UNIVERSIDAD POLITÉCNICA DE MADRID

Facultad de Ciencias de la Actividad Física y el Deporte

Analysis on the external training load of players in small sided
and friendly football games

Tesis Doctoral Internacional

D. Jesús Vicente Giménez de los Galanes

Licenciado en Ciencias de la Actividad Física y el Deporte

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DEPARTAMENTO DE CIENCIAS SOCIALES, DE LA
ACTIVIDAD FÍSICA Y DEL OCIO

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Madrid, 2017

Tribunal nombrado por el Magfco. y Excmo. Sr. Rector de la Universidad Politécnica de Madrid, el díade.....de 2017.

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Realizando el acto de defensa y lectura de la Tesis el día.....de.....
de 2017.

En.....

Calificación.....

EL PRESIDENTE

LOS VOCALES

EL SECRETARIO

A mis padres y hermanas quienes me apoyaron todo el tiempo.

A mi novia Sara quien me apoyó y alentó para continuar, cuando parecía que me iba a rendir.

Dr. Miguel Ángel Gómez Ruano, como referente en mi formación.

AGRADECIMIENTOS

Agradecer en primer lugar a la Universidad Politécnica de Madrid, a la Facultad de Ciencias de la Actividad Física por acercarme al mundo de la investigación en las Ciencias del Deporte, concretamente en análisis del fútbol.

Especial agradecimiento a mi director Dr. Gómez Ruano por ser una guía constante y una fuente inagotable de conocimientos, por sus valores, paciencia y apoyo constante; por su optimismo y cercanía. No existió día que no me diese ánimos para seguir adelante. Gracias por todo Miguel.

Al Dr. Honyou Liu por su ayuda en el diseño y colaboración de los estudios de la presente Tesis.

Agradecer también a todos los Profesores extranjeros que me acogieron en la ciudad de Gdansk (Polonia): Patrycja Lipińska, Andrzej Szwarc, Paweł Rompa. Gracias, por vuestro soporte y ayuda.

A el Dr. Juan del Coso, que me acogió sin dudarle en el laboratorio de Fisiología del Ejercicio en la Universidad Camilo José Cela (Madrid), sin pedirme nada a cambio; fruto de ello, elaboramos la primera publicación.

Resaltar la contribución del profesor Anthony Leicht (Australia), por su contribución en nuestra primera publicación, sin en hubiera sido posible.

A mí Cuerpo Técnico del Concordia Elblag (Polonia), en especial al Preparador Físico Andrés Alcolea León sin su ayuda la presente Tesis no hubiera visto la luz.

A mis amigos, entrenadores, preparadores físicos y a todos aquellos con los que comparto esta pasión por el fútbol por todas las reflexiones conjuntas y por tantas y tantas horas debatiendo: Juan Ángel Martín, Antonio Calderón, Ramón Marcote, Alvaro Mora... Gracias por dejarme disfrutar de vuestra amistad.

A mi familia y a aquellos que he sacrificado en el camino. Por estar, ser y hacer que esto sea posible.

A Sara Ruiz de la Hermosa, siempre supo esperar.

RESUMEN

En los últimos años, una cantidad considerable de investigaciones han publicado sobre el efecto de diferentes modelos de entrenamiento en el mundo del fútbol. Los modelos de entrenamientos, son modelos teóricos que permiten a los entrenadores comprender el proceso de entrenamiento y su impacto en rendimiento. Estos modelos pueden utilizarse como referencia para diseñar programas de entrenamiento tipo, para la mejora del rendimiento en el fútbol.

Otras de las líneas en auge en el mundo del fútbol es el análisis de la respuesta física, como valiosa técnica de recopilación de datos utilizada para cuantificar el registro de la carga de entrenamiento externa impuesta por el régimen de entrenamiento sobre el jugador de fútbol. El interés ha crecido sustancialmente en esta área durante la última década, ya que permite a los científicos del deporte identificar las demandas requeridas durante la competición y así; aplicar los datos mediante protocolos de entrenamiento.

En la actualidad, el acondicionamiento basado en juegos reducidos (SSGs) se ha convertido en un método popular para desarrollar aptitud aeróbica específica para el fútbol. Los investigadores han establecido que las SSG son confiables y efectivos para el desarrollo técnico y táctico de los futbolistas. Por lo tanto, los juegos reducidos (SSG) se usan comúnmente en el entrenamiento para solicitar simultáneamente los componentes tácticos, técnicos y físicos.

Ante la demanda del interés por conocer el análisis de los SSGs y la competición, surge la presente Tesis doctoral de modelo Escandinavo Manner of Manuscript Collection, que consistirá en el desarrollo tres artículos de revistas JCR para dar respuesta: en primer lugar, a pesar de la creciente popularidad de los SSGs, pocas investigaciones científicas han examinado los patrones de movimiento de los jugadores de fútbol profesional durante un juego de un solo lado (SSG), un juego de grandes caras (LSG) Partido (FM). En segundo lugar, las investigaciones disponible no hay estudios que revelen las respuestas físicas agudas al modificar el número de toques de pelota por jugador en presencia de mini-goles. Por último, también es notable que las actuales investigaciones existentes no hayan estudiado el rendimiento físico entre titulares y suplentes durante un partido amistoso.

ABSTRACT

In recent years, a considerable amount of research has been published on the effect of different models of training in the world of football. The training models are theoretical models that allow coaches to understand the training process and its impact on performance. These models can be used as a reference to design training programme type and for the improvement of performance in soccer.

Another of the boom lines in the world of soccer is the analysis of the physical response, as a valuable technique of data collection used to quantify the recording of the external training load imposed by the training regime on the soccer player. Interest has grown substantially in this area during the last decade, since it allows sports scientists to identify the demands required during the competition and thus; apply the data through training protocols.

At present, Small Side Games (SSGs) have become a popular method for developing aerobic fitness specific to soccer. Researchers have established that SSGs are reliable and effective for the technical and tactical development of footballers. Therefore, SSGs are commonly used in training to simultaneously demand tactical, technical, and physical components.

Given the interest in the analysis of SSGs and competition, the present PhD Thesis will be in the Scandinavian Manner of Manuscript Collection which will consist of three papers from JCR journals, to address: Firstly, despite the increasing popularity of SSGs, little scientific research has examined the movement patterns of professional football players during a small sided game (SSG), a large sided game (LSG) or a friendly match (FM). Secondly, there are no studies available that reveal acute physical responses by modifying the number of ball touches per player in the presence of mini goals. Finally, it is also noteworthy that existing research has not studied the physical performance between starters and substitutes during a friendly match.

GENERAL INDEX

Dedicatoria.	I
Agradecimientos.	III
Resumen.	V
Abstract.	VI
General Index.	VII
Index of Figures.	VIII
Index of Tables.	IX
Index of abbreviations	X

1. INTRODUCTION	1
1.1. The study of SSG.	3
1.2. The study of LSG.	5
1.3. The analysis of FM.	6
2.- AIMS AND HYPOTHESIS	15
3.- METHODS	19
3.1.- Sample	19
3.2.- The data collection (GPS)	20
3.3.- The research design.	21
4.- STUDY 1	25
5.- STUDY 2	43
6.- STUDY 3	63
7.-CONCLUSIONS	85
8.- LIMITATIONS AND FURTHER RESEARCH	89
9.- PRACTICAL APPLICATIONS	93
10.- APPENDIX	95

INDEX OF FIGURES

Figure 1. Coaches and players that participated in the studies of the PhD Thesis.	19
Figure 2. The use and location of GPS devices during testing protocols.	21
Figure 3. Self-reported exertion (A), maximal running speed (B) and work to rest ratio (C) during a friendly match, a small-sided game, and a large-sided game for male professional soccer players. Data are mean $\pm$ SD for 14 players. * $p < 0.05$ vs. friendly match; † $p < 0.05$ vs. large-sided game.	33
Figure 4. Design of the experimental protocol for the SSG conditions.	49
Figure 5. Results of the magnitude based inference between pairs of conditions.	53
Figure 6. Effect sizes (Cohen's d standardized, 90% confidence interval) for comparisons of match performance demands between starters and non-starters.	71

INDEX OF TABLES

Table 1. Running distance, decelerations and accelerations for different categories during a friendly match, a small-sided game, and a large-sided game for male professional soccer players. Data are mean $\pm$ SD for 14 players.	32
Table 2: Descriptive statistics of physical responses of players in the SSGs according to the number of touches (T1, T2 and FT).	52
Table 3. Match performance demands for starter and non–starter players.	70

INDEX OF ABBREVIATIONS

FM: Friendly Match
FT: free touches allowed in the SSG condition
HA: High acceleration.
HD: High deceleration
LSG: Large Sided Game
MA: Moderate acceleration
MBI: Magnitude Based Inference
MD: Moderate deceleration.
RPE: Ratings of Perceived Exertion
SSG: Small Sided Game
T1: one touch allowed in the SSG condition
T2: two touches allowed in the SSG condition

1. INTRODUCTION

1. INTRODUCTION

Soccer is a complex sport because the pitch is substantially larger than in other team sports (approximately 100 x 60 m), the ball is controlled with the feet and head and there are constant interactions among eleven teammates and eleven opponents, almost all with different roles in the game (Marco Aguiar, Botelho, Lago, Maças, & Sampaio, 2012). The amount of space in an 11-a-side pitch allows players to spend too much time running around without the ball. So performance in soccer depends on many factors such as technical and tactical, strategic, physical, physiological and/or psychological aspects (Stølen, Chamari, Castagna, & Wisløff, 2005). In addition, the huge complexity of the contents to be developed in modern soccer, the limited rest time between competitions and also the increasing requirements in the collective game with respect to the individual, has made training progress towards integral or global methodologies in which the player's performance is deployed in specific game situations presenting dual circumstances of opposition-collaboration (Reilly, 2005).

Given the importance of physiological abilities and technical-tactical skills for performance in this sport, many researchers have studied training methodologies that simulate all these demands on the player (Gabbett, Jenkins, & Abernethy, 2009), suggesting that training should reproduce the performance profile of competition activity to favour the model of fibre recruitment and the more specific metabolic adaptations (Drust, Reilly, & Cable, 2000). In order to find the answer to this question, coaching staffs developed the SSG (Small Sided Games), which despite being less structured tasks than traditional fitness training, are becoming a very popular training method for players at all levels and ages (Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011; Reilly & Gilbourne, 2003). In this respect, the different studies confirm the workability of using training and SSG exercises as a specific training method (Impellizzeri et al., 2006; Reilly & White, 2005; Sassi, Reilly, & Impellizzeri, 2005) although it is possible that the demands of high-intensity activity and sprint repetitions that are required from the player in competition are not replicated exactly during the SSGs (Gabbett & Mulvey, 2008).

In any case, training based on SSGs ensures the specific activation of muscle groups that are involved during the competition (Balsom, Lindholm, Nilsson, & Ekblom, 1999; Bangsbo, 2003), using technical tactics in real game conditions that

could promote an effective transfer to the competitive environment (Williams, Horn, & Hodges, 2003).

However, the use of this type of task does not automatically imply an adequate training stimulus, since several variables such as the size of the pitch, number of players and the modification of the rules must be manipulated meticulously. Likewise, the motivation of the coach might be constantly required. Therefore, knowledge of the physical and physiological responses to different SSG situations used by coaches and physical trainers will improve the prescription of specific training tasks. Recently, interest has also been shown for the load imposed on the player during SSG situations (Impellizzeri et al., 2006; Jones & Drust, 2007; Kelly & Drust, 2009). However few studies have verified the physical, physiological and technical demands between SSGs and competitions using the same approach (Casamichana, Castellano, & Castagna, 2012).

Other researchers have focused their attention on comparing the demands during total training with respect to the competition, in order to observe whether the requirements of official matches are reproduced, without directly analysing SSG situations (Petersen, Pyne, Dawson, Kellett, & Portus, 2011). In this sense, studies have been developed in semi-professional soccer, determining differences between training and matches (Casamichana & Castellano, 2011). These authors found differences between the variables analysed. In general, during training the players spent more time standing and walking and less in the categories of low speed, moderate speed and high intensity running and sprinting.

For this reason, the optimisation of the training includes the integration of certain rules such as: increasing practice time, reducing time losses between exercises, or carefully designing the tasks or forms played where the energy requirements are reproduced (Casamichana & Castellano, 2011). From the data provided in the scientific literature, it is logical to think that SSGs present some specific conditioning of training, reproducing the majority of the demands of competition (Gabbett et al., 2009). Even then we could surmise a limitation from the conditional point of view of the indiscriminant application of SSGs. It is possible that there is insufficient stimulation of high intensity activity, specifically, the low numbers of repeated sprints and maximum

speeds are far from the competitive demands, or work times and rest periods are different from what happens in competition (Casamichana et al., 2012; Gabbett & Mulvey, 2008).

1.1. The study of SSGs.

Small-sided games (SSGs) are one of the most common drills used by coaches for soccer training. Although in the past SSGs were mainly used to improve the interaction among players and to develop technical and tactical abilities, they are now employed by many amateur and professional teams as an effective tool for aerobic training (Balsom et al., 1999). We think that the best way to improve the players' skills is to offer more touches on the ball and repeated experience of basic tactical problems (e.g. to play football on a smaller pitch). These tasks are known as small-sided games (SSGs) and their study is currently one of the most popular topics in contemporary soccer research (Hill-Haas, Coutts, Dawson, & Rowsell, 2010; Hill-Haas, Rowsell, Dawson, & Coutts, 2009). Over the last few years there has been a substantial growth in research related to specific training methods in soccer with a strong emphasis on the effects of small-sided games. Recently, many researches have attempted to rediscover the usefulness of SSGs within soccer fitness training (Marco Aguiar et al., 2012; Clemente, Couceiro, Martins, & Mendes, 2012). SSGs offer the benefit of reproducing the movements, technical conditions and physiological intensities of a real soccer game (Gamble, 2004). Specifically, in high performance sports it has been well documented that maximum benefits are achieved when the training stimuli are similar to the competition demands (Bompa, 1994). In order to reproduce the physical, technical and tactical requirements of real match play (Hoff, Wisløff, Engen, Kemi, & Helgerud, 2002; MacLaren, Davids, Isokawa, Mellor, & Reilly, 1988; Miles, MacLaren, Reilly, & Yamanaka, 1993; Reilly & White, 2005; Sassi et al., 2005) coaches often use SSGs as the best way to improve key skills and tactics in their players during training plans. Therefore, the SSGs are used extensively to improve physical fitness levels and also technical and tactical performance in a wide variety of soccer codes (Aguiar et al., 2008; Duarte, Batalha, Folgado, & Sampaio, 2009; Stephen Hill-Haas, Coutts, Rowsell, & Dawson, 2008; Hill-Haas, Coutts, Rowsell, & Dawson, 2009; Hill-Haas et al., 2010; Hill-Haas, Dawson, Coutts, & Rowsell, 2009; Hill-Haas, Rowsell, et al., 2009; Rampinini, Coutts, Castagna, Sassi, & Impellizzeri, 2007). Due to the interaction among

technical ability, tactical skills, and the physical components, the use of SSGs can be more efficient in a medium-term process as these three factors can be trained alongside each other (i.e., concurrent training)(Gregson & Drust, 2000; Little, 2009). Nevertheless, this approach depends on the specific game formats. In fact, some variables affect the exercise intensity, time-motion characteristics, and technical requirements. Thus, coaches should try to change the training stimulus by altering some variables such as: size of the pitch, since its manipulation can affect the physical, physiological, perceptive and motor demands (Casamichana & Castellano, 2010), number of players involved, SSGs with a lower number of players obtain a higher FC, concentration of LA and PSE (Brandes, Heitmann, & Müller, 2012; Hill-Haas et al., 2011), or the use or not of goalkeepers. Accordingly, these modifications would have some effects on players' physiological and technical responses (Mallo & Navarro, 2008) such as (i) the inclusion of a goalkeeper modifies the physiological and tactical behaviour of the players; (ii) the goal orientation causes different responses in players of different categories (Castellano, Casamichana, & Dellal, 2013; Alexandre Dellal et al., 2008; Mallo & Navarro, 2008); (iii) tactical obligation - the coaches can also alter the physiological load by giving the players tactical assignments during SSGs (Sampaio et al., 2007; Sassi et al., 2005); (iv) the coach's encouragement provokes a significant increase in players' physiological responses during SSGs, (Balsom, 1999); or (v) the training regimen as SSG can be conducted in either a continuous or an intermittent manner; and both regimens can be used for aerobic maintenance training during the in-season (Hill-Haas, Rowsell, et al., 2009). Therefore, coaches can alter the physical and physiological loads choosing either a continuous or an intermittent SSG task. With regard to players' characteristics, when the fitness level was studied carefully it was concluded that players with the highest VO_{2max} had the lowest percentage of VO_{2max} during SSGs (Stone & Kilding, 2009). A lower skill level usually results in a lower technical performance during SSGs, but with higher physical and physiological loads (Van Winckel, 2014). With respect to the effect of age, it has been stated that young players do not have the same technical abilities and experience as adults, and this could lead to greater physical demands in SSGs (Dellal, Jannault, Lopez-Segovia, & Pialoux, 2011). Therefore, the age of the player has to be taken into account when developing SSGs. Considering training time distribution, when studying the effect of training intensity distribution on aerobic fitness variables in elite soccer it was reported that even

though almost two-thirds of players' training time was spent at low intensities, only the time spent at high intensities (90% of HR_{max}) was related to changes in aerobic fitness (Castagna, Impellizzeri, Chaouachi, Bordon, & Manzi, 2011). In fact, high intensity training that raises the HR to 90% of HR_{max} should constitute at least 7-8% of the total weekly training plan for elite soccer players during preseason and in-season (Castagna, Impellizzeri, Chaouachi, & Manzi, 2013). Finally, the presence of mini-goals may modify the intensity of the soccer SSGs and it is affected by many factors such as the way of scoring (Bangsbo, 1993; Mallo & Navarro, 2008). Despite this fact, we agree with Marco Aguiar et al., (2012) who did not find any previous study focused on the effect of these variables on the physiological and technical response of players during SSGs with mini-goals.

1.2. The study of LSGs.

Coaches can influence the intensity of SSGs through altering the playing area (Hill-Haas, Dawson, et al., 2009). A key concept in the present thesis is the “*individual playing area*”, which is defined (Parlebas, 2008) as the theoretical area of the pitch that corresponds to each player and is calculated by dividing the total pitch area by the number of players. The largest playing area (i.e. the large-format small-sided game) has the same individual playing area as the standard pitch used by the team for its competitive home matches (Casamichana & Castellano, 2010). In this context, few studies have proposed varying the rule of the number of ball contacts authorised per possession during SSGs and none have examined the corresponding technical and physical adaptation in comparison to elite match-play. Owen, Wong, McKenna, and Dellal, (2011) studied the effects of Large Sided Games (LSGs) in elite professional soccer players and found that by altering the number of players within the same conditioned games a significantly higher technical and physical response was elicited approximating match demands. We are also unaware of any studies that have compared the movement patterns among a small-side game, a large-sided game and a friendly match in professional soccer players according to the specific physical responses required. It was hypothesised that the use of LSGs may constitute a better choice of training to reflect that the player's activity during a friendly match-play and would be similar to those demands found during the regular match-play.

1.3. The analysis of FMs.

It is a common practice in professional and semi-professional soccer to have SSGs and weekly friendly matches (FMs) during the training week (Bangsbo, 2008). This is done in an attempt to promote individual and team fitness and skill development (Bangsbo, 2008). Previous studies comparing the physical demands of friendly matches and small-sided games in semi-professional soccer players revealed that it is unclear whether the most widely used SSGs actually reproduce the demands of competitive matches as regards repeated-sprint demands. To the best of our knowledge, no previous studies have used these types of indicators to evaluate physical demands, especially for high intensity efforts (Casamichana et al., 2012). Recently Bradley, Dellal, Mohr, Castellano, and Wilkie, (2014) studied the gender differences in match performance characteristics of soccer players competing in the UEFA Champions League. Other studies conducted by Gonçalves, Figueira, Maçãs, and Sampaio, (2014) identified differences in time–motion, modified training impulse, player’s load and movement behaviour between defenders, midfielders and forwards, during an 11-a-side simulated football game. Other studies have examined the influence of the opposing team, seasonal variations and the influence of first half activity on match performance in top level soccer players. (Rampinini, Coutts, Castagna, Sassi, & Impellizzeri, 2007). Although the available research has investigated most of the factors and aspects related to physical demands during matches, the player’s role (i.e., starters and nonstarters) has received less attention when studying the differences in physical performances between starter and non-starter soccer players during friendly matches (FMs) and other contexts in professional soccer.

All factors affecting SSGs, LSGs and FMs are analysed separately according to the studies conducted in order to understand their importance in the response of athletes to training stimulus. Despite this division the current PhD Thesis tries to address comprehending these factors. In addition, it is also focused on new features of these abilities, which although scarcely studied, are of great relevance for football training. Moreover, the present researchers add interesting variables of accelerations and decelerations (numbered) previously described as a prerequisite for success in professional football players and presenting better values in professional players compared to amateur players (Reilly, Bangsbo, & Franks, 2000). For this reason,

coaches should take into account the development of this ability (Manson, Brughelli, & Harris, 2014). In addition to the physical demands (i.e., different speeds and 2 Self-reported exertion ratings) the present PhD thesis provides evidence of new research concerning the interrelationship between acceleration and deceleration qualities in FMs, LSGs and SSGs that have not been previously studied. Overall, the literature suggests that SSGs do offer a specific method of training and manage to replicate most competitive match demands. Thus, we consider of utmost importance the effect of the accelerations and decelerations (numbered) on performance along with FMs, LSGs and SSGs and the possible differences between starter and substitute players in professional football.

A deeper understanding about the influence of manipulating these variables on this training game will assist coaches in controlling the training process. For this reason, the approach of this PhD Thesis has been geared to investigating several variables which influence soccer players' performance (physical demands) measured with GPS devices. In order to do so, the PhD Thesis is composed of 3 scientific investigations using a multidisciplinary approach with the common denominator of the sample used in professional soccer:

- Study 1: *Physical responses of professional soccer players during 4 vs. 4 small-sided games with mini-goals according to rule changes.*
- Study 2: *Comparison of the movement patterns between small- and large-side games training and competition in professional soccer players.*
- Study 3: *Impact of playing status on match performance demands for professional soccer players.*

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2. AIMS AND HYPOTHESIS

2. AIMS AND HYPOTHESIS

The general aim of the present PhD Thesis is to analyse the physical (distances covered by players at different speeds, recorded using GPS devices) and physiological (rating of perceived exertion, RPE) variables in different training conditions (SSG, LSG and FM) in professional football players. The 3 studies developed in this PhD Thesis have specific aims and hypotheses according to the analysis and experimental protocol designed:

Study 1: *Physical responses of professional soccer players during 4 vs. 4 small-sided games with mini-goals according to rule changes.*

- *Aim:* to conduct an analysis of the accuracy of performance in the presence of mini-goals and compare these with performance with rule changes in ball contact.
- *Hypothesis:* that training constraints (the allowed number of ball touches) alter the physical responses and time-motion characteristics of professional soccer players in 4 vs 4 SSGs with mini-goals.

Study 2: *Comparison of the movement patterns between small- and large-side games training and competition in professional soccer players.*

- *Aim:* to describe whether the use of LSGs vs SSGs improved the replication of movement patterns developed during a FM
- *Hypothesis:* our hypothesis assumed a better influence of the LSG vs SSG to elicit movement patterns compared with a friendly match. The hypothesis was that the LSG replicates the physical demands better than the SSG.

Study 3: *Impact of playing status on match performance demands for professional soccer players.*

- *Aim:* to document the match performance demands between starter and non-starter, professional soccer players.
- *Hypothesis:* the starter players perform better than non-starters. Then, differences between starters and non-starters may highlight potential weaknesses for coaches that need to be addressed in team preparation and selection.

3. METHODS

3. METHODS

3.1. Sample

Fourteen professional senior outfield male soccer players from a Polish professional 117 football club participated in the study (mean $\pm$ SD: age 23.2 ± 2.7 , height 177.9 ± 6.1 cm, weight: 73.2 ± 6.9 kg, body fat $12.6 \pm 2\%$, playing experience 14 ± 5 years). To obtain a homogeneous sample, only the players who played regularly in the official Football Club of Concordia Elblag (II league, east, Poland) were included, i.e. the criterion for inclusion was: the player must have played more than 65 minutes of total playing time during the regular match. Goalkeepers were excluded, because they did not participate in the same physical training programme (i.e. mini-goals). All players were notified of the aims, requirements, benefits and risks of the study, before giving written informed consent. All the research procedures were approved by the research ethics committee of the local university, in accordance with the latest version of the Declaration of Helsinki. The research also received formal approval from the club involved (see Appendix 1).

Figure 1. Coaches and players that participated in the studies of the PhD Thesis.

3.2. Procedure.

The present thesis including experimental measurement studies sought to examine the influence of SSGs with-mini goals, SSGs with goalkeeper, LSGs and Friendly Matches. The head coach, aiming to improve the ability of organisation and finalisation of the players, always designed these series of SSGs. The three sessions were distributed over a 3-week time span during the second round of the in-season

period, and they were all conducted on the same outdoor artificial grass pitch at the home training venue of the club. The SSGs were performed at the beginning of training to ensure that players were not exhausted. Each session began with the same 21-minute warm-up followed by the same soccer-specific passing game which lasted another 10 minutes. Both sides in the SSGs were encouraged to score the most goals in the time set. Consistent verbal encouragement from the head coach and assistants was provided throughout the duration of all SSGs and FMs, to maintain a high skill level. In order to avoid stoppage time in the games as much as possible, several balls were distributed around playing areas for immediate availability. Additionally, there were two assistant coaches outside of the playing area to ensure continuous play. The two assistant coaches acted as timers and referees (i.e. to ensure the rules for each ball involvement). During rest periods, players were allowed to intake fluids *ad libitum*. To limit the influence of hydration status on the variables analysed, all participants were advised to maintain their normal diet, greater focus being placed on a high intake of water and carbohydrates (50-60% of total energy intake) to avoid the effects of dehydration.

3.3. The data collection (GPS).

The physical responses, and time-motion characteristics of players, were monitored using Global Position System devices (GPS MinimaxX v4.0, Catapult Innovations, Melbourne, Australia) operating at a sampling frequency of 10 Hz, and incorporating a 100 Hz triaxial accelerometer. The technology has been previously validated, and has been proven reliable for monitoring movements and activities of different intensities of soccer players (Boyd, Ball, & Aughey, 2011; Castellano, Casamichana, Calleja-Gonzalez, San Roman, & Ostojic, 2011; Varley, Fairweather, & Aughey, 2012). The device was fitted to the upper back of each player, using the manufacturer-designed harness. The devices were activated 15 min before the start of each training session, in accordance with the manufacturer's instructions. Figure 2 shows how the GPS devices were used and placed during testing sessions.

Figure 2. The use and location of GPS devices during testing protocols.

3.4. Research design.

This PhD Thesis is part of the exchange between the Faculty of Physical Activity and Sport Sciences (Polytechnic University of Madrid, Spain) and the University of Physical Education and Sport, (Gdansk, Poland) (see Appendix 2) and did not receive any financial support.

Accordingly, the PhD Thesis has been carried out with the collaboration of the following researchers Patrycja Lipińska, Andrzej Szwarec (my supervisor in Poland), Paweł Rompa (University of Physical Education and Sport, Gdansk, Poland), Dr. Hongyou Liu (School of Physical Education and Sports Science, South China Normal University, Guangzhou, China), Andrés Alcolea (Physical Trainer of Club Concordia Elblag), and Anthony Leitch (Professor of physiology and physical training at the James Cook University, Australia).

4. STUDY 1

STUDY 1: Comparison of the movement patterns between small- and large-side games training and competition in professional soccer players.

Article accepted in: The Journal of Sports Medicine and Physical Fitness.

Doi: 10.23736/S0022-4707.17.07343-1

Running Head. Physical response of different game-based training routines

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Abstract

BACKGROUND: The purpose of this investigation was to compare the movement patterns of professional soccer players during a small-sided game (SSG), a large-sided game (LSG) and a competitive friendly match (FM).

METHOD: Fourteen professional players participated in three training routines with a similar relative pitch area per player. The SSG and LSG consisted of 8 repetitions of 4-min game play, interspersed by 2-min of active recovery, and their data were compared to the first 32 minutes of a FM. All movement patterns from walking to sprint running were recorded using 10Hz GPS devices while player perception of exertion was recorded via visual analogue scale, post-trial.

RESULTS: Total running distance (3852 ± 405 vs. 3359 ± 429 and 3088 ± 414 m), running distance at 5-6.9 m/s (222 ± 98 vs. 75 ± 53 and 49 ± 35 m) and maximal running speed (7.0 ± 0.7 vs. 6.1 ± 0.4 and 6.0 ± 0.7 m/s) were significantly greater during FM than for SSG and LSG. However, the number of accelerations (462 ± 16 vs. 458 ± 12 vs. 422 ± 15) and decelerations (733 ± 31 vs. 692 ± 24 vs. 609 ± 27), and the rating of perceived exertion (8 ± 1 vs. 7 ± 1 vs. 5 ± 1) were significantly greater during SSG compared to LSG and FM.

CONCLUSIONS: Although smaller game-based training routines do not replicate exactly the movement patterns of a competitive match, they can increase the execution of short-term and high-intensity movements for specialised training in professional soccer players.

Key words: soccer, exercise running, acceleration, deceleration, performance

Introduction

In team-sports, the use of small-sided games (SSG) has transformed traditional physical training and conditioning with the greatest benefits of training occurring when training routines simulate the specific movement and physiological demands of the sport (Halouani, Chtourou, Gabbett, Chaouachi, & Chamari, 2014). Specifically, SSG are a predominant routine during training for professional teams that simultaneously provides stimulus for the improvement of technical, tactical, and physical aspects of players' performance (Little, 2009). While an important training tool, the term SSG has been widely used for any adaptation of match play related to the reduction of the pitch area (and normally the number of players per team). The proposed tasks for SSG though involve a wide number of regulations and adaptations than can greatly affect the physical demands and the technical involvement of players during SSG (Aguiar, Botelho, Lago, Maças, & Sampaio, 2012). Coaches can modify the physical, tactical, and technical stimulus of SSG by changing several variables such as: the number of players per side (e.g. equating the number of players per team or by producing numerical disadvantages)(Aguiar et al., 2012; Aslan, 2013) incorporation of “floater” players(Mallo & Navarro, 2008) the dimensions of the playing area (e.g., maintaining or reducing the area per player)(Aslan, 2013) changing the rules of the game (e.g., the number of touches by players),(Hill-Haas, Coutts, Dawson, & Rowsell, 2010; San Román-Quintana et al., 2013). and the game format including the number of repetitions and the duration of the task (David Casamichana, Castellano, Calleja-Gonzalez, San Román, & Castagna, 2013). These variations aim to enhance training stimuli but different SSG formats could simulate different overall movement patterns and intensity of play with certain parameters (e.g. intensity of running, sprint distance) reported to be lower during SSG compared to actual soccer competitions (Barnes, Archer, Hogg, Bush, & Bradley, 2014; David Casamichana, Castellano, & Castagna, 2012).

Prior studies have reported that the physiological intensity during SSG, in terms of sprint distance and heart rate or blood lactate concentration, was higher with fewer participants (Brandes, Heitmann, & Müller, 2012; A Dellal, Jannault, Lopez-Segovia, & Pialoux, 2011; Köklü, Asçi, Koçak, Alemdaroglu, & Dündar, 2011; Ermanno Rampinini et al., 2007). However, mean values for distance covered and duration of sprints were lower when the number of players was reduced in SSG, likely due to the inability to maintain the relative pitch area per player (Fradua et al., 2013). Therefore, to

improve the replication of soccer activity patterns during training routines, the use of large-sided games (LSG) may be a novel and important means to enhance training stimuli (Malone, Solan, & Collins, 2016). LSG involve a reduced number of players combined with a larger pitch area to maintain the relative pitch area per player (Malone et al., 2016). In theory, the LSG allows a higher involvement of players and thus, appropriate intensity with a greater playing space to produce high-intensity displacement (Rebelo, Silva, Rago, Barreira, & Krstrup, 2016b). Therefore, LSG may produce a greater training stimuli that is reflective of match performance. To our knowledge, comparisons between LSG and SSG have been limited with a greater understanding of these demands and their application to soccer match performance needed (Foster et al., 2001). More accurate replication of match activities during LSG may support incorporation of LSG into standard training regimes for soccer players. Thus, the present investigation sought to examine whether LSG or SSG provided a more accurate replication of movement patterns experienced during a competitive, friendly match. Based on previous reports (Malone et al., 2016; Rebelo, Silva, Rago, Barreira, & Krstrup, 2016a) our hypothesis was that LSG, compared to SSG, would elicit more accurate movement patterns to those during a competitive, friendly match.

Material and methods

Fourteen, professional Polish, outfield, male soccer players voluntarily participated in this investigation. The players' mean $\pm$ SD age, height, body mass, body fat and soccer playing experience were 23.2 $\pm$ 2.7yr, 178 $\pm$ 6cm, 73.2 $\pm$ 6.9kg, 12.6 $\pm$ 2%, and 14 $\pm$ 5yr, respectively. To obtain a homogeneous sample, only players from one team and who competed regularly in official league matches were considered for the study. The players participated in 6 training workouts per week. All participants were in good health and none were injured within the 3 months before the initial testing sessions. All players were notified of the aims, requirements, benefits and risks of the study, before providing written informed consent. All research procedures were approved by the research ethics committee of the local university and in accordance with the latest version of the Declaration of Helsinki. The study also received formal approval from the club involved (Polish Division 2).

This study compared movement patterns and the perceived exertion of professional soccer players during three game-based trials: an 11-a-side friendly match

(FM), a SSG with 4 players per side (SSG) and a LSG with 8 players per side. Each player completed all trials with each separated by one week. The trials were conducted during the competitive season, three days after the previous official match, and at the same time of day in order to limit the effects of fatigue and/or circadian variation (Foster et al., 2001). The SSG and LSG consisted of 8 repetitions of 4-min game situations, interspersed by 2-min of active recovery (for a total of 32 min of playing time). During recovery, participants walked towards the side of the pitch to rehydrate and then returned to their position. These displacements were not included in analyses as they did not replicate typical movements during a soccer match. The data obtained during SSG and LSG was compared with the first 32-min period of the first half of the FM against a similar ranked opponent (i.e. based on the match-by-match ranking of the league).

The dimensions of the pitch area for the SSG (30x30 m) and the LSG (42.4x42.4 m) were selected to maintain a similar relative pitch area per player (113 m² per player) with these being lower than the relative pitch area per player during the FM (272 m² per player). All of the trials were performed on an outdoor artificial grass pitch with regular goals, and participants wore official clothing and soccer boots. Participants were encouraged to operate at competitive intensity levels and score the highest number of goals during each trial. During the SSG and LSG, there was one goalkeeper per side with their movements limited to saving the ball during a shot only (i.e., no other movements were allowed by the goalkeeper). Players were thoroughly familiarized with the SSG and LSG formats and regimes during previous training sessions of the season.

The day before each trial, participants were instructed to avoid caffeine-containing products and the technical staff programmed a low-intensity, low-volume recovery session. The player's diet was standardized for the 24 hours before the trials while compliance was verified by self-reported diaries. On the day of each trial, participants arrived to their habitual training facility at 10:30 and body mass (± 0.05 kg) and body height (± 0.1 cm) were measured (Seca 285, Germany). Body fat percentage was estimated by using segmental bio impedance scales (BC-418, Tanita, Japan) in line with standardised procedures for this measurement. Participants then wear their competition clothes and a GPS device was fitted to each player. A 30-min standardized warm-up that included running and soccer-specific actions was completed by each player followed by one of the trials. All players completed the same trial at the same time as a team with the order of trials being FM, SSG and LSG. In order to minimise

stoppage time, several balls were placed around the pitch area for immediate access by players. Additionally, there were two assistant coaches positioned outside of the playing area to provide encouragement and support for continuous play. The two assistant coaches monitored the timing and rule compliance (referees) for SSG and LSG while a professional referee was employed for the FM. During rest periods of each trial, players were allowed to rehydrate with water ad-libitum. Immediately after each trial, participants individually rated their perception of exertion by using a 1-to-10 point, visual analogue scale (Foster et al., 2001).

During each trial, the movement patterns and time-motion characteristics of players were monitored by calibrated GPS devices fitted to the upper back using the manufacturer-designed harness (Minimax X v4.0, Catapult Innovations, Melbourne, Australia) and operating at a sampling frequency of 10 Hz. The players utilised the same GPS unit for each trial to avoid any variability amongst GPS devices. This GPS technology was previously validated and considered reliable for monitoring movements and activities of different intensities for soccer players (Boyd, Ball, & Aughey, 2011a; Julen Castellano, Casamichana, Calleja-González, San Román, & Ostojic, 2011a; Drust, Waterhouse, Atkinson, Edwards, & Reilly, 2005). Similar to previous studies (Julen Castellano, Casamichana, & Dellal, 2013; Krstrup et al., 2009; Varley, Fairweather, & Aughey, 2012) the total running distance was examined across six speed zones of increasing speed: walking (≤ 2.2 m/s), jogging ($> 2.2 \leq 3.3$ m/s), low speed running ($> 3.3 \leq 4.2$ m/s), moderate speed running ($> 4.2 \leq 5.0$ m/s), high speed running ($> 5.0 \leq 6.9$ m/s) and sprint speed running (> 6.9 m/s). The accelerations and decelerations of player movements were also measured within ± 2 m/s² intervals (Minetti, Gaudino, Seminati, & Cazzola, 2013; Osgnach, Poser, Bernardini, Rinaldo, & Di Prampero, 2010). The work to rest ratio was calculated as the distance covered by the player at a displacement speed > 2.2 m/s (period of work) divided by the distance covered at a speed of 0 to 2.2 m/s (period of recovery). All data analyses were performed with the manufacturer's dedicated software package (Team AMS software V R1.2011.6). Statistical Analysis: All data was initially reviewed for normality using the Shapiro-Wilk test and all confirmed as following a normal distribution ($p > 0.05$). Comparisons between the three trials (SSG vs. LSG vs. FM) were performed using repeated measures ANOVA and *post-hoc* pairwise differences with Bonferroni corrections. Effects sizes (ES) were calculated using the partial eta square (η_p^2) from the ANOVA analyses to

express the magnitude of the effects using the following criteria: 0.01-0.059 = small effect, 0.06-0.13 = medium effect, ≥ 0.14 = large effect. (Cohen, 1988) All analyses were conducted using the SPSS statistical package (version 20.0, SPSS Inc., Chicago, IL) with the significance level set at $p < 0.05$. Data are presented as mean $\pm$ SD for each trial.

Results

There were significant differences in the total running distance covered during the three different trials ($F_{2,26}=12.99$; $p=.003$; $ES=0.50$, large effect). For the FM, the running distance was $14.7 \pm 16.3\%$ greater than during the SSG ($p < 0.05$) and $24.7 \pm 15.4\%$ greater than during the LSG ($p < 0.05$). Specifically, the distance covered at walking pace ($F_{2,26}=9.82$; $p=.001$; $ES=0.43$, large effect) was significantly less during the FM than during the SSG ($p < 0.05$) and the LSG ($p < 0.05$, Table 1). However, the distance covered at jogging speed ($F_{2,26}=8.764$; $p=.001$; $ES=0.40$, large effect), low speed running ($F_{2,26}=81.42$; $p < .001$; $ES=0.86$, large effect), moderate speed running ($F_{2,26}=17.57$; $p < .001$; $ES=0.58$, large effect), high speed running ($F_{2,26}=54.26$; $p < .001$; $ES=0.81$, large effect) and sprint speed running ($F_{2,26}=7.33$; $p=.003$; $ES=0.40$, large effect) were significantly greater during the FM than for the SSG and the LSG ($p < 0.05$ for all pairwise comparisons, Table 1). The distances covered at low speed running and moderate speed running were also significantly greater during the SSG than during the LSG ($p < 0.05$, Table 1).

There was a significant main effect for the number of decelerations performed during the three trials ($F_{2,26}=39.86$; $p < .001$; $ES=0.75$, large effect, Table 1). The total number of decelerations was $-8.8 \pm 4.4\%$ lower during the FM compared to the SSG ($p < 0.05$) and $-8.0 \pm 4.1\%$ lower than during the LSG ($p < 0.05$) with no differences between the SSG and the LSG. A smaller number of low intensity decelerations ($F_{2,26}=84.38$; $p < .001$; $ES=0.87$, large effect) occurred during the FM compared with the SSG and the LSG ($p < 0.05$) with no difference for the other deceleration zones ($p > .05$, Table 1). For accelerations, a significant main effect was identified ($F_{2,26}=91.64$; $p < .001$; $ES=0.88$, large effect, Table 1) with a smaller total number during the FM compared to the SSG ($-16.9 \pm 5.1\%$; $p < 0.05$) and the LSG ($-12.0 \pm 5.3\%$; $p < 0.05$). In addition, the total number of accelerations was significantly greater during the SSG than

during the LSG ($6.0 \pm 6.4\%$; $p < 0.05$). Similar differences ($FM < LSG < SSG$; $p < 0.05$) were evident for all acceleration zones (Table 1).

Table 1. Running distance, decelerations and accelerations for different categories during a friendly match, a small-sided game, and a large-sided game for male professional soccer players. Data are mean $\pm$ SD for 14 players.

	Friendly match	Small-sided game	Large-sided game
Distance covered (m)			
< 2.2 m/s	1634 $\pm$ 148	1765 $\pm$ 109*	1789 $\pm$ 102*
> 2.2 $\leq$ 3.3 m/s	1099 $\pm$ 231	925 $\pm$ 220*	825 $\pm$ 211*
> 3.3 $\leq$ 4.2 m/s	559 $\pm$ 204	379 $\pm$ 108*	289 $\pm$ 106*†
> 4.2 $\leq$ 5 m/s	287 $\pm$ 107	190 $\pm$ 86*	121 $\pm$ 74*†
> 5 $\leq$ 6.9 m/s	222 $\pm$ 98	75 $\pm$ 53*	49 $\pm$ 35*
> 6.9 m/s	22 $\pm$ 29	0 $\pm$ 0	0.6 $\pm$ 2.4
Total	3852 $\pm$ 405	3359 $\pm$ 429*	3088 $\pm$ 414*
Decelerations (number)			
-2.0 to 0.0 m/s ²	411 $\pm$ 14	449 $\pm$ 18*	446 $\pm$ 13*
-4.0 to 2.1 m/s ²	11 $\pm$ 6	13 $\pm$ 4	11 $\pm$ 4
< -4.0 m/s ²	0.2 $\pm$ 0.4	0.1 $\pm$ 0.4	0.4 $\pm$ 0.5
Total	422 $\pm$ 15	462 $\pm$ 16*	458 $\pm$ 12*†
Accelerations (number)			
0.0 to 2.0 m/s ²	603 $\pm$ 25	721 $\pm$ 32*†	684 $\pm$ 25*†
2.1 to 4.0 m/s ²	7 $\pm$ 4	12 $\pm$ 4*†	8 $\pm$ 3*†
> 4.0 m/s ²	0.1 $\pm$ 0.4	0.2 $\pm$ 0.6*†	0 $\pm$ 0*†
Total	609 $\pm$ 27	733 $\pm$ 31*	692 $\pm$ 24*†

Note. * $p < 0.05$ vs. friendly match; † $p < 0.05$ vs small-sided game

Self-reported exertion ($F_{2,26}=26.65$; $p < .001$; $ES=0.66$, large effect) was significantly lower for the FM than the LSG, which was significantly lower than the SSG (Figure 1A; $p < 0.05$). On the contrary, maximal running speed ($F_{2,26}=11.27$; $p < .001$; $ES=0.47$, large effect) and the work to rest ratio ($F_{2,26}=35.02$; $p < .001$; $ES=0.73$, large effect) were significantly greater during the FM than the SSG, which were significantly greater than the LSG (Figure 1B and C; $p < 0.05$).

Figure 3. Self-reported exertion (A), maximal running speed (B) and work to rest ratio (C) during a friendly match, a small-sided game, and a large-sided game for male professional soccer players. Data are mean $\pm$ SD for 14 players. * $p < 0.05$ vs. friendly match; † $p < 0.05$ vs. large-sided game.

Discussion

The aim of the study was to examine the movement patterns of two typical training regimes (SSG and LSG) in order to establish the type of game-based training that elicited movement patterns comparable to competition (i.e., a FM). The current results indicated that SSG resulted in significantly different movement patterns (i.e., less total running distance at various speeds, lower maximal running speed, lower work to rest ratio, greater walking distance, greater number of decelerations and accelerations) with greater perceived exertion compared to a competitive FM. Further, SSG resulted in distinct movement patterns (i.e., greater total running distance, maximal running speed, work to rest ratio, low speed and moderate speed running, and number of accelerations for all zones) and less perceived exertion compared with LSG. Despite differences between the different forms of sided games and with competition, SSG provided movement patterns and perceived effort that were more reflective of competition. The current investigation offers valuable information for soccer coaches and physical trainers to decide upon the most effective sided-games training regime for players to simulate competitive match demands (i.e., SSG).

One of the key results was that the total running distance covered was significantly greater during FM compared to both the SSG and LSG. This result demonstrated that none of the game-based training trials replicated the running volume

of competitive soccer matches with values that were 14.7-24.7% lower to that experienced during a FM. Reduced-sized soccer games are often conducted during training practice to produce high-intensity activities, even at the expense of training volume (David Casamichana et al., 2012). However, in the present investigation, players covered more distance at walking speed during SSG and LSG than in FM while the running distances covered within the other speed zones was greater for the FM. This result highlighted that both SSG and LSG did not precisely replicate the movement patterns of competitive soccer, with both sided games providing insufficient stimulation of high-intensity displacements. Similarly, maximal running speed was not achieved during SSG and LSG highlighting a limitation of sided games in reproducing competitive match activities. Previously, the use of FM was reported to be more useful in fostering adaptations for high-intensity displacements compared to reduced-size games (David Casamichana et al., 2012). The current results provide further support of the inability of sided games to replicate high-intensity activities similar to that during competitive soccer matches. Despite this limited ability for high intensity movements, SSG resulted in players experiencing greater low and moderate speed displacements compared with LSG, and values closer to that experienced during FM. Therefore, SSG may provide more effective training stimuli than LSG, and closer to that of FM when FM cannot be used for training practices.

Despite a lower distance covered within moderate-to-high-speed zones during the game-based trials, players performed more accelerations during SSG than LSG with both superior to that during FM (see Table 1). For decelerations, SSG and LSG were equally effective in increasing the frequency of this action in comparison to FM. Although this result seems contradictory (i.e. lower running distance with more accelerations/decelerations in sized-reduced games), game-based trials with smaller pitch areas and number of players have been reported to induce greater play intensity and number of short-term activities including spurts, changes of directions and stoppages (Malone et al., 2016; Rebelo et al., 2016a). In contrast, FM have been shown to produce greater player displacements with minimal accelerations and decelerations (David Casamichana et al., 2012). Collectively, these results indicated that game-based soccer situations of reduced size and players per side were more effective in inducing intense and low-displacement actions for players than friendly matches.

The higher number of accelerations and decelerations produced during SSG suggested a greater demand from the lower limb musculature during this type of game-based situation. From a simplistic point of view, one might consider SSG as a superior training stimulus for high-performance soccer players to produce better long-term and specific muscle adaptations during soccer training programs. However, the more frequent production of accelerations, decelerations, changes of direction and stoppages induced by SSG requires the generation of high horizontal forces at low speed during the first meters of the acceleration/deceleration phase. This generation may increase the risk of muscle injuries (Mendiguchia et al., 2016), specifically when recovery times between these actions are reduced (Carling, Gall, & Reilly, 2010). The higher muscle demands induced by SSG could particularly affect the risk of quadriceps and hamstrings strains because these muscles are subjected more to acceleration and deceleration forces during activity bursts and stoppage (Barroso & Thiele, 2011). While SSG may be considered as a more applicable training routine to increase player physical demands to a level comparable to that of competitive soccer matches (Fontes et al., 2007; Gabbett, Jenkins, & Abernethy, 2009) coaches should monitor the use of SSG during short-term and long-term training planning so as to avoid excessive muscle demands and to diminish the risk of muscle injuries. The final major finding of this study was that the self-reported exertion rating at the end of each trial was higher for SSG than for LSG with both higher than FM. These levels of effort were experienced despite the majority of running speed distances, and the work to rest ratio being significantly greater for the FM compared to SSG and LSG. Therefore, player effort during sided games may be influenced by multiple factors other than total distance covered and/or distance at high speed. Specifically, player effort during sided game trials likely resulted from frequent accelerations and decelerations rather than long and maintained displacements. Thus, SSG and LSG may provide a potent physical, training stimulus for professional soccer players even when the movement patterns are different to those during competition.

Some limitations should be noted for the current investigation. Measures of player internal load (e.g., heart rate and blood lactate concentration) were not assessed during the trials. Identification of player internal load would confirm further the training stimuli experienced during SSG and LSG and the importance of their imposed accelerations and decelerations as a soccer-specific training routine. Secondly, trials were not video recorded or notated and thus, it was not possible to compare technical

and/or tactical variables between the trials. Thirdly, the order of trials was not randomised due to team-directed logistics with training and playing schedules. Potential differences between trials may have resulted from the order in which they were conducted with fatigue associated with training and other competitive matches possibly impacting on results. However, players were experienced professionals and familiar with various training routines during multiple competitive seasons. Further studies utilising a randomised order of sided games and competition will elucidate any such order influence. Lastly, the competitive match examined was a FM rather than an official match that contributed to league rankings. To minimise any such impact, all players were instructed to participate in all trials at competitive intensity levels with the opposition quality matched for all trials. It remains to be seen whether examination of a non-friendly, competitive match results in greater disparity in movement patterns between SSGs and competition.

Conclusions

Despite the general perception that game-based soccer activities with a reduced size and number of players are a relevant means to replicate the demands of competitive matches (Carling et al., 2010; Mendiguchia et al., 2016), the current results demonstrated that neither SSG nor LSG elicited the same movement patterns experienced during soccer competition (FM). Specifically, SSG and LSG resulted in an increased frequency of accelerations/decelerations and augmented ratings of perceived exertion compared to a competitive match. The reduction of pitch size and number of players in SSGs may be used as a strong training stimulus to enhance high-intensity activities for soccer players. The use of SSG may be more beneficial than LSG as a training modality for professional and amateur soccer players as they induce a greater perceptual and external load. Coaches are encouraged to be mindful of the effects that manipulations of game-based tasks have on the physical demands imposed on players during training.

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5. STUDY 2

STUDY 2: physical responses of professional soccer players during 4 vs. 4 small-sided games with mini-goals according to rule changes.

Accepted in: *Biology of Sport*.

Running Head. Physical response in football players

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Abstract:

The aim of this study was to investigate the influence of the number of ball touches authorised per game (one-touch [T1], two-touches [T2], and free-touches [FT]) on the players' physical responses throughout the bouts in 4vs4 soccer small-sided games (SSGs) with mini-goals (without goalkeeper). Fourteen professional Polish players (age 23.2 ± 2.7 years, height 177.9 ± 6.1 cm, weight: 73.2 ± 6.9 kg, body fat $12.6 \pm 2\%$, and playing experience: 14 ± 5 years) completed nine series of 4vs4 SSGs). Each trial included three series of SSGs with a game duration of 4 minutes on an equalled sized pitch (30×24 m; 720 m^2 ; individual occupied area per player = 90 m^2). Differences in physical responses and time-motion characteristics of players were measured with the Global Position System (GPS) and assessed using a repeated measures ANOVA to compare the three game conditions and the magnitude-based inference to evaluate the pairwise comparison effects. The results showed that only the variables distance covered at low speed, time walking, time at low speed, and accelerations of $>4 \text{ m/s}^2$ were statistically significant among game conditions. The pairwise comparisons only identified significant effects for distance covered at low speed (between FT and T2), for time walking (between FT and T1), for time at moderate and low speed (between FT and T2), and for accelerations of $>4 \text{ m/s}^2$ (between FT and T1). The players' performances are affected by the ball touches constraint during SSGs with mini goals. The results provide useful information for training and task design that replicate specific physical demands (i.e., accelerations of $>4 \text{ m/s}^2$, time walking or running at a lower speed).

KEY WORDS: Fitness training, professional football, physical responses, athlete development, GPS device.

Introduction

Small-sided games (SSGs) are one of the most widespread soccer training drills that can be conducted among players of different ages and skill levels (Hill-Haas, Coutts, Rowsell, & Dawson, 2009; Hoff & Helgerud, 2004; Köklü, 2012; Radziminski, Rompa, Barnat, Dargiewicz, & Jastrzebski, 2013). These tasks are used to improve both technical and tactical skills, and the fitness level of soccer players, as well as to shape their volitional features (Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011). The intensity of the efforts implemented in the SSGs, both during actions with and without the ball, is very similar to what occurs in competitive games, where the players are forced to make decisions during conditions of increasing fatigue (Gabbett & Mulvey, 2008; Little, 2009; Owen, Twist, & Ford, 2004)

The nature of the effort performed during the SSGs can be modified by the aims of training sessions when changing some factors such as: the number of players, the dimension of the pitch, playing and recovery time, coach involvement or encouragement (e.g., instruction or lack of it), or the playing rules (presence or absence of goalkeepers, playing with or without goals, and playing with a limited number of ball touches). Some recent reviews focussed on studies related to SSGs show that it is difficult to make accurate conclusions based on the influence of each of these factors in isolation (Aguiar et al., 2012; Halouani et al., 2014). This is because of the lack of consistency in SSG designs according to players' fitness, age, ability, the level of coach's encouragement, and the playing rules used during each experimental design. In particular (Aguiar et al., 2012), determined that there is a lack of studies on the SSGs with mini-goals and their influence on the players' physical demands.

Some authors (Casamichana, Castellano, González, Garcia, & Garcia, 2011) studied different SSG formats and how their variations modified the players' physical demands. In particular, two oriented situations (with goalkeepers and regular goals and without goalkeepers but with mini-goals) and one non-oriented situation were analysed. The training intensity (i.e., average heart rate (HR_{mean}) in non-oriented and oriented SSGs with mini-goals was similar. However, the physical intensity was lower when the players performed regular goals with goalkeepers. This finding can be explained by the fact that when goalkeepers were included with the same pitch dimensions (25m x 32m) the players had less space for playing and showed lower HR_{mean} values.

The SSGs with mini-goals may suggest other task options that can be used to increase the physiological training load. For example, coaches and researchers simulate soccer-specific training drills using principles of play and game model in the same task (Gómez, Paulis, González-Morán, García-Cueto, & García-López, 2011). Obviously the SSGs with mini-goals must be considered with a training skill format, because they are not only adequate, but also better than SSG (maintenance) format, combining excessive workload and an inadequate time for recovery (e.g., the goals are small). Thus, great shot accuracy is necessary and the players' finishing potential can be effectively improved. This procedure requires high-skilled responses when passing and shooting rather than a large quantity of shots (i.e. this is a determining factor of good attacking players)(Liu, Hopkins, & Gómez, 2016).

Due to the interaction between players' technical ability, tactical skills, and physical demands; the training practice may be more time-efficient if these three factors are closely combined and players are trained alongside each other in SSGs (i.e. concurrent training)(Little, 2009). Nevertheless, this training approach can be achieved merely with specific game formats (e.g., SSGs with mini-goals). To achieve this, periods of loading, recovery, and tapering have to be sensibly arranged.

On the other hand, possession play generally affects the players' physical and physiological responses, meaning that the game demands are higher (Castellano et al., 2013). The modification of the type of possession game can also influence the technical and physical demands of SSGs. Specifically, the inclusion of the [1T] constraint may permit the players to play with less pass effectiveness and 1 on 1 duels and cover more distance, specifically with high-intensity runs and sprints (Dellal, Chamari, et al., 2011; Dellal et al., 2011). In addition, when [2T] were allowed during the SSG this condition generated higher high-intensity running and RPE values (Dellal et al., 2012). Lastly, when [FT] were authorised the results did not reflect consistent findings for physical demands (Dellal et al., 2012).

Accordingly, the coaching staffs can manipulate the number of touches task constraint based on the need to develop the players' performance regarding technical and/or physical demands. A specific concern of SSGs with mini-goals is that the physical load imposed on players would be different through the modification of constraints of rules (e.g., limitation of ball touches). Previous investigations have shown the effect of the number of ball contacts within bouts of 4 vs 4 SSGs (Dellal, Lago-

Penas, Wong, & Chamari, 2011). Despite this, to our knowledge, no study has assessed the effect of the number of ball contacts within 4 vs 4 SSGs (absence of mini-goals). In order to systematise the knowledge on this topic, previous studies have examined physical responses to SSGs (inclusion of goals). However, no available study was found focussed on the effect of these variables (i.e. players' physical and technical responses) during SSGs with mini-goals (Aguiar et al., 2012). Therefore, the aim of this study was to examine acute physical responses when modifying the number of ball touches per player in the presence of mini-goals. It was hypothesised that the SSGs with-mini-goals [1T] would provide a more intense physical stimulus compared with [2T] and [FT] respectively.

Method

Subject and sample

Fourteen professional outfield male soccer players, from a Polish professional football club, voluntarily participated in this investigation. They had a mean $\pm$ SD age of 23.2 ± 2.7 yr, height of 178 ± 6 cm, body mass of 73.2 ± 6.9 kg, body fat of $12.6 \pm 2\%$ and a soccer experience of 14 ± 5 yr. To obtain a homogeneous sample, only the players who played regularly in the official league games were considered for the study (i.e. the criteria for inclusion were: the player must have played more than 65 minutes of total playing time during the regular match). Goalkeepers were excluded from the sample, because they did not participate in the same physical training programme. All players were notified of the aims, requirements, benefits and risks of the study, before giving their written informed consent. All the research procedures were approved by the research ethics committee of the local university, in accordance with the latest version of the Declaration of Helsinki. The research also received formal approval from the club involved.

Research design

The SSGs consisted of 3 trials (a total of 9 repetitions of 4-min game situations), interspersed by 3 min of active recovery (for a total of 36 min of playing time). Each trial included three repetitions of 4 vs 4 SSGs with four mini-goals (without goalkeeper, see Figure 1), with a game duration of 4 minutes. All the SSG repetitions were played and completed by the same 14 players under the same conditions during three sessions

distributed over a 3-week time span during the second round of the in-season period. The number of ball touches (1 touch [T1], 2 touches [T2], and free touches [FT]), varied in each repetition of each trial, in a random order (the ball touches conditions were equally distributed during each trial, only varying the randomised order). During the recovery period, participants went to a side of the pitch at walking speed to rehydrate (the players were allowed to take fluids ad libitum) and then returned to their position: however, these displacements were removed from the analysis because they did not replicate typical routines during a soccer match. The dimensions of the pitch area for the SSGs with mini-goals were (30 x 24; 720 m²), individual occupied areas were selected to maintain a similar relative pitch area per player (90 m² per player, see Figure1). The SSGs were conducted on the same outdoor artificial grass pitch at the home training venue of the club. All the game situations were performed on an outdoor artificial grass pitch with normal mini-goals, and participants wore official clothing and soccer boots. In all the experimental situations, participants were encouraged to score the highest number of goals during the game. There was no presence of a goalkeeper per side. The verbal encouragement throughout all the SSG situations was also standardised by the technical staff (head coach and assistants) with the help of the experimenters, to maintain a high skill level. Players had been familiarised with the SSG with mini-goals formats and regimes during previous training sessions in the season. The SSGs were performed at the beginning of training to ensure that players were not exhausted. Each session began with the same 20 minute period of general movement patterns, specific movement patterns with ball, specific movement patterns without ball, see (Zois, Bishop, Ball, & Aughey, 2011), followed by the same soccer-specific passing game which lasted another 10 minutes. Both teams in the SSGs were encouraged to score the highest number of goals in the time delimited. In order to avoid stoppage time to a maximum extent in the games, several balls were located around playing areas for immediate availability. Additionally, there were two assistant coaches outside the playing area to ensure continuous play. The two assistant coaches acted as timers and referees (i.e., to enforce the rules of each SSG: 1T, 2T, FT for each ball involvement). To limit the influence of hydration status on the variables analysed, all participants were advised to maintain their normal diet, greater focus being placed on a high consumption of water and carbohydrates (50-60% of total energy intake) (Kirkendall, 1993), to avoid the effects of dehydration (Convertino et al., 1996).

Figure 4. Design of the experimental protocol for the SSG conditions.

Data collection

The physical responses, and time-motion characteristics of players, were monitored using Global Position System devices (GPS MinimaxX v4.0, Catapult Innovations, Melbourne, Australia) operating at a sampling frequency of 10 Hz, and incorporating a 100 Hz triaxial accelerometer. This technology has been previously validated, and has been proven reliable for monitoring movements and activities of different intensities of soccer players (Boyd et al., 2011a; Castellano et al., 2011a; Varley et al., 2012). The device was fitted to the upper back of each player, using the manufacturer-designed harness. The devices were activated 15 min before the start of each training session, in accordance with the manufacturer's instructions. The device was fitted to the upper back of each player, using the manufacturer-designed harness.

According to the available research (Boyd et al., 2011a; Castellano et al., 2011a; Varley et al., 2012), and by a priori importance for performance in soccer, the following variables were assessed: player load (an estimate of physical demand, combining the instantaneous rate of change in acceleration in three planes: forward/backward X, side/side Y, and up/down Z; for details, see (Randers, Nielsen, Bangsbo, & Krstrup, 2014); exertion index (an index calculated basing on the sum of a weighted instantaneous speed: a weighted accumulated speed over 10s, and a weighted accumulated speed over 60s; for details, see (Wisbey, Montgomery, Pyne, & Rattray, 2010); maximum velocity reached (m/s), total distance covered (m), distance covered at different thresholds/zones (m), time spent at different intensities (%), and the distance covered with different acceleration bands (m). Similarly to previous studies

(Casamichana, Suarez-Arrones, Castellano, & Román-Quintana, 2014; Castellano et al., 2013; Krustrup et al., 2009), intensity was classified in seven speed zones of players' movements: standing (≤ 1.67 m/s), walking (> 1.67 m/s, ≤ 2.22 m/s), jogging (> 2.22 m/s, ≤ 3.33 m/s), low-speed running (> 3.33 m/s, ≤ 4.17 m/s), moderate-speed running (> 4.17 m/s, ≤ 5 m/s), high-speed running (> 5 m/s, ≤ 6.94 m/s), and sprinting (> 6.94 m/s). The rate of acceleration variables can be pre-set within a minimum range modification of 0.5s, with at least a 0.5ms^2 , and maximum acceleration was required to consider an acceleration activity (Gaudino et al., 2015). This was measured on the basis of the change in GPS speed data.

Despite previous categories used during match analysis (Akenhead, Hayes, Thompson, & French, 2013; Osgnach et al., 2010), new outcomes have shown substantial constancy in running metabolic cost at speeds oscillating from up to -2 to $+2\text{ m/s}^2$ (Minetti et al., 2013). Therefore, we decided only to analyse those changes $>2\text{ m/s}^2$, and $\pm 2\text{ m/s}^2$, in acceleration and deceleration, respectively. Without a doubt, the following categories were established: moderate deceleration (MD) was from -2 to -3.2 m/s^2 ; high deceleration (HD) was $<-3.2\text{ m/s}^2$; moderate acceleration (MA) was from 2 to 3.2 m/s^2 ; and high acceleration (HA) was $>3.2\text{ m/s}^2$ (Osgnach et al., 2010). The intensity of standing generated no distance measurement, so that it was incorporated into walking. Due to the fact that there was not enough space in SSGs for the players to reach sprinting speed; the values recorded in this category were very low. Hence, it was combined with the high-speed running category. The acceleration bands were divided into the following 6 categories: acceleration 1 ($<-4\text{ m/s}^2$), acceleration 2 (-4 to -2 m/s^2), acceleration 3 (-2 to 0 m/s^2), acceleration 4 (0 to 2 m/s^2), acceleration 5 (2 to 4 m/s^2), and acceleration 6 ($>4\text{ m/s}^2$).

Statistical analysis

The physical responses and time-motion characteristics of the players, playing according to the three different rules (i.e., 1-touch (1T), 2-touch (2T), and free-touches (FT), for each ball involvement) in the same format of training (4 vs 4 SSGs with 4 mini-goals), were compared using a repeated measures ANOVA. Statistical analyses were performed using SPSS 22.0 (IBM Corp., Armonk, NY, USA) and the level of significance was set at $p \leq 0.05$. Afterwards, in order to test all the pairwise comparisons between the game formats, the magnitude-based inference method with repeated

measurements was applied. The pairwise comparisons on each variable were calculated with a Hopkins spreadsheet (Hopkins, 2006) that computes the standardised Cohen's *d* values (adjusted effect size). The thresholds for the effect size (ES) statistics were 0.2 = trivial, 0.6 = small, 1.2 = moderate, 2.0 = large, and >2.0 = very large effect. Mechanistic magnitude-based inferences were assessed using the smallest worthwhile difference. The smallest worthwhile difference was calculated by 0.2 times the standardisation, estimated from the between-subject standard deviation. Differences were defined as unclear if the confidence intervals for the difference in the means included substantial positive and negative values ($\pm 0.2 \times \text{standardisation}$) simultaneously (Hopkins, Marshall, Batterham, & Hanin, 2009). Magnitudes of clear differences were assessed as follows: >0.25, trivial; 0.25 – 0.5, possibly; 0.5 – 0.75, likely; 0.75 – 1.0, very likely; >1.0 most likely (Hopkins, 2007).

Results

Table 1 shows the descriptive statistics for each variable according to the game conditions (1T, 2T, and FT) and the mean differences between conditions. The results of the repeated measures ANOVA showed that only the variables distance covered at low speed ($F=8.151$; $p=0.007$), time walking ($F=3.181$; $p=0.043$), time at moderate speed ($F=4.4751$; $p=0.0127$) and low speed ($F=4.770$; $p=0.036$), and acceleration 6 ($F=4.343$; $p=0.014$) were statistically significant among game conditions.

Table 2: Descriptive statistics of physical responses of players in the SSGs according to the number of touches (T1, T2 and FT).

Variable	T1	T2	FT	T2-T1	FT-T2	FT-T1	ANOVA
	M $\pm$ SD	M $\pm$ SD	M $\pm$ SD	Difference (%); $\pm$ 90%CL	Difference (%); $\pm$ 90%CL	Difference (%); $\pm$ 90%CL	P
Indicator of workload							
Player Load	39.7 $\pm$ 8.5	46.6 $\pm$ 10	40.2 $\pm$ 9.5	6.9; $\pm$ 4.3	-6.4; $\pm$ 3.5	0.5; $\pm$ 4.6	0.106
Exertion Index	2.9 $\pm$ 0.8	3.1 $\pm$ 1.1	3.0 $\pm$ 1.0	0.2; $\pm$ 6.7	-0.1; $\pm$ 4.7	0.1; $\pm$ 6.9	0.163
Maxima Velocity(m/s)	5.2 $\pm$ 0.7	5.1 $\pm$ 0.7	5.2 $\pm$ 0.7	-0.13; $\pm$ 2.8	0.1; $\pm$ 5.7	-0.1; $\pm$ 6.0	0.293
Distance covered rate(m/s)							
Total Distance	394 $\pm$ 70	411 $\pm$ 84	396 $\pm$ 78	16.8; $\pm$ 3.4	-14.4; $\pm$ 2.1	2.4; $\pm$ 3.7	0.326
Distance Walking	207 $\pm$ 20	204 $\pm$ 25	197 $\pm$ 19	-3.0; $\pm$ 3.4	-6.8; $\pm$ 3.5	-9.8; $\pm$ 2.7	0.477
Distance Jogging	102 $\pm$ 37	116 $\pm$ 44	111 $\pm$ 47	13.3; $\pm$ 9.1	-4.3; $\pm$ 7.6	9.0; $\pm$ 12.8	0.207
Distance Low-speed	48.4 $\pm$ 23.3	52.6 $\pm$ 29.6	49.9 $\pm$ 22.4	4.2; $\pm$ 16.6	-2.7; $\pm$ 9.6	1.5; $\pm$ 13.1	0.007**
Distance Moderate-speed	22.6 $\pm$ 14.4	25.4 $\pm$ 19.0	23.5 $\pm$ 14.7	2.8; $\pm$ 5.3	-1.9; $\pm$ 5.1	0.9; $\pm$ 4.6	0.189
Distance High-speed	8.8 $\pm$ 8.3	7.6 $\pm$ 8.5	8.7 $\pm$ 10.2	-1.2; $\pm$ 2.8	1.1; $\pm$ 2.8	-0.1; $\pm$ 3.3	0.412
Time (%)							
Time Standing	9.0 $\pm$ 5.5	8.5 $\pm$ 6.3	10.2 $\pm$ 6.6	-0.5; $\pm$ 16.1	1.7; $\pm$ 18.4	1.2; $\pm$ 23.2	0.355
Time Walking	67.4 $\pm$ 5.8	65.2 $\pm$ 7.5	64.5 $\pm$ 6.3	-2.2; $\pm$ 2.9	-0.7; $\pm$ 3.0	-2.9; $\pm$ 2.2	0.043*
Time Jogging	15.0 $\pm$ 5.3	17.0 $\pm$ 6.2	16.4 $\pm$ 6.6	2.0; $\pm$ 9.8	-0.6; $\pm$ 8.5	1.4; $\pm$ 12.3	0.178
Time Low-speed	5.4 $\pm$ 2.6	5.9 $\pm$ 3.3	5.6 $\pm$ 2.5	0.5; $\pm$ 16.5	-0.3; $\pm$ 10.1	0.2; $\pm$ 13.9	0.036*
Time Moderate-speed	1.9 $\pm$ 1.4	2.4 $\pm$ 1.8	2.1 $\pm$ 1.4	2.8; $\pm$ 21.6	-7.9; $\pm$ 18.7	0.2; $\pm$ 18.5	0.012*
Time High-speed	0.6 $\pm$ 0.7	0.5 $\pm$ 0.7	0.6 $\pm$ 0.8	-0.1; $\pm$ 2.8	0.1; $\pm$ 2.8	0.0; $\pm$ 3.3	0.369
Acceleration(numbered)							
Distance Acc. 1	1.6 $\pm$ 1.0	1.5 $\pm$ 1.2	1.5 $\pm$ 1.0	-0.1; $\pm$ 14.5	0.0; $\pm$ 24.2	-0.1; $\pm$ 18.0	0.401
Distance Acc. 2	10.4 $\pm$ 3.3	10.6 $\pm$ 4.2	10.0 $\pm$ 3.3	0.2; $\pm$ 12.5	-0.6; $\pm$ 12.6	-0.4; $\pm$ 6.2	0.468
Distance Acc. 3	130 $\pm$ 22	133 $\pm$ 26	131 $\pm$ 25	0.3; $\pm$ 4.1	-2.1; $\pm$ 4.2	0.9; $\pm$ 4.1	0.378
Distance Acc. 4	212 $\pm$ 40	226 $\pm$ 47	219 $\pm$ 44	14.0; $\pm$ 3.8	-7.6; $\pm$ 2.6	6.8; $\pm$ 4.2	0.194
Distance Acc. 5	13.3 $\pm$ 3.8	14.0 $\pm$ 4.0	13.0 $\pm$ 3.8	0.7; $\pm$ 7.1	-1.1; $\pm$ 9.2	-0.4; $\pm$ 8.0	0.153
Distance Acc. 6	3.9 $\pm$ 1.4	3.3 $\pm$ 1.4	3.3 $\pm$ 1.4	-0.4; $\pm$ 10.5	0.0; $\pm$ 18.5	-0.6; $\pm$ 17.7	0.014*

*p<0.05; **p<0.01

The Figure 2 shows the results of the pairwise comparisons and their effects (Magnitude Based Inference Method). Significant effects were only identified among SSGs with mini-goals (ball touches restriction of 1T, 2T, and FT) for distance covered at low speed (likely effects between FT and T2: greater distance covered during T2), for time walking (likely effects between FT and T1: more time walking with T1), for time at moderate speed (possibly effects between FT and T2: more time at moderate speed during T2), for time at low speed (likely effects between FT and T2: more time at low speed during T2), and for acceleration of >4 m/s² (likely effects between FT and T1: more distance covered at acceleration 6 during T1).

Figure 5. Results of the magnitude based inference between pairs of conditions.

Discussion

This experimental study sought to examine the influence of the number of ball touches authorised per game (one-touch [T1], two-touches [T2], and free-touches [FT]) on the physical response of professional players throughout the bouts in the 4vs4 soccer SSGs with mini-goals. On the one hand, the key findings reflect that during SSGs played with 1T the players performed their highest intensity of exercise (acceleration of >4 m/s²) and time walking. These contradictory results may be explained by the influence of the pitch dimensions of 4 vs 4 SSGs. These tasks meant that the players increased the number of accelerations and decelerations in shorter distances with high intensity movements (Malone, Solan, & Collins, 2017). Then, the players covered less distances but with greater effort (Vilar, Duarte, Silva, Chow, & Davids, 2014). The results are in accordance with the available research that identified more turnovers, missed passes and

less 1 on 1 situations during T1 SSGs (Malone et al., 2017; Mallo & Navarro, 2008; Vilar et al., 2014). In fact, this type of SSG increases intermittent efforts and then produces higher lactate concentrations (Malone et al., 2017) improving anaerobic performance.

On the other hand, greater distances covered at lower velocities (moderate and low-speed) occur during 2T play. These findings have been partly confirmed by (Mallo & Navarro, 2008) who noticed an increase in distance covered by players at different velocities, in relation to the increasing number of touches during play, which was focussed on keeping the ball by two neutral players. Specifically, the T2 SSGs allow contacting the ball before passing or kicking the ball or after dribbling, so the players' actions are of lower intensity compared with T1. Accordingly, players' decision-making and quick responses characterise the T1, but T2 implies more time to decide, act and react during the games. Therefore, the T2 SSGs may involve more distances covered at different intensities, more RPE values and aerobic performances due to better passing effectiveness, lower game pace and more ball possession duration (Malone et al., 2017). In particular, Rebelo et al. (2016b) identified, when analysing the 4 vs 4 SSGs, that this game was highly demanding in relation to repetitions and fatigue development in muscle power-based actions compared to other SSG formats with larger pitches and numbers of players such as 8 vs 8 games. However, the present results are different from those reported by Malone et al. (2017) who found higher RPE and high intensity running during T2 SSGs and FT.

Our research highlights the fact that the modification of the number of ball touches during SSGs could be a useful task constraint in order to permit and improve the players' physical responses (i.e., repetitions and muscle-power actions). It seems that SSGs, in the format of 4 vs 4 with mini-goals, are a very favourable training task that facilitates the effective development of players' fitness, while concurrently improving their technical and tactical abilities. The current findings might help individuals involved in the physical preparation of players (e.g., technical coaches, fitness coaches, and sports science staff) when developing training programmes and training sessions in line with the use of one, two or free touches playing SSGs with mini-goals, and with the levels of high speed accelerations targeted to reach during specific training drills. In addition, this rule modification allows reducing or increasing the fatigue induced to elicit adaptations related to physical performance.

Indeed, situations regarding mini-goals using T2 or FT could be used for recovery (i.e. less action at high intensity and more time spent in low or moderate sided-games) and T1 during competitive and impact microcycles (i.e., intermittent efforts with accelerations, decelerations and walking actions).

Despite the results, there are several limitations to the current research that should be considered in further studies concerning players' physical demands and the use of GPS devices. Firstly, recent available literature showed that $<15\text{Hz}$ is not reliable (Haugen & Buchheit, 2016) when analysing SSG conditions. Secondly, the margins of victory (i.e., goal differences between teams) during SSGs were not accounted for in the present study, thus future research should assess the impact of the match/game status (winning, drawing or losing) on the physical and technical-tactical performance (Lupo & Tessitore, 2016). Finally, the findings were in line with the principle of specificity that justifies the use of SSGs during training sessions (Reilly, Morris, & Whyte, 2009). Specifically, it is a regular practice in professional and semi-professional soccer to have SSGs and weekly friendly matches (FMs) during the training week (Bangsbo, 2008) for this reason, future studies should compare the performance variation between the physical responses during official matches, friendly matches and SSGs with mini-goals.

Conclusion

In conclusion, this recent research improves the understanding of some of the physical responses affecting SSG intensity when using mini-goals. The number of touches during SSGs has influenced the players' performances. Then, the result pointed out two important issues for coaching staffs when design and controlling for training tasks. On the one hand, the use of one touch during SSGs increases the time walking and high intensity accelerations (acceleration of $>4\text{ m/s}^2$). This fact may lead coaches to design training plans close to competitive situations during a match (i.e., passing with a high defensive pressure without time to control the ball or anticipating quick responses for each playing position during the SSG improving the tactical and technical skills). In addition, these task conditions can be used during between matches' microcycles in order to prepare the players' physical fitness for specific competition demands. On the other hand, the use of two touches during SSGs allow the players to cover more distance at low intensity and more time at low and intermediate intensity. These conditions reinforce the importance to develop training tasks focused on recovery after

high intensity matches, congested fixture periods or during post-season trainings. Accordingly, the purpose of coaches using two touches during SSGs can be to perform at moderate physical intensity focusing the players' attention on tactical requirements such as players' positioning, open spaces, decision-making for each playing position or offensive and defensive strategies in small contexts (4 vs 4 SSG). Therefore, the results found point out the importance of ball touches constraint during SSGs with mini goals, and provide useful information for training and task design that replicate specific physical demands of elite football players.

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6. STUDY 3

STUDY 3: Impact of playing status on match performance demands for professional soccer players.

Submitted to: *Perceptual and Motor Skills*, currently is under review.

Running Head. Playing status on soccer match performance

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Abstract:

The aim of this study was to investigate the match performance demands between starters and non-starters during friendly soccer matches over the same time-period during official matches (90 minutes). Fourteen professional players (age: 23.2 ± 2.7 years, height: 178 ± 6 cm, body mass: 73.2 ± 6.9 kg) took part in this study. Twenty, physical performance-related match variables were studied (distance covered at different intensities, accelerations and decelerations, player load, maximal running speed, exertion index, work to rest ratio and exertion rating). Comparisons between starter and non-starters were conducted using magnitude-based inferences. Different responses between player roles were identified with non-starters experiencing greater distances covered at 3.3 to 4.2 m/s, 4.2 to 5.0 m/s, and 5.0 to 6.9 m/s, player load, exertion index and work to rest ratio, and lower, self-reported, rating of exertion compared to starters. No significant differences in acceleration and deceleration movement patterns were evident between player roles. Match performance differences between player roles may indicate greater fatigue and/or use of pacing strategies by starters.

Key words: acceleration, competition, football, performance, substitutes.

Introduction

Soccer is a team sport played at different competitive levels (e.g. junior, senior, amateur and professional) with an emphasis on intermittent movements including brief bouts of high-intensity exercise and longer periods of low-intensity exercise (Rampinini, Coutts, Castagna, Sassi, & Impellizzeri, 2007; Rampinini et al., 2007). Soccer players require a high level of aerobic fitness in order to generate and maintain power output during repeated high-intensity efforts (Van Winckel, Helsen, De Roover, & Vanharen, 2014). The ability to recover between bouts of high intensity activity and subsequently, repeating these efforts has been reported as a critical physical ability of modern-day soccer players (Gabbett & Mulvey, 2008). Consequently, the physical preparation of elite soccer players has become an important component of professional training to deal with the increasing energy demands of match play (Carling, Bloomfield, Nelsen, & Reilly, 2008; Iaia, Rampinini, & Bangsbo, 2009).

The physical preparation of elite soccer players for match-play has been well described with elite players reported to cover approximately 9.1 km during a match including 1-3 km at a high-intensity (Bradley et al., 2009; Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009). A large number of studies have reported on the specific energetic and physical performance demands of elite soccer players, including the effects of positional variation, using time motion analysis (Bradley et al., 2009; Di Salvo et al., 2009; Rampinini et al., 2007). For example, central midfielders were reported to cover more total distance than any other positions with the wide midfielders and fullbacks also displaying superior high-intensity efforts during a match (Bradley et al., 2009; Di Salvo et al., 2009; Rampinini et al., 2007). In contrast, attacking forwards and central defenders consistently exhibited poorer physical performance during matches (Bradley et al., 2009). These results clearly demonstrated the importance of training specificity for different playing positions within a team and the need for specialist players to maximize team success. Typically, this specialization is focused upon when formulating a team of players that start and compete for the majority of a match (i.e. starters). However, during official matches the players are substituted due to injury or as a strategy to enhance success. These players (i.e., non-starters) may possess different physical abilities and match skills that reflect unique demands of playing roles within the team. Specifically, Bradley, Lago-Peñas, and Rey (2014) studied the physical

performance differences between starters and non-starter players in the English Premier League. Their main results demonstrated that high intensity running distance was greater for non-starter players. However, these comparisons were undertaken without consideration of playing time with non-starters engaging in a substantially smaller amount of match time compared to starters. Therefore, this prior comparison may be skewed by the length of match time for each player role. Limited research has analysed the match performance demands of soccer players according to their role (starter or non-starter) over the same time-period during official matches (90 minutes). Thus, the aim of this study was to document the match performance demands between starter and non-starter, professional soccer players. Differences between starters and non-starters may highlight potential weaknesses for coaches that need to be addressed in team preparation and selection.

Methods

Participants

Fourteen, outfield, male, soccer players (mean $\pm$ SD: age 23.2 $\pm$ 2.7 years, height 177.9 $\pm$ 6.1 cm, mass: 73.2 $\pm$ 6.9 kg, body fat 12.6 $\pm$ 2%, training experience 14 $\pm$ 5 years) from a professional Polish football club participated in this study. Participants were fully informed of any risks and discomforts associated with the study before providing their informed written consent to participate. The study was approved by the local University Ethics Committee in accordance with the latest version of the Declaration of Helsinki.

Experimental design

Each player participated in two friendly matches consisting of 11 players per side under the same environmental conditions (16 $\pm$ 1 °C; 87 $\pm$ 5 % relative humidity). Matches were separated by 1 week and played during the second round of the 2014 competition. The matches were played at the home training venue of the club which housed a regular artificial turf soccer field (90 x 60 m). For both matches, participants were allocated to separate teams according to their habitual outfield position and coaches' recommendation for playing status (i.e. starter or non-starter). For each match, there were 9 starters and 3 non-starters (playing the full time, 90min) examined in the current

study resulting in a total of 18 and 6 sets for starters and non-starters, respectively. All matches followed the official FIFA rules with the team's coaches officiating the match.

During each match, players wore their competition clothes and carried a GPS device inserted into a small harness (Catapult Innovations, Melbourne, Australia) attached to their back to record match demands. Participants were allowed to consume fluids *ad libitum* during rest periods of the matches. To minimize the influence of hydration status on performance, and to avoid dehydration (Convertino et al., 1996), all participants were advised to maintain their normal pre-match diet with a greater focus being placed on a high consumption of water and carbohydrate (i.e. 50-60% of total energy intake) (Kirkendall, 1993).

Experimental protocol

At 10:00, participants arrived at their habitual training stadium and prepared for the matches by positioning the GPS units under their competition clothes. All participants then performed a standardized 20-minute warm-up consisting of general movement patterns, specific movement patterns with ball, and specific movement patterns without ball, as previously described (Zois et al., 2011). Matches then commenced with the GPS units continuously monitoring participants as previously reported (Boyd, Ball, & Aughey, 2011b; Castellano, Casamichana, Calleja-Gonzalez, San Roman, & Ostojic, 2011; Varley, Fairweather, & Aughey, 2012). Within 5 minutes of match completion, participants individually self-rated their perception of exertion (RPE) using a 1-to-10 point, visual analogue scale (Foster et al., 2001).

The day before each match, participants were instructed to avoid caffeine-containing products and the technical staff programmed a low-intensity, low-volume recovery session. The player's diet was standardized for the 24 hours before the matches while compliance was verified by self-reported diaries. On the day of each match, participants arrived at their habitual training facility and body mass (± 0.05 kg) and body height (± 0.1 cm) were measured (Seca 285, Germany). Body fat percentage was estimated by using segmental bioimpedance scales (BC-418, Tanita, Japan) in line with standardised procedures for this measurement. Participants then completed the standardized warm-up followed by the match. In order to minimise stoppage time, several balls were placed

around the pitch area for immediate access by players. Additionally, there were two assistant coaches positioned outside of the playing area to provide encouragement and support for continuous play. The two assistant coaches monitored the timing and rule compliance (referees) for each match.

During each match, the movement patterns and time-motion characteristics (i.e. match performance demands) of players were monitored by calibrated GPS devices (Catapult Innovations, Melbourne, Australia) that operated at a sampling frequency of 10 Hz. The players utilised the same GPS unit for each match to avoid any variability amongst GPS devices. This GPS technology has been previously validated and reported to be reliable for monitoring movements and activities of different intensities for soccer players (Boyd et al., 2011b; Castellano, Casamichana, Calleja-González, San Román, & Ostojic, 2011b; M. C. Varley et al., 2012). Similar to previous studies (Casamichana et al., 2014; Castellano et al., 2013; Krstrup et al., 2009), the total running distance was examined across six zones of increasing speed: walking (≤ 2.2 m/s), jogging ($> 2.2 \leq 3.3$ m/s), low speed running ($> 3.3 \leq 4.2$ m/s), moderate speed running ($> 4.2 \leq 5.0$ m/s), high speed running ($> 5.0 \leq 6.9$ m/s) and sprint speed running (> 6.9 m/s). The accelerations and decelerations of player movements were also measured within $\pm 2 \text{ m/s}^2$ intervals (Minetti et al., 2013; Osgnach et al., 2010). The work to rest ratio was calculated as the distance covered by the player at a displacement speed > 2.2 m/s (period of work) divided by the distance covered at a speed of 0 to 2.2 m/s (period of recovery). All match recordings from the GPS units were analyzed based upon an *a priori* importance for performance in soccer such as player and ball movements, interaction of players, and involved elements of speed, time and space (location) (Randers et al., 2010). All data analyses were performed with the manufacturer's dedicated software package (Team AMS software V R1.2011.6). All GPS data were downloaded using the commercial GPS software (Catapult Sprint, version 5.0.9.2; Firmware 6.75) and transferred to a statistical software package (IBM SPSS Statistics for Windows, v20; SPSS Inc, Chicago, IL, USA) for analysis.

Statistical analysis

The match performance demands (i.e. time-motion characteristics) between groups were examined using magnitude-based inferences with standardized mean differences and

their respective 90% confidence intervals (CI) reported (Hopkins, 2006). Magnitude-based inferences were assessed by examining the smallest worthwhile difference, calculated as 0.2 times the between-subject standard deviation. Differences were defined as unclear if the confidence intervals for the difference in the means included substantial positive and negative values simultaneously (Hopkins, Marshall, Batterham, & Hanin, 2009). The magnitude of clear differences was assessed qualitatively as follows: <0.25%, *trivial*; 0.25%-75% *possibly*, 75%-95% *likely*, 95%-99% *very likely*, and >99% *most likely* (Hopkins, 2007). Effect sizes (ES, standardized Cohen's *d*) for between group comparisons were also determined using the following criteria: ≤ 0.2 as trivial; ≤ 0.6 as small; ≤ 1.2 as moderate; ≤ 2.0 as large; > 2.0 as very large (Hopkins, Marshall, Batterham, & Hanin, 2009).

Results

Table 1 shows the match performance demands for starters and non-starters during matches. Non-starters *likely* to *very likely* covered more distance than starter players at running speeds of $>3.3 \leq 4.2$ m/s, $> 4.2 \leq 5$ m/s, and $> 5 \leq 6.9$ m/s (Table 1) with small to large ES (Figure 1). In contrast, measures of acceleration and deceleration were similar between starter and non-starter players with trivial differences (Table 1) and trivial to moderate ES (Figure 1).

Table 3. Match performance demands for starter and non-starter players.

	Starters (n=18)	Non-starters (n=6)	Mean difference ± 90% CI	Qualitative interpretation
Distance Covered (m)				
< 2.2 m/s	2,352 ± 72	2,241 ± 273	0.11 ± 191	Trivial
> 2.2 ≤ 3.3 m/s	1,390 ± 205	1,536 ± 366	-0.15 ± 220	Trivial
> 3.3 ≤ 4.2 m/s	621 ± 108	902 ± 267	-281 ± 134	Very Likely
> 4.2 ≤ 5 m/s	351 ± 104	467 ± 161	-116 ± 98	Likely
> 5 ≤ 6.9 m/s	256 ± 134	403 ± 119	-147 ± 116	Likely
> 6.9 m/s	28 ± 32	12 ± 21	16 ± 20	Trivial
Total	4,998 ± 285	5,581 ± 531	-581 ± 281	Trivial
Decelerations (number)				
-2.0 to 0.0 m/s ²	00 ± 00	01 ± 00	-1 ± 1.5	Trivial
-4.0 to 2.1 m/s ²	11 ± 05	18 ± 08	-7 ± 3.9	Trivial
<-4.0 m/s ²	576 ± 24	574 ± 21	2 ± 15.9	Trivial
Total	587 ± 21	592 ± 24	-5 ± 15.4	Trivial
Accelerations (number)				
0.0 to 2.0 m/s ²	841 ± 35	869 ± 33	-28 ± 27.5	Trivial
2.1 to 4.0 m/s ²	08 ± 04	10 ± 06	-2 ± 2.2	Trivial
> 4.0 m/s ²	00 ± 01	01 ± 01	-1 ± 2.8	Trivial
Total	850 ± 35	879 ± 39	-29 ± 17.1	Trivial
Indicators of Workload				
Player Load	455.4 ± 48.4	523.1 ± 66.3	-67.7 ± 12.7	Very Likely
Maximum running speed	07 ± 01	07 ± 01	0 ± 0.1	Trivial
Exertion Index	45 ± 05	55 ± 09	-10 ± 0.9	Very Likely
Work Rest Ratio	01 ± 00	02 ± 00	-1 ± 0.2	Very Likely
Self-reported Exertion	06 ± 01	05 ± 01	1 ± 0.9	Likely

Values are mean ± SD unless otherwise stated; CI – confidence interval.

For workload indicators, the non-starters exhibited *very likely* greater values for player load, exertion index and work to rest ratio (Table 1) compared to starters with moderate to large ES (Figure 1). Conversely, the starter players exhibited *likely* greater self-reported RPE values than non-starters (Table 1) with a moderate ES (Figure 1).

Figure 6. Effect sizes (Cohen's d standardized, 90% confidence interval) for comparisons of match performance demands between starters and non-starters. Asterisks indicate the qualitative interpretation from Table 1 as follows: **likely; ***very likely.

Discussion

The aim of this study was to document the match performance demands between starter and non-starter professional soccer players. The current findings demonstrated that non-starter players covered greater distances at 3.3-6.9 m/s, greater player load, exertion

index and work to rest ratio, and lower self-reported RPE compared to starters. Collectively, these results highlighted the unique match performance demands between different player roles that should be considered by coaches for team preparation and selection.

Previous studies with soccer players have reported that the performance levels of starters were affected more (i.e. greater reductions) than non-starters over the course of the competitive season (Kraemer et al., 2004; Pierre, 2008). Although the extra muscle stimulus provided by more playing time has been postulated to maintain or improve performance levels (Stevens, de Ruiter, Twisk, Savelsbergh, & Beek, 2017), such stimulus may actually cause muscular fatigue and subsequent decreased physical performance during matches (Florini, 1987). In the current study, starters reported greater RPE values and reduced match demands (e.g. workload indicators) compared to non-starters that may have resulted from an accumulation of match play during the season. Subsequently, differences in match performance demands between starters and non-starters may provide an early indication of fatigue for starters that may lead to poorer performance in future matches. Comparison of match performance demands between starter and non-starters during simulated matches may provide coaches with a simple tool to assist in identification of accumulated stress/fatigue in starters for management by appropriate strategies to maximize player and ultimately team performance.

Whilst notable differences in some match performance demands were identified between player roles, the current findings of greater high-intensity-running distances (3.3-6.9 m/s) by non-starters was in accordance with a previous study examining players within the English Premier League (Bradley, Lago-Peñas, & Rey, 2014). The current study has extended upon these results and confirmed the unique match performance profiles of starters and non-starters, potentially as a result of accumulated competition fatigue (Fransson, Krustup, & Mohr, 2017) and/or pacing strategies (Bradley et al., 2014). Bradley et al. (2014) reported that non-starter players adopted an unconstrained style of effort compared to when they started a match. Thus, starters may employ more effective pacing strategies, due to the anticipation of longer playing time, that results in lower match performance demands compared to a non-starter role. More recently, Fransson et al. (2017) identified similar trends with non-starter players covering more distance at moderate and high intensity than starters during the last 15

minutes of the match. Therefore, non-starters may employ all of their effort during their short period of playing time that is then replicated when they experience longer playing times. In contrast, starters carefully manage their efforts (i.e. pace) in order to finish the match with less fatigue. Jasper, Brink, Probst, Frenken, and Helsen (2017) contended that player's exposure time to match conditions was significantly related to the positive and/or negative changes in players' physical performances in soccer. Pacing strategies by different team roles may therefore influence overall team performance that remains to be examined further in future studies.

An intriguing result was the absence of differences in accelerations and decelerations between starter and non-starter players during matches. This similarity may be due to both roles mastering basic and fundamental skills with the ball, and the high volume of specific, technical training undertaken by both within stable and predictable conditions (Anderson et al., 2016). Subsequently, this training may condition all players to engage/disengage instinctively with the ball or with a close opponent, irrespective of their fatigue level, pacing strategy or playing role. Future studies are encouraged to examine further the impact of these factors on movement patterns of players during different styles of soccer matches.

Practical applications and limitations

The present study identified some performance trends that should be considered for training and competition by coaches. Specifically, both starter and non-starter players displayed the same level of accelerations and decelerations during matches, but different levels of high intensity activities and exertion (RPE). Consequently, different training foci may be important for different player roles. Specific training tasks to improve the control of predictable (i.e. circuit training or technical tasks without opponents) and unpredictable (i.e. tactical situations with opponents and game constraints such as Small Sided Games or modified games) contexts during matches could cater for player role differences while also focusing on the high intensity demands needed for soccer (Anderson et al., 2016). Previously, Stevens et al. (2017) commented that non-starter players were potentially under-loaded in terms of high-speed running compared to starters, and that training sessions during the season should include specific ones focused on non-starter demands while others for starters, centered on recovery processes.

Several limitations of the current research should be considered in future studies. Firstly, the current study examined two matches only with longer-term examination of player loads and roles needed to confirm the current results. Secondly, a modest number of players from the same professional team at one time point of the season were examined. Further research could involve a larger player base across multiple teams and/or competitions, and over different stages over a competitive season to provide a more thorough understanding of the impact of player role on improving match performance.

Conclusion

The current study has demonstrated that starter and non-starter players experience different performance demands and time motion characteristic during full soccer match. Specifically, high-intensity running and workload indicators were less for starters that may indicate greater fatigue and/or use of pacing strategies. This information may assist coaches in their management of training tasks and foci s (e.g. post-match or recovery) for the starter and/or non-starter players. While such data are insufficient to be considered “normative”, they may provide greater insights into the physiological demands of the modern soccer match and the impact of player role.

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7. CONCLUSIONS

6. CONCLUSIONS

The main conclusions obtained from the present PhD thesis are as follows according to the studies developed:

Study 1: *Physical responses of professional soccer players during 4 vs. 4 small-sided games with mini-goals according to rule changes.* This study improves the understanding of some of the physical responses affecting SSG intensity when using mini-goals:

- The players spent more time walking and performed accelerations at high intensity (acceleration of >4 m/s²) during T1 SSG conditions.
- The players covered more distance at low intensity and more time at low and intermediate intensity during T2 SSG conditions.
- The importance of ball touch constraint is evident during SSGs with mini goals, and provides useful information for training and task design that replicates specific physical demands (i.e. accelerations of >4 m/s², time walking or at moderate or lower speed) of elite football players.

Study 2: *Comparison of the movement patterns between small- and large-side games training and competition in professional soccer players.* Despite the general perception that game-based soccer activities with a reduced size and number of players are a relevant means to replicate the demands of competitive matches the current results demonstrated that neither SSGs nor LSGs elicited the same movement patterns experienced during soccer competition (FM).

- SSGs and LSGs resulted in an increased frequency of accelerations/decelerations and augmented ratings of perceived exertion compared to a competitive match.
- The reduction of pitch size and number of players in SSGs may be used as a strong training stimulus to enhance high-intensity activities for soccer players.
- The use of SSGs may be more beneficial than LSGs as a training modality for professional and amateur soccer players as they induce a greater perceptual and external load.

Study 3: *Impact of playing status on match performance demands for professional soccer players.* The current study has demonstrated that starter and non-starter players

experience different performance demands and time-motion characteristics during a full soccer match.

- The high-intensity running and workload indicators were less for starters which may indicate greater fatigue and/or use of pacing strategies.
- The information obtained may assist coaches in their management of training tasks and foci s (e.g. post-match or recovery) for the starter and/or non-starter players. While such data are insufficient to be considered “normative”, they may provide greater insights into the physiological demands of the modern soccer match and the impact of player role.

Thesis conclusion: In summary, the data from these three studies improves knowledge about physical demands during small, large and friendly games. Therefore, the information obtained may be used to assist coaches and scientists involved with soccer in evaluating the effects of training interventions on the basis of match running performance.

8. LIMITATIONS AND FURTHER RESEARCH

7. LIMITATIONS AND FURTHER RESEARCH

The limitations of the present PhD. Thesis include the current ban on the use of GPS units in competitive match play in football (FIFA regulations). This therefore limits match play data to Friendly Matches. It might be speculated that the intensity of exercise in the FM games might be significantly lower than during in-season match play; however intrinsic motivation factors (such as team selection for the start of the season) would have increased the intensity of pre-season games to a comparable level to that of competitive match play. In addition, the inability to control the team's formation (1-4-2-3-1) during the match play (which was dictated by the coaches), injuries to players, the level of opposition, dietary practices and weather conditions were beyond the researchers' control during the data collection period.

There are several limitations in the current PhD Thesis that should be considered in further studies concerning:

- First an important contextual factor that has not been explored by the present thesis (Lupo & Tessitore, 2016) should be underlined, as in balanced and close games in different team sports, performance aspects can determine crucial influences in performance analysis (and in the following practical applications related to training).
- There is a lack of information about the influence of scoring a goal, considering the score-line, which is important in order to dig deeper into the within-match variation of performance and the difference between close and balance games in elite soccer (Lago-Peñas & Gómez-López, 2014).
- Finally, the current research employed the performance data in FM game training which may or may not show within-match dynamics. Future studies can include official match play because, if the club asks for permission to use GPS devices in official matches, they can be used for data collection (International Board, within a series of 'amendments to the Rules of the game for 2015-2016).

According to these limitations and the prospects for football research, we have suggested 3 further studies that would increase the knowledge about physical demands during small, large and friendly games in football:

- *Study 4:* Effect of 45min- movement profile monitoring in professional soccer players between small-sided games with mini goals and large-side games training and competition (This study will be initiated and carried out in collaborations with CreativeLab, Research Centre for Sports Science, Health and Human Development, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal)
- *Study 5:* Comparison of the movement patterns between small side games, mini-goals and circuit training in professional soccer players (This study will be developed, by Dr. Gómez Ruano and Jesús Vicente Giménez (PhD, Candidate).
- *Study 6:* Physical load imposed on soccer players during different interactions in small-sided training games (This study will be developed, by Dr. Gómez Ruano, Nakamura, Fábio Y. (State University of Londrina, Londrina, Brazil) and Jesús Vicente Giménez (PhD, Candidate).

9. PRACTICAL APPLICATIONS

9. PRACTICAL APPLICATIONS

Established performance profiles from our findings can be used as baseline references for the training process, for example, increasing or decreasing the physical demands in relation to the weekly objective. Thus, competition status, strengths and weaknesses can be identified, and ultimately, training sessions and match preparations can be specifically modified according to the identified information.

The profiles of physical demands can also be used for identifying training value respecting friendly matches. For instance, as presented in the discussion of the paper, the game play that is more similar to competitions is LSG rather than SSG in comparison with F.M. Furthermore, coaches and analysts should be cautious when using some physical performance demands. To make an accurate assessment the evaluation should be done on training days to interpret players' match performance, because they are sensitive measures with high match-to-match and training-to-training variations. Meanwhile, these variables are so imperative for a forward that they should not be completely discounted by coaches.

Finally, comparing between starters and substitutes could alert coaches to whether players should play as starters and substitutes in relation to physical demands.

10. APPENDIX

10. APPENDIX

10.1. Authorization of Concordia Elblag FC

Miejski Młodzieżowy Klub Sportowy

„CONCORDIA ELBLĄG”

www.concordia.elblag.pl , www.szkolka.concordia.elblag.pl

Authorization

This is to authorize

Mr. Jesús Vicente Giménez (Spanish Nationality, DNI. 05684291W)

Mr. Hongyou Liu (Chinese Nationality, Passport No. G55961899)

the right to use the team and player's training and match data of the **Football Club of Concordia Elblag** (II Liga, East, Poland) in their PhD thesis, academic and practical publications.

Mirosław Pelc
President
Football Club of Concordia Elblag
Elblag, Poland
10th June, 2014

PREZES
M.M.K.S. „CONCORDIA” ELBLĄG
Pelc
Mirosław Pelc

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NIP 578-295-17-52, Regon 280053410, KRS nr 0000278728
PKO BP o/Elbląg nr 81 1020 1752 0000 0602 0100 6428

10.2. Letter form AWFis w Gdańsku

Akademia Wychowania Fizycznego i Sportu im. Jędrzeja Śniadeckiego w Gdańsku

Biuro Dziekana Wydziału Wychowania Fizycznego

80-336 Gdańsk, ul. Kazimierza Górskiego 1

Dziekan Wydziału WF prof. nadzw. dr hab. Tomasz Tomiak

e-mail: dziekan@awf.gda.pl

Gdańsk, 2014-03-26

Dear Dr Miguel Ángel Gómez Ruano,

On behalf of Gdansk University of Physical Education and Sport it is my pleasure to invite your PhD students: Mr.Hongyou Liu and Mr. Jesus-VincenteGimenez to conduct part of their PhD research at our University.

In accordance with your expectations, I fully accept Prof. Andrzej Szwarec (for Mr. Jesus-VincenteGimenez) and Dr. Patrycja Lipinska (for Mr.Hongyou Liu) as our local supervisors of their PhD research till the end of June.

I hope for our further cooperation.

Please, do not hesitate to contact me if you have any other questions.

Yours sincerely,

Prof. Tomasz Tomiak, Ph.D., D.

Patrycja Lipinska
Chang Liu

sekretariat tel. 58 55 47 285

dziekan@awf.gda.pl

10.3. Local Supervisors (Poland)

AKADEMIA WYCHOWANIA FIZYCZNEGO I SPORTU
IM. JĘDRZEJA ŚNIADECKIEGO W GDAŃSKU

Certificate

This is to certify that

Mr. **Jesús Vicente Giménez** (Spanish Nationality, DNI. 05684291W)

has been doing part of his Ph.D. research within an exchange program at the **Faculty of Physical Education, Gdańsk University of Physical Education and Sport**, for a period of **three months** (from 26th March to 30th June, 2014).

During his stay here, **Prof. Andrzej Szwarec** has acted as his local supervisor. The main work being finished here was collecting research data of training sessions from a Polish professional football club (MMKS Concordia Elbląg) using the equipment provided by the Gdańsk University of Physical Education and Sport under the guidance of the local supervisor. The expected outcome of this cooperation is to publish in the nearest future a scientific article in a journal from the JCR list including the local supervisor as co-author.

Prof. Tomasz Tomiak, Ph.D., Doctor of Science
Dean of Faculty of Physical Education
Gdańsk University of Physical Education and Sport
30th June, 2014

DZIEKAN
Wydziału Wychowania Fizycznego

prof. nadzw. dr hab. Tomasz Tomiak