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Lab conducted by Genadijus Sokolovas, Ph.D., Global Sport Technology, Inc.
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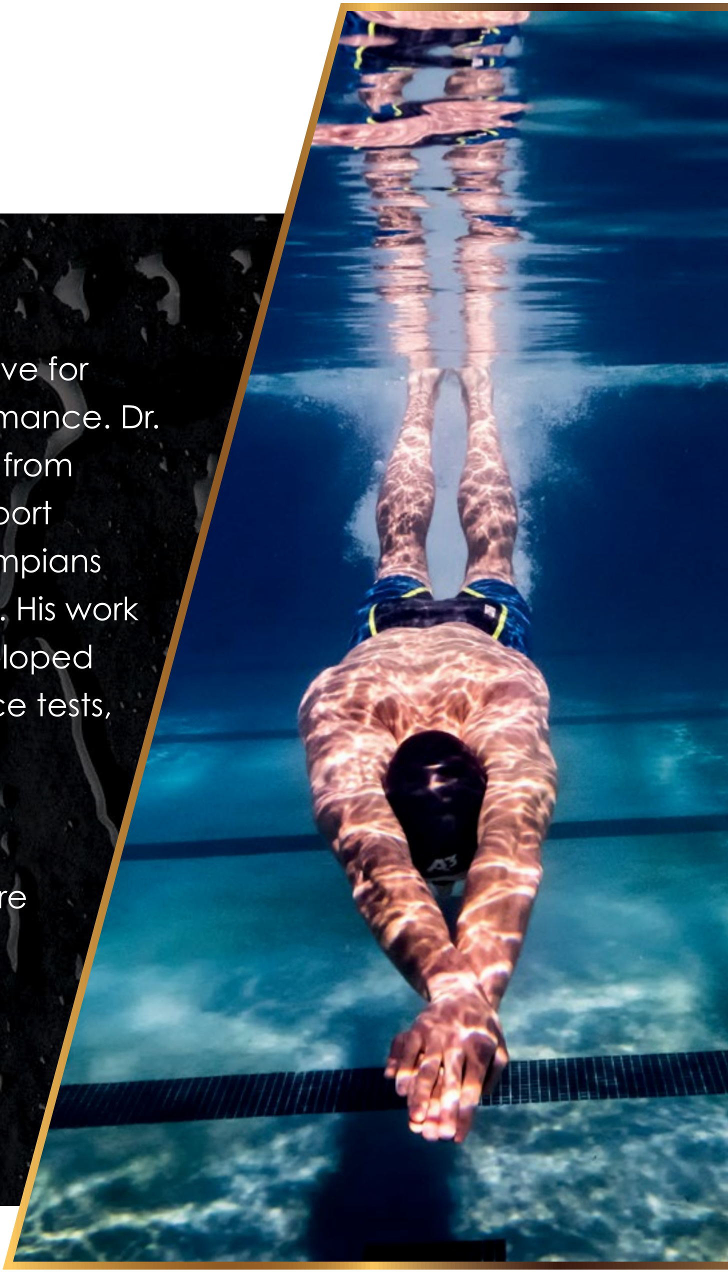
The Scientist Behind the Lab

Dr. Genadijus Sokolovas (Dr. G) was born and raised in Lithuania. What started as a love for swimming later turned into a strong interest in exercise physiology and athlete performance. Dr. G earned his credible and respectable reputation in the swimming world particularly from 2000-2008, when he worked as USA Swimming's Director of Physiology & Director of Sport Science. During this time, Dr. G worked closely with National Team members and Olympians studying and testing athlete adaptation to swimming and their overall performances. His work was particularly helpful working up to both the Athens and Beijing Olympics. He developed several innovative testing programs for these elite athletes including lactate clearance tests, land/water strength tests, biomechanical analysis, and training design programs.

Before his work at USA Swimming, Dr. G was the Dean of Coaching Faculty at the Lithuanian Academy of Physical Education between 1987-2000. During his tenure there he served as the Scientific Advisor of Lithuanian Swimming, Modern Pentathlon, and Track & Field. He also served as the Head of Laboratory of Computerization in Sport, optimizing training strategies in swimming, running, race walking, modern pentathlon and triathlon. Additionally, he developed mathematical models of adaptation of athletes in career, season, and weekly training.



Dr. G received his doctorate from the Russian Academy of Physical Education in Moscow – he used physiological, biochemical, and pedagogical testing programs to assess adaptation in swimming to different workload.

After an already reputable career advising approximately 100 Olympic Champions and 150 Olympians, Dr. G co-founded Global Sport Technology, Inc.—an organization determined to bring the latest technologies and sport science services to athletes, coaches, physical therapists, athletic trainers, and physicians.

Background on Testing

There are just a few studies about the effects of full-body swimsuits on the swimming performances. Some swimsuit manufacturers claim that their suits can improve swimming times as much as 2 seconds per 100 meters. Several studies investigated the characteristics of the swimsuits. It has been proposed that swimsuits improve swimmers' buoyancy, reduce frontal drag, and changes some physiological parameters, such as oxygen consumption and blood lactate concentration (Toussaint et al., 2002; Mollendorf et al., 2004; Trappe et al., 1996; Roberts et al., 2003, etc.). As result, athletes wearing swimsuits increase distance per stroke and reduce performance time (Chatard et al.2008; Starling et al., 1995, etc.).

Coaches, swimmers, and scientists agree that swimsuits help to improve performances. As a clear evidence of that, hundreds of world records have been broken using the new generation swimsuits in 2008 and 2009. The question remains if some swimsuits are better than other ones. To our knowledge, there is no study published comparing various swimsuits. The purpose of this study was to examine the relationships between swimming velocity and distance per stroke for several swimsuits.

Lab Methods

An athlete volunteer participated in the study. The new GST Swim Power device (see Figure 1) was used to record the instantaneous swimming velocity (V, m/s) at 60 Hz (times per second). The standard drag of 1.2 KG was applied during the test. Applied resistance didn't change swimming technique during the test.

The Swim Power device has been manufactured by the Global Sport Technology, Inc. (2012). It includes an electronic box with a brake and converter to record the swimming distance via a fishing line attached to an athlete. The Power Pro fishing line has no elasticity and can hold 200 lbs. weight. The Swim Power software converts the distance and time to swimming velocity at the rate of 60 times per second (60 Hz) (see Figure 2). The Swim Power device was calibrated for the distance and force (resistance) using the electronic tensiometer (IMADA, Japan).

Eight swimsuits were tested in total. Four swimsuits were A3 Performance technology, and four swimsuits were the latest technology from the sport's top brands.

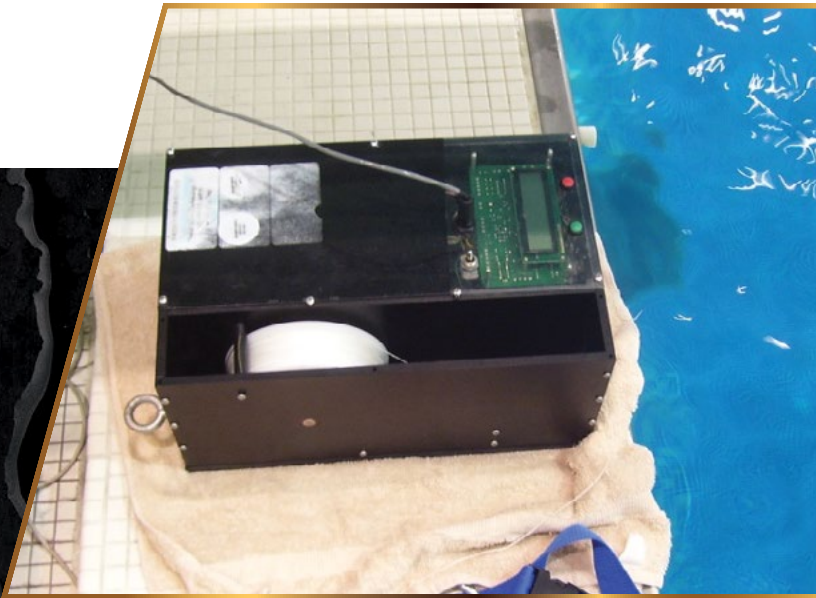


Figure 1. The new GST Swim Power device.

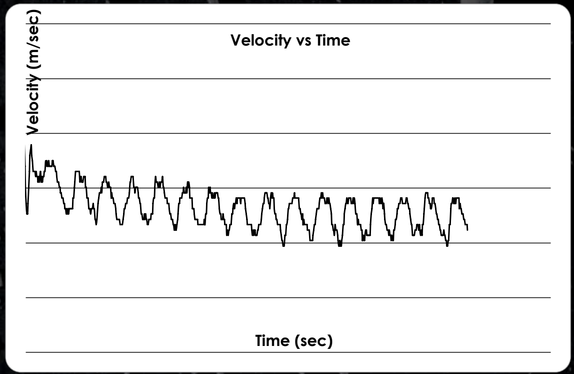


Figure 2. Fluctuations of swimming velocity at 60 Hz during the Swim Power test.

The testing protocol included 6 x 20 yard swims. An athlete swam at various velocities: from aerobic pace (60% effort) for the first swim to the max pace for the last swim. The freestyle pulling position keeping a pull buoy between ankles was used for tests to avoid any interference with the fishing line. The athlete was swimming 20 yards without breathing in order to standardize the testing conditions. Six swimming cycles were selected in the middle of testing distance to calculate the average swimming velocity and distance per cycle (DPC). The relations between DPC and swimming velocity were calculated for every swimsuit.

Distance Per Cycle (DPC) and Swimming Velocity

DPC shows the efficiency of swimsuits: the longer DPC at the same swimming velocity, the lower drag is created wearing a swimsuit. Thus, swimmers can swim faster if they can maintain a longer DPC at the same tempo.

Relationship between DPC and swimming velocity is described as a linear dependence: the faster athletes are swimming, the lower DPC and higher stroke rate (Garland Fritzdorf et al., 2009; Craig et al., 1985). The world's best swimmers tend to swim at a longer DPC than other swimmers. It shows the efficiency of their swimming technique.

Our testing results showed that the relation between DPC and swimming velocity is linear (see Figure 3).

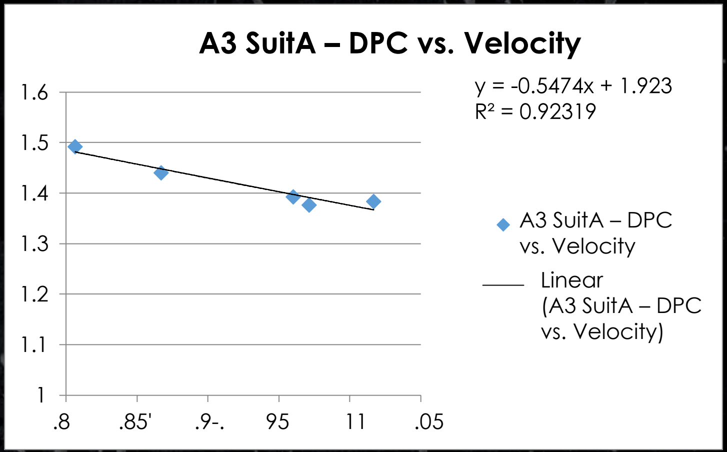


Figure 3. Linear relation between DPC and velocity at higher swimming speeds.

Mathematical Regression

To compare DPC and swimming velocity for various swimsuits, mathematical regression was performed. Since swimming velocity may change depending on athlete's effort and it is impossible to swim exactly the same speed during the test, linear regression model was created using the best fit mathematical function for every swimsuit (see Figure 4).

Testing Results

At swimming velocity 1.1 meters/sec, the linear model shows that the longest Distance per Stroke (DPC) is reached wearing the A3 VICI swimsuit (1.339 meters). Brand D swimsuit had the shortest DPC at 1.1 meters/sec velocity (1.205 meters).

Here is the order of swimsuits starting with the best suit at 1.1 meters/sec speed:

1. **A3 VICI, DPC 1.339 meters**
2. A3 SuitA, DPC 1.321 meters
3. A3 LEGEND, DPC 1.313 meters
4. Brand A, DPC 1.303 meters
5. Brand B, DPC 1.289 meters
6. Brand C, DPC 1.278 meters
7. A3 Nova, DPC 1.277 meters
8. Brand D, DPC 1.205 meters

Velocity	Brand D	Brand B	Brand C	A3 LEGEND	A3 NOVA	**A3 VICI**	A3 SuitA	Brand A
0.8	1.847	1.501	1.494	1.453	1.541	1.456	1.485	1.481
0.85	1.740	1.466	1.458	1.430	1.497	1.437	1.458	1.451
0.9	1.633	1.431	1.422	1.406	1.453	1.417	1.430	1.422
0.95	1.526	1.395	1.386	1.383	1.409	1.397	1.403	1.392
1	1.419	1.360	1.350	1.360	1.365	1.378	1.376	1.362
1.05	1.312	1.325	1.314	1.336	1.321	1.358	1.348	1.333
1.1	1.205	1.289	1.278	1.313	1.277	1.339	1.321	1.303

Table 1: DPCs for all swimsuits at various speeds

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The DPC difference between various swimsuits is presented in Table 2 (Brand D, the shortest DPC swimsuit, was selected as 100%). Data shows that a swimmer can benefit with up to 11.1% longer DPC wearing an A3 VICI swimsuit in comparison with a Brand D swimsuit at 1.1 meters/sec velocity.

Velocity, M/Sec	Brand D	Brand B	Brand C	A3 LEGEND	A3 NOVA	**A3 VICI**	A3 SuitA	Brand A
0.8	100.0%	81.3%	80.9%	78.7%	83.4%	78.9%	80.4%	80.2%
0.85	100.0%	84.3%	83.8%	82.2%	86.0%	82.6%	83.8%	83.4%
0.9	100.0%	87.6%	87.1%	86.1%	89.0%	86.8%	87.6%	87.1%
0.95	100.0%	91.4%	90.8%	90.6%	92.3%	91.6%	91.9%	91.2%
1	100.0%	95.8%	95.1%	95.8%	96.2%	97.1%	96.9%	96.0%
1.05	100.0%	100.9%	100.1%	101.8%	100.6%	103.5%	102.7%	101.5%
1.1	100.0%	106.9%	106.0%	108.9%	105.9%	111.1%	109.6%	108.1%

Table 2: The DPC Differences between swimsuits

Conclusions

1. A swimmer participated in the study. To determine DPC (distance per cycle), a swimmer swam 6 x 20 yds. descending in pulling position. Swimmers swam without breathing to avoid its influence on testing results.

2. Based on the analysis of testing results, the linear regression model was selected as the best fit of the relationships between DPC and swimming velocity.

3. During the tests, a swimmer had the speed range between 0.8 and 1.1 meters/sec. Using the linear regression model, it was determined that swimmer swam with the longest DPC using **A3 VICI** (1.339 meters). The shortest DPC at 1.1 meters/sec swimming velocity was for Brand D swimsuit (1.205 meters).

4. A swimmer would swim faster races wearing swimsuits with the longest DPC (**A3 VICI**). It appears that this swimsuit creates the smallest drag, especially at speeds higher than 1 meter/sec.