COMPARISON OF BUOYANCY, ACTIVE AND PASSIVE DRAG WITH FULL LENGTH AND STANDARD SWIMSUITS

Nat Benjanuvatra, Gary Dawson, Brian Blanksby, and Bruce Elliott
Department of Human Movement and Exercise Science, The University of Western Australia, Perth, Australia

A cross-sectional study compared the buoyancy characteristics of the full-length, Fastskin swimsuit with normal swimsuits, in conjunction with analysis of net towing force differences between swimsuit types. The participants were nine elite. Open National level swimmers. The subjects were hydrostatically weighed, and then towed at the surface and 0.4 m depth, at three velocities (1.6, 2.2 and 2.8 m/s). The subjects performed a prone streamlined glide and flutter kick at niaximum effort for each towing velocity and depth. The full-length. Fastskin swimsuit was more effective (≈ 4.8 to 10.2%) than normal swimsuits in reducing total hydrodynamic resistance, specifically frictional resistance, while providing no benefits through additional buoyancy.

KEY **WORDS:** swimming, drag, swimsuits, hydrostatic weighing

INTRODUCTION: Swimsuit manufacturers recently have developed costumes such as the Fastskin full-length swimsuit (Speedo) with material designed to reduce resistance and assist the swimmer to grip the water better when stroking (Rushall, 2000). The manufacturers claim also that these suits offer no flotation or buoyancy advantage over a standard costume. This is an important consideration because the Federation Internationale de Natation Amateur (FINA), stated that "No swimmer shall be permitted to use or wear any device that may aid speed, buoyancy or endurance during competition."
Several studies have indicated that a reduction in hydrodynamic resistance (form, frictional or wave-making drag) impacts positively on performance. The combined influences of buoyancy and drag also have been shown to improve swimming efficiency (McLean & Hinrichs, 1998). An increase in buoyancy reduces form drag as a smaller cross-sectional area is exposed to the direction of movement through the water. Chatard et al. (1990) found that hydrostatic lift accounted for 10% of the variance in the performance of a 400 m swim. The aim of this study was to establish if the Fastskin swimsuit reduced drag and altered the buoyancy level of a swimmer when compared with results from normal racing costumes.

METHODS: Nine Open National level swimmers who had been provided with a Fastskin full-length swimsuit consented to take part in the study. Differences in each swimmer's weight while wearing the different styled swimsuits was determined using hydrostatic weighing. The weight of the seat was recorded while the participant was in the water to account for the added buoyancy from a raised water level. The hydrostatic weight was measured to the nearest 0.1 N with the subject submerged in a steady position following maximum exhalation. The procedure was repeated 10 times with the average of the last three trials recorded for each condition.
Figure 1 outlines the experimental towing set-up used to determine net resistive forces (see Lyttle et al., 1999b for technical details). The subjects were towed through the water at 1.6, 2.2 and 2.8 m/s, in four conditions: surface glide; surface kick; 0.4 m depth glide and 0.4 m depth kick. These velocity ranges cover wall push-off and stroke resumption depths and velocities reached during freestyle turns (Lyttle et al., 1999a). During the passive trials, the subjects were towed in a static, prone streamlined position with both arms extended over the head, feet together and ankles plantar flexed. In the active trials, swimmers performed as above with a maximum effort flutter kick. The participants wore a rubber cap and swimming goggles. They completed the protocol once with the standard swimming costume and again with the full-length swimsuit in randomly assigned order. Subjects were allowed as many practice trials as required to become familiar with the test procedures. A Panasonic SVHS video camera contained in underwater housing was positioned perpendicular to the line of motion to ensure correct depth, and body position throughout the towing trials. Inter- and intra-day reliability tests previously

have determined that the towing system consistently measures the resistive forces of a swimmer for a given set of conditions (Lyttle et al., 1999b).

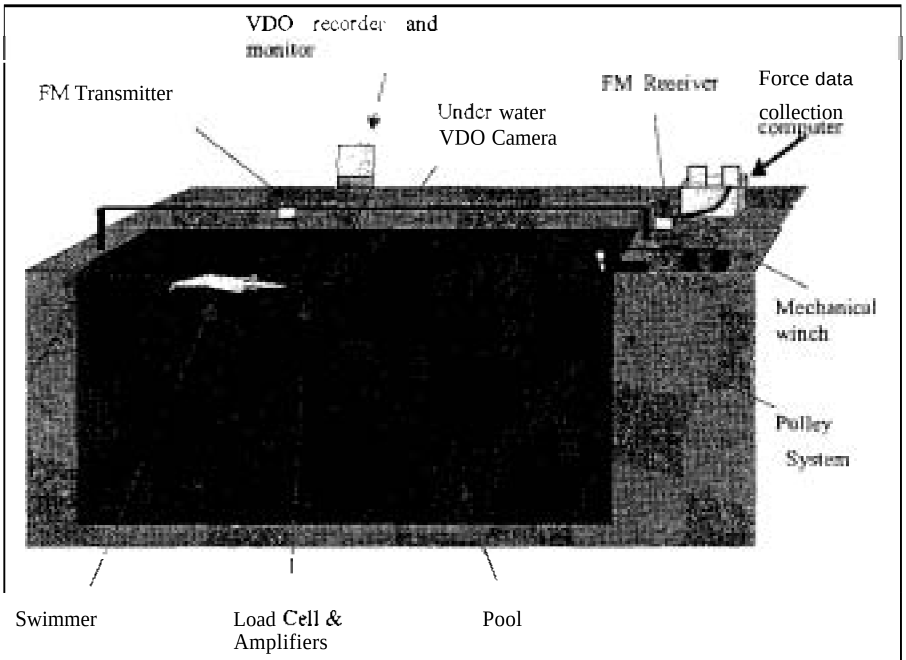


Figure 1 - Testing set-up for quantifying hydrodynamic drag.

Paired sample t-tests were used to compare the means of the hydrostatic weighing conditions. Four separate repeated measure analyses of variance with Scheffe post hoc analyses were conducted to examine the net force data for each of the test conditions.

RESULTS AND DISCUSSION: Comparison of swimsuit types indicated no significant differences existed for hydrostatic weight (Table 1). Hence, the Fastskin fabric alone does not enhance buoyancy. These finding are in contrast to those reported for studies involving wetsuits (Chatard et al., 1995; Cordain & Kopriva, 1991). These studies suggested a 'wetsuit effect' in that the material itself added extra buoyancy enabling the swimmers to maintain a more horizontal swimming position. Therefore, the kicking action was more effective, and hydrodynamic resistance and energy cost were reduced (Cordain & Kopriva, 1991).

Table 1 Means, SD, t Scores and p Values for Hydrostatic Weight.

Subjects	Normal (N)	**Fastskin** (N)	t value	Significance Level
	Mean ± SD	Mean ± SD		
Mean ($n = 9$)	26.5 ± 7.8	27.4 ± 7.8	-1.258	0.244

In this study, the net forces recorded during passive towing comprised solely of a resistive force while subjects were in a static, streamlined position. The results indicated that swimmers created significantly lower passive drag with the Fastskin suit than the standard swimsuit both at the surface and 0.4 m deep (Figure 2). Results from this study agree with the 7.5% reduction reported by Speedo (2000), with the full-length Fastskin swimsuit reducing passive net drag values for all towing velocities and depths by a mean of 7.7%.

Total hydrodynamic resistance of a swimmer is composed of frictional, form and wave-making drag (Jiskoot & Clarys, 1975). As the subjects wearing the swimsuits were towed at the same velocities and depths for each condition, and the swimmer's cross-sectional area was constant, then the wave-making and form components of total drag should have remained the same for each swimsuit type. Therefore, it is most likely that it would be a change in frictional drag that caused any differences between swimsuit net drag values.

Figure 2: Passive Net Drag Forcer Produced Between Swimsuit Types During Surface and Depth Towing

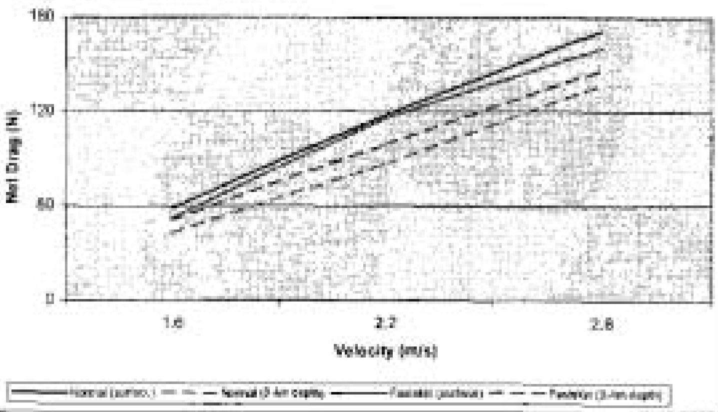
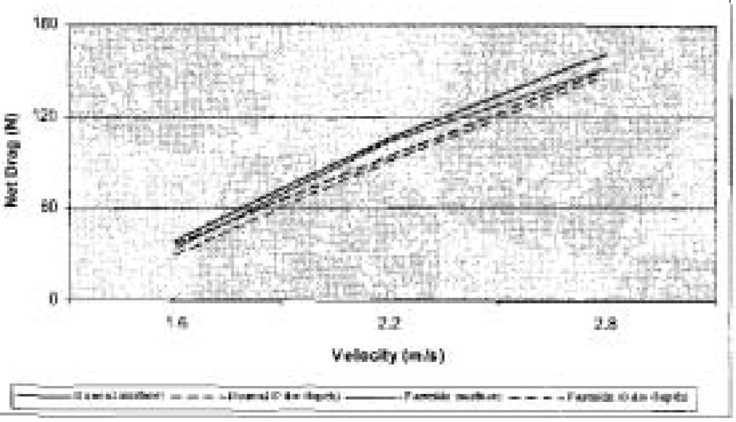


Figure 3: Active Net hag Forces Produced Between Swimsuit Types During Surface and Depth Towing



The net forces when kicking were an interaction between swimmer resistive force and the propulsive force generated by the kick. The Fastskin swimsuit exhibited significantly lower active drag values across all towing velocities when measured on the surface (Figure 3). At 0.4 m depth, the Fastskin swimsuit also exhibited lower net active drag than a normal swimsuit. However, this was not significant. Preliminary results from Toussaint (2000), using the MAD system to measure active drag on the surface, reported no statistical significance between the Fastskin swimsuit and conventional swimwear. However, Toussaint (2000) cautioned against claiming that the Fastskin swimsuit had no effect at all on active drag.

Starling et al. (1995) reported that the distance per stroke was increased for male swimmers when wearing a specially designed torso suit. They claimed this increase was due specifically to the fabric of the torso suit providing a smooth surface that created lower frictional drag. The Fastskin swimsuit appears to advantage swimming performance in the same manner as torso suits, with active drag results being less than normal swimsuits when at the surface. The benefits of the Fastskin swimsuit on active drag at 0.4 m depth remain unclear.

Passive drag has been suggested to have a significant role in swimming (Cappeart, 1997; Chatard et al. 1990). Therefore, significantly lower passive drag values from the swimsuit could be expected to improve total swimming performance.

CONCLUSION: The Fastskin swimsuit produces significantly less resistance (range 4.8 to 10.2%) than a normal suit when swimmers are towed passively at the surface, 0.4 m deep and when kicking at the surface. Therefore, swimmers wearing the Fastskin swimsuit would be significantly advantaged compared with those wearing normal swimming costumes due to a significant decrease in total hydrodynamic resistance.

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