Kinematic Analysis in Official Soccer Matches: Preliminary Results
GPS Analysis in Soccer Matches

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Keywords: GPS, Match Analysis, Soccer.

Abstract: Soccer match analysis was initially establish by coach to evaluate tactical aspects, after this approach was used for physical effort. Previously this assessment has been done by video interpretation of the matches. The aim of this study was to analyze the official matches in adults athletes for the first time with a wearable device as GPS. Five official games of sixth division of Italian Football League were assessed with GPS system. Parameters represented the volume of physical activity as Total Distance covered and Relative Distance derived directly from the instrument, while the values of intensity as speed, acceleration and deceleration have been indexed respect to the maximum individual of each athletes. Was also made a tactical analysis respect the roles of players. Values of volume shows lower values than previous studies, while the values of intensity confirm the data present in the literature. Tactical analysis shows predominantly low speed for defenders, medium for midfielders and high speed for forward. Acceleration not differ significantly between the roles. Decelerations are predominantly for midfielders. These are the preliminary results of a larger study involved for the first time soccer official matches assessed with a wearable system. In addition a new approach has been used in order to individualized threshold for speed, acceleration and deceleration.

1   INTRODUCTION

Video analysis of matches was introduced into soccer to check the roles assigned to each player and the real tactics performance decided by the coach. Soccer federal laws prevent players from wearing any technological devices, therefore video analysis is the only method allow to evaluate official matches. This method was also used for physical performance through parameters as "total distance covered", "speed" and "acceleration" (Mohr M, 2003; Bangsbo J., 1994).

Recently many studies were conducted in order to find an uniform values on the metres covered by athletes during a match. At present there are still differences in "speed" and "acceleration/deceleration" of soccer players in official matches (Cummins C., 2013).

Respect "speed" values in a soccer match, the researchers agreed to create six areas of intensity, but the identification and the description of these is still unclear.

At present there are few studies on the evaluation of "acceleration" and these were made by sprint tests during a training session (Castagna C, 2009; Bucheit M, 2010).

Recent studies have introduced the use of the Global Positioning System (GPS) as a tool for analyzing the performance of athletes (Gray AJ, 2010).

Studies with GPS system in sports show a growing   attention to an individualized assessment. One method is to identify the maximum value of each athlete of team regard his performance of "speed", "acceleration" and "deceleration" (Abt G, 2009)

A second approach is to analyze tactical aspects of each role in team sports (Di Salvo V, 2007).

The first aim of the study was to, for the first time, report kinematic values of soccer performance of five official matches with a wearable device. This data will be compared with the ones present derived from video match analysis.

The second aim was regard tactical aspects, in order to verify any possible differences of physical effort according to role of each soccer player.

2 METHODS

Observational Study

An Italian Soccer team playing in Campionato di Eccellenza (sixth division) was analyzed.

According with the Regional Committee of the Italian Soccer Federation, players wear GPS devices during all official matches of the regular season 2013/2014.

10 soccer players, (age 23.1±2.1 years, weight 73.7±5.3 kg, height 176.5±11.9 cm) wore under their official shirts the GPS (K-Sport - Italy, sampling frequency of 10 Hz), and kept on the device on for the time they played during first five matches of the season.

During the week before the first official match tests were carried out to determine the maximum value of speed, acceleration and deceleration of each team member.

Every athletes, wearing the appropriate GPS equipment, complete:
- three 50 m all out sprints to determine their maximum speed,
- four 20 m all out shuttle sprints to determine their maximum accelerations and maximum decelerations.

Therefore during the regular season, at the end of each match, GPS device was downloaded and the data were analyzed, values were tabled and divided into the following categories:
- time played (T, min);
- total distance covered (TD, m);
- relative distance - defined as the ratio between total distance and time (RD, m/min).

In addition to these it tabled the values of speed, deceleration and acceleration were divided into zones:
- speed, divided into 6 zones (S1, S2, S3, S4, S5, S6, m/sec);
- deceleration, divided into 4 zones (D1, D2, D3, D4, m/sec^2);
- acceleration, divided into 4 zones (A1, A2, A3, A4, m/sec^2).

Each division was estimated considering the individual maximum value of speed, acceleration and deceleration.

For the division of speed there is still no consensus, however we chose the six zones present in literature (Barbero Alvarez J, Hill-Haas SV, 2008), choosing the interval from 0% to 20% for S1 and then every 16% up to 100%, in order to have a uniform percentage breakdown.

This is the first work with a threshold approach for values of acceleration and deceleration, therefore the four categories were chosen for every 25%.

The primary aim of the present study was to describe the physical activity of soccer player for the first time with the use of a wearable system, this being an observational study no statistical analyses were performed for this purpose.

The roles of the players for the tactical analysis was decided to divide the 10 players in:
- 2 Full Back
- 2 Central Defender
- 3 Midfield
- 2 Lateral Forward
- 1 Forward

Averages and standard deviations were calculated into a new subdivision, and then tested by the Anova Test to establish any significant differences between five different samples.

After five competitive games have been downloaded from the GPS, 50 players who played at the start, we eliminated from the statistics all the players replaced during the match so that it does not interrupt the minutes and the meters of complete match.

They were therefore excluded 10 athletes:
3 lateral defender, 2 central defender, 3 midfield, 1 lateral forward, 1 forward.

3 RESULTS

The average of maximum values obtained from tests before the season are:
- 9.14±0.32 m/sec for speed
- 7.46±0.84 m/s^2 for acceleration
- -8.06±0.95 m/s^2 for deceleration.

Therefore six zone of speed (S) are:

S1 = from 0 to 1.74±0.06 m/sec (6.3 km/h)
S2 = up to 3.13±0.11 m/sec (11.3 km/h)
S3 = up to 4.53±0.16 m/sec (16.3 km/h)
S4 = up to 5.92±0.21 m/sec (21.3 km/h)
S5 = up to 7.31±0.26 m/sec (26.3 km/h)
S6 = maximum is 9.15±0.32 m/sec (32.9 km/h)

The zone for acceleration (A) and deceleration (D) are:

A1 = from 0 to 1.78±0.20 m/s^2
A2 = up to 3.55±0.40 m/s^2
A3 = up to 5.33±0.60 m/s^2
A4 = up to 7.46±0.84 m/s^2
D1 = from 0 to -1.92±0.23 m/s^2
D2 = up to -3.84±0.45 m/s^2
D3 = up to -5.76±0.68 m/s^2
D4 = up to -8.06±0.95 m/s^2

Results obtained during the matches are reported in table 1.

Table 1: values of "total distance covered" (TD), "relative distance" (RD) and "metres covered in different zones" of speed, acceleration and deceleration during four official matches. The percentage in the right column is given by the ratio between the different zones of T.

	Mean ± SD	% of TD
TD (m)	9591.9 ± 898.4	
T (min:sec)	93:58	
RD (m/min)	102.0 ± 7.9	
S1 (m)	3552.2 ± 429.5	37.0
S2 (m)	2710.7 ± 392.7	28.2
S3 (m)	2188.3 ± 566.4	22.8
S4 (m)	828.2 ± 185.2	8.6
S5 (m)	262.3 ± 92.3	2.7
S6 (m)	50.2 ± 35.1	0.5
A1 (m)	4112.7 ± 455.2	42.8
A2 (m)	501.3 ± 69.3	5.2
A3 (m)	72.3 ± 14.9	0.7
A4 (m)	16.2 ± 4.3	0.2
D1 (m)	4089.1 ± 329.4	42.6
D2 (m)	422.1 ± 95.8	4.4
D3 (m)	65.8 ± 23.7	0.7
D4 (m)	11.2 ± 5.4	0.1

88% of total distance covered was below of threshold of S3 corresponding at 16,3 km/h (52% of maximum speed): only a small portion of the game was played at high speeds.

95% of TD was ranged from -50% to 50% of speed variation: therefore around 480 m was in acceleration or in deceleration upper than 50% of individual maximum.

The results reported for tactical aspects are reported in table 2. The players who ran more meters were midfielders (TD = 10102,1±629,1 m) and lateral forwards (TD = 9759,3±889,6m).The speed analysis shows that the majority of high speeds are attributable to the forward, average speeds for midfielders, and low speeds for defenders. The evaluation of the acceleration showed no significant differences in roles, while the deceleration show an increased workload of midfielders at all intensities.

4 DISCUSSION

For a reliable data it is requires a larger number of matches, in fact soccer has variables intrinsic in the game such as opponents, pitch, match result, weather and more.

Table 2: values of "total distance covered" (TD). "relative distance" (RD) and "metres covered in different zones" of speed. acceleration and deceleration during four official matches for each role.

ROLE	Lateral Defender	Central Defender	Midfield	Lateral Forward	Forward	Anova
TD (m)	9058.9±469.2	8571.2±635.5	10102.1±629.1	9759.3±889.6	9031.4±729.3	<0.01
RD (m/min)	96.9±4.7	90.2±6.9	106.2±7.3	105.4±23.9	98.7±2.4	<0.001
S1 (m)	3251.1±348.4	3548.7±336.4	3227.8±318.1	3921.7±789.1	3537.2±521.1	<0.05
S2 (m)	2815.7±165.1	2332.4±161.0	2876.4±346.2	2551.1±774.8	2288.1±30.1	<0.05
S3 (m)	1985.1±168.8	1739.1±284.8	2754.7±362.1	2030.2±674.1	1754.7±286.2	<0.001
S4 (m)	769.1±117.1	699.3±128.7	977.1±185.9	888.7±287.1	912.4±103.7	<0.05
S5 (m)	223.2±50.1	215.2±80.1	210.6±53.1	325.1±110.1	421.3±111.7	<0.01
S6 (m)	20.9±10.8	51.7±41.4	25.2±22.1	65.3±30.1	118.7±86.9	<0.01
A1 (m)	3960.7 ±225.9	3710.1±332.1	4530.2±407.7	4270.3±579.2	3959.0±179.2	NS
A2 (m)	510.6±65.4	479.1±67.1	492.5±77.3	566.1±177.1	495.1±13.1	NS
A3 (m)	75.7±14.9	76.4±15.2	73.1±21.2	82.1±23.2	74.1±11.4	NS
A4 (m)	13.1±2.8	13.3±5.3	16.7±2.9	18.7±8.7	17.4±5.2	NS
D1 (m)	4074.2±224.5	3910.4±279.4	4365.8±288.7	4278.1±568.1	4131.7±443.1	<0.05
D2 (m)	384.7±76.5	352.7±42.4	506.9±94.1	464.1±121.1	320.1±30.9	<0.001
D3 (m)	51.1±20.1	52.70±8.8	87.1±28.7	85.7±21.4	37.2±7.7	<0.001
D4 (m)	7.1±3.2	7.4±2.1	13.7±6.1	13.2±3.2	2.4±2.1	<0.01

This study has the principal finding to investigate the kinematic data as speed, acceleration and deceleration in soccer players. Therefore the present results are to be considered as preliminary results that allow researchers to improve their evaluation of larger series.

This is first study with data analysis directly from GPS instrument in an official game of soccer (Larsson P, 2003).

The approach to the analysis follows the trend of recent major studies on sports match analysis: before to evaluate the matches were performed test in order to establish maximum values of speed, acceleration and deceleration. Setting the maximum values of speed, acceleration and deceleration is limited to recording artefacts due to too high values for a given athlete (Abt G, 2009).

The zones of percentage of speed, acceleration and deceleration have been set according a scale for each athlete: a standardized values cannot represent the real intensity of the individual player.

A limitation of the present study is the comparison of the parameters related to the performance of athletes of Italian sixth division, and the international top level generally found in previous studies.

The results obtained from tests completed before the start of the regular season showed high values of maximum speed, but the data regarding the maximum values of acceleration and deceleration was the most interesting: the maximum values of acceleration and deceleration are similar and very

high. These maximum values are reached during the games in fact only for negligible periods of time within the ninety minutes.

Tactical analysis shown how the speed is specific for different areas of the field, defenders and forwards must therefore have high speed abilities to be able to meet the demands of the game.

In addition particular attention is for the deceleration in midfielders.

5 CONCLUSIONS

Sports science in soccer is constantly changing as well as the methods used during the training in this sport (Randers M, 2010). Initially in match analysis, the most common parameters were "total distance" and "relative distance": the first one only provides information about the volume of physical effort; the second one can be considered a simple parameter estimating the intensity of physical activity.

The presence of ball in sports game influences the physical engagement with sudden accelerations and decelerations, recent studies show these as the main parameters to be evaluated the intensity in team sport, leaving at relative distance less value in this particular evaluation (Di Salvo, 2009).

Video match analysis can considered a risk factor in the estimation of athletes movements in order to assess speed, acceleration and deceleration only indirectly: the use of tools such as wearable GPS in this evaluation should lead to a reduction of estimation error.

If it compare the results between this study with a wearable systems in sixth division and studies reported with video analysis of top level athletes, you may notice a greater volume of workload at high levels (9591.9 ± 898.4 m versus 10950±1044 m), but the characteristics of intensity is comparable (Osgnach C., 2010).

On average every player:

- runs approximately 1140 m with a speed above 21.3 km/h,
- along 88 m above the acceleration 3.5 m/s^2,
- along 77 m below the -3.84 m/s^2.

The study of the physical effort following a tactic division by roles can provide interesting ideas on how to improve training methods according to the different natures of physical demand in sport games such as soccer.

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