

SWIMMING BODYSUIT IN ALL-OUT AND CONSTANT-PACE TRIALS

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Abstract. There is no doubt that many swimmers do benefit from wearing bodysuit. The questions whether these suits improve performance and should they be allowed in competition are still being asked. The first aim of the study was to determine the influence of swimming suit (FS) on 50 m crawl overall time. Furthermore, possible differences of different segments of the race as well as their impact on total time for two different conditions were also examined. Fifteen male national and international level swimmers completed two trials of 50 m-crawl swimming in regular suit and swimming body suit. Block-off time, Start time, Turn time, Split time, Race time and number of strokes per 50 m were recorded. The second part of the study analysed the differences in fatigue parameters (heart rate, blood lactate concentrations, and number of strokes) in 400 m crawl constant pace test. The results show that the FS suit appears to enhance performance on 50 m crawls. Furthermore turn time, split time and race time were significantly faster while swimming wearing FS. Most of the difference (0.31 s) was gained after first 25 m and turn had been completed. In this research swimming body suit improved performance by 1.6% (0.41 s). It appears that the suit is more beneficial for start and turn (streamlining and kicking) than for swimming the full stroke. The 400 m-crawl constant pace trial determined the differences in fatigue parameters. The post-swim blood lactate concentrations and heart rate values were significantly lower while swimming in the FS suit even though there were no differences in number of strokes. These findings suggest that the FS suit seems to reduce the level of fatigue during 400 m-crawl constant pace test.

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Key words: Swimming suit – Bodysuit - Swimming performance - Fatigue

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Introduction

The questions whether the swimming suits improve performance and should they be allowed in competition are still being asked [7] Furthermore, the question whether the long suit represents a serious threat to competitive swimming has also been raised [6]. Even though the suits are widespread, there is a considerable lack of studies dealing with its influence on speed or fatigue. Only a couple of references could be found in major sport-science journals, dealing mostly with biomechanical problems of swimming with or without a swimming suit.

After many years of research the manufacturer developed the swimming body suit with material designed to reduce resistance. The suit mimics shark's skin. At the Sidney 2000 Games 83% of all medals were won by swimmers wearing the swimsuit. The swimming body suits were first introduced at the FINA World Swimming Championship (Athena, March, 2000). To date over 60 swimmers wearing swimming body suit have broken world records. Manufacturers claim that the suit reduces friction drag and that the body slips through water more smoothly. The suit appears to reduce muscle vibration thus increasing productivity from muscles. According to the manufacturer, the suit reduces resistance by 7% and improve results by 3%. Some test in flumes have shown that passive drag can be reduced as much as 10% in some swimming positions when wearing the full-body swimsuit. The benefits decrease as the swimmers perform the flutter kick and full stroke [1]. Scientists still dwell whether the suit has beneficial effect on buoyancy. The manufacturer claims that the suit is neutrally buoyant [8]. A study of underwater weight of swimmers when wearing bodysuit indicated also that the swimsuit did not help buoyancy [1] but swimmers claim that the suit helps their legs be higher in the water. Distance swimmers, on the other hand, reported that the suit feel buoyant for the first half of the race but after that they begin to feel "dragged down" by the suit.

Drag reduction and result improvement issue: A basic problem with researching the effects of bodysuits on swimming performance is that the testing itself cannot be done in competitive environment. Those made in flume may not be good indicators for establishing the real effect of swimming body suit suits.

Method used by Toussaint et al. with MAD system [9] is considered to yield very good estimation of active drag. In their research a non-significant reduction in drag of 2% ($P=0.31$) was found. On the other side the manufacturer claims [8] that swimming body suit reduces passive drag by 7% and improves results by 3%.

There have been several researches where test conclusions were based not on drag reductions but on swimming speed. Swimmers would conduct a practical test



in regular and traditional suit. The main problem of these researches is that swimmers were not shaven when wearing regular suits. Also a regular suit can increase drag resistance if stretched and loosen. Some coaches estimate a significant advantage of bodysuit on underwater kicking and above-water swimming in crawl stroke and butterfly; no advantage for backstroke and negative effects on breaststroke. An international level backstroker and butterfly specialist compared full bodysuit and regular suit and it was found that swimming velocity was higher when wearing the bodysuit [8]. The total work performed comprises also the work needed to overcome hydrodynamic resistance which can be calculated from measures of active drag. Since the drag contributes to fatigue [10], we might conclude that minimizing the resistance and the drag, the parameters of fatigue might also be reduced

The aim of the study was to test the influence of swimming body suit in two different conditions. First, we wanted to determine the influence of bodysuit on the 50 m crawl overall time and to determine whether particular parts of the race significantly contribute to different total time while swimming in the briefs and in the swimsuit. In the second test our objective was to determine the influence of swimming body suit on physiological parameters of fatigue while performing 400 m constant velocity test

Materials and Methods

The sample comprised 15 male swimmers of national and international level, mean age 18.3 ± 2.7 . The subjects were tested at the end of the physical conditioning phase of the season. Measurements were performed in two separate weeks. The 50m and 400m distances were selected because 50 m represents speed test and 400m crawl represents appropriate distance to test the fatigue.

Day	Day	Day	Day	Day	Day	Day	Day	Day	Day	Day
1	2	3	4	5	6	7	8	9	10	11
							HRb LAB			HRb, LAB
50 m			50 m				400 m			400 m
briefs			suit				briefs			suit
							HRa, LAa			HRa, LAa

Fig. 1

Study protocol (HR- heart rate., LA- lactate; b- before test, a- after test)



Part 1. All-out 50 m test: During the first week the subjects completed the 50 m all out tests. First swim was performed in regular suit and second, 72 h later, in the swimming body suit.

Six variables were measured to test the influence of swimming body suit on speed:

- Block-off time
- Start time (15 m)
- Turn time (7.5-7.5)
- Split time (25 m)
- Race time (50 m)
- Number of strokes per 50 m

Part 2. Constant pace 400 m test: In the following week, the 400m constant pace tests were performed. The pace lights were placed at the bottom of the pool to dictate the pace set for each swimmer individually. Swimmers completed both 400 at the same pace (10 seconds of their personal best time). Five variables were measured to test the influence of swimming body suit on endurance:

- Heart rate, before the test (HR_b)
- Heart rate, after the test (HR_a)
- Blood lactate (mmol/l), before the test (LA_b)
- Blood lactate (mmol/l), after the test (LA_a)
- Average number of strokes per 50 m (N of Str.)

Heart rate and blood lactate before the test were measured in order to exclude any differences in fatigue parameters at the start of both tests.

Data were analysed by means of descriptive statistics, Student t-test for independent samples and multiple regression analysis.

Results

PART 1: All-out 50 m test: Descriptive statistics and Student-t-test were used to compare the data obtained in two trials, with and without Fast-Skin swimming suit (Table 1).



Table 1

Means, SD and P level of significance between two trials

	Regular Suit		Body Suit		P values
	Mean	SD	Mean	SD	
Block-off time (s)	0.76	0.54	0.78	0.50	0.135
Start time (s)	6.34	0.36	6.29	0.36	0.287
Turn time (s)	7.44	0.39	7.33	0.44	0.023*
Split time –25 m (s)	12.34	0.65	12.14	0.66	0.0001*
Race time –50 m (s)	25.53	1.29	25.12	1.30	0.0003*
N of strokes	37.5	3.38	37.46	3.13	0.843

*Marked values significant on level $P < 0.05$

Multiple regression analysis was used in order to determine the influence of particular part of the race on total race time while swimming in regular and swimming body suit (Table 2).

Table 2

Regression summary (influence of particular part of the race on total race time while swimming in regular and swimming body suit)

	Regular Suit		Bodysuit Suit	
	BETA	P-level	BETA	P-level
Block-off time	0.08	0.083	-0.06	0.253
Start time	-0.12	0.531	0.18	0.384
Turn time	0.18	0.264	0.57	0.021*
Split time (25m)	0.96	0.003*	0.18	0.465
Num. of strokes	0.05	0.144	0.04	0.202

*Marked values significant on level $P < 0.05$

The first part of the race (Split time at 25 m) had the highest influence on the overall 50 m time while swimming in the regular suit which can be concluded by analysing individual variables when swimming in regular suit. The turn time was the most significant variable in predicting the race time while swimming in the swimming body suit (Table 2).



PART 2. Constant pace 400 m test: Table 3 illustrates the values of mean, SD and (non)-significant differences between the variables in two tests. Although the heart rate before the test was higher when swimmers had their suits it was not statistically significant and could be explained by the physical effort caused by putting the suits on. However,, the post-swim results show that swimmers had significantly lower heart rate after the test was completed in the suit. The blood lactate after the test when wearing the suit was also significantly lower. No significant difference was determined for the average number of strokes (Table 3).

Table 3

Means, SD and p values for lactate (LA), heart rate (HR) and number of strokes per 50/m

	Regular Suit		Fastkin Suit		P values
	Mean	SD	Mean	SD	
HR before 400m	85	11.74	93	19.54	0.292
HR after 400m	154	13.10	143	12.32	0.021*
LA before 400m	1.81	0.64	1.70	0.29	0.661
LA after 400m	8.20	2.37	6.42	2.41	0.002*
N of strokes	32.2	4.52	30.4	3.83	0.005*

Discussion

The bodysuit appears to enhance performance in 50 m crawls. The results indicate that turn time, split time and race time were significantly faster in the second swim. Swimmers performed faster turn, 25m and 50m by 0,11 sec, 0,20 sec, and 0,41 sec respectively when wearing swimming body suit. Most of the difference (0.31 s) originated from first 25m and the turn. Although the block off time in the body. Further analysis revealed that only one swimmer was slower while wearing the suit. Altogether, swimming body suit improved performance by 1.6 % (0.41 s). Additionally, we confirmed some previous findings that swimming body suit improves performance more through the improvement of the diving phase meaning during the turns and less during the swimming phase [2,9]. It appears that the suit is more beneficial for start and turn (streamlining and kicking) than for swimming the full stroke.

The second part of the study focused on the parameters representing fatigue. A limited number of studies, were focused on velocity during all-out tests, and to our knowledge, only one study [5] examined the effect of the suit at submaximal



swimming performance. In our study, lower post-trial lactate values are in contradiction to the previously published paper by Roberts *et al.* [5]. In that study the better results were accompanied by increase in oxygen consumption as well as the increase in blood lactate concentration. The difference between these two studies might originate from the fact that the constant-pace velocity was higher in our study because it was set in a way the swimmer would complete 400 m in 10 s off their best performance. Also, the distance was twice as large (400 m vs. 183 m) so the higher lactate concentrations were achieved altogether. Heart rate values were in concordance to the blood lactate values meaning the lower values measured after swimming in FS suit. Additional analysis showed that swimmers had lower and constant stroke rate during the entire race when wearing the leg suit (first 200 they averaged 30.4 strokes per 50 meters and in second 200 they had 31.8 strokes). When swimming in regular suit they applied on average 31.3 strokes in the first half of the test, and their stroke rate deteriorated in the second half (34.4). This would be contrary to the beliefs that the suit becomes "drag suit" after 200 m, because the fabric absorbs the water.

According to the results in both tests the bodysuit might have an influence on buoyancy. In the 50 m crawl trial; the most of the difference in speed was gained during the diving and gliding phase (most notably during start and turn,) and no difference was observed while swimming. Moreover, in the second half of 400 m trial, when we usually expect higher front resistance (caused by fatigue and sinking legs) [4], the subjects swimming in bodysuit sustained the same stroke frequency as in the first 200m with lower lactate values, which was not observed while wearing regular suit.

The results of this study could point to the fact that swimming body suit appeared to have beneficial effect on endurance; and it seemed that the swimmers fatigued less in the bodysuit for having lower heart rate and blood lactate at the same speed. Additionally the study showed that swimmers had fewer strokes in 400 m (~ 2 strokes/50 m.) and for the same result when swimming in bodysuit. Swimmers seemed to benefit the most in second half of the 400 test for having fewer strokes (~ 3 strokes/50 m) when wearing the swimming body suit. The interesting fact was observed in statements that were made by the swimmers, as they all claimed beneficial effect of the FS suit from the psychological point of view (positive motivation) so the further investigations should include the that component also and encompass collaboration with exercise psychologists. In conclusion, as the obtained results are in contradiction with the results of the similar study of Roberts *et al.* [5], but confirm what Mollendorf *et al.* [3] had found, we think more detailed research should be performed.



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