IMPROVING PERFORMANCE IN SWIMMING:

SWIMSUIT AND TECHNIQUE RESISTANCE FACTORS

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SWIMMING TECHNOLOGY RESEARCH

Swimmers, like all competitive athletes, look for every possible way to improve performance. Unfortunately, those improvements are smaller and take longer as swimmers grow and develop. That's why it is so difficult to ignore advertising that promises an instantaneous benefit from wearing swimsuits that reduce resistance. Other strategies (such as a comprehensive instructional program using advanced technology) require more resources (time, effort, and finances) but yield considerably greater returns. Comparing the size of performance improvements provides a scientific basis for allocating resources.

STANDARDIZED COMPARISONS OF RESISTANCE FACTORS

The drag coefficient (C_d) is an index for comparing resistance improvements from factors such as swimsuits and technique adjustments. Resistance can be tested for passive (streamline) drag or active (swimming) drag. Improvements in C_d can be standardized with the "effect size" - a statistical ratio expressed as a fraction of a standard deviation (σ). For comparisons, a .2σ effect size is small, .5σ is medium, and .8σ is large.

For example, swimmers were split into faster and slower groups according to their swimming speed and tested on resistance factors. As shown in Figure 1, the faster swimmers had a more effective streamline (Havriluk, 2005) and swimming technique (Havriluk, 2003) than the slower swimmers. The difference is a medium size effect: .57σ for passive drag and .46σ for active drag.

Figure 1

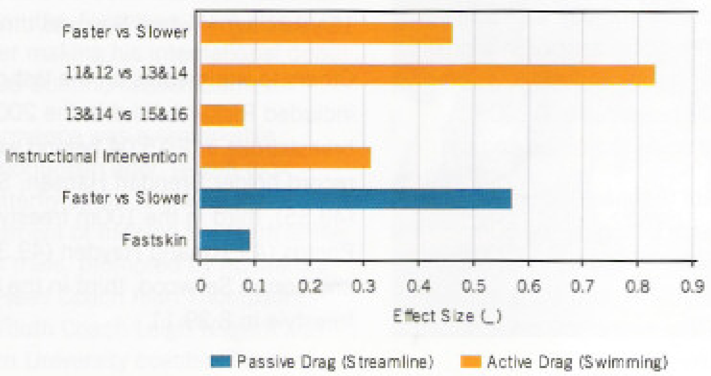


Figure 1. Improvements in resistance from selected factors. The values are expressed as drag coefficient effect sizes.

The active drag study also showed the improvement in technique from the 11&12 age group to the 13&14 age group was large, but from 13&14 to 15&16 was very small. This finding is consistent with normal development. The body control of pre-teens develops rapidly. Combined with the focus that coaches put on technique, young swimmers quickly gain skills. The training for teenagers, however, often emphasizes distance and, as the standardized comparisons show, their technique improvement is minimal.

EFFECT OF SWIMSUIT DESIGN AND INSTRUCTIONAL INTERVENTIONS ON RESISTANCE

Varying decreases in the Cd for a Fastskin® swimsuit were found, but the average improvement (based on two studies) is very small (.09σ) and not statistically significant (Havriluk, 2007). (The "not statistically significant" finding means the measured improvement may be by chance alone.) In contrast, a one-week instructional intervention produced a .31σ improvement in Cd (Havriluk, 2006). The improvement from technique adjustments was statistically significant and considerably greater than the swimsuit effect.

The instructional intervention was a substantial proportion of the difference between slower and faster swimmers. Repeated interventions with even modest additional gains could approach a medium size effect and turn "slower" swimmers into "faster" ones. An investment in technique analysis and instruction provides an opportunity for a far greater improvement than from a swimsuit.

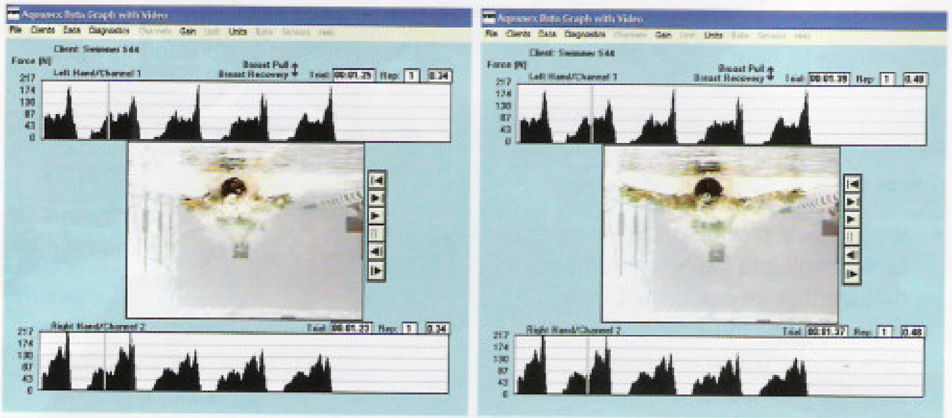
RESOURCE REQUIREMENTS

The greater improvement of the instructional intervention also required greater resources of time, effort, and finances. The program included classroom and pool sessions utilizing advanced technology. Sophisticated hardware and software provided a detailed analysis of each swimmer and a thorough explanation of effective technique.

Aquanex+Video – a system that includes an underwater video camera and sensors that measure hand force – was used to analyze the swimmers. The system has a tremendous advantage over standard video because it synchronizes video with force data. A frame-by-frame playback showed the swimmers exactly how much force they generated at each point in the stroke. The variations in force identified phases where the swimmers were using their strength effectively and where they were wasting motion.

Although video is useful for describing swimming motions, combining it with force data is essential to determine the effectiveness of each motion. This is particularly important for swimmers who have progressed beyond basic skills. For example, the national champion in Figure 2 has increased his breaststroke hand force to over 80 N in the first .34 sec of the first full stroke (left image). However, over the next .15 sec, the force does not increase. While the video image at .48 sec (Figure 2, right image) may appear to be an effective continuation of the arm motion, the force graphs tell a different story. A closer look at the arm position shows that the hands have moved slightly above the shoulders and into a weaker (less mechanically advantageous) position.

Figure 2



This detailed analysis clearly showed the exact motions that limit performance and provided feedback about key skills that each swimmer needed to improve.

Figure 2. Aquanex+Video synchronized underwater video and hand force graphs for a national champion breaststroker. The vertical lines on the graphs are synchronized with the video image. Note that the force does not increase from .34 sec (left image) to .48 sec (right image) due to the slight upward motion of the hands that put the arms in a weaker position.

In addition to the analysis, the intervention also included a thorough instructional component. A biomechanical model for technique (MONA - Figure 3) had been developed, based on principles of physics and research on hundreds of elite swimmers. The model included all the effective elements of technique, without the limitations of even the fastest swimmers. The model was presented in the classroom along with visual and kinesthetic cues to facilitate learning. The MONA software has features to play the model swimming continuously and to pause at critical points in the stroke to explain the related cues. For example, the position in Figure 3 has the visual cue to "see the hand pass under the chest."

Figure 3. A biomechanical model for optimal swimming technique. The model includes visual and kinesthetic cues (specific body orientations to see and feel) for each position within the stroke cycle.

The pool sessions included numerous short swims at a low intensity with limited breathing so that the subjects could better focus on the cues. For example, a set of 12 x 25 m swims without an interval allowed adequate time to "cue" the swimmers before each swim and give feedback about cue compliance after each swim.

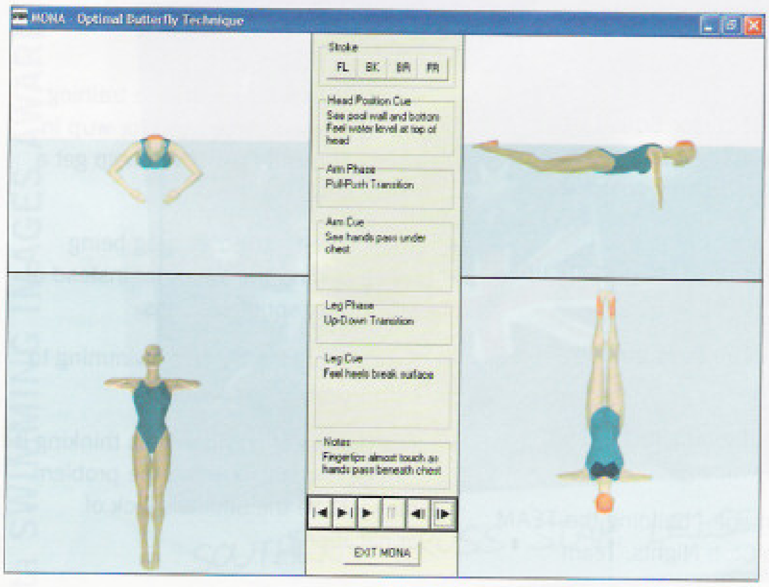


Figure 3

The swimmers were given the opportunity to make the transition to racing speed by maintaining the technique changes at faster speeds. This was done both by increasing the speed within 25 m swims and by increasing the speed over a series of 25 m swims. The combination of learning strategies produced an improvement in one week that far exceeded the typical improvement for swimmers of that age over a two-year span (from the 13&14 to the 15&16 age group).

A swimsuit requires a relatively minimal financial investment. However, only a minimal return can be expected. While virtually every swimmer invests in the latest swimsuit technology, a much smaller proportion of swimmers (or teams) devote an entire week of training to intensive technique analysis and instruction.

CONCLUSION

While every performance advantage must be considered, it is important for coaches to evaluate strategies that require more resources but yield a much greater return. As clearly documented, just one week of a comprehensive technique program had an effect on Cd that was 3.5 times as great as the effect from wearing a Fastskin®. While swimsuit design may make an immediate but minimal improvement, technique adjustments can produce much greater though more gradual gains. Allocating resources for a thorough program of technique analysis and instruction is an effective way to significantly improve performance.

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