Original Article

Influence of games system on the physical and physiological demands in young soccer 7 (U12)

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Abstract:
The aim of this article was to describe activity patterns and heart rate frequency of young players in soccer 7 through GPS technology and to determine whether differences exist according to the game system utilized during matches. 42 players were investigated (11.2±0.7 years; 146±0.1 cm; 42±9.4 kg; 19.6±3.2 body mass). The players participated in fifteen matches using the 1-3-3 system and another fifteen using the 1-2-3-1 system, each match lasting twenty five minutes. Maximum heart rate (HRmax) and average heart rate(HRavg) were registered (absolute and relative) and so were the following physical variables: total distance, distance covered in different speed ranges, sprint characteristics, number of accelerations/decelerations during the different ranges of intensity and the indicators of global load (work-rest ratio, maximum speed and Effindex). In both of the game play systems studied (1-3-3 and 1-2-3-1) similar results were obtained in all the physical variables. However the time that the players spent over 90% of HRmax (6.86% vs. 3.17%) were significantly (p=0.015) higher in the 1-3-3 system than in the 1-2-3-1 system. It is also worth noting that the distance covered in the last 5 minutes of the game was significantly (p<0.01) lower than the distances covered in the first four periods of five minutes in both of the game systems. Knowing the demands of competition is the basis on which specific training for each sport is based. In this sense it is necessary to undertake further investigations that provide precise data on the demands (load) in each specialization, not only among the elite, but also in inferior categories.
Key-Words:young soccer, GPS, physical load, heart rate, player position.

Introduction

The game systems are basic structures that represent the way in which the players are positioned on the field. They establish the functions and dispositions that they must perform in offensive actions and defensive actions within a previously established game plan by the team (Pacheco, 2004). The most common game systems in soccer 7 are the 1-3-3, 1-2-3-1, 1-3-1-2, 1-3-2-1 and 1-2-2-2.

The dominion of the game space and the position that the young players must occupy in the midst of the game are acquired and developed over their sporting career, through teaching sessions and competitions. It is important not to put the young players in specific positions too early, thus avoiding early specialization (Giménez, Abad & Robles, 2010).

In soccer 7 all players of a team must know the theory of the offensive and defensive tactics that must be undertaken on the pitch according to the position they occupy in the game system (Ardá & Casal, 2003). The coach must develop activities during training sessions, that reflect what the player has to undertake on the pitch, according to the chosen system and which fundamentally develops the psychophysical capacity of the players (Sánchez, 2005).

For this reason to be able to perfect a training model specific for sports it is necessary to know the physical, physiological and energy demands of each activity. Said knowledge of the physical and physiological demands during competition will allow the sports technicians to compare them with the ones imposed during training (from a general all encompassing point of view) and with the different tasks planned in the training process (from a specific and concrete point of view) allowing evaluate if these training situations really occur during competition (Castellano & Casamichana, 2015).

This need to know the specific demands of each sport, has taken investigators to focus on the description of collective behaviour during competition (Castellano, Álvarez & Blanco, 2013; Castellano, Álvarez, Figueira, Coutinho & Sampaio, 2012). The availability of the physical profile of the player or players at the same time as their tactical behaviour during training or competition enriches, the evaluation of players and teams at all levels (Gréhaigne et al., 2011).

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At this point a problem arises for the coaches of soccer 7, derived from the distribution of young players on the playing field, with the aim that they cover spaces more efficiently (Pacheco, 2004). The type of effort is related to the roll that each player occupies on the field, but each match is different, hence the dimension of the analysed elements changes in function of conditions in competition. Tactical planning for the match as well as the style and philosophy of the game used by the home team and the rival team can modify the expression of performance. These issues impede team sport to be managed through an analysis of the physical, technical and tactical demands. However a series of indicators allow sufficient information to determine the planning structure. These factors are a combination of the so called "external indicators" and " internal indicators".

The rise of technology to monitor training and/or competition load (Borresen & Lambert, 2008) has made it easier to measure the observable activity of the players (external load) in non-professional soccer (Scott, Lockie, Knight, Clark & Janse de Jonge, 2013).The monitoring of the displacements undergone by the players is a useful technique to learn about the physical demands on the players (Rienzi, Drust, Reilly, Carter & Martin, 2000), allowing specific intervention in training and evaluation of performance during competition (Barros et al., 2007). Said monitoring attempts to quantify movement patterns undertaken by players (Dobson & Keogh, 2007).

The aim of this study was to uncover the activity patterns and the heart rate of the young players in soccer 7, and to determine if differences exist according to which game system is used during the matches.To achieve this GPS technology was used.

Material & methods
Participants
Forty two young players (11.2±0.7 years; 146±0.1 cm; 42±9.4 kg; 19.6±3.2 body mass) members of a football federated club in the Valencian Community took part in this investigation (the goalkeeper position was not analysed). The subjects in the study had over two years previous competitive and practical experience , they trained three times a week for ninety minute sessions, and they played a competition match once a week.

Thirty matches were analysed,they took place during the competitive season. The matches were played at the same time of day on artificial grass measuring 60x45m and they lasted 25 minutes. To prevent dehydration the players were allowed to drink ad libitum during the matches.

Performance Analyses
The variables analysed for the study of the physical profile were: total distance covered (DT) and distance covered in each speed category; standing (ST, 0-0.4 km/h), walking (W, 0.4-3 km/h), jogging (J, 3-8 km/h), medium-intensity running (MIR, 8-13 km/h), high-intensity running (HIR, 13-18 km/h), sprinting (SPR, >18 km/h) and high-intensity activity (HIA, >13 km/h; CIA + SPR),racing expressed absolutely (m) and relatively (%). The zones of speed and the locomotive categories chosen are those proposed by Castagna, Impellizzeri, Cecchini, Rampinini & Barbero (2009) for players of these ages. At the same time the matches have been divided into 5 minute periods (Carling, Espié, Le Gall, Bloomfield & Jullien, 2010) to observe if there is a decrease in physical performance relative to distance covered.

Other indicators of the external charge have also been included such as the work/rest ratio, understood as the coefficient between the distance covered by the player in categories of speed over to 8 km/h (work period) and the distance covered in the range of speeds below 8 km/h as a rest period (Castagna et al., 2009). The maximum speed (km/h) registered during matches was also registered, as was the individual efficiency index (Effindex), which is measured through arbitrary units (UA) and is calculated by dividing the average speed (m/min) by the average heart rate (HRavg), and expressed as a maximum percentage (%HRmax) (Barbero, Boullosa, Nakamura, Andrín & Castagna, 2012).

In the same way the number of accelerations/decelerations during the football matches in different ranges of intensity: low (1-1.9 m/s2), moderate (2-2.9 m/s2) and high (>3 m/s2) accelerations were established according to the work of Osgnach, Poser, Bernardini, Rinaldo & Di Prampero (2010).

Heart Rate
To determine the HRmax of each player the Yo-Yo Intermittent Recovery Test Level 1 (Bangsbo, Iaia & Krustrup, 2008), was implemented, from which six intensity zones were established: 0-50% HRmax, 50-60% HRmax; 60-70% HRmax, 70-80% HRmax, 80-90% HRmax and >90% HRmax similar to earlier studies (Casamichana & Castellano, 2010; Hill-Haas, Dawson, Coutts & Rowsell, 2008). The variables studied were: average HR and peak HR expressed both as the absolute form (bpm) with respect to the individual maximum obtained during the trial period of the analysis undertaken and the percentage (%) of time in each intensity zone per match.

Procedure
The forty two players made up six teams of similar sporting level and took part in a league of thirty matches lasting twenty five minutes each, they all played against each other on double round match for ten days. On even days the teams used the 1-3-3 system whilst on uneven days the 1-2-3-1 system was used. The distribution of the players in the 1-2-3-1 system was:one goalkeeper, two defenders that marked the zone, a line

of three midfielders in which one would perform the functions of a mid-centre and the other two as wings for each side and one forward. Whilst the 1-3-3 was comprised of a goalkeeper, three defenders in which one would be a central defender and the other two wing defenders, and three forwards one which would be the centre forward and two wing forwards. Before starting the competition some training sessions were undertaken to practice the way of playing for each of the systems used.

Before the start of each match, the players went to the zone were the investigators were and had fitted a small quilted bag just under their neck on their backs. This contained the GPS SPI Elite. This gadget allows to register at 1HZ (a register per second) time,position,speed,distance, altitude, direction and heart rate (with a thoracic band in place). Also the accelerometer allows to register in 100hz all the movements that occur on the three axes (x,y,z) and calculates their sum. At the end of the match the data was analysed by the software GPSsports (Team AMS V R1-2013-19).

Statistical analysis

All results were analyzed using Statistical Package for Social Sciences (SPSS v.23 for Windows, SPSS Inc, Chicago, USA). Data is presented as mean and standard deviation and the alpha level of significance was set at $p<0.05$. The Kolmogorov-Smirnoff test was first applied to establish the goodness of fit to normality, confirming that the variables studied are normally distributed. Therefore, the t-test was applied for the analysis of differences for all variables of each game system. Additionally, Cohen's d effect sizes (ES) between systems were calculated to provide meaningful analysis for significant comparisons by applying the t-test. The following scale was applied for effect sizes: <0.2 (trivial), 0.2–0.6 (small), 0.6–1.2 (moderate), >1.2 (large) (Batterham & Hopkins, 2006).

Results

In table I, we can observe that in the 1-2-3-1 system a larger distance and meters per minute are covered than in the 1-3-3; where the distance covered in the last 5 minutes of the match was significantly inferior ($p<0.001$) than those covered in the first four periods of five minutes each in the two systems analysed, and the distance covered in all the zones in the 1-2-3-1 system is superior to the 1-3-3 system except for the distance covered trotting (3-8 km/h).

Table I. Distance and speed per system and comparative between them. Date are means (±SD).

	System 1-3-3(n=15)	System 1-2-3-1(n=15)	ES
Total distance (m)	2223.3±148.5	2231.5±170.1	.05
Average speed (m/min)	88.9±5.9	89.3±6.8	.05
Distance (m) every 5 minutes			
0- 5 min	464.9±50.8*	454.3±50.5&	-.24
5 - 10 min	452.6±45.7*	455.9±50.1&	.07
10 - 15 min	437.4±43.4*	445.2±46.1&	.17
15 - 20 min	436±48.6*	445.7±54.7&	.19
20 - 25 min	399.1±53.9*	392.4±68.4&	-.11
Distance and percent timeat differents intensities			
Standing (ST)(0-0.4 km/h)	10.9±4.9(0.5%)	11.2±5.8(0.5%)	.06
Walking (W)(0.4-3 km/h)	270 ±38.4(12.2%)	278.4±49.3(12.5%)	.19
Jogging (J)(3-8 km/h)	1126.9±101.3(50.7%)	1105.2±104.3(49.5%)	.22
Medium-intensity running (MIR)(8-13 km/h)	594 ±129.7 (26.7%)	610.1±124.3(27.3%)	.14
High-intensity running (HIR)(13-18 km/h)	196.6±65.5 (8.8%)	199.8±74.8 (9%)	.04
Sprinting (SPR)(>18 km/h)	24.8±22.3(1.1%)	26.7±29.9(1.2%)	.07
High-intensity activity (HIA)(HIR + SPR)	221.4±78.9 (10%)	226.5±90.9 (10.2%)	.05

* *p<0.001* compare with the first 20 minutes of the system 1-3-3.
&*p<0.001*compare with the first 20 minutes of the system1-2-3-1.

Table II shows how the work/rest ratio was higher in the 1-3-3 systems than in the 1-2-3-1, the opposite occurring with the Effindex, the maximum speed and the average speed. Where as the number of accelerations that occurred in the 1-3-3 were superior to 1 to 2m/s2 with higher frequency than in the 1-2-3-1 system, however the acceleration superior to 2m/s2 occurred more frequently in the 1-2-3-1 than in the 1-3-3. With reference to the sprints undertaken we can see that in the 1-3-3 system fewer occur but for a longer duration whilst in the 1-2-3-1 system sprints were shorter both in duration and distance. No significant differences have been found in either of the variables described above.

Tabla II. Work/rest ratio, effindex, speed, accelerations and sprint feature per system and comparative between them. Date are means (±SD).

	System 1-3-3(n=15)	System 1-2-3-1(n=15)	ES
Work/rest ratio	1:1.8 ±0.5	1:1.7±0.4	-.14
Effindex (UA)	102.8±8.3	103.9±8.8	.13
Speed (km/h)			
Max. Speed (km/h)	19.7±1.6	19.9±1.3	-.10
Average Speed (km/h)	5.3±0.4	5.4±0.4	.02
Accel. m/s2			
Accel. 1 a 2 m/s2	55.8±11.5	52.8±12.9	-.27
Accel. 2 a 3 m/s2	5.7±3.3	6.9±4.4	.24
Accel.> 3 m/s2	0.1±0.4	0.2±0.5	.10
Sprint feature			
Sprint number	2.9±2	3.3±2.1	.11
Duration(s) sprinting	1.8±0.9 s	1.6±0.6 s	-.33
Distance (m) sprinting	9.2±4.8 m	8.5±3.6 m	-.30

In table III the mean heart rateand peak heart rate are described for each game system. The Mean HR in the systems was of 167.7±11.5 and 164.5 ±10.7 bpm, which correspond to 80.8±9.8% and 80.5±5.4% of the HRmax in the 1-3-3 and the 1-2-3-1 systems respectively. Peak values of 193.9±11.5 bpm were reached in the 1-3-3 system and 191.4±10.5 bpm in the 1-2-3-1 which correspond to 93.4±10.8% and 93.7±5 HRmax although there are no significant differences between them. When it comes to the time (%) in each intensity zone of HR, in zones 1,2 and 3 (<70%HRmax) is superior in the 1-2-3-1 system than in the 1-3-3. While the time spent in zones 4,5and 6 (<70% HRmax) is greater in the 1-3-3 system than in the 1-2-3-1system. Significant differences (p=0.015) have been found in zone 6 where in 1-3-3 system they worked for longer at an intensity superior to 90% of the HRmax than in the 1-2-3-1 system.

Tabla III. Heart rate and percent time in each HR zone. Date are means (±SD).

	System 1-3-3(n=15)	System 1-2-3-1(n=15)	ES
Mean HR(bpm)	167.7±11.5	164.5±10.7	-.30
Mean HR (%)	80.8±9.8	80.5±5.4	-.04
HRmax (bpm)	193.9±11.5	191.4±10.5	-.23
HRmax (%)	93.4±10.8	93.7±5	-.03
Z1: < 50 % HRmax	1.6	2.2	.16
Z2: 50–60 % HRmax	18.5	22.5	.23
Z3: 60 – 70 % HRmax	36.8	38.1	.10
Z4: 70 – 80 % HRmax	22.6	21.5	-.09
Z5: 80 – 90 % HRmax	13.7	12.6	-.11
Z6: > 90 % HRmax	6.9*	3.2*	-.39
* p= 0.015 between system 1-3-3 and system 1-2-3-1.			

Dicussion

This is the first study that analyses activity patterns and physiological demands on young (U12) players in soccer 7 according to the game system used in the match.

The distances covered, total or in different speed ranges will be used to enable us to describe the real demands of competition (Casamichana & Castellano, 2011) and training (Castellano et al., 2013). The total distance covered during 25 minutes of the match was 2223.3±148.5m in the 1-3-3 system and 2231.5±170.1m in the 1-2-3-1 system, these results are similar to those given by Barbero et al. (2017) during the second half of soccer 7 matches (2x25) in U12 and U14 categories (2557.6 m). The average speed of 88.9±5.9 m/min (system 1-3-3) and 89.3±6.8m/min (1-2-3-1) found in our study is inferior to the studies in Barbero et al. (2017) which was 107.2±6.0m/min and in Buchheit,Mendez-Villanueva, Delhomel, Brughelli & Ahmaidi (2010) which was 105.5 m/min, this could be due to the fact that players in both studies were from higher categorise (U14). However the results of this study (89.3±6.8m/min) are similar to those given by Mora, Núñez, Martínez, Rodríguez & Suárez (2014) where the average speed was 86.40±8.29 m/min, this is because in both studies the players were from the same young category and played soccer 7 matches.

Some studies have divided the matches into periods of a different duration, using 15 min periods (Carling & Dupont, 2011) or as in this study in 5 minute periods (Carling et al., 2010; Barbero et al., 2017). In these studies we observe the lowering of physical performance (distance covered and distance covered at maximum speed) in the last two periods of the match with respect to the first two periods, results similar to this study where the total distance fell with the passing of time in the match finding significant differences (p< 0.001) between the last 5 minutes and the rest in both games systems used (1-3-3 and 1-2-3-1).These results suggest that during soccer 7 matches, players undergo temporal and cumulative fatigue, which leads to a progressive decline

in the work ratio (Krustrup et al., 2006). This means that to lengthen the game time, coaches and physical technicians can make use of substitutions with more frequency to improve the level and physical conditions of the players (Castagna et al., 2009).

The distance covered in the categories of speed ST,W, MIR,HIR, SPP and HIA is superior in the 1-2-3-1, however in the 1-3-3 system the distance covered in the J zone is superior. It has been demonstrated that distances covered at high intensity (HIA = CIA + SPR) are the best for physical performance, both in formative soccer and adult soccer, due to the ability to discriminate between game positions at different competition levels (Buchheit et al., 2010; Mohr, Krustrup & Bangsbo, 2003). The results of both systems (1-2-3-1 and 1-3-3) show that the percentage of the match in the HIA (10% and 10.2% respectively) in soccer 7 is lower than in the data published by Barbero et al. (2017) were the HIA was 16.4±4.5% in U12 and U14 players in soccer 7 matches. In other studies the results also come close to those of this investigation, although they are studies performed on soccer 11 like those by Buchheit et al (2010) were it was found that the HIA oscillates between 12.7 and 21.1% in U13 and U14 players; Castagna et al(2009) were the HIA was 15.9±5.8% in U14 players in Barbero,Barbero & Granda (2007) were the HIA was 14.9±4.5% in U12 players. We assume that these results are higher than the ones achieved in this study due to the fact that the players are older and participated in soccer 11 competitions. No significant differences between the 1-2-3-1 system and the 1-3-3 system have been found in the zones of speed or peak speed.

The work/rest ratio is the coefficient of the distance covered by the player in displacement categories 1, 2 and 3, where the intensity is lower "rest" periods, whilst in categories 4,5 and 6 are considered "work" categories (Barbero et al., 2007). The result of this indicator in both categories was of 1:1.8±0.5 a result similar to that found in the work of Casamichana & Castellano (2010) where the matches in a reduced space of large dimensions the rest/work ratio was of 1:1.7±0.3.

In this study the Effindex was higher in the 1-2-3-1 system (103.9±8.8) than in the 1-3-3 (102.8±8.3), according to Barbero et al. (2017) the lowering of the Effindex suggests that for the same level of cardiovascular effort the rhythm of work during the match is affected.This index confirms that when matches are played on small playing fields and with few players like in soccer 7, fatigue is produced. In our study the players that used the 1-2-3-1 system rest less, perform at higher speeds and are more efficient during the match, although significant differences were not found in any of the three variables studied.

High accelerations place energetic and mechanical demands on the players and are decisive in gaining advantage over opponents, allowing possession of the ball or creating space to receive the ball (Osgnach, 2010). In this study the number of accelerations is defined as a change in speed higher than $1m/s2$ (Ingebrigtsen, Dalen, Hjelde, Drust & Wisloff, 2014), there were 61.65±13.29 and 59.82±15.72 for the 1-3-3 system and the 1-2-3-1 system respectively. Results that coincide in being half of the acceleration covered in the study by Barbero et al. (2017) which were 124.2±20.8 and 132.5±20.8 in U12 and U14 players where they played two 25 minute periods. This can indicate that multiple accelerations occur each minute of the match, and in turn it suggests that football can be characterized as an activity of repeated acceleration. Therefore the coaches and physical technicians must have as an aim the improvement of the capacity of the players to repeat several accelerations with short recuperation intervals, and not only the ability to repeat sprints (Buchheit et al., 2010). Future studies must determine if the ability to repeat acceleration is able to distinguish between the different levels of football players and their sensibility to the interventions of training.

Concerning the profile of high intensity efforts or sprints undertaken, where the player reaches speeds higher than 18km/h, there are studies (Bradley et al, 2009) (Di Salvo et al 2009) that determine the duration of each sprint to be between 2 and 4s, covering an average distance of 16m. In this study we have found that in both systems and average of 3.1±2.1 sprints occurred lasting 1.7±0.8s, the number of sprints is lower than those found by Barbero,Coutts,Granda, Barbero & Castagna (2010) where U14 players in matches lasting 35 minutes did a total of 10.1±3.6 sprints lasting 2.2±0.5s, the same as in another study by Barbero et al(2017) in which U12 players participated in soccer 7 matches of two 25 minute halves where the average sprints were 12.5±12.9 lasting 1.8±0.4s, this could be due to the fact that they played for a longer period of time than in our study. However, the results in duration of the sprints are very similar to previous studies and no significant differences were found in any of the sprint aspects studied in either games system. Buchheit et al (2010) recently suggested that football involves few repeated sprint series during the match, in this study the high speed in both systems was 19.8±1.5 km/h an inferior result to those found by Barbero et al (2010).

In the study by Barbero et al (2017) the players maintained approximately 86% of the HRmax during each soccer 7 match, results similar to those obtained in this study which were 80.8±9.8% and 80.5±5.4% HRmax in the 1-3-3 and the 1-2-3-1 respectively. These results are similar to those of soccer matches (Mohr et al., 2003; Rampinini et al., 2007), which suggests that soccer 7 is very demanding from a cardiovascular point of view and more so if the 1-3-3 system is implemented due to the fact that the percentage of time that the player is over 70% HRmax is higher than in the 1-2-3-1, with no significant differences (p=0.015) in zone 6 (>90%FCmáx).

Conclusions

The results of this study show that soccer 7 matches in the U12 young categories, the teams that use the game system composed of three lines(1-2-3-1)have higher physical demands (total distance m/min, number of sprints, acceleration>2m/s2, Effindex and maximum speed) than teams that use two lines (1-3-3). On the contrary young (U12) teams that use the 1-3-3 system in soccer 7 matches have higher physiological demands (mean HR, peak HRand time in HRmax>70%) than those who play with a 1-2-3-1 system.

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