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Original article

EFFORT ANALYSIS IN REAL TIME DURING A FOOTBALL GAME – JUNIOR II USING GPSPORTS DEVICE

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Abstract[*]

Aim. In the game of football, acyclic movements grafted on a cyclic effort are prevailing. Knowing the complexity and speed at which technical and tactical actions are performed during a football game requires monitoring specific effort through modern equipment able to provide real-time information about the values of external and internal effort parameters, the metabolic effort zones which are exerted, etc. All these data allow coaches to identify the strengths and weaknesses of the players/team and to conduct specific preparation in a scientific way. The experiment tested athletes in the 1988 age group from two clubs listed in the Municipal Football Championship of Bucharest, namely Dinamo Club (ranked 1st) and CSS1 Club (ranked 4th).

Research purpose: to achieve a comparative analysis of effort dynamics in an official football game using the data provided by GPSports device.

Research hypothesis: knowledge of higher aerobic exercise capacity can also provide information about anaerobic exercise capacity, and therefore about sports performance.

Results: In our research, we analyze a single parameter, namely the "quality of running", through the information generated by it: HR min., maximal HR, maximal speed (m/s), total distance (m), MAV levels (m/s), anaerobic plateau (HR> 165 bpm). The average distance covered is 4431m for the athletes from Dinamo Club and 4747m for the athletes from CSS1 Club. The difference between the two means is 316m in favor of the athletes belonging to CSS1 Club. The coefficients of variation indicate a lack of homogeneity/a high degree of dispersion for the two teams (31.11 Dinamo team and 25.69 CSS1 team). The arithmetic mean of maximal speed (m/s) reached during the game shows that on average a player from Dinamo runs faster (7.39 m/s) than a player from CSS1 (6.76 m/s); the difference is 0.63 m/s.

*Conclusions:*Using GPSports device is particularly helpful in the scientific management of training; Heart rate is a good indicator of higher aerobic capacity/endurance; The slight gap between heart rate and maximal oxygen consumption is determined by the transitory states of the latter; Higher endurance training improves the oxidative capacity of red fibers, but also the oxidative component of white fibers.

Keywords: Football, junior II, MAV, anaerobic plateau, GPSports.

Introduction

The metabolic support of effort in the game of football is dominated by aerobic zones (aerobic threshold, anaerobic threshold and maximal oxygen consumption – VO_2 max), on which there are grafted the penetrations of anaerobic effort zones (power efforts, lactate peaks and tolerance to lactic acid accumulations); and in terms of cyclicality of the effort, there are encountered acyclic movements grafted on a cyclic effort.

Knowing the complexity and speed at which technical and tactical actions are performed during a football game requires monitoring specific effort through modern equipment able to provide real-time information about the values of external and internal effort parameters, the metabolic effort zones which are exerted, etc. All these data allow coaches to identify the strengths and weaknesses of the players/team and to conduct specific preparation in a scientific way.

Monitoring and assessing the power and capacity of maximal aerobic endurance zone involve knowing the concepts of anaerobic threshold, maximal aerobic power (MAP) or the corresponding maximal aerobic velocity (MAV). (Guedj, 2006)

In training, besides knowing maximal oxygen consumption, it is much more important to know maximal aerobic velocity (MAV), which represents the speed at which the subject must mobilize to reach maximal aerobic power (MAP). (Cordun, 2011)

We mention that a very good MAV value allows the entry into the higher aerobiosis zone (VO_2

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max) earlier than the 3 minutes described by the specialists in ergo-physiology as being an essential methodical prerequisite for the body's entry into the maximal oxygen consumption. (Maglischo, 1982)

We draw attention: the concept of EPOC (Excess Postexercise Oxygen Consumption) states that any effort starts and ends with an oxygen debt (O_2D max); it results that, for mobilizing the body to reach maximal oxygen consumption, at least 3 minutes must elapse, depending on the length of the event. In the post-effort break, it is paid off the oxygen consumed at the beginning of exercise, extracted from myoglobin (Wilmore, 2008).

The measurement of aerobic capacity can be achieved in percentages of VO_2 max or MAV. It is worth noting that a minor error in VO_2 max or MAP or MAV, for a scheduled power, will induce a significant error in the maximal aerobic endurance zone, 10 times higher in percentages. (Guedj, 2006)

In our research, we use an internal parameter, the heart rate (HR), which is a good indicator of the increase in VO_2 max, with the specification that there is only a slight gap between HR variations and maximal oxygen consumption in the transitory steady states. The relationship between HR and O_2 debt or the power of exercise (HR/VO_2 or W) is almost linear, because of the HR comprised between 20% and 70% of HR reserve. There is also a zone (35% to 55% of VO_2 max) for which the increase in the heart rate compared to the increase in power is slightly lower, which can be translated as a better cardiac output. At a percentage of 60% - 80% of maximal HR, the increase in the heart rate is a little bit smaller and can be described as a threshold (Conconi), which is either different or below the aerobic and anaerobic lactic thresholds (Guedj, 2006).

In this research, we shall also make an analysis of HR referring to the anaerobic threshold parameter (relative steady state) in correlation with maximal HR, maximal speed reached in m/sec and MAV levels. We mention that, in the HR analysis, we used Spiro's formula to calculate the theoretical maximum HR = 210 – 0.65 x age (Spiro, 1977)

Methods

Premise: The effort monitoring in real time (during the game) by means of GPSports device will provide coaches with important data for the scientific management/prospective modeling of the training effort in order to reach maximal performances.

Research purpose: to achieve a comparative analysis of effort dynamics in an official football game using the data provided by GPSports device.

Research hypothesis: knowledge of higher aerobic exercise capacity can also provide information about anaerobic exercise capacity, and therefore about sports performance.

Research subjects: 31 in number, they are athletes registered at two clubs listed in the Municipal Football Championship of Bucharest (School Sports Club 1 – CSS1, ranked 4th, and Dinamo Club, ranked 1st). There were tested athletes in the 1988 age group, basic players at the club teams where they were performing. Testing was conducted during an official game of the championship, in the month of June 2014. The game was played on the football field within the Dinamo Sports Complex and ended with the score 4-1 in favor of FC Dinamo Club.

Research methods: The research is based on a comparative-ascertaining pedagogical experiment. To monitor the players' effort during the game, we used GPSports device and SPI IQ software (figure 1 and figure 2). The device allows coaches to track in real time the effort provided during the game, to know the metabolic cost during exercise, to divide by zone the effort, covered distances and travel and acceleration velocities, MAV levels, HR, etc. (Marinescu, Gh. et al., 2016). As statistical and mathematical methods, there were used: arithmetic mean, standard deviation, coefficient of variation, Pearson's linear correlation coefficient (Popa, 2008).

Figure 1. GPSports measurement device

Figure 2. Vest housing the device

Table 1. Results recorded during the game, for the studied parameters, by the athletes from FC Dinamo Club and their analysis

Item no.	Surname and name of the athletes	HR before exercise (bpm)	Maximal speed recorded (m/s)	Maximal HR recorded during exercise (bpm)	Total distance run during the game (m)	MAV 18 4.8 – 5.3 m/s (m)	MAV 19 5.3 – 7.2 m/s (m)	MAV 20 7.2 – 8.8 m/s (m)	Anaerobic threshold HR > 165 bpm (min)
1	A.F.	88	8.3	192	4100	112	248	11	43
2	N.D.	105	7.9	189	4000	130	176	8	23
3	O.N.	78	7.8	200	3800	164	190	7	31
4	P.D.	90	7.7	198	4000	151	307	10	32
5	M.G.	84	7.7	201	3400	110	238	0	14
6	P.A.	69	7.6	188	3600	150	260	0	43
7	B.S.	67	7.6	200	4400	145	194	0	18
8	M.A.	61	7.5	197	3800	218	183	0	17
9	D.B.	71	7.4	182	8100	105	143	0	2
10	M.L.	130	7.4	196	4300	133	104	0	38
11	R.M.	86	7.3	198	3900	212	391	0	29
12	S.D.	66	7.3	199	7900	249	325	0	38
13	P.C.	80	7.2	198	3800	181	184	0	26
14	P.I.	76	6.9	180	4100	142	75	0	9
15	B.R.	82	6.7	188	3400	147	119	0	6
16	G.I.	97	5.9	191	4300	105	70	0	35
	X	83.1	7.3	193.5	4431.2	153.3	200.4	2.2	25.2
	Stdv	±17.17	±0.55	±6.602	±1423.94	±42.525	±90.814	±4.106	±13.091
	Covar	20.67%	7.53%	3.41%	32.13%	27.73%	45.31%	186.63 %	51.94%
	Pearson	Maximal HR and MAV for level 19 / **r = 0.517**							

Results

Table 1 shows the results recorded during the game and an analysis of these data for the athletes from FC Dinamo Club.

Table 2 shows the results recorded during the game and an analysis of these data for the athletes from CSS1 Club.

Table 2. Results recorded during the game, for the studied parameters, by the athletes from CSS1 Club and their analysis

Item no.	Surname and name of the athletes	HR before exercise (bpm)	Maximal speed recorded (m/s)	Maximal HR recorded during exercise (bpm)	Total distance run during the game (m)	MAV 18 4.8 – 5.3 m/s (m)	MAV 19 5.3 – 7.2 m/s (m)	MAV 20 7.2 – 8.8 m/s (m)	Anaerobic threshold HR > 165 bpm (min)
1	R.A.	83	8.1	199	6600	267	272	11	44
2	M.M.	93	7.6	196	4530	115	131	8	13
3	M.C.	83	7.6	216	6850	165	186	6	60
4	T.G.	60	7.5	197	2300	62	128	7	14
5	D.V.	79	7	209	4900	219	162	0	34
6	B.I.	60	7	204	4150	144	152	0	31
7	M.I.	120	6.6	206	3800	159	146	0	32
8	B.N.	105	6.5	211	4900	161	181	0	33
9	T.C.	90	6.4	203	4800	83	51	0	43
10	D.S.	88	6.3	205	7000	105	97	0	59
11	V.M.	66	6.3	207	4300	128	96	0	30
12	G.S.	60	6.3	203	3700	97	94	0	28

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13	C.I.	84	6.1	190	4100	122	41	0	26
14	M.C.	74	6.1	192	5020	77	39	0	28
15	A.C.	66	6	203	4250	154	98	0	34
	X	80.7	6.7	202.7	4746.6	137.2	124.9	2.1	33.9
	Stdv	±17.34	±0.664	±7.014	±1262.25	±54.353	±62.274	±3.795	±13.333
	Covar	21.49%	9.91%	3.46%	26.59%	39.61%	49.85%	180.71%	39.33%
	Pearson	Maximal HR and MAV for level 19 / **r = 0.453**							

Table 3. Comparison between the average results achieved by the athletes of both clubs studied

	HR before exercise (bpm)	Total distance run during the game (m)	Maximal HR recorded during exercise (bpm)	Maximal speed recorded (m/s)	MAV 18 4.8 – 5.3 m/s (m)	MAV 19 5.3 – 7.2 m/s (m)	MAV 20 7.2 – 8.8 m/s (m)	Anaerobic threshold HR > 165 bpm (min)
Dinamo	**83.1**	4431	193.5	**7.39**	**153.3**	**200.4**	**2.2**	25.2
CSS1	80.7	**4747**	**202.7**	6.76	137.2	124.9	2.1	**33.9**

An analysis of the obtained data is presented in table 3. As regards the arithmetic mean for the parameter HR before exercise, the athletes from FC Dinamo Club have recorded a value of 83.1 bpm, and the athletes from CSS1, a value of 80.7 bpm; the achieved values fall within the real steady-state effort, excepting four athletes who have values comprised between 105 and 130 bpm; this increased basal HR can be attributed to emotionality (figure 3).

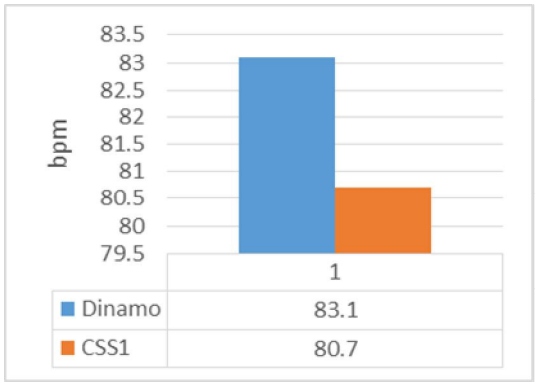

Figure 3. Average HR at the beginning of exercise

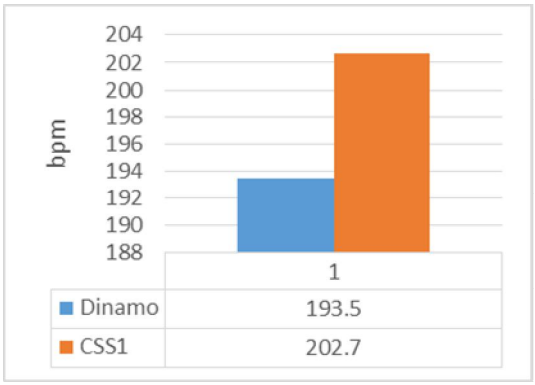

Figure 4. Average peak HR reached during the game

For the parameter Maximal HR recorded during the game, the athletes from FC Dinamo have recorded an average maximal HR of 193.5 bpm, while the athletes from CSS1 have recorded a value of 202.7 bpm; it can be concluded that the achieved values fall within the maximal higher aerobiosis effort (relative steady state/stamina/ ergostasis) (figure 4). Correlating the obtained results with Spiro's formula, it can be noted that this parameter falls within the maximal oxygen consumption zone characterizing the effort specific to football game for both teams.

Regarding the parameter Total distance run during the game, the athletes belonging to FC Dinamo Club have run on average 4431m, and the athletes from CSS1, the distance of 4747m; the average difference is an extra 316m run for the CSS1 athletes (figure 5).

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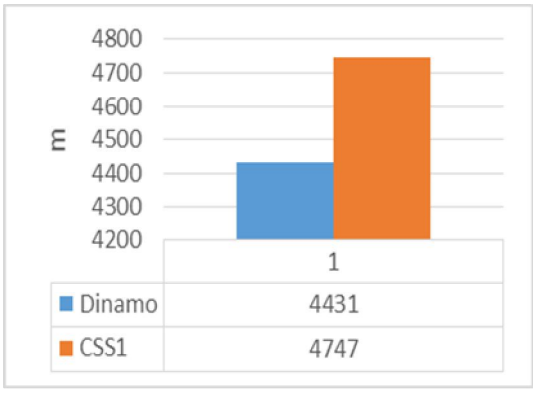

Figure 5. Average total distance run during the game

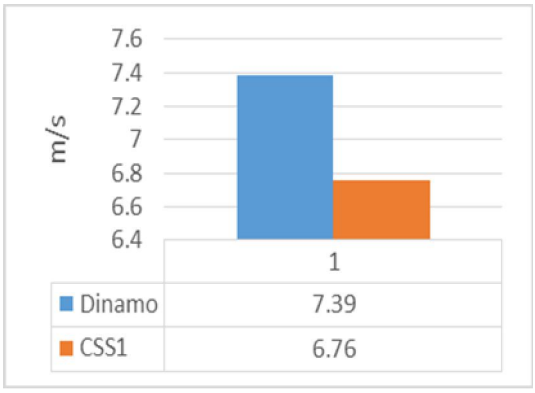

Figure 6. Average maximal speed reached during the game

For the athletes from FC Dinamo Club, the average value of maximal speed reached is 7.3 m/s, while the athletes from CSS1 have an arithmetic mean of 6.7 m/s for this parameter (figure 6).

For the parameter Maximal aerobic velocity (MAV - level 18, velocity comprised between 4.8 and 5.3 m/s), the FC Dinamo athletes reach on average the distance of 153.3m; the CSS1 athletes reach on average, for the same level, the distance of 137.2m; the average difference is an extra 16.1m run for the FC Dinamo athletes (figure 7).

For the parameter Maximal aerobic velocity (MAV - level 19, velocity comprised between 5.3 and 7.2 m/s), the athletes from FC Dinamo Club reach on average the distance of 200.4m; the athletes from CSS1 Club reach on average, for the same level, the distance of 124.9m; the average difference is an extra 75.5m run for the athletes from FC Dinamo (figure 8).

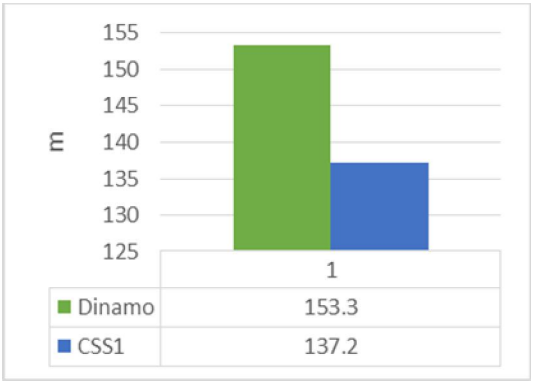

Figure 7. Average distance traveled on MAV level 18

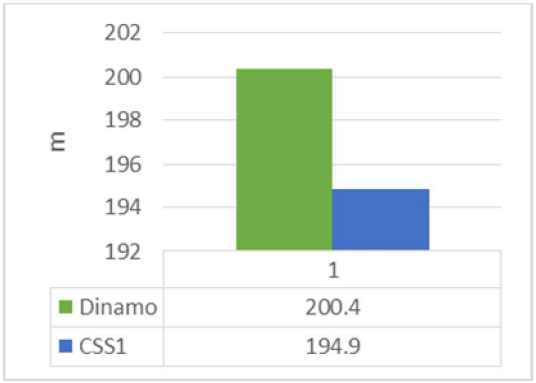

Figure 8. Average distance traveled on MAV level 19

For the parameter Maximal aerobic velocity (MAV - level 20, velocity comprised between 7.2 and 8.8 m/s), the athletes from FC Dinamo Club reach on average the distance of 2.2m; the athletes from CSS1 Club reach on average, for the same level, the distance of 2.1m; it is noted that this very hard level has been reached by only 8 athletes (4 athletes from FC Dinamo and 4 athletes from CSS1) (figure 9).

For the parameter Anaerobic plateau (HR > 165 bpm), the athletes belonging to FC Dinamo Club remained in this zone on average 25.2 minutes of the statutory playing time (80 minutes); the athletes belonging to CSS1 remained in this zone on average 33.9 minutes of the statutory playing time (80 minutes) (figure 10).

Figure 9. Average distance traveled on MAV level 20

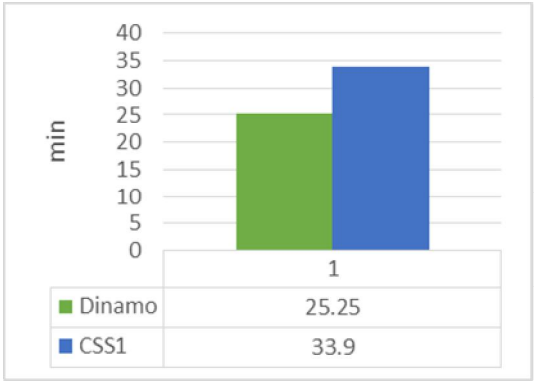

Figure 10. Average game time spent in the anaerobic plateau zone

Discussion

Analyzing the presented data, it is noticed that: the athletes from FC Dinamo reach an average maximal HR of 193.5 bpm (a more economical maximal HR than that of the athletes from CSS1) and cover a shorter distance by 316m than the distance covered by the athletes from CSS1, with an average maximal HR of 202.7 bpm. Although the maximal speed reached by the FC Dinamo athletes is superior to that reached by the CSS1 athletes (7.39m/s with a HR = 193.5 bpm vs. 6.76 m/s with a HR = 202.7 bpm), it can be concluded that the athletes from FC Dinamo run with a higher intensity and a more economical HR than the athletes from CSS1. The athletes from CSS1 cover a longer distance by 316m, but with a travel speed lower than that of FC Dinamo athletes; this can be explained by the fact that the athletes belonging to CSS1 run more but without technical and tactical efficiency, compared to the athletes from FC Dinamo (e.g.: they release the ball more quickly, are better placed on the field and do not need to cover a longer distance), therefore the quality-quantity ratio is in favor of the players from FC Dinamo. Regarding the metabolic cost, it is noted an apparent paradox: CSS1 maintains the anaerobic threshold for 33.9 minutes (about 41% of the statutory time), with an intensity of 6.76 m/s, seeming to be better prepared than the FC Dinamo athletes, who maintain the anaerobic threshold for 25.5 minutes (about 31% of the statutory time), but with a higher intensity of 7.39 m/s. The intensity of running for the athletes from FC Dinamo (maximal speed reached) represents the qualitative parameter and the explanation of the paradox.

Concerning the athletes' homogeneity, only for two parameters (maximal HR and maximal speed reached) they fall within a low dispersion of results and high homogeneity in both teams (see tables 1 and 2).

As to the Pearson's correlation between the parameter Maximal HR and the parameter MAV - level 19, for the athletes from FC Dinamo, it is noted a substantial degree of association intensity (r = 0.517); the athletes from CSS1 have a moderate degree of association intensity (r = 0.453).

Conclusions

Using GPSports device is particularly helpful in the scientific management of training;

Heart rate is a good indicator of higher aerobic capacity/endurance;

The slight gap between heart rate and maximal oxygen consumption is determined by the transitory states of the latter;

For higher endurance, preparation in the "anaerobic threshold" effort zone (intensity: 65% - 80% of VO_2 max; 4 - 6 mmol lactic acid) is efficient in comparison with the "maximal oxygen consumption" effort zone, because the athletes can train for a long time on the accumulation of a substantial amount of lactic acid, but which can be metabolized by the oxygen supply;

Higher endurance training improves the oxidative capacity of red fibers, but also the oxidative component of white fibers;

Knowledge of higher aerobic exercise capacity can also provide information about anaerobic exercise capacity, and therefore about sports performance – **the research hypothesis is confirmed.**

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