Intracycle speed and coordination vs fatigue in swimming

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Intracycle speed variations have been widely studied. However, few studies have focused on the fatigue effect on such intra-cycle speed in freestylers. The aim of this study was to analyse such effects. Hence, a synchronized speedmeter connected with a video camera was used and 17 swimmers were recorded with and without fatigue conditions. A complete cycle, four phases average speed and arms coordination were analysed in both conditions. There is a correlation of the average speed with phases 1 and 3 speed in both genders with and without fatigue. Also phase 2 speed in male and phase 4 in female swimmers are related to the average speed with fatigue. Coordination is related to the phase 4 in female swimmers with fatigue. Summarizing, the whole analysis of the partial speed and the coordination index gives us relevant information about intracycle kinematic responses of freestyle swimmers.

Keywords: *intracycle speed, fatigue, coordination index and freestyle.*

INTRODUCTION

The analyses of the speed variations carried out within a swim cycle provides information about the way in which the different phases of the cycle contribute to the swimmer's movement (2). The unequal application of the propulsion forces and the resistance forces to the advance is the cause of the changes of acceleration and, as a consequence, of the fluctuation of the speed during a complete swim cycle (4). Interaction between both generates fluctuations of the intracycle speed (5). A coordination index is used to evaluate freestyle coordination. This index is focused on the position of the upper limbs (3). For the study of the intracycle speed, 4 phases can be established in freestyle swimmers (6). Before and after appearing the muscular fatigue to a maximum intensity, the average speed of the complete cycle diminishes, the times of propulsion of the propulsive phases increase and differs neither in the percentage variations of the maximum and minimal speed, nor in the coefficient of variation of the speed (1). The aim of this study is to establish a model of changes of intracycle speed in freestylers in efforts of maximum intensity with and without fatigue and its relation with swimming coordination.

METHODS

Sample: 17 national level swimmers (10 males and 7 females) aged between 14 and 16. Equipment: In order to record the intracycle speed, a JLML MV-30m speedmeter was worn by the swimmers through a belt and wire. The sample frequency was 1000Hz. Such record was synchronized to an underwater video camera. The image registered to a frequency of 50 Hz. The synchronization of both signs is marked by a common base of times generated by the measuring computer. The video camera was located at 15 meters off the start line, and in a perpendicular way at a distance of 5 meters to the swimmer's movement. Intracycle velocities record protocol: swimmers performed two series at maximum speed. The first over a distance of 25m was considered “without fatigue” condition (A), while the second one over a 100m distance was as “with fatigue” condition (B). There was a break of about 10 seconds between the first 75m and the last 25m so as the swimmer could have the belt attached. There was a 10 min rest between first and second conditions. A complete cycle of the swimmer was selected as he was passing in front of the camera, about 15 meters from the start in both series (“with fatigue” and “without fatigue”). Data report: Each cycle was divided in four phases from the video pictures (table 1). The cycle was divided on the basis of the propulsive actions performed, so the insweep of an arm does not coincide with the propulsive action of the other arm. However, the upsweep and the downsweep do coincide in some instants with the opposite arm propulsive actions. Therefore, phase 1 coincides with the right arm insweep and phase 3 with the left arm insweep. Phases 2 and 4 start with the upsweep of one of the arms and finish with the downsweep of the opposite arm. The index of coordination (IC) was used for the evaluation of the coordination. This index is a percentage value on the total time of a complete cycle and there is zero when the end (purpose) of the propulsion of an arm with the beginning of another one coincides. IC is negative in case of a delay (dead time). It is positive if there exists overlapping of the actions of both arms (3). The dependent variables were: cycle length (CL), cycle frequency (CF), cycle index (CI), speed of cycle (V) and index of coordination (IC) as well as the average speed, and the speed of each one of the phases (Sph1, Sph2, Sph3 and Sph4). The statistical analysis was with the statistical package SPSS 11.5 and consisted of a descriptive analysis (comparison of related samples and independent samples) and of a correlational analysis (Pearson correlation coefficients) for the variables above mentioned

Table 1. Phases selected for the analysis intracycle

	phase 1(insweep right arm)	phase 2	phase 3 (insweep left arm)	phase 4
Start phase	Final of the downsweep right arm	start of the upsweep right arm	Final of the downsweep left arm	start of the upsweep left arm
Final phase	start of the upsweep right arm	Final of the downsweep left arm	start of the upsweep left arm	Final of the downsweep right arm

RESULTS

The table 2 shows the differences between the dependent variables CF (cycles/minute), CL (meters/cycle), CI (CL*V), V (meters/Second) and IC (%). According to the type of series, both male and female swimmers obtain significant differences in CF, V and CI. According to gender, in A series the significant differences are obtained in the CL, V and CI. In the B series only significant differences are obtained in V and in CI between genders.

Table 2. Differences between the dependent variables CF, CL, CI , V and IC

		Male				Female			
	Set	N	Mean	sd	p	N	Mean	sd	p
CF	A	10	56.87	4.29	0.000	7	54.75	6.78	0.002
CF	B	10	48.89	4.85		7	45.37	7.29	
CL	A	10	1.78*	0.12		7	1.60*	0.26	
CL	B	10	1.76	0.12		7	1.60	0.23	
S	A	10	1.68**	0.07	0.000	7	1.43**	0.09	0.001
S	B	10	1.42**	0.09		7	1.19**	0.13	
CI	A	10	3.02**	0.33	0.000	7	2.32**	0.36	0.001
CI	B	10	2.54**	0.23		7	1.85**	0.28	
IC	A	10	4.84	2.48		7	6.34	2.41	
IC	B	10	5.47	4.05		7	8.44	3.85	

Differences male-female * p<0.05 ** p<0.01

The intracycle analysis shows the differences between the average speeds in each of the phases (table 3 and graph 1). Thus, when the different speeds are compared between genders, only the Sph4 in the B series does not show significant differences. There are only significant differences between the Sph1 and the Sph2 in the B series from the analysis of the evolution of the speeds of the different phases in swimmers. In female swimmers, there are significant differences in both Sph1 and Sph2, as with Sph2 and Sph3 and between Sph3 and Sph4 in the A series. The differences found in the average speeds by phases in the A series with regard to the series B are significant in both genders.

Table 3. Statistics of the average speeds in each phase

							Same gender and set			Same gender and set B			
							Sph2	Sph3	Sph4	Sph1	Sph2	Sph3	Sph4
	Set	Gender	N	Mean	sd	p	p	p	p	p	p	p	p
Sph1	A	M	10	1.68	0.09	0.000				0.000			
		F	7	1.42	0.10		0.004			0.001			
Sph2	A	M	10	1.71	0.10	0.000					0.001		
		F	7	1.55	0.03			0.004			0.002		
Sph3	A	M	10	1.65	0.09	0.000						0.000	
		F	7	1.41	0.10				0.032			0.001	
Sph4	A	M	10	1.74	0.12	0.001							0.001
		F	7	1.52	0.09								0.004
Sph1	B	M	10	1.40	0.11	0.002	0.026						
		F	7	1.17	0.15								
Sph2	B	M	10	1.49	0.13	0.003							
		F	7	1.26	0.13								
Sph3	B	M	10	1.43	0.10	0.000							
		F	7	1.18	0.11								
Sph4	B	M	10	1.39	0.23								
		F	7	1.25	0.20								

The correlational analysis shows that, in A and B, S has a high and positive correlation ($r>0,8$; $p<0,01$) with Sph1 and Sph3 in both sexes. In B, Sph2 for the male swimmers ($r=0,8$; $p<0,01$) and Sph4 for the female swimmers ($r=0,9$; $p<0,01$) obtain a positive correlation. In B, IC shows a high and positive correlation ($r=0,9$; $p<0,01$)) in female swimmers with Sph4.

Table 4. Relationship average S and IC with S, Sph1, Sph2, Sph3 and Sph4 in female and male.

S	N	S phase 1	S phase 2	S phase 3	S phase 4	IC	S	S phase 1	S phase 2	S phase 3	S phase 4
$Male_A$	10	.84**	.55	.89**	.18	$Male_A$	0.14	0.41	-0.05	-0.13	0.02
$Male_B$	10	.84**	.77**	.96**	.24	$Male_B$	-0.02	-0.13	0.19	0.03	-0.23
$Female_A$	7	.96**	.67	.97**	.52	$Female_A$	-0.09	-0.01	0.27	-0.19	0.50
$Female_B$	7	.98**	.60	.99**	.92**	$Female_B$	0.79*	0.69	0.49	0.70	0.88**

* p< 0.05   ** p<0.01

DISCUSSION

The CL and the IC in fatigue do not differ with the values obtained without fatigue. CF, V and CI reduce their values in a significative way. This information contrasts with the reduction of CL and IC in other studies that analyze these variables at the beginning and at the end of a maximum effort (1). The difference between the results obtained with the present study can be caused due to the variability in which the swimmers response to the speed loss. The correlational analyses of these variables with the intracycle speed might facilitate information on how the best swimmers modify the CL and IC.

As for the speeds obtained in the different studied phases, the female swimmers obtain lower speeds that the male swimmers in all the phases and series, except in the phase 4 and in conditions of fatigue. Without fatigue, the speeds of the phases 2 and 4 are higher than the speeds of the phases 1 and 3. This is significant as for of the female swimmers is concerned. With fatigue, the differences between the speeds are not significant. According to these results, the changes of speed for phases that take are produced by female swimmers in the A series can only be emphasized as a repetitive pattern.

Also the losses of speed obtained in the different studied phases do respond to repetitive pattern in both genders. Concerning the changes of speed in the described phases in this study, it would be necessary to do new studies with more swimmers to determine, if so, the patterns of change of the best swimmers.

The results allow determining that the best swimmers obtain the highest speeds in the phases 1 and 3 in both series. This distinguishes the importance of these phases in the performance of both male and female swimmers. Contrary to this, only the best male swimmers have higher speeds in the phase 2 in situation of fatigue, as well as the best female swimmers obtain the higher speeds in the phase 4 in situation of fatigue.

These relations in the phases 2 and 4 may occur because the best swimmers have a better balance between the propulsive forces and the resistance forces. As well as the fatigue in the worst swimmers might impede the coordination body/arms/legs in a few phases where the body rolling is maximum (4 and 5).

In this study, the IC does not change when the swimmers are fatigued. This fact contrasts with IC's decrease in other studies (1). Hereby, IC's increase obtained before diminishing speeds (3) cannot take place when the speed loss is due to a situation of fatigue as it is described in the present study. For this the IC cannot contribute with relevant information about the changes of coordination in situations of fatigue.

The correlational study of the IC with the average intracycle speeds and with the average speeds in the different phases shows that no relation exists between the best male swimmers and the type of coordination. On the other hand, in the female swimmers, the established relation indicates that the swimming improvements in situation of fatigue have a higher IC. Hereby it is possible to indicate that the best female swimmers, when tired, reach major speeds due to a higher IC. Also they obtain a high relation between the speed in the phase 4 and IC's values, which can emphasize the importance of supporting IC's high values to reduce the speed losses registered of Sf4 in conditions of fatigue. The speed of the phase 4 in conditions of fatigue does not obtain significant differences between male and female swimmers. This descriptive information might be justified by the increase of the IC in the female swimmers in conditions of fatigue and its high correlation with the speed in the phase 4.

CONCLUSION

1-When swimming without fatigue, Sph1 and Sph3 seem to be good indicators of the performance. 2-When swimming with fatigue, Sph1, Sph2 and Sph3 for the male swimmers and Sph1, Sph3 and Sph4 for the female swimmers ones are good indicators of the performance. 3-In the female swimmers, a high IC when swimming with fatigue is related to a better performance in S and Sph4. In conclusion, the whole analysis of the IC and of the Sph1, Sph2, Sph3 and Sph4, can contribute to relevant information about the most suitable type of coordination when swimming in different conditions of fatigue.

REFERENCES

1. Alberty M, Hespel JM, Huot-Marchand F, Pelayo P (2003). Effect de la fatigue sur la vitesse de nage instantanee et sur les coordinations en crawl. 3èmes Journées Specialisées de notation. Lille: Publibook.
2. Chollet, D (1997). Natattion sportive: Aproche scientifique. Paris: Vigot
3. Chollet D, Chalies S, Chatard JC (2000). A new index of coordination for the crawl: description and usefulness. Int J Sport Med, 21: 54-59
4. D´Aquisto GL, Costill DL (1998). Relationship between intracicle linear body speed fluctuations, power and sprint breaststroke performance. The Journal of swimming Research, 13: 8-14
5. Kreighbaum E, Barthels KM (1990) Biomechanics. A Qualitative Approach for Studying Human Movement. New York: Macmillan Publishing Company
6. Tella V, Jordá J, Madera J, Saavedra P, Benavent J, Llana S (2005). Fatigue effects on intracycle speed in freestylers. 1er Congres Mundial de natation. Paris: INSEP