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Effects of fatigue and time-out on physiological, time-motion indicators and in patterns of spatial organization of the teams in basketball

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EFFECTS OF FATIGUE AND TIME-OUT ON PHYSIOLOGICAL, TIME-MOTION INDICATORS AND IN PATTERNS OF SPATIAL ORGANIZATION OF THE TEAMS IN BASKETBALL

KEY WORDS: Basketball, Fatigue, GPS, Time-out.

ABSTRACT: The aim of this study was to identify the effects of fatigue on physiological variables, time-motion indicators and patterns of spatial organization of the teams in basketball. The study sample consisted of 10 basketball players of the under-18 with a mean age of 17.5 ± 0.3 years. There were two sessions: session a) game continuous (C1) 10 minutes - *yo-yo intermittent recovery test (level 1)* - 1 minute timeout – game continuous (C2) 10 minutes. Session b) game interrupted (I1) 5 minutes - 1 minute timeout - 5 minutes game - yo-yo intermittent recovery test (level 1) –1 minute timeout - game interrupted (I2) - 5 minutes - 1 minute timeout - 5 minutes game. HR values were determinate by the *YYIRTL1* and registered by short range radio-telemetry heart-rate monitors *(Polar Team System, Polar Electro*, Finland), time-motion analysis were registered with GPS (SPI Elite. *GPSports Systems*, Australia), and a digital camera was used to record the game. The results suggest that the fatigue and the time-outs promote betters patterns of spatial organization. Additionally the results showed that with the accumulated fatigue the players covered a less total distance and in a slower way.

The studies developed within the game analysis in different team sports have demonstrated that an improvement of sprint performance and in ability to repeat high-intensity efforts are associated to higher competitive level games (Sirotic et al., 2009). Recognizing the importance of such actions for the differential performance in team sports, some authors have developed several studies in order to detect patterns and trends in teams behaviors (Dellal et al., 2011; Hill Haas et al., 2011; Sirotic et al., 2009). The *Global Positioning Systems* (GPS) have been used to measure and evaluate physiological performance indicators in training sessions and competitions on team sports (Barbero-Álvarez et al., 2010; Cunniffe et al., 2009). Based on the benefits and characteristics of this technology, several studies have been carried to identify and characterize the movement pattern of players in team sports and also to identify the physiological requirements to develop more efficient training programs (Coutts and Duffield, 2010; Hill Haas et al., 2011; Sirotic et al., 2009).

The vast quantity of actions performed at high intensities that characterize the Basketball game (Ben Abdelkrim et al., 2007), are confirmed by the physiological indicator Heart Rate (HR) and studies have presented mean values above 85% of HR_{max} (Castagna et al., 2010). Arnett et al. (2000) add that the accumulated fatigue during games results by the anaerobic work that players execute in anaerobic tasks. This idea is supported by the study of Ben Abdelkrim et al. (2007), whose have registered values of mean HR_{max} of 171 ± 4 bmp in a game, which correspond to values of 91% ± 2% of the HR_{max}.

Sports performance emerges from the self-organization and the interaction among the parts that composes the system. These interactions, the inter-coupling and intra-coupling dyads, were viewed as the baseline of time-motion analysis in different sports (McGarry et al., 2002). Although, quite unpredictable, this interaction may increase a consistent collective behavior among players, which can be expressed for example by his movement on field as a function of distance to geometric center of the team and to the distance of opposing team geometric center. In a basketball game, for a team that follows a dynamical collective positional organization, it will be much easier to predict subsequent actions as more loyal are to this dynamical the previous actions. The concept of approximate entropy allows to measure the degree of predictability of a positional dynamical of a team, and will be much lower as more organized it is (Pincus and Goldberger, 1994).

Despite of the quantity of studies carry out with these variables, the literature misses in study the effect of fatigue in physiological variables and in team spatial organization. Similarly, the implications of a rupture in game sequences provoked by the time-out, lacks a deep understanding. Thus, the aim of the present study was analyze the effect of fatigue on physiological variables, time-motion analysis and spatial organization of games with time-out. Additionally we aim to evaluate the effect of time-out on physiological variables, time-motion analysis and spatial organization.

Method

The study sample consisted of 10 basketball male players (age 17.5 ± 0.3 years; height 175.4 ± 4.83 cm; weight 64.5 ± 6.44; HR_{max} 199.1 ± 9.08 bpm; basketball years of practice 8.06 ± 1.98). All subject belong to the same under-18 team of Basket Club de Vila Real. All players, coaches and club were notified about the proceedings of the investigation na gave their consent.

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There were two sessions: session a) game continuous 1 (C1) 10 minutes (min) - *yo-yo intermittent recovery test level 1*(*YYIRTL1*) - 1 min timeout – game continuous 2 (C2) 10 min. session b) game interrupted 1 (I1) 5 min - 1 min timeout - 5 min game *YYIRTL1* - 1 min timeout – game interrupted 2 (I2) 5 min - 1 min timeout - 5 min game. No specific rules were established, so it doesn't influence the intensity of the games (Drust and Kelly, 2008). Several balls were placed around the playing area so that when the ball leave the boundary lines of the field was quickly replace (Drust and Kelly, 2008), thus avoiding interruptions during the exercise and consequently breaks the intensity of the game.

To perform the YYIRTl1 was necessary a sound system, CD (audio) with the beep sounds and cones for marking lines. The HR were measured and registered (5 seconds intervals) by short range radio-telemetry (*Polar Team System, Polar Electro*, Finland). After each session, all records were downloaded to a laptop (*HP Pavilion dv5*) through an appropriate interface (*Polar Precision Performance SW – Version 4.01.029*). The time-motion analysis was registered with GPS (SPI Elite. *GPSports Systems*, Australia). The games were recorded with a camcorder Sony Handycam DCR-SX30.

The *t-test* was used to compare the means for both paired and independent samples. All data were analyzed with the statistical software SPSS for Windows, version 16.0 (SPSS Inc., Chicago, IL). The level of statistical significance was set at $p \leq .05$.

Results

The results for the descriptive statistics to physiological variables, time-motion and approximate entropy for I1 and I2 are presented in Table 1. Figure 1 presents significant effects between games with and without time-out. The results showed significant effects of fatigue between the two games with time-out in distance covered, HR zones and for approximate entropy. Regardless to the effect of time-out before fatigue only presented differences in approximate entropy. Finally, in relation to the effect of time-out in games with accumulated fatigue, significant differences were obtained in distance covered at different speed zones, number of actions performed at speeds ≥ 18 km/h and approximate entropy.

Games with Time-Out (11 and 12)

Variables	Game	Mean (m)	DP	*t*	*p*	Variables	Game	Mean (m)	DP	*t*	*p*
ZONE 1 (0-6.9 km/h)	1	372.458	±41.1	-4.8	0.001*	GC	1	0.935	±0.1	1.6	0.156
	2	405.915	±39.9				2	0.902	±0.1		
ZONE 2 (7-9.9 km/h)	1	178.058	±33.7	3.1	0.014*	GC (< 13 km/h)	1	0.927	±0.1	0.8	0.437
	2	142.440	±25.6				2	0.912	±0.1		
ZONE 3 (10-12.9 km/h)	1	188.650	±49.4	1.8	0.106	GC (> 13 km/h)	1	1.111	±0.3	2.8	0.022*
	2	164.510	±37.1				2	0.977	±0.3		
ZONE 4 (13-15.9 km/h)	1	128.310	±41.7	3.5	0.007*	OGC	1	1.135	±0.1	1.9	0.082
	2	98.963	±53.2				2	1.064	±0.1		
ZONE 5 (16-17.9 km/h)	1	41.043	±20.4	2.1	0.070	OGC (< 13km/h)	1	1.124	±0.1	1.5	0.160
	2	25.903	±12.4				2	1.072	±0.1		
ZONE 6 (> 18 km/h)	1	20.915	±15.5	1.2	0.262	OGC (> 13 km/h)	1	1.176	±0.1	1.4	0.188
	2	14.130	±9.5								
TOTAL DISTANCE	1	932.833	±82.1	4.8	0.001*		2	1.079	±0.2		
	2	851.873	±72.2								
ZONE (< 75% HR_{max})	1	2.053	±2.2	1.6	0.149	ZONE 3 (85-89.9% HR_{max})	1	2.202	±1.3	-0.5	0.615
	2	0.805	±0.4				2	2.451	±1.3		
ZONE 2 (75-84,9% HR_{max})	1	1.882	±1.2	-2.9	0.019*	ZONE 4 (> 90% HR_{max})	1	3.859	±2.4	-0.6	0.149
	2	2.441	±1.4				2	4.300	±2.6		

Table 1. The mean (±SD) results to physiological variables, time-motion and approximate entropy to the games with time-out (I1 and I2).

Discussion

This study aimed to analyze the effect of fatigue on physiological variables, time-motion analysis and spatial organization of the team in games with time-out. Additionally we aim to evaluate the effect of time-outs in the same variables. The main findings suggest that the accumulated fatigue in games with time-out doesn't affect significantly the physiological and time-motion variables, however were recorded better patterns of spatial coordination in relation to team geometric center. The results also showed that with the accumulated fatigue the players covered a less total distance and in a slower speed zone.

All games present a higher distance covered at the lower speeds zone. Ours findings follows the same trend as studies developed in team sports, such as field hockey (Macutkiewicz and Sunderland, 2011), football (Randers et al., 2010) and rugby (Sirotic et al., 2009). The results showed significant effects between C2 and I2 after accumulated fatigue for zone 2 and zone 6, with less distance covered by the players with time-out. The possible decreasing game intensity caused by the time-out could promote better patterns of coordination among players, reducing the probability to perform individual high-intensity actions. Also in the games with time-out, the results showed that the I1 covered an average 80.6 meters more than I2 in total distance. Similar

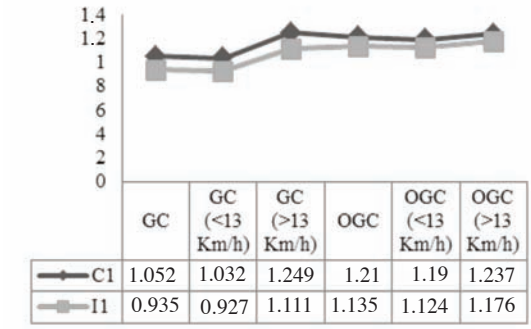
results were obtained by Ben Abdelkrim et al. (2007). Despite the lower values obtained by the I2, the accumulated fatigue seems that doesn't inhibit the ability to perform high-intensity movements. The increase of distance travelled in Zone 1 (0-6.9 Km/h) in games realized with time-out is complemented by a decrease in distance covered in other zones. These results suggest an adaption of the players, with lower paced game as consequence of accumulated fatigue. The analysis of the number, mean covered distance and mean time (s) of the actions performed in Zone 6 (> 18 km/h) had present, only, significant differences between C2 and I2, however, the results from our study are below than those reported in the study of Ben Abdelkrim et al. (2007), and could be explained by the lower level of preparation and competition of our sample.

The results from the HR_{max} showed that both games, continuous or interrupted, spent more time in the highest intensity zone (zone 4, ≥ 90% HR_{max}) and significant effects were found in zone 2 (75-84.9% HR_{max}) between the games realized with time-out. The higher values obtained by I2 are produced by the decrease of the distance covered at higher speeds zones.

In order to understand the variation in the spatial orientation of the teams, the values from the EnAp indicate differences between C1 and I1 suggesting the beneficial effect of a time-out in the adjustment and coordination of players actions, especially in lower velocities (≤ 13 Km/h). The players assume a more organized collective behavior, better understood and spatial-temporal coordinated. After the accumulated fatigue, the results from the EnAp indicate in I2 a better pattern of coordination of the team to the geometric center and geometric center of opposing team, than C2. The perception of a game performed a lower speed, as previously mentioned, might be the reason for this better coordination. In relation to the games performed with time-out, the results showed, in relation to the center of team, an improve in spatial orientation of team with accumulated fatigue. The slower paced game and the nonexistence of variation of distance covered by the players in zone 5 and 6 (≥ 16km/h) could sustain this argument.

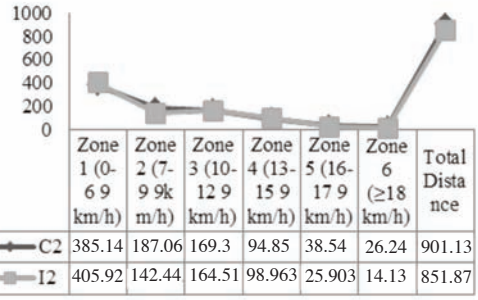
The main findings in this study in relation to collective behavior were that the accumulated fatigue and the time-out promote a better pattern of spatial coordination. In practical implications, these results suggested that the coaches could designing and implementing training programs based on intermittent exercises and exercises were fatigue are imposed in order to better achieve decision-making in collective principles, and consequently overall game performances.

Values to EnAp



	GC	GC (<13 Km/h)	GC (>13 Km/h)	OGC	OGC (<13 Km/h)	OGC (>13 Km/h)
C1	1.052	1.032	1.249	1.21	1.19	1.237
I1	0.935	0.927	1.111	1.135	1.124	1.176

Values for distance covered at different speed zones

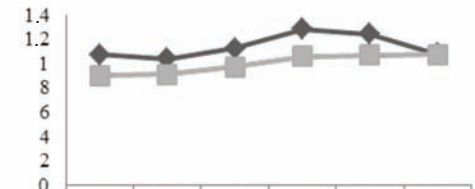


	Zone 1 (0-6 9 km/h)	Zone 2 (7-9 9k m/h)	Zone 3 (10-12 9 km/h)	Zone 4 (13-15 9 km/h)	Zone 5 (16-17 9 km/h)	Zone 6 (≥18 km/h)	Total Distance
C2	385.14	187.06	169.3	94.85	38.54	26.24	901.13
I2	405.92	142.44	164.51	98.963	25.903	14.13	851.87

Values for number of actions, time and mean distance at speeds > 18 km/h

	(> 18 km/h) (n)	Time in sprint (min)	Mean Distance (> 18 Km/h) (m)
C2	385.14	187.06	169.3
I2	405.915	142.44	164.51

Values for EnAp



	GC	GC (<13 Km/h)	GC (>13 Km/h)	OGC	OGC (<13 Km/h)	OGC (>13 Km/h)
C2	1.078	1.039	1.127	1.289	1.246	1.082
I2	0.902	0.912	0.977	1.064	1.072	1.079

Figure 1. Significant differences found between games with and without time-out (C1 Vs I1; C2 Vs I2).

EFECTOS DE LA FATIGA Y TIEMPOS MUERTOS EN LAS VARIABLES FISIOLÓGICAS, DE TIEMPO Y MOVIMIENTO Y EN LA DINÁMICA DE ORGANIZACIÓN ESPACIAL DE LOS EQUIPOS DE BALONCESTO

PALABRAS CLAVE: Baloncesto, Fatiga, GPS, Tiempo muerto.

RESUMEN: El objetivo de este estudio fue identificar los efectos de la fatiga en las variables fisiológicas, estándares de tiempo y movimiento y en la organización espacial de los equipos de baloncesto. La muestra del estudio consistió de 10 jugadores de baloncesto de categoría sub-18, con una edad media de 17.5 ± 0.3 años. Se han realizado dos sesiones: sesión 1: juego continuo (C1) 10 minutos + *yo-yo intermitent recovery test* (level 1) + 1 minuto de descanso + juego continuo 2 (C2) 10 minutos; sesión 2: juego de 5 minutos (I1) + tiempo muerto (1 minuto) + juego de 5 minutos + *yo-yo intermitent recovery test* (level 1) + juego de 5 minutos (I2) + tiempo muerto (1 minuto) + juego de 5 minutos. La frecuencia cardiaca máxima se obtuvo por *yo-yo intermitent recovery test* (level 1) y se registró por telemetría de radio de corto alcance (*Team System Polar, Polar Electro*, Finlandia), el análisis del tiempo y movimiento se ha obtenido mediante GPS (SPI Elite. *Sistemas GPSports*, Australia) y se ha utilizado una cámara digital para grabar el juego. Los resultados sugieren que la fatiga y tiempos de muertos mejoran los niveles de organización espacial del equipo. Además, los resultados muestran que con la fatiga, los jugadores recorren menos distancias totales y con velocidades más bajas.

EFEITOS DA FADIGA E DESCONTOS DE TEMPO EM VARIÁVEIS FISIOLÓGICAS, DE TEMPO E MOVIMENTO E EM PADRÕES DE ORGANIZAÇÃO ESPACIAL DAS EQUIPAS EM BASQUETEBOL

PALAVRAS CHAVE: Basquetebol, Fadiga, GPS, Desconto de Tempo.

RESUMO: O objectivo deste estudo foi identificar os efeitos da fadiga em variáveis fisiológicas, de tempo e movimento e padrões de organização espacial das equipas em basquetebol. A amostra de estudo foi constituída por 10 jogadores de basquetebol do escalão de sub-18 com uma média de idades de 17.5 ± 0.3 anos. Foram realizadas duas sessões: sessão a) jogo contínuo (C1) 10 minutos - *yo-yo intermitent recovery test* (nível 1) – 1 minuto desconto de tempo – jogo contínuo 2 (C2) 10 minutos. Sessão b) jogo interrompido (I1) 5 minutos – 1 minuto desconto de tempo – jogo 5 minutos – *yo-yo intermitent recovery test* (nível 1) – jogo interrompido (I2) 1 minuto desconto de tempo – jogo 5 minutos – 1 minuto desconto de tempo – jogo 5 minutos. A $FC_{máx}$ foi determinada pelo *yo-yo intermitent recovery test* (nível1) e registada por radiotelemetria de curto alcance (*Polar Team System*, *Polar Electro*, Finland), a análise de tempo e movimento foi obtida pelo GPS (SPI Elite. *GPSports Systems*, Australia), e foi usada uma camara digital para gravar o jogo. Os resultados sugerem que a fadiga e os descontos de tempo promovem melhores padrões de organização espacial. Adicionalmente os resultados demonstraram que com fadiga os jogadores percorrem uma distância total menor e em velocidades inferiores.

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