33rd International Conference on Biomechanics in Sports, Poitiers, France, June 29 - July 3, 2015
Floren Colloud, Mathieu Domalain & Tony Monnet (Editors)
Equipment / Instrumentation

TECHNICAL AND PHYSIOLOGICAL RESPONSES OF SWIMMING CRAWL-STROKE USING HAND PADDLES, FINS AND SNORKEL IN SWIMMING FLUME: A PILOT STUDY

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We evaluated the effect on front-crawl during a 5 minutes effort in a swimming flume, at a speed 95% of 400m wearing swimming paddles, fins or frontal snorkel. It was evaluated measuring changes on stroke frequency, stroke length, ERP, lactate concentration and pulse rate post-effort. An one-way repeated measures ANOVA showed the stroke frequency was significantly affected $F(2.3, 27.6) = 20.69$ $p<0.01$, the stroke length $F(2.67, 32.23) = 21.56$ $p<0.01$, the RPE $F(25.5, 36.0) = 14.87$ $p<0.01$, the lactate on 3' $F(2.3, 27.8) = 11.30$ $p<0.01$, the lactate on 5' $F(2.8, 33.5) = 12.80$ $p<0.01$ and the pulse rate $F(3, 30) = 4.73$ $p<0.01$. The use of swimming paddles and fins increases the stroke efficiency and reduce the load of the exercise while the use of snorkel did not differ from normal crawl-stroke.

KEY WORDS: swimming training aids, blood lactate, heart rate, RPE.

INTRODUCTION: The use of training equipment has a long tradition in competitive swimming. Devices as fins, hand paddles and snorkels of different characteristics are frequently used by most of the swimming squads of all training levels and age groups.
The use of swimming aids as hand paddles or fins during swimming training contributes to greater swimming efficiency (Gourgoulis et al., 2008; Messinis et al., 2014; Zamparo, Pendergast, Termin, & Minetti, 2002), decreasing the stroke rate at similar efforts, or the intensity measured with pulse rate or lactate. Other devices, as the snorkel, has been analysed, in most of occasions, to evaluate its applicability on VO2 kinetic studies (Fernandes, Figueiredo, & Vilas-Boas, 2013) or crawl-stroke arm coordination symmetry that is improved with this device (Seifert, Chehensse, Tourny-Chollet, Lemaitre, & Chollet, 2008).

The study aims to evaluate the effect on front-crawl swimming performance in a 5 minutes effort developed in a swimming flume, at a speed 95% of the best 400m, when the swimmer wear swimming paddles, fins or frontal snorkel compared with front-crawl swimming. This effect will be evaluated measuring the predicted changes on stroke frequency, stroke length, ERP, lactate concentration post-effort (3 and 5 minutes), pulse rate post-effort.

METHODS: Participants: Thirteen subjects (8 male and 5 females) participated in the study. Basic characteristics are shown in the table 1. The Institutional Ethic's Committee approved the experimental protocol and the subjects were informed about the methods and aims of the study and gave their written informed consent prior to participation. To avoid compromising the results of this study all participants were instructed about food intake rules and not participate in any exhaustive workout on the days of testing. They were asked to swim 5 minutes front-crawl in a swimming flume (Endless pool, Elite, 7.5 HP, that has been previously calibrated with 3 flow-meters) under the next experimental conditions: a) standard front-crawl; b) front-crawl with snorkel (Aquasphere Front Purge); c) front-crawl with fins (AquaSphere Zip VX Fin) and; with swimming paddles (AquaSphere Ergoflex). Each subject performed each experimental condition in a randomly assigned order with a difference of time of forty-eight hours. Before each trial a standardized warm-up was performed followed of five minutes rest. The intensity was set a 95% of their best performance 400m freestyle. It was measured about a week before the beginning of the experiments.

Table 1: Characteristics of participants on the study (eight male and five female)

Variables	Mean±SD
N	13
Age (Years)	20.3±2.43
Height (cm)	170.3±5.36
Weight (kg)	61.52±8.98
Arm Spam (cm)	175.84±5.7
Mean time on 400m freestyle (s)	345.56±51.68
Mean velocity in the swimming flume (m/s)	1.16±0.18

Instruments: During all testing trials, four cameras connected to a video multiplexor (Omikron, Barcelona, Spain) allowed the simultaneous record to a SONY MiniDV (GV-HD700) of the 3 submergible colour cameras (SONY HAD CCD, 50 Hz) and one overwater cameras (see figure 1). Stroke rate (SR, Hz). was measured in this study during the last minute and determined over five cycles [5 cycles/time]. Stroke length was then calculated dividing swimming speed (V) by SR in Hz and expressed as the result of the distance swum during a complete cycle (m/cycle). Once each trial was completed, heart rate (measured using a CardioSwim, [Freelap, Fleurier, Switzerland]) and Börg´s rating of perceived exertion (RPE) were registered. Blood lactate concentration (BLa, $mmol \cdot l^{-1}$) was taken three and five minutes after finishing the test from the fingertip, using a portable blood lactate analyser Lactate Pro (ARKRAY).

Statistical Analysis: Means and standard deviation or standard error has been calculated for each variable. One-way repeated measures ANOVA has been performed to find the effect on the variables studied under the experimental conditions. Sphericity was tested applying the Mauchly's test. If data violates the sphericity assumption, a specific correction was applied to produce a valid F-ratio. Bonferroni post-hoc test was applied to compare the experimental conditions averages. All the analysis was performed using IBM SPSS Statistics v22. The significance level was set at 0,05.

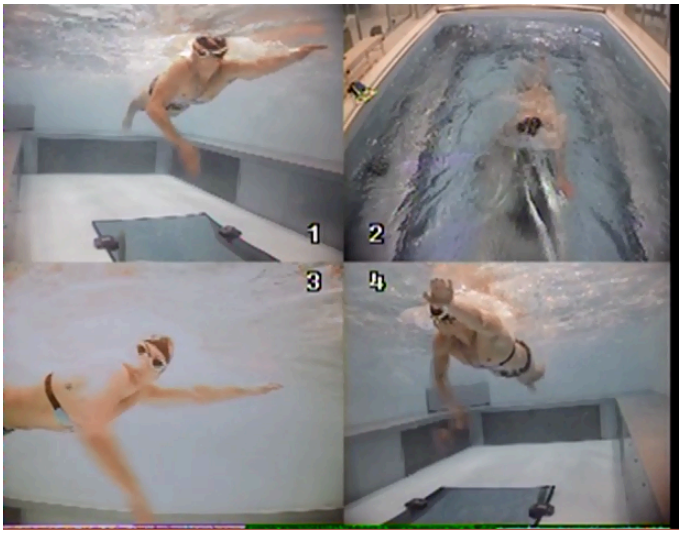

Figure 1: Sample picture of the video recording set-up installed in the swimming flume.

RESULTS: All the means of the variables studied for each experimental condition are shown in the table 2. In all cases the Mauchly's test indicated that the assumption of the sphericity had not been violated. The results of the one-way repeated measures ANOVA show that stroke frequency was significantly affected by the experimental conditions $F(2.3, 27.6) =$

20.69 p<0.01, stroke length F(2.67, 32.23) = 21.56 p<0.01, RPE F(25.5, 36.0) = 14.87 p<0.01, lactate on 3' F(2.3, 27.8) = 11.30 p<0.01, lactate on 5' F(2.8, 33.5) = 12.80 p<0.01 and heart rate F(3, 30) = 4.73 p<0.01.Results of the Bonferroni post-hoc tests are included in the table 2. We compared exclusively crawl-stroke means with each experimental condition. Other variables combination is not performed in this occasion. The experimental conditions crawl-stroke with hand-paddles and with fins were significantly different (lower) in all the variables analysed compared with crawl-stroke, except heart rate where only 11 subjects were analysed. No differences were found with the crawl stroke with snorkel.

Table 2: Means and standard error of the variables analysed in the study, grouped by experimental conditions (n=13)

Variables	Crawl-Stroke	Crawl-Stroke With Hand Paddles	Crawl-Stroke With Fins	Crawl-Stroke With Snorkel
Lactate 3' (mmol·l^{-1})	5.72±0.60	4.43±0.43*	3.80±0.45**	5.02±0.40
Lactate 5' (mmol·l^{-1})	5.42±0.72	4.13±0.49*	3.32±0.44**	5.24±0.47
Heart Rate (beats/min)	131.27±10.65	148.18±7.67	123.73±7.72	136.90±10.19
Stroke Frequency (Hz)	0.50±0.02	0.43±0.02*	0.42±0.02**	0.50±0.02
Stroke Length (m/cic)	2.61±0.113	3.05±0.16*	3.13±0.17**	2.60±0.11
RPE	13.54±0.45	11.85±0.48*	10.23±0.43**	12.62±0.37

* Significant difference (p<0.05) between crawl-stroke and crawl-stroke with hand paddles, ** Significant difference (p<0.05) between crawl-stroke and crawl-stroke with fins.

DISCUSSION: Our results showed significant differences in the variables studied between a 5 minutes effort crawl-stroke and crawl-stroke with paddles and crawl-stroke with fins. In both situations the results demonstrated an increase in the efficiency, thanks to the reduction of the stroke rate, an increase of the stroke length and lower values of lactate concentration, pulse rate and RPE. This situation did not happen when the subjects performed the 5 minutes crawl-stroke effort wearing a snorkel. The physiological variables were smaller but not significant, while the technical variables were very similar. This is the first study where the effect of three types of equipment is evaluated.

The effect on lactate concentrations that decreased about a 23% using hand paddles and a 37% using fins demonstrate a clear reduction on the effort intensity. An additional hand surface provided by the hand paddles or propelling surface in the feet thanks to the fins is a clear advantage to the swimmer that increases its propelling efficiency. Similar results were obtained in studies where only one experimental condition was compared to the crawl-stroke, as swimming with fins (Zamparo, Pendergast, Termin, & Minetti, 2006; Zamparo et al., 2002). In the case of the use of hand paddles the studies did not compare lactate concentration and are more focused on biomechanical variables as stroke frequency or stroke length. Our reported reduction of stroke frequency or increase of the stroke length has been similarly obtained when these variables were compared after three 100m trials wearing hand paddles with two different sizes (Lopez-Plaza, Alacid, Lopez-Minarro, & Muyor, 2012). When this comparison is made in a detailed 3D analysis (Gourgoulis et al., 2008), the stroke length is mostly modified with the swimming velocity (kept constant in our study).

The similar results found in our study between crawl-stroke and crawl-stroke with snorkel (but with a smaller reduction in the intensity not significant) was not predicted. We expected in this case a higher intensity due to the possible respiratory difficulties. But our results did not confirm this effect. In a similar situation, to evaluate the VO2, no differences were found (Reis et al., 2010), but these authors compared two types of breath collection procedures. Only a possible change on the head (that should be confirmed) or a more symmetrical stroke (Seifert et al., 2008) could explain the compensation effect to obtain similar o reduced intensity as our results demonstrate.

Additional analysis will be developed in the near future, including more subjects, a more detailed analysis of heart rate during the 5 minutes effort and the index of coordination evolution during the effort, to try to find clear differences between the experimental conditions presented in this study.

CONCLUSION: This study evaluates the effect on front-crawl swimming when the swimmer wear swimming paddles, fins or frontal snorkel compared with front-crawl swimming. The use of swimming paddles and fins increases the stroke efficiency and reduce the load of the exercise while the use of snorkel did not differ from normal crawl-stroke.

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Acknowledgement

Project funded by Spanish Ministry of Science and Innovation, VI National Plan for Research, Development and Technological Innovation (I+D+i) 2005-2008, DEP2009-08411: “ESTUDIO DE LOS MOVIMIENTOS PROPULSIVOS EN NATACION ("SCULLING") APLICANDO ANALISIS 3D, VISUALIZACION DE FLUIDOS, CFD Y PIV”