2011). This technology has been established as an accurate and valid tool to record positions of players in outdoor and indoor fields, providing accurate data in static and dynamic conditions at various speeds (Leser et al., 2011; Ogris, Leser, Horsak, Kornfeind, Heller, & Baca, 2012). The average absolute error during local position tacking measurements is estimated in 23.4±20.7 cm, the average velocities range from 0.01 to 0.23 Km.h-1 and the high speed estimations diverged by up to 2.71 Km.h-1 (Ogris et al., 2012). The accuracy of the tracking system is limited by the strength of the radio signal and the number of players' tracked (Mandeljc, Kovacic, Kristan, & Pers, 2013). Also, the system is not portable and the players need to wear radio-emitting tags, which is not allowed during competition.

The computer-vision technology uses multiple video cameras to provide players' tracking information (Mandeljc et al., 2013). It requires an elaborated system installed around the stadium to obtain accurate and reliable positional data based in high frequency, time-synchronized and calibrated cameras (Di Salvo et al., 2006; Frencken, Poel, Visscher, & Lemmink, 2012). The computer vision cameras capture video and, afterwards, several combined algorithms extract the positioning data from all objects on the field. Finally, the obtained data are converted into performance variables. The validity studies of these systems revealed high correlations during paced runs of 60m and 50m (r = 0.999), maximal 15m sprints (r = 0.970) and during maximal 20m sprints with right or left turns (r = 0.960) (Di Salvo et al., 2006). The players do not need to carry any device, which allows using the technology during formal competitions. Nevertheless, there are difficulties in maintaining automatic tracking over longer periods, since the players move quickly, unexpectedly change direction and collide with another players (Needham & Boyle, 2001). Also, these systems are not easily portable and have major costs associated. The available research is using these data mainly to describe the players' physical demands (Abt & Lovell, 2009; Dellal, Lago-Penas, Rey, Chamari, & Orhant, 2013).

Lastly, the GPS technology has changed the performance analysis in outdoor team sports. The system uses the earth-orbiting satellites (at least three) that emit constant coded signals to track the position of a receiver (Larsson, 2003). After that, the devices are able to record real-time data concerning time, speed, distance, position, altitude and direction. This technology has been widely used in team sports and its validity was already identified for several frequencies (5 and 10 Hz). Johnston and colleagues (2012) showed that 5 Hz GPS units were valid to measure the total distance covered (percentage typical error of measurement below 5%) and peak speed (percentage typical error of measurement from 5 to 10%). Nevertheless, the 10 Hz GPS devices revealed higher accuracy when compared with a criterion value for range of velocities (coefficient of variation 3.1–11.3%) and for measuring instantaneous velocity (coefficient of variation 1.9–6.0%) (Varley et al., 2012). The main advantage of these measurement systems is portability and low-cost price, when compared to other systems. However, the system operates only outdoors and requires the attachment of portable devices, which are still not allowed in official football competitions.

An extensive number of studies were developed to quantify the physical and physiological demands of footballers using GPS (Abade, Goncalves, Leite, & Sampaio, 2013; Aguiar, Botelho, Goncalves, & Sampaio, 2012; Cummins, Orr, O'Connor, & West, 2013). However, the physical demands seem to be dependent on the team tactical behaviour and, added together, this information may contribute to a better understanding of players' performances and football complexity (Gonçalves et al., 2013; Sampaio et al., 2013). In fact, the tactical behaviour can be measured by positioning when calculating individual (players) and collective (teams) measures based on a two-dimensional Cartesian coordinate representation.

## MATCH PHYSIOLOGICAL AND PHYSICAL PERFORMANCE

The players' heart rate during a game is rarely below 65% of maximum (Bangsbo et al., 2006) with mean and peak around 85% and 98% of maximal values, respectively (Krustrup, Mohr, Ellingsgaard, & Bangsbo, 2005). The time motion profiles measure the number of sprints performed, high-intensity running and total distance covered, usually described according to specific positions (Bradley, Di Mascio, Peart, Olsen, & Sheldon, 2010), playing levels (Mohr, Krustrup, & Bangsbo, 2003) and ages (Abade et al., 2013). For instance, the total distance covered by youth players during a match approximately ranges from 4435 to 8098m, with 12% comprising high intensity activities (Rebelo et al., 2012), and these trend increases with age (Buchheit, Mendez-Villanueva, Simpson, & Bourdon, 2010a). The defender players cover shorter distances in high-intensity than other players, while midfielders and full-backs cover similar distances at high intensity (Mohr et al., 2003). Interestingly, the amount of distance covered during a match is strongly correlated with the ability to perform repeated sprints (Rampinini, Bishop, Marcora, Bravo, Sassi, & Impellizzeri, 2007). Therefore, the repeated sprint ability is considered a key quality discriminating highly skilled players (Gabbett, 2010). Moreover, the repeated sprint sequences and number of sprints are affected by age, playing position and playing time and decrease throughout the game (Buchheit et al., 2010b).

### Training applications

The football training sessions have a strong focus on game like situations with high variability of technical, tactical and physiological stimuli (Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011). For that reason, manipulating the task constraints is a very complex issue because the players' unique characteristics may allow different behaviours to emerge from similar stimulus (Chow, Davids, Hristovski, Araujo, & Passos, 2011). Even though, different demands can be identified according to age groups. For example, it was already showed that players' U15 years old training sessions' were less physiologically demanding than U17 and U19 years old (Abade et al., 2013) probably caused by increased focus on small-sided games to develop basic tactical principles and technical skills. The focus on game like-situations seems to impose a higher external and internal workload on U17 and U19 players.

Although many youth team competitions are organized according to age groups, most motor skills experience significant developments during the pubertal period (Côté & Fraser-Thomas, 2007; Fernandez-Gonzalo, De Souza-Teixeira, Bresciani et al., 2010). Consequently, the physical and physiological profiles may vary among players with identical ages and playing experience (Cobley, Baker, Wattie, & McKenna, 2009). Yet, coaches can use the data from training performances to classify players and establish homogenous groups for talent identification and training prescription, allowing optimal performances in all players. When clustering players of similar physiological profiles and fitness levels, the variability of physiological outcomes will be minimized, allowing coaches to have a more effective control on the players' responses.

The weekly training loads vary according to the phases of the annual cycle, which may result in different physiological stress imposed on players (Impellizzeri et al., 2004). The preseason period is generally associated to greater intensities, mainly due to a high concentration of training loads (Issurin, 2010) and time spent in technical/tactical specific sessions that typically consist of high intensity small sided games and simulated matches (Jeong, Reilly, Morton, Bae, & Drust, 2011). On the other hand, the in-season competitive schedule creates unique constraints such as the post-game recovery and tapering the training to the next game (Gastin, Fahrner, Cook, Huntsman, Meyer, & Robinson, 2010). Therefore, the coaches' main concern during this period is to maintain the physical fitness developed during pre-season (Reilly, 2007). In accordance with this idea, a study with junior elite players showed that the overall physiological load of the weekly training was higher in pre-season than in-season, with higher mean heart rate, time in the highest intensity heart rate zones and RPE-based training loads (Jeong et al., 2011).

The weekly training loads appear to vary according to age with an increased intensity of training observed in older age groups, probably due to a higher focus on physical development and competition (Wrigley, Drust, Stratton, Scott, & Gregson, 2012). As a result, the weekly cycle is adjusted to support such objectives. For example, research has shown that U18 players experienced higher training volume reflected in additional field and gym sessions when compared to U16 and U14 (Wrigley et al., 2012). In fact, the progression of overall physical load is crucial to improve the physical performance and prevent injuries (Matos & Winsley, 2007). This trend seems to reproduce the training principles advocated for the long term athletic development of adolescents and suggests a training load structured in relation to maturity status (Balyi & Hamilton, 2004).

## MATCH TACTICAL PERFORMANCE

Given the nonlinear nature of the football matches events, tactical performance depends mostly on interactions between players, rather than solely in individual characteristics or conditioning (Lames & McGarry, 2007). As such, tactical performance may be understood as the individual and collective behaviours, emerging from the opposing sides interactions, while attempting to gain advantage over the adversary, both attacking and defending (Gréhaigne, Godbout, & Bouthier, 1999; McGarry, Anderson, Wallace, Hughes, & Franks, 2002). In this way, measuring tactical performance in football implies the analysis of individual player positions, but taking into account their time and context dependence. As seen earlier, this analysis can be addressed by using the players' relative pitch positioning data.

Available studies tend to focus their analysis either on the cooperation or competition behaviours (intra or inter team/player analysis) or, on the density of relations established (study the relations of a pair of players or players dyad; a group of players or a whole team). Different combinations of these aspects represent distinct approaches to study tactical behaviour, trying to capture and describe players and teams' performance characteristics at different levels of interaction (micro, meso and macro).

At the micro-level, several studies described 1x1 situations focusing on parameters related to the attacker or defender success (Grehaigne, Bouthier, & David, 1997). Analyses are usually performed on the interpersonal distance between opponents, individual and relative (difference between attacker and defender) velocities and distances to the goal. Results showed that attackers are more successful on passing the defender when a higher difference of relative velocity is achieved (Duarte, Araújo, Gazimba et al., 2010). Also, the attacker has more chances of success while attempting to score goals if his interpersonal distance to the defender and distance to the goal is smaller, and when a higher difference of relative velocity is achieved (Vilar, Araújo, Davids, Travassos, Duarte, & Parreira, 2012).

Although presented as a level of analysis, few studies have focused on the cooperative relation between a players dyad of the same team. Sampaio and Maçãs (2012) measured inter-players coordination in a pre – post study with college students, using a relative-phase analysis of two individual player distance to the team centroid. Results showed that despite no trend in coordination was revealed in the pre-test, post-test evidenced clear phase and anti-phase patterns of coordination. These results reflect the higher awareness to a collective approach to the situation, related to a more developed tactical skill. On a related approach in futsal, the cooperation between two defenders was studied in a ball passing task (Travassos, Araújo, Davids, Esteves, & Fernandes, 2012). Results showed that defenders where more successful intercepting the pass when the distance between the ball carrier and the second defender was higher, thus providing more time to the ball interception.

At a meso level of analysis, research is focused on every interaction based in more than two opposing or same team players, but less than the whole team. Research done in this level of analysis tends to use small-sided games situations, as they contain similar principles present in the global system (Davids, Araújo, & Shuttleworth, 2005). Most common measures focus on the teams' centroid (geometrical centre from the players positions), distance between centroids, teams' areas and/or teams' length and width.

Results tend to show a strong coordination tendency between opposing teams centroid (Duarte, Araújo, Freire, Folgado, Fernandes, & Davids, 2012), although crossing centroids (i.e. attacking centroid more close to the opposing goal than defending centroid) is not always related to goal score situations (Frencken, Lemmink, Delleman, & Visscher, 2011). Some authors have also used these collective measures in order to study their ability to discriminate different levels of expertise. Measuring the length and width relation of different age group teams on 3x3 situations, older players presented lower levels of variability when comparing to younger teams (Folgado, Lemmink, Frencken, & Sampaio, 2012). These results suggest a more consistent application of the tactical principles of play and reflect a higher level of collective tactical behaviour. ¡

Macro level studies represent a more difficult scenario for data collection. Most measures are common to the meso level analysis, adapted to a larger number of players – teams and sector centroid, distance between centroids, teams' areas and/or teams' length and width. For example, research has shown possibilities to measure players' coordination by using players' positioning relative to their specific position centroid and the regularity of this displacement (Gonçalves et al., 2013). Results showed a higher degree of coordination relative to each player position (attackers, midfielders or defenders), which diminished as groups became more offensive. Also, in terms of regularity, attackers presented less predictable displacements, in order to disrupt the opponents' defensive organization.

Other approaches showed no relation between teams' longitudinal and lateral centroid distances with goal scoring situations, but found a link to teams space and temporal reorganization after changes in the ball position (Frencken et al., 2012). At this macreo level, the variability of collective behaviours reveals tendencies for a higher degree of regularity and predictability throughout the match, found in several variables, such as areas, length and width (Duarte, Araújo, Folgado, Esteves, Marques, & Davids, 2013). These results were related to the fatigue build up, but also to, different strategically approaches, as teams may explore different styles of play and respond differently to match adaptations.

**Training Applications**

The different levels of analysis (micro, meso and macro) contain a clear relation between them, presenting the same core principles at different scales of coordination (Davids et al., 2005). This characteristic is key in order to establish a relation between training and competition tactical behaviours, as players may experience sub-phases of the game in practice, which are relevant to the match performance. However, task designs must be taken in consideration, because the simple decomposition of expected match behaviour into less complex situations, fails to provide the contextual information relevant for players' practice, diminishing the potential practice transfer to competition scenarios (Travassos, Duarte, Vilar, Davids, & Araújo, 2012). As such coaches should be advised to simplify tasks in practice, but always maintaining a context where match traits may be adapted, but are still present, such as structural characteristics – field, ball, goals – but also functional characteristics – cooperation and opposition relations, and attack-defend flow changes. This context dependence is evident in a 1x1 dyadic relation, where the proximity to the goal influences considerably attacker-defender interaction (Headrick, Davids, Renshaw, Araújo, Passos, & Fernandes, 2012). Also, the number of player involved in a situation as adding one more player to each team in small-sided game situation (3x3 to 4x4) does not promotes the same collective behaviour adaptations to different age groups (Folgado et al., 2012).

## CONCLUSION

The recent technological advances have allowed improving the validity of available data on physiological and physical requirements of football matches. These advances have also the potential to be used in monitoring the training activity and, therefore, provide accurate data to be used in training prescription, injury prevention and rehabilitation. The availability of positioning data has revealed new possibilities for understanding the tactical performance in practice and competition. Current research is already identifying new performance indicators at different levels of analysis, helping coaches to improve the reliability of tactical analysis. Ultimately, the interaction between all these multi-dimensional variables can be a further advance to refine representativeness of practice task designs and to improve match performance.

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