THE CrossFit JOURNAL

Torpedo School 4: Up From the Depths

By mastering underwater swimming and breakouts after starts and turns, athletes can maintain speed off the wall and reduce race times.

By Adam Palmer **December 2014**

All photos: Dave Re/CrossFit Journal

In previous articles I've talked about basic elements of freestyle swimming: turns and starts. The element I intentionally left out was how to properly transition from a start or turn without causing massive deceleration upon surfacing. This article was written to help athletes of all levels improve race transitions.

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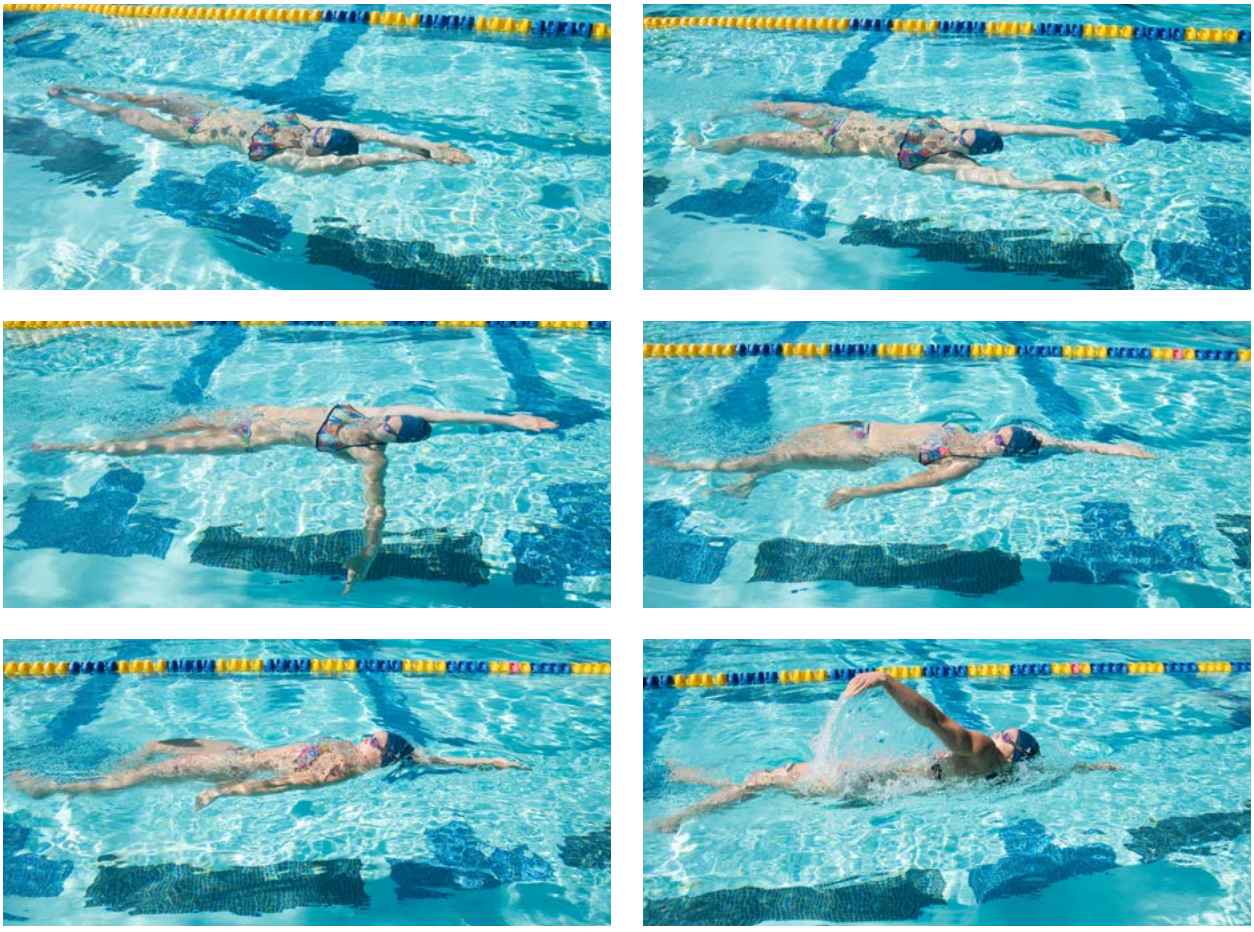
Breaking It Down

Fédération Internationale de Natation (FINA) governing rules limit underwater travel in competitive swimming races to 15 m (or yards for American short-course pools) on any single length. The total distance traveled underwater can account for up to 30 percent of a long-course race distance and 60 percent of a short-course race. Mastering the hydrodynamics between the wall and the surface can pay huge dividends in both speed and efficiency, equating to faster times. Independent of stroke, the basic principles for getting from Point A (the wall) to Point B (the breakout) are the same whether coming off a turn or after the start of a race. These principles can be broken down into three steps:

- Push-off and streamline—The push-off is covered in Torpedo School 2: Learn to Turn. I'll focus on the specific points for an effective streamline in this article.
- Underwater kick or underwater pull-out—Breaststroke races exclusively employ the underwater pull-out, which will be covered in a separate article on the breaststroke itself. The underwater kick for butterfly is the dolphin kick. For freestyle or backstroke, athletes have a choice to make. They may choose to use either the flutter or dolphin kick. I'll go into the pros and cons of each, explain how to effectively employ the dolphin kick, and outline the optimal depth and distance to travel while underwater.
- The breakout—The breakout is the transition point from underwater to surface swimming. I'll discuss some key points to help create smooth transitions.



With a smooth transition, swimmers can carry their underwater speed in the stroke they use on the surface.

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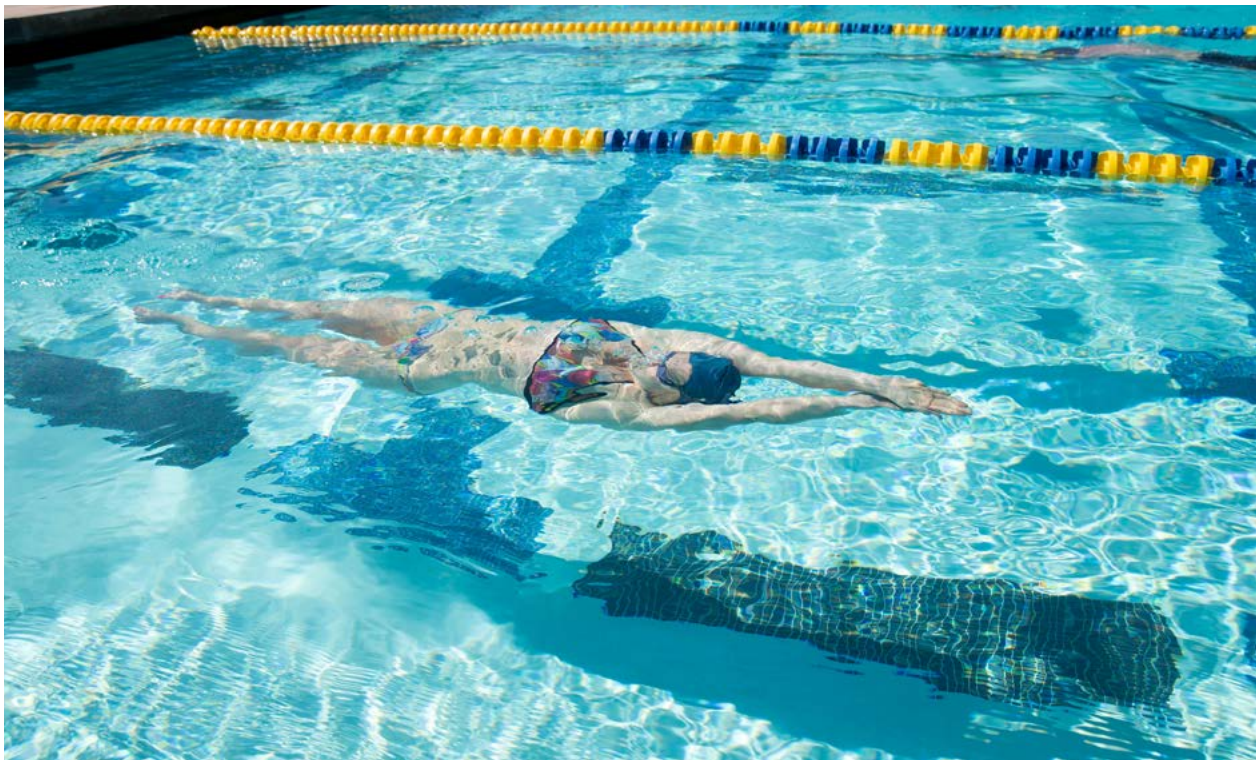

The streamline position is designed to limit drag, allowing an athlete to maintain as much speed as possible while gliding.

Streamlines

The streamline position is to swimming as the hollow position is to gymnastics: It's foundational.

Key Points of the Streamline

- One hand on top of the other—There are no hard rules about whether right over left or vice versa is better, but consistency is very important. Specific to freestyle and backstroke, if you are going to initiate the breakout with the left arm, the right hand should be placed on top of the left in the streamline to better facilitate a left-arm stroke after emerging. The key is consistent practice of one way or the other to build muscle memory.

- Activate the shoulders and squeeze—In a perfect streamline, the head sits slightly in front of or between the biceps. Activating the shoulders allows the greatest reach possible.

- Tuck the chin and keep the core tight—This helps streamline the body more and ensures the upper torso acts as one unit.

- Point the toes back—This action is essential to lengthening the body and putting the feet in the right position to initiate a kick for any of the competitive strokes.

The Dolphin Kick

The dolphin kick drives the butterfly stroke but is used in other ways in competitive swimming, specifically underwater. Without going into the mechanics of the butterfly stroke, our focus on dolphin kicking will be within the context of starts and turns prior to breakout.

A great dolphin kick requires flexible ankles and powerful legs. It is a whole-body movement driven by the head and core. The athlete's goal should be to quite literally mimic the movement patterns of a dolphin. With the flutter kick, the legs move independently, but in the dolphin kick the feet and legs stay together and operate in unison, acting

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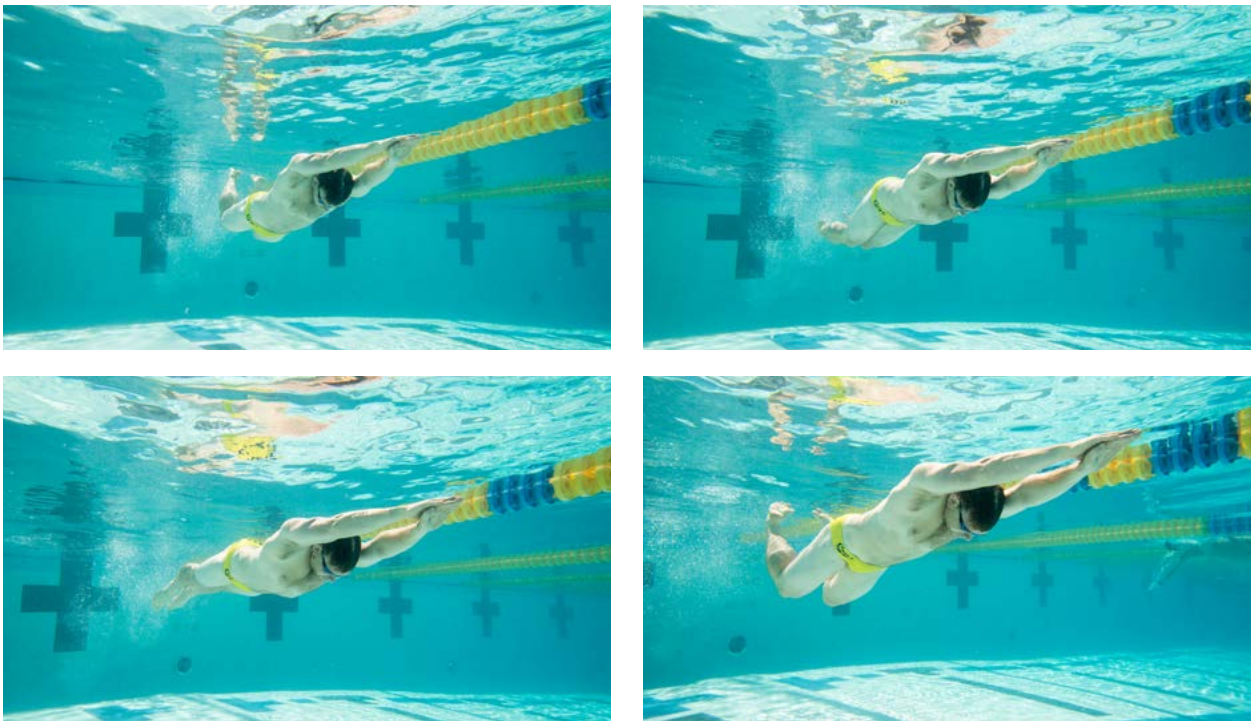

The dolphin kick effectively turns the entire body into a whip and can be used to generate significant speed underwater.

like a single fin. The propulsive force of the kick comes from the whip-like extension of the legs (3).

While not required, the kick may be augmented by subtle head and upper-body undulations (typically between 5 and 10 degrees from horizontal). It's important to remember this movement shouldn't be the main focus of the kick. Similarly, you don't need a lot of movement to significantly affect the kick. The rest of the body should be flexible enough to allow the upper-body undulation to translate down to the feet. As the hips extend, the legs and ankles should be relatively relaxed, which will allow the knee to flex to approximately 45 degrees with the toes pointed. From here, powerful hip flexion and leg extension add tremendous power to the dolphin kick. The finishing position should have the feet finish below the horizontal body (3), and the finishing position very closely resembles the hollow position in gymnastics.

Another way to look at the dolphin kick is to imagine a whip. Slight yet sharp movements in the grip result in a wave that travels down the length of the whip and creates a crack at the other end. This is fundamentally how the dolphin kick works. With a human body, the effective length of our "whip" is limited to the length of our body. The head, shoulders and arms effectively act as the handle or grip. The up-and-down oscillations of the "grip" contribute to the kick through the physics law governing the conservation of momentum. Power from the leg extension (still a core-to-extremity movement when factoring in hip drive) augments this action.

As with the flutter kick, it's important to consider potential drag generated by an inefficient or weak kick. Generally, weak or lazy kicks will generate more drag and be less powerful and efficient than faster, snappier kicks. Unnecessary up, down or side-to-side torso movement will also generate detrimental drag. It's easy for swimmers to fall into the trap of neglecting the kick by being lazy. When observing world-class athletes, the fastest swimmers kick approximately 145-150 beats per minute underwater. As stated earlier, it doesn't require a large amount of head and upper-body undulation to generate an extremely powerful kick, but all great dolphin kickers kick aggressively and with high frequency. A great example is Michael Phelps' technique as seen in any of his individual-medley or butterfly races.

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Underwater Dolphin Kick Vs. Flutter Kick for Freestyle and Backstroke

Underwater dolphin kick should be used if the athlete has a strong kick and is comfortable performing it in a race. If done well, the dolphin kick is significantly more efficient than the flutter kick underwater and allows the athlete to maintain off-the-wall acceleration prior to the breakout.

By comparison, Phelps is able to dolphin-kick underwater at approximately half the speed of an actual dolphin with a body wave that starts in the head and chest and makes a whip-like snap at the ankles. The wave increases in amplitude as it travels down Phelps' body to end in an ankle snap with a 0.75-m amplitude (1). This massive dolphin kick is one of the key elements that made Phelps a 39-time world record holder.

Developing the Dolphin Kick

Aside from practicing the dolphin kick off every wall during butterfly, backstroke and freestyle swimming, an athlete can develop the skill in a few other ways.

Drill—Swimming With Fins

The use of fins can aid in developing the proper rhythm. With fins, water displacement will be greater and body undulations can be more fluid. The result is a faster, more efficient kick. Fins can also help develop and improve ankle flexibility due to the additional stress placed on the joint as a result of the larger moment arm and surface area of the fin itself. Following a training session incorporating fin work, it isn't uncommon for athletes to have sore ankles. Fin work can be programmed with or without the use of a kickboard and in the same distances and intervals used for other sets.

Drill—Vertical Kicking

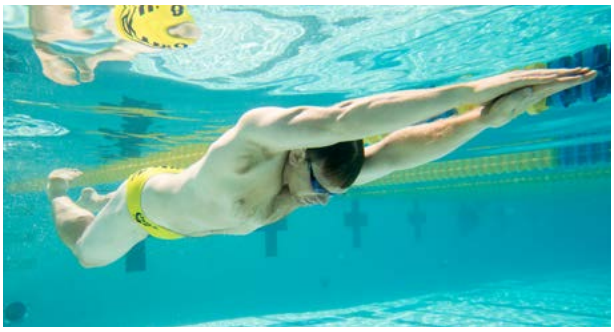
Another way to improve the dolphin kick is vertical kicking. Vertical kicking will improve both the speed and balance of a swimmer's kick. As a baseline, an athlete should first be comfortable treading in at least 5 or 6 feet of water with the head above the surface and the hands down to aid flotation. Additionally, this drill will be made easier by using fins until the athlete develops enough strength to perform the drill without them.

The arms may be up out of the water (more challenging)

A flutter kick may be employed underwater, though it's slower than a dolphin kick.

While the dolphin kick uses the legs as a single unit, the legs alternate in the flutter kick.

Weak or lazy kicking can increase drag and reduce speed.



The flutter kick is used in some strokes, so it should be practiced, but swimmers are encouraged to master the dolphin kick to maximize underwater speed.

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or under the water (less challenging) while the swimmer kicks with toes pointed toward the bottom of the pool. Crossing the arms over the chest and keeping the body from moving forward or backward will help the swimmer focus on the balance of the kick. The most challenging version of this drill is with the arms in the streamline position overhead.

A Tabata interval would be an excellent routine to employ when training the dolphin kick in this manner. However, the intervals may be longer in duration if the goal is overall endurance.

Depth and Distance

Studies have shown that hydrodynamic drag at certain points below the surface is reduced relative to surface swimming. The optimal depth is between 0.4 and 0.6 m below the surface. This results in an appreciable 10-20 percent reduction of surface-level drag forces while traveling at speeds between 1.5 and 2.5 m/s (the velocities used in the study) for accomplished athletes (2).

Distance traveled underwater prior to breakout largely depends on the ability of the athlete. In a normal race, the distance is limited to no more than 15 m (or yards) on any single length, measured by an off-colored doughnut in the lane ropes. With that rule in mind, it can be very advantageous to travel the full distance underwater, provided aerobic capacity allows it and the athlete is comfortable and fast underwater. For skilled swimmers, the velocity underwater will be between 1.5 and 2.5 m/s depending on the stroke—higher than speed on the surface (5).

Off the final turn of the 200-m backstroke at the 2008 Mutual of Omaha's Duel in the Pool, Phelps surged ahead of Aaron Peirsol by dolphin-kick streamlining nearly the first 15 m of the final length. Peirsol, the leader going into the final turn, had taken three or four strokes before Phelps surfaced. With a stopwatch on Piersol, I calculated the peak speed of his underwater portions (both off the start and after the turn at the 50-m mark) as about 2.7 m/s, with the surface swim averaging about 1.7m/s.

The graph below highlights two world-record performances by Brazilian swimmer Cesar Cielo. Note the peak velocity is seen at the 15-m or 15-yard mark, as the athlete has the advantage of both the dive off the starting blocks and the underwater swim. The velocity spike at the

Fins can be used to help a swimmer develop the correct rhythm for the dolphin kick.

Fins place additional stress on the ankles, and being sore after working with fins is not uncommon.

By displacing more water, athletes can generate significant speed with fins.

With a fluid transition to the next undulation, swimmers are able to carry their speed.

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Vertical kicking can be made easier with fins.

Keeping the arms underwater reduces difficulty.

Vertical kicking will help improve the speed of the kick.

Tabata intervals can be employed to practice vertical kicking.

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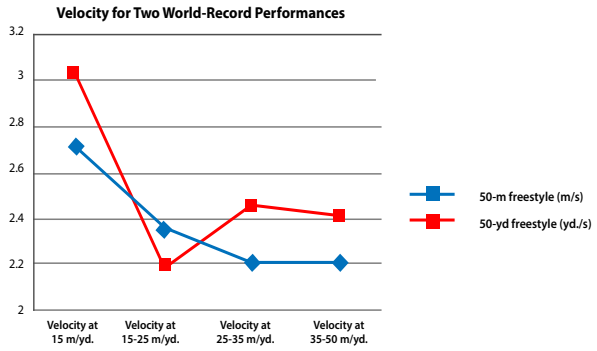
25-yard mark of the 50-yard race is due to the turn, push off the wall and underwater streamline, whereas there are no turns in the 50-m long-course race (4).

For novice swimmers, it is less common to see high speed after 15 m of streamlining, so it is best to transition to the breakout when the athlete perceives an overall loss in velocity.



In this evaluation of Cesar Cielo's speed at various points in two races, velocity is highest at the start due to a push off the blocks and a strong streamline. In a 50-yard race, velocity increases significantly after the turn as the athlete streamlines underwater.

The Breakout

The best way to develop smooth, fast transitions is practice through repetition. It's already built into your workout. Here are some key points to think about at each transition:

- The breakout begins an inch or two below the surface. This is an absolutely critical element, because if you start your breakout too early, you create drag. Start too late and you create drag. The best-timed breakouts allow arm strokes to optimally transition the speed from the underwater portion of the swim to surface swimming. As you get more and more comfortable, you will develop better spatial awareness in the water and will be able to tell whether you are 3 or 18 inches below the surface—or anywhere in between. This awareness comes from practice and time in the pool.

- The breakout, regardless of stroke, begins with an arm pull first. If you are using the dolphin kick during a freestyle or backstroke race, try to begin your opening arm pull on the downbeat of the final kick or begin flutter kicking earlier below the surface.

- Maintain the body line and a neutral spine when breaking out to the surface. Always wait at least a few stroke cycles before taking the first breath for freestyle or butterfly (usually two or three). Popping your head out of the water on a transition is like putting the parking brakes on, and it creates a tremendous amount of drag.

- You've made the transition, now focus on stroke mechanics, breathing or pacing depending on the race distance.

The Need for Speed

Maximizing effectiveness off the wall, maintaining optimal hydrodynamics during underwater kicking and executing smooth breakouts through consistent practice are keys to fast swimming. Mastering these elements allows the athlete to move faster while using less energy. The fastest athletes use a dolphin kick for the maximum allowable distance on every length. This technique is difficult to master and maintain in an oxygen-depleted state mid-race, but it is something every athlete should strive to learn. Get the most out of your underwater swimming and your transitions, and I am sure you will see results.

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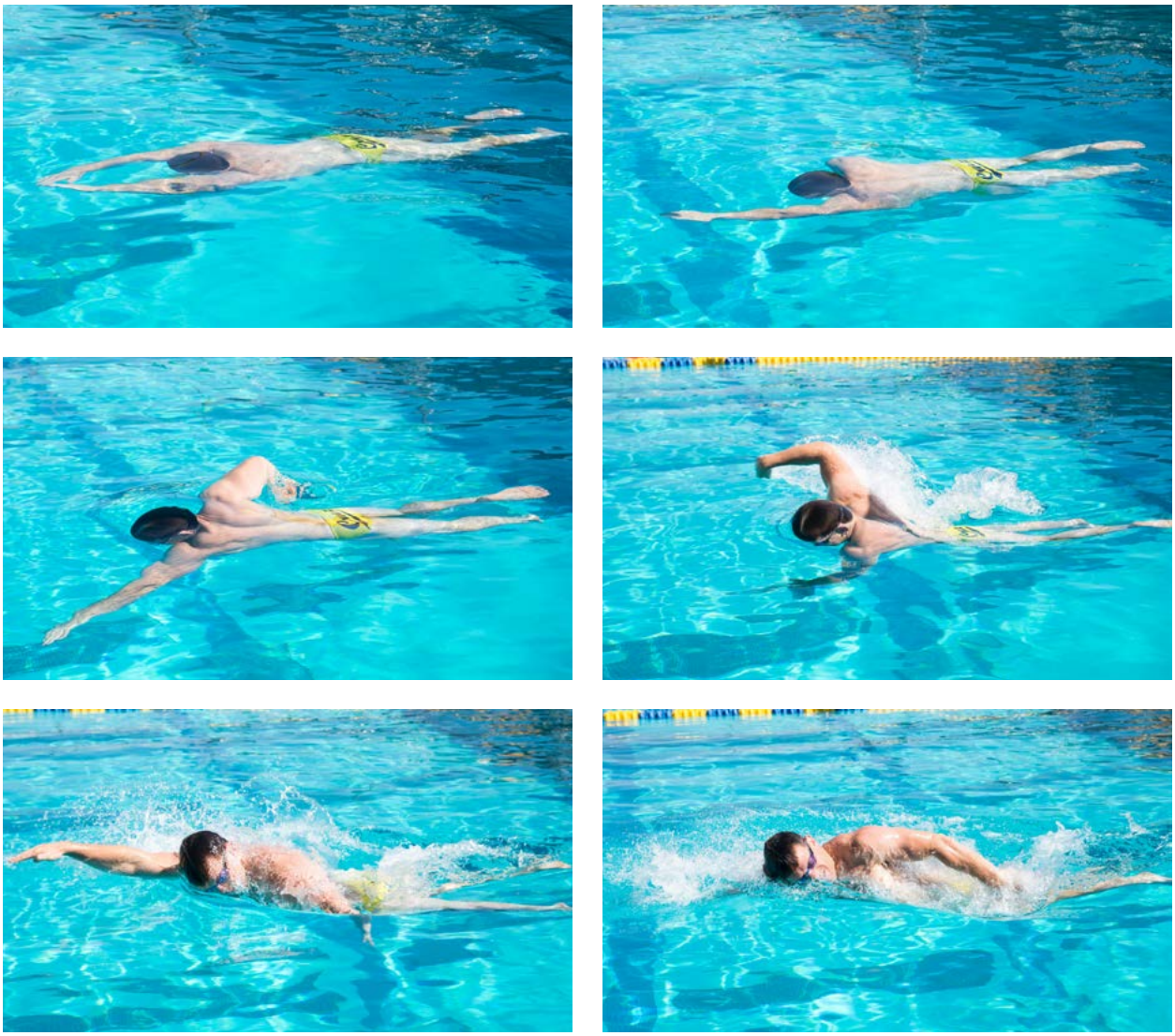

Timing your breakout is critical. If you are too early or too late, you'll create drag and lose precious speed.

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About the Author

Adam Palmer is an active-duty Air Force officer, CrossFit Level 1 certificate holder and the managing editor for Reactive Training Systems. Prior to discovering CrossFit in 2008, he competed at the NCAA Division 1 level and was a United States Swimming club athlete for more than 16 years.