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THE ROLE OF FATIGUE IN FOOTBALL MATCHES, PERFORMANCE MODEL ANALYSIS AND EVALUATION DURING QUARTERS USING LIVE GLOBAL POSITIONING SYSTEM TECHNOLOGY AT 50HZ

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Original scientific paper

Abstract
The aim of this research was to analyze the Player performance model (PPM) of 7th Italian League using GPS Live 50 Hz (K-Sport, Montelabbate, Italy), in order to evaluate the role of the fatigue during the course of a match, analyzing it by quarters. In total were analyzed 14 matches of one team, 140 data collections (10 for each match). Matches were divided in First Half (T1), Second Half (T2), Full Match, and even by quarters 0-15, 15-30, 30-45, 45-60, 60-75 and 75-90. Only players playing all matches were included into the analyses by quarters, in order to check the performance decreasing during the time. Data were processed with proprietary software (K-Fitness, K-Sport Universal, Stats Performance, Montelabbate, PU, Italy) and then analyzed using anExcel spreadsheets (Microsoft, USA).Physical data represent a performance indicator but also the qualitative level of players, the evaluations of quarters can indicate us the level of fatigue during the match, giving useful information to coaching staff. For this reason, the use of the match analysis could be decisive to verify the PPM, in order to evaluate the individual fitness status to better individualize training.

***Key words**: match analysis, performance model, GPS, fatigue, amateur football.*

Introduction

Analyzing the performances of footballers during matches and training has been the main aim of sport sciences in the last decade. Thanks to the video-tracking and GPS analysis during matches and trainings is possible to define the Player Performance Model (PPM) of a league, a championship and more in specific of a team. Thanks to these new technologies during years were executed several studies, that took into consideration the distances traveled and the movements of the players in the field (Di Salvo et al., 2006[1] and Rampinini et al., 2007[2]). In 2010 (Osgnach at al. 2010[3]), was proposed a new method to analyze the PPM during matches and training, this was a turning point the evolution of performance analysis. Subsequently numerous studies were performed through GPS technology and semi-automatic video tracking system, trying to evaluate the PPM (Bradley at al.2009[4],2010[5], Whebe at al.2014[6]). The GPS provide a kinematic analysis to measure the movement of the players during trainings or matches and then quantify the level of physical effort. The accuracy of the detection depends on weather conditions, satellites positions, and the propagation effects of the signals [7]. The use of video tracking systems are an important tool for identifying players physical efforts during professional official matches played in stadium with big stands (where GPS could be inefficient) and even to let players free from use of GPS jacket, that could damage the physical and psychological confidence during games[8]. Both systems are reliable in measuring the total distance in different thresholds, the peak of maximum speed, and the acceleration and deceleration activities [9]. The analysis of the PPM using GPS or video tracking of a specific championship could provide crucial information to define the level of players and allow the comparisons with other leagues and nations [10]. The PPM could provide information about level of fatigue derived from a single match (analyzing the decreasing of performance during time) and the level of fitness of team or single players during a select time-line: n° series of matches, first or second part of the season and the total season. The analysis of fatigue during a football match, is an argument well studied during past, fatigue is defined as a decline in the capacity to sustain a physical

performance that is manifested as a reduction in work rate towards the end of the game [11-12]. Several studies indicated the importance of the comprehension of the energy demands in football [13]. In terms of performance, a decline in work rate in the second half was consistently found irrespective of the level of competition and the physical fitness of participants [14]. Table 1 shows the percentage differences between total distance traveled between Frist Half (T1) and Second Half (T2) from different leagues.Table 1. Comparison of the distances covered in the first and second halves of football match-play in different leagues.

References	League	Difference in Distance Travelled Between T1 and T2
15	Armenia	3%
16	Brasilian	8%
17	Danish	5%
18	Euro Cup	1%
19	English	2%
20	Italian	3%
21	S. American	4%
22	Swedish	3%

Not a single metabolic factor can be related to the development of fatigue during football matches. Rather, it has been recently speculated that a central metabolic control system (CNS) may govern the peripheral physiological responses (i.e. fluid loss, metabolite accumulation, core temperature), such that players may be adopting pacing strategies during the game to counteract the potential failure of any peripheral physiological system and thus may ascribe for the absence of a single metabolic factor to fatigue [23]. Also the psychological effort should be taken into consideration, during the constantly changing environment of a football match; players are processing information and subsequently making decisions, influenced by team tactics, technical ability and physical capacity [24].

An interesting evaluation of the percentage of decreasing of physical performance during a football match was investigated byLinke et al. (2018)[25] comparing the team average of distance traveled in the 0-15 with 75-90. They discovered that the decreasing of performance is lower if the analysis of the match is divided in the quantification of effective playing time (Teff) then in the usual analysis of the total playing time (Ttot): Total Distance -6,6% if detection is filtered with Teff and -21,2% if the analysis is filtered with Tot andRunning -12% if detection is filtered with Teff and -25,6% if the analysis is filtered with Tot. The decline in players' match running performance during football matches is substantially amplified by an increase in game interruptions as the game progresses, indicating that there may be a tendency among match analysts to overestimate fatigue.

Means and methods

The aim of this research was to analyze the decreasing of physical performance during football matches, using 10 GPS 50 Hz (K-Sport, Stats Perform, Montelabbate, Italy). The survey was assessed analyzing the 7th Italian Football League (Amateur) in total were analyzed 14 matches of one team. Matches were divided in First Half (T1), Second Half (T2), Full Match, and even by quarters 0-15, 15-30, 30-45, 45-60, 60-75 and 75-90. Only players that playing all match were included in the analyses of quarters, in order to check the performance decreasing during the time. Data were processed with proprietary software (K-Fitness, K-Sport, Stats Perform, Montelabbate, Italy, PU, Italy) and then analyzed using an Excel spreadsheets (Microsoft, USA). The following parameters were taken into consideration:

- Total Distance (meters, D); Distance per minutes (meters/minutes, Drel);
- Distance covered at High-Intensity (speed ≥ than 16 km/h, HI);
- Distance covered at High-Metabolic Intensity (MP≥20 watt·kg-1, MPHI);
- Distance at Medium Acceleration > 2 m/s2 (meters, Acc);
- Distance at Medium Deceleration < - 2 m/s2 (meters, Dec).

Performance data were also divided by players role in order to detect different decrease by position: Central Defender (CD), Full Back (FB), Central Midfielder (CM), External Midfielder (EM), External Attacker (EA) and Forward (FO). The GPS analysis don't allow to perform the evaluation of the Teff, data output shows the Ttot.

Data analysis

Table 2 shows data from team average (TA) from T1 and T2 and the percentage of decreasing (Diff), Table 3 shows data from quarters and Table 4 shows increasing and decreasing by quarters. Higher value of decreasing between T1 and T2, -16,5% is detected in the MPHI parameter, the lower in the D -9,4%.

The quarters 15-30/30-45 and 60-75/75-90 show a positive value of Diff, in all parameters for 15-30/30-45, and for D and Acc, Dec for 60-75/75-90. The comparisons 0-15/15-30 and 45-60/60-75 shows for all parameters negative decreasing. The difference between the first quarter 0-15 and the last 75-90 are: -20% for D, -42% for HI, -26% for Acc, -28% for Dec and -40% for MPHI. The decreasing of D are following the value showed in the literature from Ttot (-20% our study and -21,2% from Linke et al., 2018).

Table 2. Average data from all detected matches for T1 and T2.

Type	D	HI	Acc	Dec	MPHI
T1	4493 ± 207	582 ± 58	227 ± 12	227 ± 16	1076 ± 72
T2	4106 ± 371	508 ± 70	207 ± 27	203 ± 34	923 ± 105
% Diff	-9,4	-14,5	-9,6	-11,8	-16,5

Table 3. Average data from quarters.

Type	D	HI	Acc	Dec	MPHI
0-15	1565 ± 110	212 ± 26	82 ± 5	81 ± 7	392 ± 34
15-30	1443 ± 94	181 ± 30	71 ± 5	71 ± 6	336 ± 35
30-45	1471 ± 94	189 ± 36	71 ± 6	72 ± 7	345 ± 45
45-60	1407 ± 110	179 ± 39	72 ± 6	72 ± 8	331 ± 42
60-75	1283 ± 173	162 ± 34	62 ± 12	62 ± 12	289 ± 58
75-90	1299 ± 110	148 ± 29	65 ± 9	63 ± 10	281 ± 38
Average	1411	178	70	70	329

Table 4. Percentage of decrease or increase between quarters.

Type	D	HI	Acc	Dec	MPHI
0-15/15-30	-8,5%	-16,7%	-15,6%	-14,3%	-16,5%
15-30/30-45	1,9%	4,2%	0,4%	1,8%	2,5%
30-45/45-60	-4,5%	-5,8%	0,6%	-0,9%	-4,3%
45-60/60-75	-9,7%	-10,1%	-14,6%	-15,8%	-14,3%
60-75/75-90	1,2%	-9,2%	3,7%	2,1%	-3,1%
0-15/75-90	*-20%*	*-42%*	*-26%*	*-28%*	*-40%*

Table 5 shows data from Full Match divided by roles, the CD is the position that recorded the lower values in other hand the EA show the higher results in D, HI and MPHI. Acc is higher FO and Dec in CM, anyway the Acc and Dec don't show relevant differences between CM, EA and FO. Table 6 shows the Diff from T1 and T2 divided by roles, the FO evince the higher decrement and lower was performed from CM.

Table 5. Data from Full Match divided by role.

Full Match					
Role	D	HI	Acc	Dec	MPHI
CD	7997 ± 453	736 ± 200	378 ± 53	348 ± 54	1600 ± 240
FB	8334 ± 632	1086 ± 150	470 ± 65	463 ± 67	1912 ± 223
CM	8648 ± 442	1394 ± 207	480 ± 42	496 ± 55	2242 ± 196
EM	9235 ± 662	1142 ± 315	443 ± 52	449 ± 64	2187 ± 305
EA	9377 ± 605	1616 ± 225	475 ± 65	493 ± 57	2512 ± 266
FO	8700 ± 937	1407 ± 396	481 ± 20	477 ± 41	2241 ± 295

Table 6; Percentage of Diff between T1 and T2.

Diff T1/T2					
Role	D	HI	Acc	Dec	MPHI
CD	-6%	-16%	-10%	-10%	-14%
FB	-7%	-16%	-4%	-7%	-14%
CM	-7%	-5%	-9%	-8%	-10%
EM	-12%	-2%	-11%	-15%	-15%
EA	-7%	-8%	-10%	-14%	-10%
FO	-17%	-55%	-13%	-16%	-33%

Table 7 shows the decreasing value between the 0-15 quarter and the 75-90 divided by roles, the higher decreasing in all parameters was recorded by the EM, in the other hand the role that shows the lower value of decreasing is the CD.

Table 7. Decreasing data from 0-15 to 75-90 by role

0-15/75-90					
Role	D	HI	Acc	Dec	MPHI
CD	-19,6%	-31,3%	-20,5%	-20,0%	-33,6%
FB	-20,5%	-44,9%	-29,1%	-31,5%	-43,9%
CM	-19,8%	-39,8%	-31,4%	-32,7%	-39,6%
EM	-55,7%	-93,7%	-38,4%	-44,2%	-85,5%
EA	-12,6%	-43,3%	-22,6%	-26,2%	-31,8%
FO	-17,5%	-35,4%	-21,8%	-22,9%	-32,0%

Table 8. Comparison from 7° Italian League with Elitè Euro Championship (Castagna et al., 2016).

Category	D	HI	Acc	Decc	MPHI
7° ITA League	8589	1094	437	432	1992
Euro	10672	1778	636	612	2759
% Diff	-24%	-63%	-45%	-42%	-39%

Table 8 shows the comparison between Full Match average obtained from our study one 7th Italian Football League (amateur level) between data from literature from Elitè European Championships [26], the higher difference is in HI that show a -63% Diff.

Discussion

The aim of this research was to analyze the decreasing of physical performance during football matches, using GPS 50 Hz (K-Sport, Montelabbate, Italy). The survey was assessed analyzing the 7th Italian Football League (Amateur) in total were analyzed 14 matches of one team. Matches were divided in First Half (T1), Second Half (T2), Full Match, and even by quarters 0-15, 15-30, 30-45, 45-60, 60-75 and 75-90. Only players playing all match were included in the analyses by quarters, in order to check the performance decreasing during the time.

The data collection and comparison between the T1 and T2 shows that HI was the parameter that showed the higher value of Diff -14,5%, the D recorded a -9,4% Diff, the Acc -9,6%, the Diff -11,8% and the MPHI -16,5%. The decreasing of Acc is lower than Dec, this can be correlated with the deceleration movements and with an eccentric contraction that is more difficult to execute when muscle soreness rise up. The Diff of D was -9,4% higher then value available in literature that at maximum shows -8% for the Brazilian Championship.

Discussing about the volume of parameters during the quarters; the higher values are showed in the 0-15, but in the other hand the lower value are not all situated in the 75-90. The Diff in performance between quarters shows all negative value in comparison between 0-15/15-30 and in 45-60/60-75, and in total the comparisons that shows the higher decreasing is the 0-15/15-30. The 15-30/30-45 recorded a positive Diff in all parameters, as contrary to previous studies [27] the Diff 30-45/45-60 was negative. Usually after the rest time between half the performance suffer and increases. The comparison between 0-15/75-90 recorded the higher Diff in HI -42% and lower in D -20%, a value that is linear to the literature, when the performance is detected with Ttot method. The Full Match analysis divided by roles shows that the EA in D, HI and MPHI showed the higher value.

In Acc and Dec were not big difference between role and the higher values were showed from CM, EA, FO. The CD showed the lower values in all parameters. Was also analyzed the percentage Diff between T1 and T2 in different roles, the role that show the higher decrement was the FO and the lower the CM. Same analysis were performed between the first and last quarter (0-15/75-90), in this case the EM was the role that showed the higher Diff percentage in all parameters. In HI, Acc and Dec the CD recorded the lower Diff, in the other hand in D and MPHI the lower value was performed by EA. The last comparison analyzed was between the Full Match averages from our detection between data from Élite European Championship obtained by literature. The Diff detected are all-negative for 7° ITA League and respectively are: -24% in D, 63% in HI, -45% in Acc, -42% in Dec and -39% in MPHI.

This last comparison is important to establish that even if the Diff between D in 0-15/75-90 analyzed with Ttot analysis show same value between our study and professional level (-20% our study and -21,2% professional), the volume that means the total distance performed between the two groups have an important difference -24%.

Conclusion

Analyzing the Diff in performance and the upcoming of fatigue during matches could be an efficient method to support the coaching staff with relevant data, useful to take decision during the matches or to modify the trainings protocol. This kind of analysis can be developed by using video-tracking and GPS system analyzing the T1, T2 and all quarters (0-15, 15-30, 30-45, 45-60, 60-75 and 75-90) in order to analyze the Diff. Same system was proposed by Linke et al. (2018) and Izzo at al. (2019), in first case was analyzed the differences between the comparison Ttot and Teff. The data showed that analyzing the Teff the decreasing od D between 0-15 and 75/90 was lower than prospectus, -6,6% Teff against 21,2% Ttot. In our study processed with GPS was not possible to define the Teff that is possible to define easier using a video-tracking system, the Diff on D in 0-15/75-90 using Ttot analysis was -20% in line with data from literature. Is important to notice that even if the Diff detected in our study is similar to professional level, the volume and intensity is much lower than professional footballers. Talking about HI the decreasing 0-15/75-90 for Ttot was -42%, much higher than the decreasing detected in professional players -25,7%. That show how the major differences between professional players and amateur are not in total distance performed but in the high intensity actions (volume and intensity), also the decreasing in high intensity parameters is higher talking about amateur footballers[28].

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