EFFECT OF FAST-SKIN BODY SUIT ON PROPULSION IN FOUR STROKES BY USING INDIRECT MEASUREMENT OF ACTIVE DRAG (IMAD)

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The effect of Fast- skin suit compared to conventional swimsuits on propulsion in four strokes in 16 female national-level swimmers was studied. The propulsion was estimated by Indirect Measurement of Active Drag (IMAD). IMAD is an estimate of the overall propulsive drag on a swimmer measured in conditions near maximal speed. Remarkable difference in propulsive force has been obtained for butterfly swim: 15%, while 5.2% was achieved for backstroke. Our findings also showed that Fast-skin effect is more important in breaststroke; 9.5% than in even front crawl; 7.9%. The method has also enabled us to find out the changes in mean velocities; 5.7% for butterfly and 1.8% for back crawl and for maximal velocities 16.5% for butterfly and 3.4% for back crawl.

KEY WORDS: comparison, velocities, drag force, four strokes, swimming

INTRODUCTION:

The total water resistance (drag) consists of skin friction, pressure drag and wave-making resistance. Skin friction has got special importance and swimwear manufacturers have developed fabrics which supposedly reduce the friction of water flowing over the swimsuit. Toussaint et al., (1988b, 2002), using Measuring Active Drag (MAD), showed that friction drag was negligible (<5% of total drag) given the high Reynolds numbers (>10^5) that occur during swimming. The manufacturer (Speedo) has also claimed that a swimmer can retain a better position in water with a Fast-skin, which reduces form and friction drag. Combined with fabric that reduces friction drag, Fast-skin would contribute to the overall reduction of total drag Toussaint et al., (2002). The aim of the present study was to examine the potential reduction of active drag using the Fast-skin suit in four strokes using IMAD method, Shahbazi and Sanders (2002, 2004).

METHODS:

In order to estimate the influence of Fast-skin, total drag for sixteen female national-level swimmers was measured while wearing the Fast-skin suit and again wearing conventional swimwear. The measurements were using the IMAD method, whose validity has already been verified by filming and reliability by comparing with other methods (Shahbazi & Sanders, 2002 and 2004). The swimmers swam 10 meters distance, four trials with enough rest in between, from still position and stopped swimming at the end of this distance and glided as far as they could. The time of 10 meters swim and the glided distance, in all four strokes, were then put into the formulae suggested by the IMAD method to estimate the propulsion in two cases; with and without Fast-skin suit.

The IMAD method is based on 2D video measurements of time of 10 meters swim, therefore the equation of motion of the swimmer in water was proposed by Shahbazi and Sanders (2002, 2004) as followings:

$$F_P - (C_1 V + C_2 V^2) = M dv/dt \qquad (1)$$

C_1 and C_2 are the hydrodynamic coefficients, which are given as:

$$C_1 = \frac{2MV}{X+10} \qquad (2)$$

V is the mean velocity in 10-m swim, X is the glided distance, M is the swimmer mass, and

$$C_2 = M/X \qquad (3)$$

The limit speed V_L is given as:

$$V_L = 0.5[C_1 / C_2 + \sqrt{(C_1/C_2)^2 + 4MV/C_2.t}\,] \quad (4)$$

V_L is the maximum speed the swimmer can reach in 10-m swim.
By inserting these values in the following relationship, the propulsive force, which at limit speed equals the drag force; can be obtained:

$$F_P = C_1 V_L + C_2 V_L^2 \quad (5)$$

RESULTS AND DISCUSSION:
All subjects used the Fast-skin bodysuit, in which trunk and legs are covered, while the arms remained bare. The effect on propulsion was evaluated by comparing the estimated propulsion value obtained with the Fast-skin and with the conventional swimwear. In Table 1, the mean values of swimmers characteristics such as, T: time of 10 meters swim, X: the glide distance, V_{Mean}: mean velocity, hydrodynamic coefficients: C_1 and C_2, V_L: the maximal velocity, and finally the propulsive force: F_P in all four strokes with and without Fast-skin suit is presented. In order to find out how much the Fast-skin could affect the parameters and specially the propulsive force, individual differences, in percentage, with respect to the values with conventional swimwear, are presented in Table 2. In each stroke, the propulsive force value with Fast-skin is higher than its value with conventional swimwear. Accordingly, the mean velocity increases while drag force reduces with respect to their values with conventional suit. T test has been used to find out the significance of our findings at α=0.05, which is indicated in Table 2. In column 2 of Table 2, the reduction in time of 10 meters swim with Fast-skin is maximum for butterfly swim; 5.7% and the minimum reduction is for back crawl; 1.8%. This seems reasonable because in butterfly swim the frictional drag is more important than in back crawl. In column four the change in mean velocity with Fast-skin supports well the gain in time.

Table 1- Swimmers' different parameters mean values ± SD in all strokes with Fast-Skin and with Ordinary Suit

Swim-types	T Sec.	X m	Vmean m/s	C1 Ns/m	C2 Ns²/m²	VL m/s	FP N
FC FS	6.86±0.23	4.89±0.38	1.46±0.08	10.09±1.6	10.91±1.5	1.61±0.13	44.32±2.3
FC OS	7.04±0.28	4.75±0.41	1.43±0.12	10.27±1.7	11.09±1.9	1.55±0.11	41.07±3.3
BC FS	7.76±0.29	6.27±0.43	1.29±0.13	9.83±1.4	9.92±1.3	1.53±0.14	42.37±2.8
BC OS	7.92±0.25	5.67±0.38	1.27±0.11	10.02±1.7	10.15±1.6	1.47±0.15	40.33±2.9
BS FS	8.84±0.22	4.85±032	1.13±0.09	8.72±1.1	11.18±1.9	1.24±0.16	27.25±1.7
BS OS	9.15±0.24	4.33±0.43	1.09±0.07	9.03±1.9	12.47±1.7	1.12±0.13	24.89±1.8
BF FS	7.49±0.23	6.19±0.46	1.34±0.12	9.76±1.8	8.76±1.1	1.82±0.23	46.68±2.9
BF OS	7.92±0.27	5.73±043	1.26±0.13	10.09±1.7	10.04±1.2	1.52±0.18	40.58±2.7

FC: Front Crawl, BC: Back crawl, BS: Breast Stroke, BF: Butterfly, FS: Fast Skin, OS: Ordinary Suit

Fast-skin had an effective decrease on hydrodynamic coefficient C_2, which would also affect on drag force effectively. As can be noticed, the greatest decrease is for butterfly swim; 14.6% and then for breaststroke; 10.4%, while the minimum is for front crawl; 1.8% and back crawl; 2.3%. Our observations have not shown any significant decrease in hydrodynamic C_1 that means that the drag force is mainly determined by $C_2V_L^2$ rather than C_1V_L.
Finally, in third column the propulsive forces are presented in which again the maximum increase is for butterfly swim; 15%, while the minimum: 5.2% is for backstroke. Conversely to the results reported by Toussaint et al., (2002), our findings show a good increase in propulsive force of 7.9% in front crawl which supports the claim of manufacturer. Contrary to MAD, which is not able to analyze any other strokes except front crawl, the IMAD enabled us not only to analyze the front crawl but also to go through other strokes and find out that the minimum percentage of drag force or in other words, the maximum percentage of increase in propulsive force was found for butterfly swim; 15%. In conclusion, the present observations

corroborate well the reduction of 7.5% in drag force which is claimed by the manufacturer and conversely to the work done by Toussaint et al. (2002).

Table 2- The difference (in percentage) of swimmers parameters & significance

Swim types	% T	% F	%Vm	t	α	P
Front Crawl	-2.1	7.9	2.2	-7.02	0.05	<0.02
Back Crawl	-1.8	5.2	1.8	-4.89	0.05	<0.04
Breaststroke	-3.6	9.5	3.6	-4.60	0.05	<0.05
Butterfly	-5.7	15	5.7	-4.63	0.05	<0.03

On Fig. 1, the dependence of propulsive force on swimmers mean velocities are depicted. The upper figure shows a lower dependence (0.922) for Fast-skin, while lower figure shows a higher dependence (0.977). This observation shows that with Fast-skin drag force is less dependent on velocity. Our statistical study revealed finally that the Fast-skin in all four strokes reduced the drag force and the time of 10m swim, while increased the mean velocity.

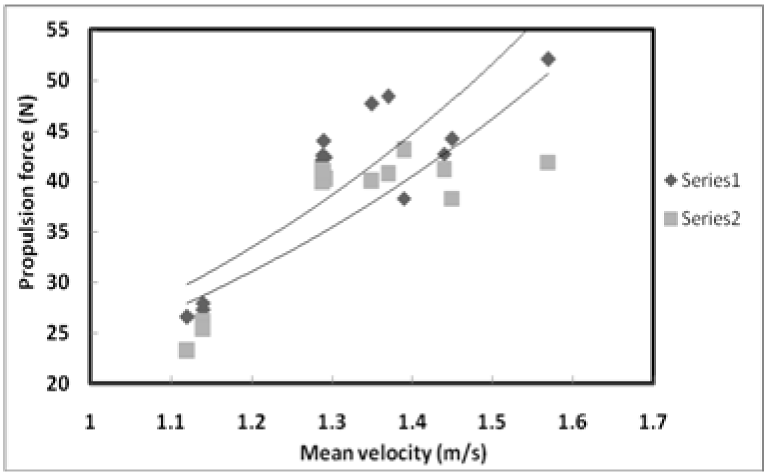

Fig. 1- Relation between drag force and mean velocity of all strokes with (upper) and without (lower) Fast-skin

CONCLUSION:

A comparison of the effect on propulsion of Fast- skin suit and conventional suit in four strokes was estimated by Indirect Measurement of Active Drag (IMAD). Remarkable difference in propulsive force has been obtained for butterfly swim: 15%, while 5.2% was achieved for backstroke. Our findings also showed that Fast-skin effect is even more important in breaststroke (9.5%) than in front crawl (7.9%). The method, with its simplicity, has also enabled us to find out changes in all variables such as; maximum gain of 5.7% in time and also in mean velocity for butterfly. In the end, our findings revealed that the Fast-skin suit is more effective for butterfly swim than other strokes.

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