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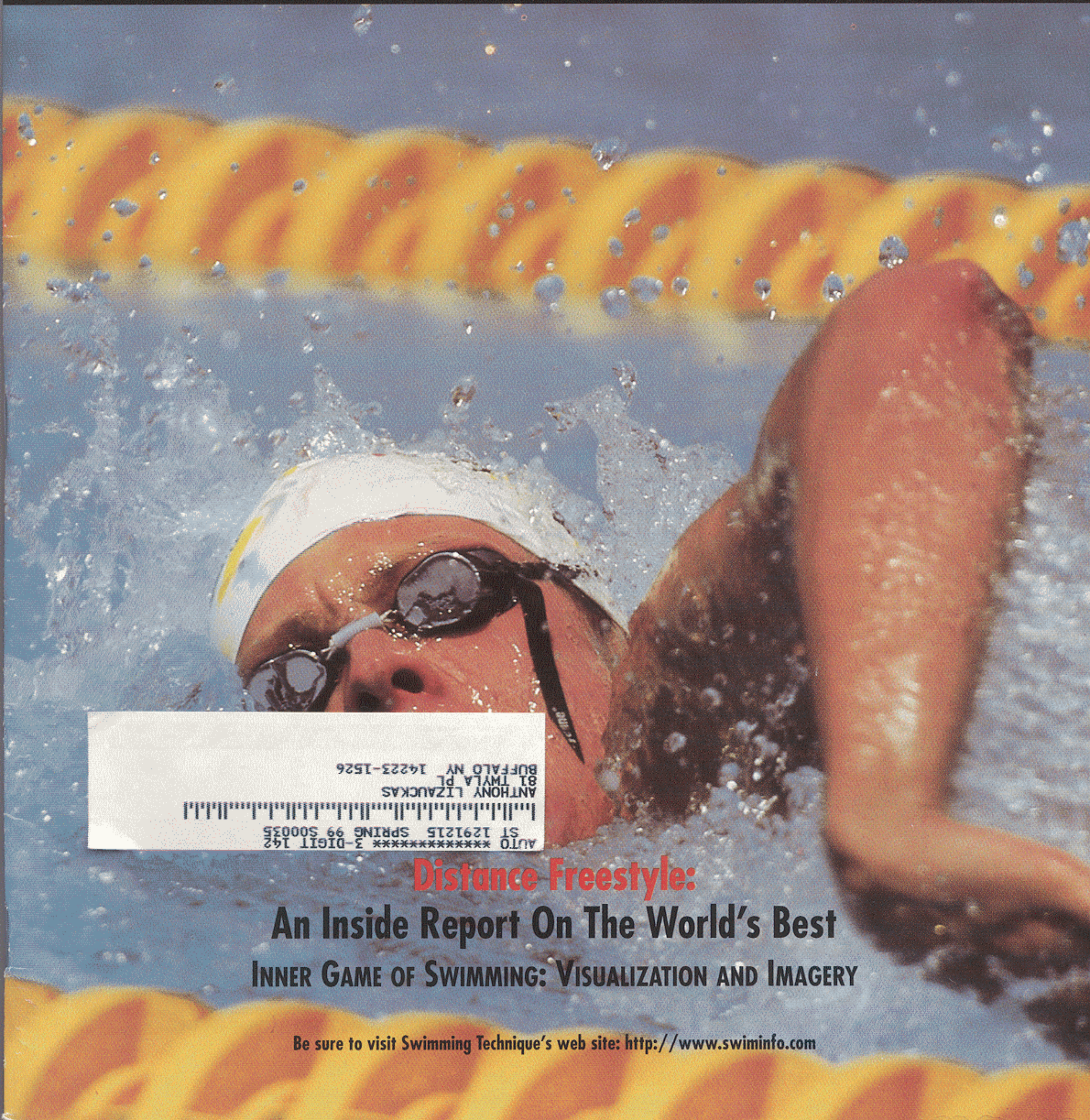
THE MANUAL FOR COACHES & SWIMMERS EVERYWHERE

SWIMMING TECHNIQUE

New Breaststroke Pull-Out, Is It Faster?

An exclusive report: exciting new research suggests that less may be more, shorter may be better.



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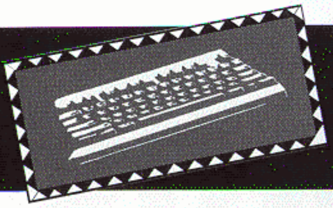

Editor's
NOTE

BREAKING THE PARADIGM

By Phillip Whitten

Never take anything for granted. Always ask, "Why?" and "How do you know?" Challenge yourself to think outside the current paradigm. Search constantly for a better way.

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No, this is not a prescription for making yourself unpopular. It's a description of the state of mind that leads to creative new ideas, to innovative concepts and techniques.

It characterizes the greatest scientists and thinkers of the modern age—Darwin, Einstein, Hawking. And it is the hallmark of the greatest thinkers in our sport—people such as Doc Counsilman.

Challenge the unchallengeable: it was that mindset that led Bob Gillett to think about emulating the way fish swim, which, in turn, led to the invention of the side-swimming underwater "fish kick," used so effectively by Misty Hyman and others.

In this issue, we present a new article that challenges the unchallengeable: the way the breaststroke pull-out is performed. Coach Budd Termin and his colleague, David Pendergast, Ph.D., have analyzed precisely what occurs during the traditional breaststroke pull-out and concluded that that there is, indeed, a better way.

Their article, "The Breaststroke Pull-Out Technique: How To Optimize Performance" challenges our notion not only of the breaststroke pull-out, but the way in which the transition from turn to stroke is performed in all four strokes. It is a provocative article, one sure to evoke controversy as well as thoughtful experimentation.

Ron Johnson takes a similar iconoclastic approach in "What The Australians Are *Really* Doing," which looks at the day-to-day training and preparation of Kieren Perkins under the direction of Australian coach, John Carew.

Australia has produced the world's greatest distance swimmers while American distance swimming has regressed since the mid-1970s. Coach Johnson asks, "Could the reason be that the precepts underlying our distance training philosophy are faulty?" Read how Perkins, Grant Hackett, Dan Kowalski and Ian Thrope train, and decide for yourself.

❑

This issue has a lot of other meat—useful, practical information you can use on a daily basis. Check out these features:

- Cecil Colwin draws upon his years of experience as coach, writer and illustrator to outline the essentials of the backstroke.
- Rayma Ditson-Sommer, Ph.D., explores the concepts of *visualization* and *imagery*—similar but distinct concepts that can be highly useful in the preparation of athletes at all levels.
- At a more mundane level, Clay Daughtrey explains how coaches can take a few simple steps to reduce their liability for negligence.
- Finally, you can use our 1998 Aquatic Directory found in the middle of your magazine as your one-stop shopping guide to camps, manufacturers, suppliers and retailers specializing in the swimming market.

On the cover: Australia's Kieren Perkins is the current world record holder in both the 400, 800 and 1500 meter freestyles. All three standards were set during the 1994 season. In August of that year, he clocked 7:46.00s and 14:41.66 in the same 1500 race at the Commonwealth Games in Victoria, B.C. About two-and-a-half weeks later, he lowered the standard in the 400 to 3:43.80 at the World Championships in Rome. Perkins is prominently featured in "What The Australians Are *Really* Doing" (page 9). *(Photo by Simon Bruty, Allsport)*

Inset photo: Competitive swimmers and coaches are always searching for ways to optimize performance. That was the motivating force behind the detailed studies of the breaststroke pull-out technique (page 41). *(Inset photo by Shaun Botterill, Allsport)*

How to Optimize Performance

By Budd Termin and David Pendergast

Competitive swimmers and coaches are always searching for ways to optimize performance. Performance in swimming is judged as the time it takes to cover specific distances, which can also be expressed as velocity in meters per second.

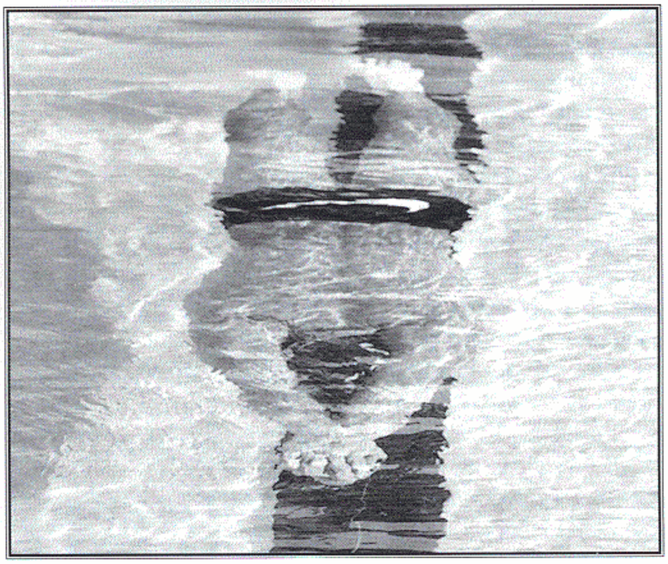


Photo by Bill Collins

Velocity in swimming is determined by the number of strokes taken per minute and the distance the body travels per stroke. The velocity across a competitive distance is not constant because of variations during the starts and turns and, in fact, during the strokes themselves.

These variations can be measured as instantaneous velocity; their average over a given distance or time is the average velocity. Increases in the instantaneous velocity occur when the propulsive force of the swimmer exceeds the drag, while decreases in velocity occur when the drag exceeds the propulsive force.

During starts and turns, the initial velocity is high. However, with time, the velocity decreases due to the swimmer's drag.

In freestyle swimming, the arm stroke and leg kick provide the propulsive force to overcome the body's drag. The drag of the body is determined in part by the surface area opposing progression through the water that is increased during the recovery and early pull phases. The instantaneous velocity is the balance between drag and propulsive force. Differentiating visually between propulsive force and drag is impossible.

For example, during the arm pull or the thrust phase of the kick, you observe an apparent increase in velocity. What you *really* see is an increase in the velocity of the arms and legs; in fact, the body could be stopped, moving slowly or not moving as fast as the arms or legs.

The apparent increase in velocity might be possible if you assume that the arm or leg movement is all propulsive force; however, there is drag created during this phase as well, which may offset all or part of the propulsive force. In this example, reducing the drag could increase velocity more than increasing propulsive force, as the latter would increase drag as well. Based on this analysis, we believe it is important to measure instantaneous velocity and, preferably, couple it with video analysis.

Without question, the greatest fluctuations in velocity occur in the breaststroke and, particularly, during the pull-out phase, which is the focus of this article; however, this type of analysis and these data can be used for the exit phase off the wall for the other competitive strokes as well. Their use can optimize the transition to the regular swimming portion of the strokes.

Our study revealed evidence that the pull-out technique currently used by almost all elite breaststroke swimmers, both male and female, produced velocities well below the mean swimming speed for their breaststroke swimming, and provided an excellent benchmark for comparison.

It also demonstrated that the traditional method of executing a breaststroke pull-out could be improved by 20 percent in one session. This was accomplished by executing the pull-out phase sooner off the wall and by reducing the drag incurred during the pull-out and recovery phase.

The velocity attained can match or exceed the swimmers' mean velocity for breaststroke swimming, thus giving swimmers a way to optimize their performance for this technique.

METHODS

The subjects for this study were all highly skilled breaststroke swimmers. The female subjects were Sarah Miller, an NCAA Division I finalist from Buffalo and the University of Georgia, as well as one swimmer from the 1996 U.S.

Olympic team. The male subjects were Matt Buck, an NCAA Division I champion in the 200 yard breast from the University of Georgia, and Carl Carlson, the school record holder in the 100 yard breast (57.41) at the University at Buffalo. All of the data were collected in the past year-and-a half at the University at Buffalo Swimming Complex.

We used the following definitions to describe the different parts of the underwater pull-out technique:

Push-off Phase: The leg push off the wall with the arms overhead in a streamlined position. This phase continues until the instant the hands begin to separate to begin the underwater pull.

Pull Phase: The instant the hands come apart to pull until the hands are at the side of the body.

Recovery Phase: The instant the swimmer begins to move the hands from the side of the body up and underneath, while the legs are drawn up to kick, until the beginning of the first complete stroke of regular swimming.

The subjects were connected by a belt around the waist that was attached by piano wire that ran through a series of pulleys across a calibrated DC generator. The voltage emitted by the generator was converted to a digital signal that was sampled by a computer. A tracing of instantaneous velocity for each trial was shown on the computer screen.

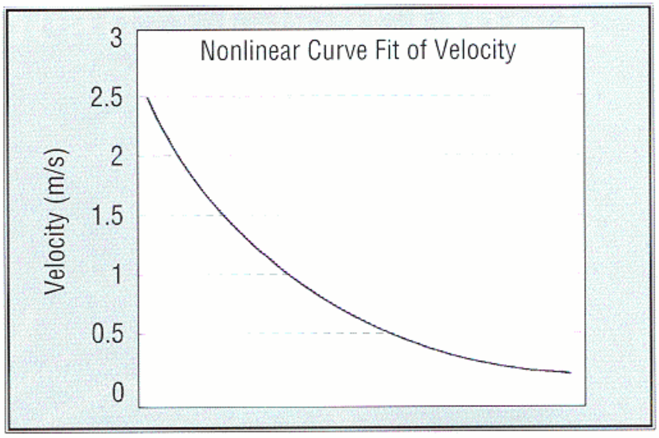
Along with a digital readout, the software calculated the maximal and minimal velocities and the mean swimming velocity attained during the time of collection. Mean swimming velocities were calculated for all subjects based on their best competitive time (short course) in order to compare the velocities attained during the pull-out phase of each subject to their steady stable swimming speed. All of the velocity data were expressed in meters per second, the standard unit of measure for velocity.

As the subject performed a trial, the computer software measured and stored instantaneous velocity; thus, we can determine how and when changes in technique affect velocity. In all cases, the subjects in this analysis were first asked to push off the side of the pool and perform a breaststroke underwater pull-out and one regular stroke that represented the technique they would use during competition. Each subject completed five trials.

After each trial, the subjects were given three to five minutes' rest to ensure that adequate metabolic recovery was attained. For our purposes, only the pull-out phase of the breaststroke was analyzed. The data analysis started just as the hands of the swimmer began the out-sweep phase through the pull and the recovery to the completion of one regular stroke on top of the water.

RESULTS

Before we examine the results of the pull-outs, let's look at another important discovery that was made in conjunction with this study. When the subjects were asked just to push off the wall underwater in a streamlined position, an analysis of velocity (drag) was also collected.



Push-off and Glide Data

Time (seconds)	Velocity (m/s)	Distance (meters)
0.00	2.520	
0.180	2.348	0.44
0.360	2.193	0.85
0.540	2.053	1.23
0.720	1.926	1.59
0.900	1.809	1.93
1.080	1.703	2.25
1.260	1.605	2.55
1.440	1.514	2.83
1.620	1.431	3.10
1.800	1.354	3.35
1.980	1.282	3.59
2.160	1.215	3.81

Figure 1
A push-off and glide phase of a subject in a streamlined position. The peak velocity is the moment the feet leave the wall. The table represents the decrease in velocity in 2-tenths of a second increments. Notice that the velocity decreases exponentially and immediately as the swimmer leaves the wall.

Figure 1 shows the results of this analysis. There is not a phase just after leaving the wall, where swimmers sustain the velocity developed from the push-off. This (drag) curve and the corresponding table alongside show how quickly the body slows down immediately after the feet leave the wall. The decrease in velocity, as a function of time, is determined by the body drag. It falls exponentially.

Time zero represents the instant the feet are no longer in contact with the wall. Our software then calculates the velocity and the distance from the wall in increments of 2-tenths of a second. We discovered that in all cases, the instant the feet leave the wall, the subjects immediately began to decelerate and continued to decelerate until velocity was zero.

As a point of reference, when you calculate the mean swimming velocity of Matt Buck based on his best time, it corresponds to 1.70 meters per second. You can see from the table (above) that when Matt pushes off the wall, if he holds his glide for more than one second in time, his velocity decelerates below his mean swimming speed.

We have extended the table for two seconds to show how quickly the velocity declines. This will be important later when we attempt to improve the mean velocities of these swimmers during the pull-out phase.

It is also important to recognize that after gliding 2.25 meters in distance (*Figure 1, Column 3*), the velocity is virtually equal to the mean swimming speed. You should also note

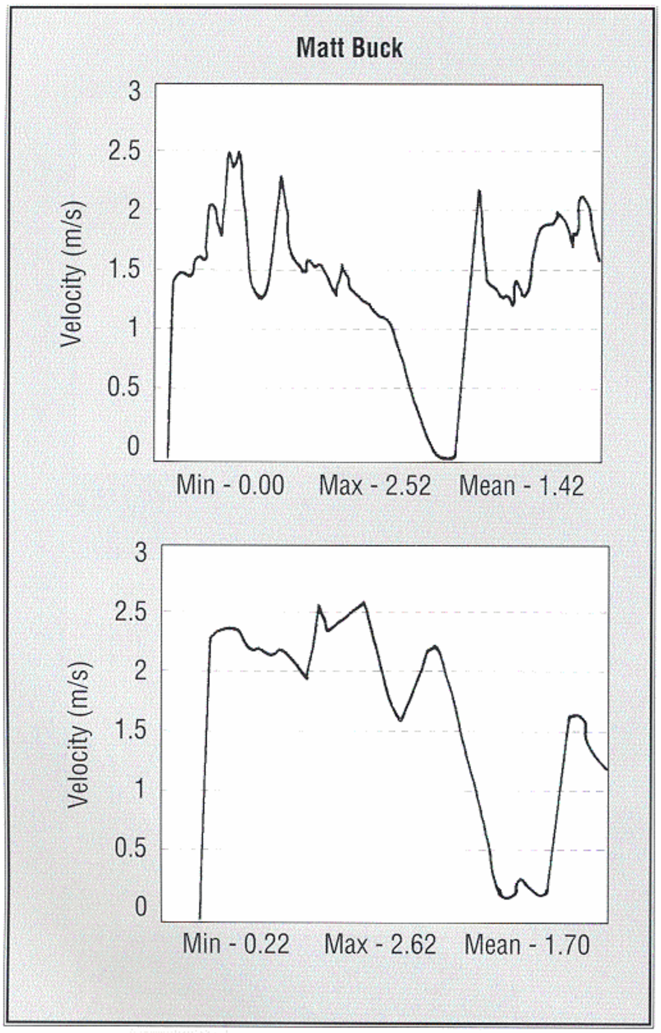


Figure 2

Top: the best of five pull-outs performed by Matt Buck. The initial mean velocities attained for the trials are almost exactly the same.

Bottom: the improvement Matt was able to make by shorting the initial push-off glide phase and eliminating the drag during the pull and recovery phase.

that this table can be used for any push-off phase after a turn or start for any of the competitive strokes by using the average speed of the specific stroke and distance and this curve. We are using the breaststroke because the overall potential effect is the greatest, as the speed fluctuations are the largest.

Figure 2 represents the best of Matt Buck's five trials. Each tracing represented—starts with the push-off the wall phase, the pull-out phase, the recovery phase and the glide to the surface for one stroke. Our software calculates the maximum, minimum and the mean velocity attained for each trial during the pull-out phase only. You will note that Matt's instantaneous velocity at one point reached zero and remained at zero for a period of time.

In fact, all the swimmers in this analysis produced the same effect. Since that time, we have tested many swimmers of all ability levels and ages with the same result. *In all cases, the swimmers come to a complete stop.* The stop occurs during the recovery phase of the pull-out and is caused by the increased surface area due to opening the legs for the kick, bringing the arms forward and the body's movement from the horizontal plane.

This pattern is very reproducible. In Matt's five trials, the maximal push-off speed was always between 2.52 and 2.62 meters per second, and the mean speed of the pull-outs was between 1.38 and 1.42 meters per second.

What is also very interesting is that the pull-out technique can be corrected rather quickly. The first part of the correction is found in the initial push-off phase of the pull-out. If you refer back to *Figure 1*, you can see how quickly the swimmer's velocity declines. For all the swimmers in this study, the initial glide phase was too long; that is, they glided too far off the wall before beginning the initial pull phase.

In *Figure 1*, you will see that if Matt glides for one second, he is only 2.25 meters from the wall and is virtually at his mean swimming speed of 1.70 meters per second.

The second problem with the technique occurs after the pull phase. When his hands reached the side of his body, Matt would glide for a longer period of time. So, with two long glide phases, his velocity declines so low that during the recovery phase when the legs are drawn up underneath the body, and the most drag is incurred, Matt's progress comes to a complete stop.

The observer's eye is deceived because, although the body has stopped, the arms and legs are moving and it appears that he is still moving forward. In reality, as the computer tracing shows, his body has stopped moving forward.

In some cases, he remains at zero velocity for a significant period of time (an estimated 2- to 5-tenths of a second). The longer this period, the lower the mean speed during the pull-out and, thus, during the event. As you can see (*Figures 2, 3 and 4—top panel*), the same phenomenon exists for the other three swimmers.

Matt Buck

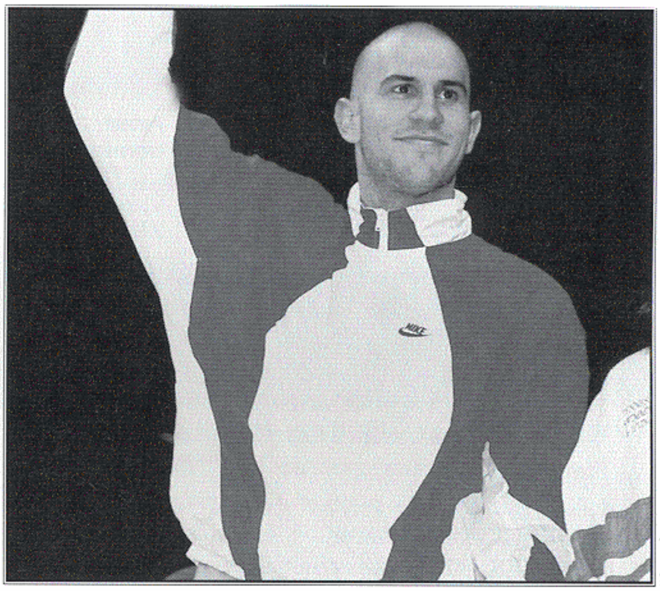


Photo by Tim Morse

Fortunately, this effect can be completely eliminated if attention is given to a couple of components of this technique. Matt's mean swimming velocity is 1.70 meters per second. In a very short time, the technique was corrected so that the mean velocity of his pull-out virtually matched his mean swimming velocity.

Figure 2 (bottom tracing) shows how Matt successfully corrected his pull-out. Because swimmers are taught to push and glide, pull and glide, this change will feel awkward to the swimmer. It is important to note that for all the swimmers tested, the pull-out that felt the worst was always the one that produced the best result.

It is clear from the analysis of these athletes and many breaststrokers tested since, that what swimmers feel slowing them down is the drag created by their technique. When that happens, swimmers perceive that they have lost their feel. In reality, what they have eliminated is the drag in their technique, letting them slip through the water cleaner and with increasing speed.

To their credit, Matt and all the other swimmers were excellent subjects for this study. When Matt was given suggestions on how to improve his pull-out, even though the feel was different, he was very good at just trying to execute the technique, not being as concerned with how it felt.

After the first five trials, the computer screen was turned around to face the pool, so all the subjects could see the results on the screen for themselves. The first prescription for Matt was to start his pull-out much sooner off the wall. To him, it felt as if he were pulling right away. The goal was to get Matt to begin the pull sooner, that is, at a higher velocity after the push-off.

Table 1
Summary data for the best pull-out mean velocity and best pull-out after being "dialed in" plus the percent improvement:

	Initial Data	After Change in Technique	Percent Improvement
Matt Buck			
Mean Swim Velocity	1.70 m/s		
Mean Pull-out Velocity	1.42 m/s	1.70 m/s	19.71%
Initial Peak Push-off Velocity	2.52 m/s	2.62 m/s	3.96%
Carl Carlson			
Mean Swim Velocity	1.61 m/s		
Mean Pull-out Velocity	1.05 m/s	1.71 m/s	62.86%
Initial Peak Push-off Velocity	2.52 m/s	2.54 m/s	0.79%
Olympic Swimmer (Female)			
Mean Swim Velocity	1.31 m/s		
Mean Pull-out Velocity	1.10 m/s	1.38 m/s	25.45%
Initial Peak Push-off Velocity	1.79 m/s	2.20 m/s	22.90%
Sarah Miller			
Mean Swim Velocity	1.25 m/s		
Mean Pull-out Velocity	1.04 m/s	1.30 m/s	25.00%
Initial Peak Push-off Velocity	1.83 m/s	2.08 m/s	13.66%

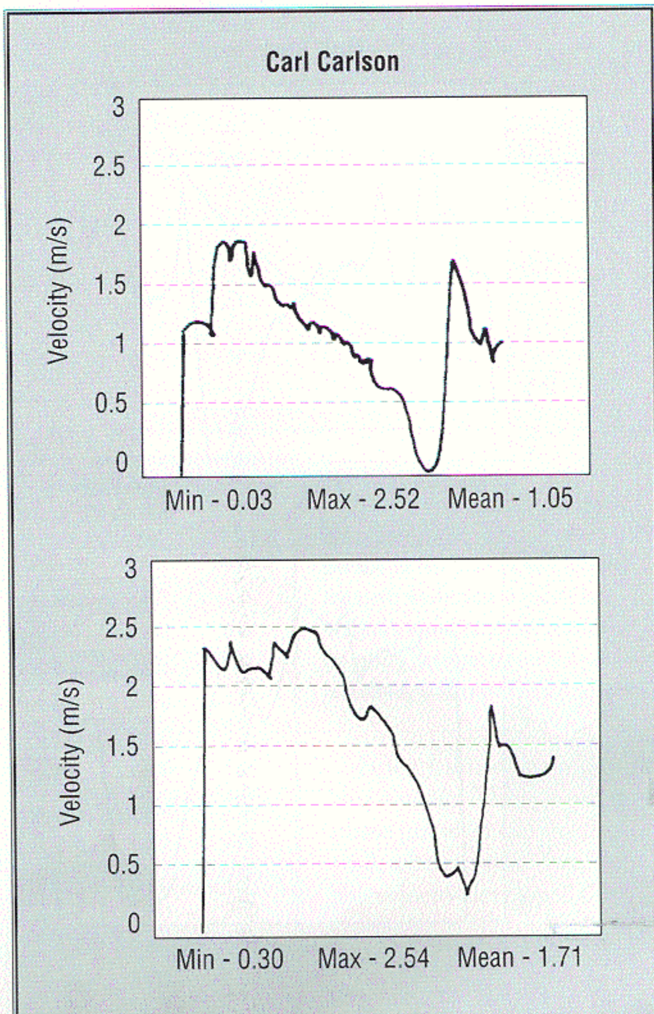


Figure 3
Tracings for Carl Carlson. The data represented could be used as a benchmark for demonstrating what is possible for subjects who can be tested on a regular basis.

Another suggestion was that he eliminate the second glide phase when the hands are at his side. *Figure 2* (page 43) and *Table 1* (at left) display the results of the changes made. The mean velocity of the pull-out increased from 1.42 to 1.70 meters per second, right at his steady state swimming speed.

Now, the pull-out and the swimming velocity were virtually the same. This change in mean velocity during the pull-out represents an improvement of 19.71 percent in velocity (*Table 1*) over this phase of the swim. For elite swimmers, this is a very significant change. Instead of executing the pull-out phase below his mean speed, he was in a position to continue his regular breaststroke swimming at his mean stable swimming speed during this entire phase.

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Carl Carlson is a swimmer on the University at Buffalo's men's team. Because we can work with him on a daily basis, his pull-outs show the biggest change and could be used as a model for what might be possible for other swimmers if the new pull-out technique could be tuned up on a regular basis.

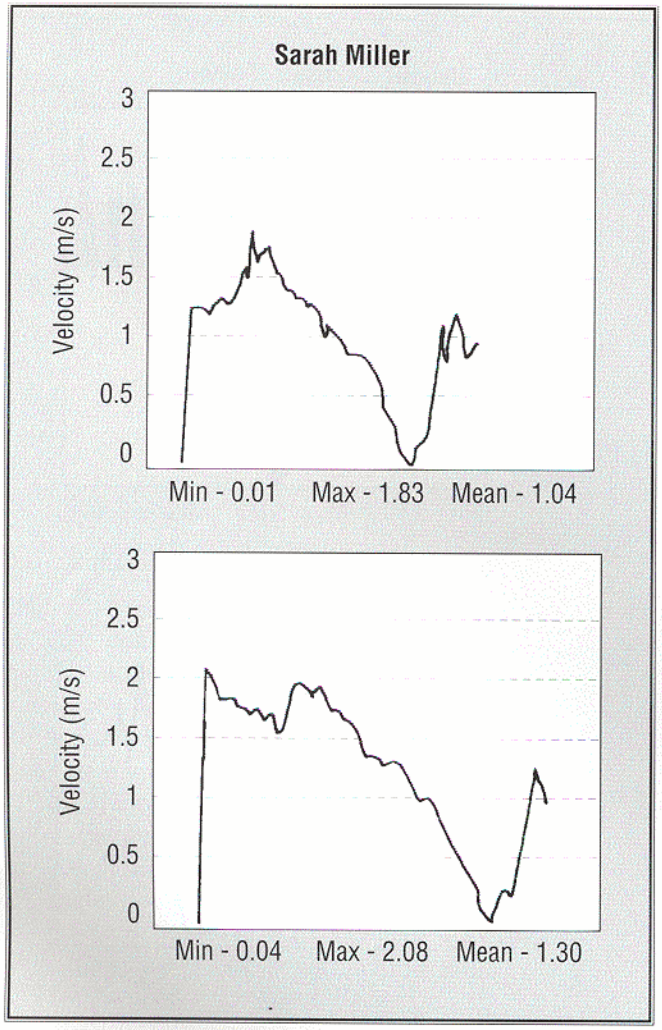

Figure 4

Comparison graphs for Sarah Miller. Tracing on the top is representative of her typical pull-out technique, and the tracing on the bottom is the improvement. Sarah was actually able to achieve velocities above her normal mean breaststroke swimming speed.

The top tracing of *Figure 3* shows the first pull-out he did as a freshman; the bottom shows a pull-out representative of his improvement. Carl's mean swimming speed calculated from his best time was 1.61 meters per second. His push-off velocity improved from 2.52 meters per second to 2.54, which is .793 percent.

Improvements that he has achieved from the initial tests conducted on him when he first came to Buffalo have been remarkable. His mean pull-out velocity improved from 1.05 meters per second to 1.71, a positive change of 62.86 percent.

❑

The data for the female swimmers are shown in *Figures 4 and 5*. The phenomenon of coming to a complete stop was also found in the female subjects.

Figure 4 shows the data collected from Sarah Miller. Her mean swimming velocity was calculated at 1.25 meters per second. The mean velocity in her best initial pull-out was 1.04 meters per second. In a very short time, her mean speed improved to 1.30 meters per second, an improvement of 25 percent.

Sarah was so good at changing her technique, she was able to register velocities above her mean speed. Instead of executing the pull-out phase under her mean speed, she was able to execute her pull-out above her swimming speed, which would allow her to slow down to mean swimming speed.

When testing Sarah, another interesting event occurred. Not only did the mean speed of the pull-out improve, but the initial push-off velocity improved by 13.66 percent from 1.83 meters per second to 2.08 meters per second. Both of the female subjects improved in a similar manner.

Figure 5 shows the tracing of a female Olympic swimmer. Improvement in her initial push-off phase (the front part of the tracing) from 1.79 meters per second to 2.20 resulted in a 22.90 percent change.

It appears that the swimmers get a gain in initial velocity if they begin their pull-out much sooner from the wall. This is a big benefit because the pull-out phase now begins at higher velocities on the velocity curve (*Figure 1*).

The swimmers have a chance to avoid decelerating below their mean speed and coming to a complete stop during the recovery phase, thus decreasing drag. *Table 1* is a summary of all the data for all the subjects.

DISCUSSION

Considering the data in this study, there are some general recommendations that can be made for all swimmers interested in improving their pull-outs:

- From the initial push-off from the wall into the initial glide phase, holding the glide for more than one second is probably on the edge of gliding too long. Use the glide curve in *Figure 1* as a baseline.
- The female subjects showed that pulling sooner actually *increased* their initial peak velocity, so beginning the initial pull phase earlier does not inhibit the velocity.
- The pull phase down to the side of the body should be narrow to minimize the drag profile, which eliminates a more rapid deceleration. Pulling very wide opens that profile and slows the swimmer.
- When the hands reach the side of the body, start the recovery phase to the top of the water as quickly as possible and begin swimming.
- To reduce the size of the drag profile, the kick should be small and narrow. A small fast kick has less drag and is shorter in time duration.

Another inconsistency that the analysis revealed—although deceiving to the eye—was that while the swimmers were executing the pull phase, there was no increase in velocity; the velocity decreased immediately.One of the female subjects at the beginning of our testing employed a very wide out-sweep when beginning her pull. If the profile is too wide—even though the swimmer is pulling the arms through the water—the drag created by the arm stroke is greater than the propulsion of the arm stroke. Thus, the body continues to decelerate throughout that phase. The tracing of the instantaneous velocity confirms continued deceleration, even though she is pulling.

The phase that incurs the most drag is the recovery phase because the legs are separated and pulled up for the kick. To reduce the size of the drag profile, the kick should be small and narrow. This will probably be the one area that will cause the most concern for coaches.

The feedback that coaches will probably get is that it feels as if the swimmers are not getting anything out of their kick. As described before, what they are feeling on their legs is drag, because a wide kick increases the drag profile outside the body. A small fast kick has less drag and is shorter in time duration. This will allow the swimmers to get to the surface sooner, decelerate less and, thus, avoid coming to a complete stop.

One other important aspect that coaches and swimmers should also understand is that the fastest swimmers pay the biggest bill when the mean pull-out velocity and the mean swimming velocity are so different. Our analysis shows that with a little testing, these swimmers on average were able to improve their technique about 20 percent, or improve their pull-out velocity to match and even exceed their swimming velocity. For these subjects, this improvement could make a real difference in their standing at the national or world level.

❑

This analysis concentrated only on one breaststroke pull-out. Swimmers and coaches should also consider the cumulative effect on performance because these results are multiplied by the number of turns in any given competition. We used the breaststroke pull-out to demonstrate this effect because the overall potential effect is the greatest, as the speed fluctuations are the largest.

Please note that the effect demonstrated for the push-off phase is the same for the start as well. The same deceleration in velocity that was observed for the push-off also existed for the starts.

❑

All of the turns for the four competitive strokes incorporate a glide phase from the wall. The recent trend of using a dolphin kick off the wall for the fly, back and freestyle turns can also be analyzed in the same fashion as the breaststroke pull-outs.

It is possible, especially in the execution of the underwater dolphin kick, to optimize the distance with velocity, so that like the swimmers tested for the breaststroke pull-out, swimmers using any of the other three strokes can begin the regular swimming phase at the same or greater mean velocity than they can swim using the regular stroke. The optimal velocity and distance can then be "dialed in."

Again, it can be deceiving to compare swimmers against each other, or by using elapsed time, when deciding how efficient a particular swimmer performs this technique. At any given distance from the wall, when the mean velocity of the dolphin technique drops below the velocity the swimmer can achieve by regular swimming, optimal performance is compromised.

The analysis of the breaststroke pull-outs and the discussion about the starts and the dolphin kick for the different strokes is about helping swimmers optimize their performance.

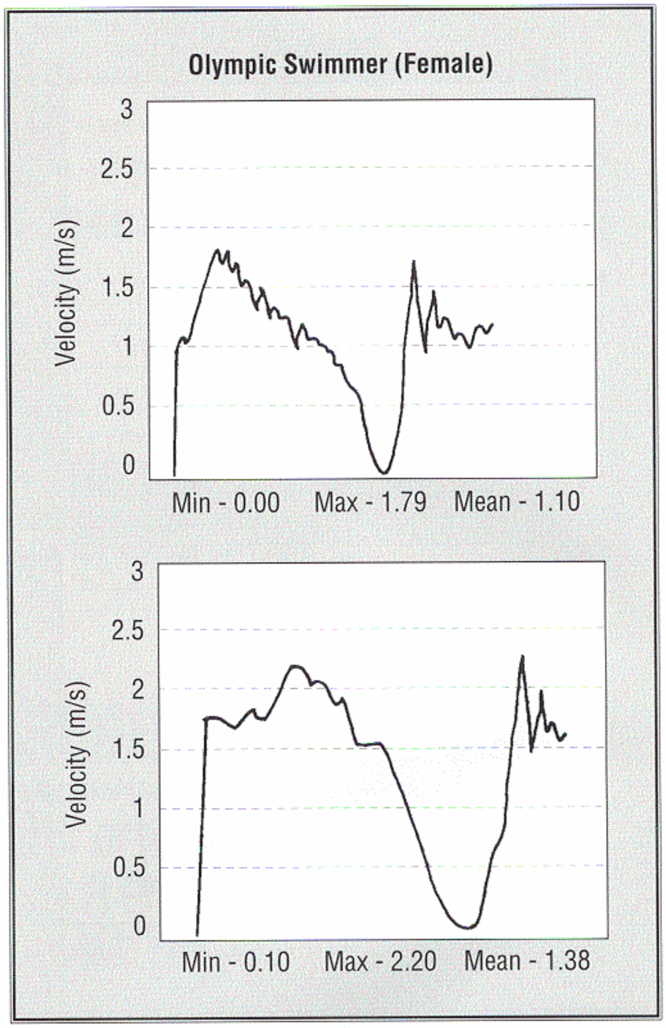

Figure 5

Tracings of the female Olympic team swimmer. Note that not only does the mean speed improve, but pulling sooner also improved the initial push-off velocity. This was true for both female subjects.

Acknowledgements

The authors would like sincerely to thank the swimmers who participated in this particular study. We would also like to thank **John Zaharkin, Michael Zaharkin** and **Eric Oppenheim** for the computer software and hardware developed for this study.

Anyone interested in this type of analysis may contact us at the University at Buffalo through our World Wide Web site at the following address: http://ub-swimming.buffalo.edu/

About the Authors

Budd Termin is the head men's swimming coach at the University at Buffalo. **David Pendergast, Ph.D.**, also at the University at Buffalo, is a professor in the department of physiology.