FUNDAMENTALS OF FAST SWIMMING

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At The Race Club I have had the opportunity to observe and work with some of the fastest swimmers in the world. Though I have come to appreciate that stroke techniques differ between sprinters and distance swimmers, and that there is not one technique that is ideal for everyone, regardless of the race distance, I also recognize that the best sprinters demonstrate the most efficient techniques. After all, if they weren't efficient swimmers, they wouldn't be great sprinters.

Whether distance or sprint, however, I believe there are three common fundamentals that are desirable to achieve in all strokes in order to swim fast. These fundamentals are not new. They have been presented by experienced and knowledgeable swim coaches, though not always together or in the same way. The following is simply The Race Club way of presenting these three important fundamentals with a few novel ideas thrown in.

FUNDAMENTAL # 1 THICK AS A BRICK

Since moving to the Florida Keys, I have been on the underwater lookout for any fish or aquatic mammal that closely resembles the human being. So far, aside from a slow moving jellyfish, I haven't found one single species with long arms or legs. The fact is, I suspect that most of the snapper, grouper and yellow tail that swim away from me with a flick of their tail, kind of smirk when they look back at me with my spear gun in hand, calculatingly out-of-reach for a kill. To them, I must look like a brick with long fins on. Come to think of it, that is what we are; live bricks in the water.

In the mini-evolution of humans as aquatic mammals, which unofficially began in the 1896 Olympic Games, when, for the first time in sport, it became desirable for the human to move quickly through the water, we have actually come a long way. Some of our progress in swimming faster has been learned (training smarter and harder, streamlining, shaving the body), some of it genetic and/or developmental (taller, bigger hands and feet, more flexibility, hyper-extended joints) and some of it technological (swim caps, wool to nylon to Lycra to full-bodied carbon fiber suits). Yes, we've come a long way, baby, but to that Tarpon that swims by my dock every night, even Michael Phelps still swims like a brick.

Since the human brick-like body is not streamlined nor designed for the water, we must try to do the best we can with it. It just happens that as with all non-streamlined objects, little things we do with our bodies to make them closer to being streamlined turn out to make a big difference. In a sport where winning or not is determined by hundredths of seconds, the little things we do to make ourselves more streamlined turn out to be not so little.

In general, coaches around the world have come to recognize how important streamlining the human body is, if the swimmer wants to win. Of the hundreds of swimmers I have taught at The Race Club, virtually all of the swimmers under 30 years of age know exactly how to make a streamline in the water. In major competitions, they wouldn't dream of not swimming with the highest tech suit, racing cap, shaved body and low-profile goggles on. Yet even with all of that high tech gear, using a perfect entry track start off the blocks, hitting the water at approximately 5 miles per hour and making the tightest, wrist-over-wrist streamline they can manage, utilizing no kicks or pulls, they will come to a virtual stop in the water in about 5 seconds. Alas, the human brick.

In our ongoing quest to become less brick-like and more fish-like, I have found two problems that occur in over 90% of the swimmers I teach. I don't blame the coaches. One is almost beyond their control. The other is simply not obvious. The first problem is head position. In freestyle (as in fly, back and breast) the head position is often held too high. Why is this bad? When the head is elevated in the water, the hips immediately sink. The human body swimming through the water with the head elevated is a body moving with a slight angle. If one has ever tried to pull a kick board through the water in any other way but flat, one will understand what that slight angle does to create drag or resistance. If a small kickboard causes that kind of drag, imagine how much drag is created with a slightly angled 5 or 6-foot body! Ouch.

The head position needs to be in alignment with the body, not elevated. That means the line of sight is directed to the bottom of the pool, not in front. Or in backstroke, the head needs to be positioned back far enough to allow a small stream of water to go over the face between breaths and with each stroke. Any higher head position than that and one is swimming on an angle. Great freestylers will breathe back and to the side so that when the head returns to the down position, the chin is tucked down and the head remains in alignment with the body. Seems simple, so why do 90% of swimmers have their heads too high? Self defense.

When you swim freestyle or fly and your head is in the correct position, you can't really see where you are going. It is only a matter of time before someone swimming backstroke veers over to your side of the lane, or someone pushes off the wall crooked, or some flyer decides to take over the middle of the lane. It only takes one smack of the head and you will be swimming with your head up from that point on, even if you look like Tarzan, in order to avoid that happening again.

So how does a coach teach the proper head position in the midst of a frenzied workout? Drills, drills and drills….then allow swimmers to swim at least one length correctly when there is no oncoming traffic. Try to give them enough space in sendoffs so they don't need to be looking up all the time.

The second most common problem I encounter that contributes to our brick-like motion in the water is the dropped elbow. Once again, I give most coaches credit for trying. Most swimmers are being told to swim with a high elbow underwater. They just aren't being told why or correctly why. If a swimmer is given a reason for swimming with a high elbow, which is not often, it is usually related to increasing the pulling area or power of the underwater pull, neither of which I believe is true. First, a straight arm has the same surface area as a bent arm, so that does not change. As for power, I believe a high elbow creates neither a natural nor a stronger position for the pull. In fact, at first attempt, pulling with a high elbow is downright awkward. What the high elbow does create, however, is a significant reduction in drag. There is a very simple way one can demonstrate this.

Put on a pair of fins. Kick as fast as you can across a 25 yard or meter pool with one arm held over your head in a streamlined position and the other arm straight down toward the bottom of the pool. You will have to work to keep your arm pointed straight down as the drag created by it will cause it to go backwards. Once you feel the enormous drag your arm creates (like dragging a bucket) you will have a greater appreciation for why there are no fish with long arms. Now do the same exercise, kicking as fast as possible with the fins, but instead of pointing the arm straight down toward the bottom, let the upper arm protrude straight out to the side and perpendicular to the body (keep it under water) and then bend the elbow 90 degrees toward the bottom of the pool. Same arm, same surface area, just in a different position. You should still feel considerable drag from the arm in the 'high elbow' position, yet significantly less than with the straight arm.

Admittedly, swimming is not quite the same as dragging your arm through the water. This long appendage that causes this huge drag problem is also providing the surface area that enables our muscles all the way from the core (abdominal, lower back) upper back, chest, shoulder, upper to lower arm help power us up; to provide most of our propulsive force. In other words, our arm is both our best friend and our worst enemy. In order to better understand why, let's examine what is happening to the entire arm during the freestyle stroke.

Today, a world-class woman sprinter will swim 50 meters in 25 seconds. That means that her body will average a speed of 2 meters per second. If her body is moving that fast through the water, how fast are her hands moving underwater? Surprisingly, few people I ask this question to know the answer. Doc Counsilman, back in the 70's, was the first to analyze the hand movements underwater during the freestyle stroke. He did so by placing a small light on the fingertips of Mark Spitz, me and other world-class swimmers, then photographing us swimming freestyle from the bottom of the pool with a stationary movie camera in a darkened indoor pool.1 He discovered that there is very little forward or backward motion of the hand in the water (there is some forward motion at the beginning (the glide or hold) and some backward motion during the fast phase, when the hand moves from around the shoulder to its release from the water). Much of the motion of the hand is actually from side to side and/or down and up, but almost invariably the hand will exit the water very near or slightly in front of the point where it entered, meaning that the net velocity of the hand in the forward direction is near zero.

Even a brick sitting still in the water does not create drag. Forward drag (of which there are three types; pressure drag, surface drag and friction) is dependent on having velocity in the water. At the beginning of the underwater pull, when the hand is moving forward some, it is in a streamlined position and creates little forward drag but does create propulsive lift. As the hand accelerates backward with some velocity in that direction, it creates propulsive drag, but now it contributes nothing to our forward (resistive) drag. What about the rest of the arm? What is it doing during the freestyle pull?

Since the arm is attached at to the body at the shoulder and we know the body is traveling at 2 meters per second, then this part of the arm is also moving forward at 2 meters per second. If the net velocity of the hand is zero, then as we move up the arm from the wrist to the forearm to the elbow to the upper arm, we will find an increasing forward velocity of that part through the pull, though not necessarily in a linear fashion, even when the hand is moving backward. The faster an object moves through the water, the more drag is created, unless of course, like a boat, it can move to a completely different position, like hydroplaning over the water. So far, no human has been powerful enough to plane over the water. So we can assume that the upper arm causes much more forward drag than the lower arm because it is bigger and is traveling forward faster. How we position that upper arm, that is, elbow down or elbow up, makes a big difference in how much more drag that part of the arm contributes.

One can think of the arm as two people in a canoe. The person in front (representing the lower arm) wants to win the race and is paddling like crazy. The person in the back of the canoe (representing the upper arm) doesn't really want to be there. In fact, he got talked into going, so his plan was to sit back and let the front guy do all the work. But he knew that eventually the front guy would wonder why they weren't winning, so he would turn around and find him sitting back and relaxing. In order not to get caught slacking, the guy in the back of the canoe decides to put his paddle in the water at all times. Whenever the front guy would turn around, he would make a face and grunt like he was pulling hard, when all he was doing was putting his paddle in the water. By putting his paddle in the water, however, and not pulling, he is creating a bigger problem than by doing nothing; causing more drag. He has a choice, though. He can put his paddle in the water with the blade parallel or perpendicular to the line of forward motion. If he puts the blade in perpendicular (dropped elbow) he creates a huge problem for the guy up front. If he puts the blade in parallel (high elbow), he creates less of problem for the guy up front.

Watching world-class swimmer after world-class swimmer underwater, whether with The Race Club or not, I am struck by the consistency of the high elbow in free and fly. The elbows move very quickly from a high position, as the body moves by the hand (not vice versa) into a tucked position near the body as the hand prepares to release from the water. I believe that this rather unnatural position is not a position of power, but rather a position of least forward drag or resistance. It is one of the less obvious ways we can make ourselves less like a brick.

FUNDAMENTAL #2 SWIM WITH YOUR BODY

Many of the swimmers I teach at The Race Club come from strong aerobic programs that have given them a good base of fitness. The freestyle stroke they use is very flat; like a paddleboard or a surfboard that grew arms and legs. I call it the survival stroke, because it is the type of stroke one adopts when one is trying to survive a long, tough set, such as 10 x 400 with ten seconds rest. It is also the stroke you would choose if your plane crashed in the middle of the Atlantic and you needed to swim to shore. But it does not enable one to swim fast.

In order to swim fast, one must learn to swim with the body, not just the arms and legs. Swimming with the body entails a rotation along the pathway (long axis) that incorporates movements of the shoulders, hips and core to varying degrees. It also involves work. No one said swimming fast was easy. Why does this rotation of our body enable us to swim faster? I can think of at least three good reasons.

First, fast swimmers don't rotate their bodies like rotisserie chickens. They snap their shoulders or hips from one side to the other. This quick rotation requires even more work, but the speed of the rotation helps transfer energy into the forward motion, much like a torpedo spins as it goes down the gun barrel.

Second, by rotating our body we position our propulsive arm into a stronger mechanical position, engaging more muscle groups, particularly in our back and core that enable us to create more power.

Third, and perhaps most important, is the understanding of while we are trying to hold the water with our hand and arm, what exactly are we pulling against? Dr. Jan Prins, a biomechanical expert at the University of Hawaii, once did a study with a baseball pitcher who was able to throw the ball from a pitching mound at about 60 miles per hour.2 However, when the same pitcher jumped in the pool into deep water and tried to throw as fast as possible, the velocity of the ball was about half. The only difference was that in the pool there was nothing solid or stable like the pitching mound to push against with the throw. It is easy to understand where we generate the power from our starts and turns because we have a stable starting block or wall to push off of. What about in the middle of the pool? What are we pulling against out there where it is just the water and us? The answer is our core. In the case of swimming, the core is not stable, but moving in a counter-rotation to our pull. We initiate the catch at the end of the hip rotation (the connection) and continue to hold the water as the hip counter rotates to generate a force to pull against. The counter rotation of our core is our pitching mound.

Some of my campers have asked me if when we rotate our bodies from side to side, do we reduce forward drag? Possibly, but I really don't know the answer. Regardless, believing that first three reasons to use our bodies while swimming are valid ones is good enough for me.

Mike Bottom, one of the most successful sprint coaches in the world, has further defined swimming with the body into three different styles of freestyle; shoulder-driven, hip-driven and body (core)-driven.3 Shoulder driven uses a higher stroke rate and because the arms are turning over faster, less hip rotation. The fastest sprinters all use a shoulder-driven technique. Hip-driven freestyle uses a lower stroke rate but in order to do well, requires strong legs and more hip rotation to sustain speed. Body-driven freestyle occurs when the hips and shoulders rotate more uniformly together and is equated in Mike's program with a straight-arm recovery.

Does a straight-arm freestyle recovery help one to swim with the body? Since the arm flexes (moves forward) in the shoulder joint much better than it extends (moves backward), the only way one can use a straight-arm, over-the-top freestyle recovery is to rotate the shoulders to the near vertical position. It just doesn't work any other way. Therefore, the straight-arm recovery may force a swimmer to use his body more than he might otherwise do. Once the shoulder is rotated back, recovering with a straight arm is actually the most relaxed biomechanical position possible for the arm. Bending the elbow causes more muscle contraction in the shoulder than the straight-arm recovery does.

There are some great drills to help you learn to use your body more effectively when you swim. One of my favorites is the 3-stroke, 6-kick drill where you hold one hand over your head and the other at your side with the head down. The shoulder of the back hand should be held in the vertical position above the water for 6 straight kicks, followed by 3 deliberate arm strokes bringing the shoulders back with each stroke to the vertical position, then six more kicks on the opposite side. Practice this drill with either the straight-arm or bent-arm recovery and you will really get the feeling that your entire core is being used to create the power in your pull. Just like Tiger Woods uses his body to drive a golf ball or Tom Brady uses his body to throw the football, whether shoulder-driven, hip-driven or core-driven, all great swimmers will use their bodies to enable them to swim fast.

FUNDAMENTAL #3 SWIM ON THE FREEWAY

If you ever looked on the sticker on a new car window, you may have noticed that there are two numbers given for fuel consumption. The higher gas mileage usually says Highway underneath it and the lower value refers to what you might expect to get around town. Did you ever stop to wonder why you might get 30 miles per gallon on the highway, driving at 65 miles per hour, while in town, averaging say 30 miles per hour, you may only get 22 miles per gallon?

The answer is based on something called inertia. Inertia simply means that it is more efficient to keep something moving steadily than it is to get it moving in the first place, then have it slow down or stop, and finally get it moving again. If you ever had to push a car from a dead stop, you will appreciate inertia more. Or more relevant to a swimmer, if you have ever had the misfortune of completely misjudging the wall on a turn and to push off against only water, you will also understand inertia. The amount of energy required to get your body back up to race speed from that dead stop in the water is overwhelming.

Inertia is just as important to a swimmer in the water as it is to a car on the freeway, or perhaps even more. This simply means that the most efficient way to swim is to sustain as close to the same speed, whatever that might be, for the duration of the swim stroke cycle. Because our long arms serve as both our primary source of power and also the cause of significant drag, it is impossible with our human design to maintain a constant velocity during the swim cycle. In a recent Swimming World article, Genadijus Sokolovas, PhD, director of sport science for USA swimming, showed that with a freestyler who can average 2 meters per second, the speed will vary from around 2.5 meters per second at the fastest point to 1.5 meters per second at the slowest.4 Freestyle and backstroke come the closest to being the ‘freeway’ strokes because the arms are pulling non-uniformly, allowing the speed to remain more constant. He also showed that the range of speed in the butterfly and breaststroke cycle is much more extreme, varying from over 3 meters per second in fly at the fastest point to less than 1 meter per second at the slowest. In breaststroke, the range of speed may range from over 2 meters per second to less than ½ meter per second during the stroke cycle. By their design, with most of the propulsion occurring with arms or legs working uniformly and simultaneously, butterfly and breaststroke are inefficient, ‘stop-and-go’ strokes.

So the question is, even if we cannot get on the freeway in fly or breast, how do we get on the freeway with free and backstroke? To understand how, one must first understand the stroke cycle. The fastest speed in the cycle occurs when the arms are in the most streamlined positions, which are in front of us or at the very end of the underwater stroke. The slowest speed in the cycle occurs when we are in the least streamlined position, which occurs when our upper arms are protruding either down (dropped elbow) or out (high elbow) but are more or less perpendicular to our bodyline. What is also misunderstood about the freestyle and backstroke pull cycle is the notion that each arm is working separately; in other words, while one arm is underwater the other is on top and vice versa. That is not true. With any efficient and fast freestyler, when one hand enters the water for the underwater pull, the other hand is usually underwater at around the chin to shoulder level. That not only means that both hands are simultaneously under water for some period, it also means that the time spent ‘holding ‘ the water from the outstretched arm at entry to when the hand is at the shoulder level is the same as the time it takes for the hand to accelerate through the underwater pull and make the complete out-of-water recovery and re-enter the water. In other words, in the time it takes to make a complete stroke with each arm, half of that time is spent in the small space between the outstretched hand entering the water until the hand and shoulder are even. It is here in this space, I believe, that the greatest power is derived from the freestyle and backstroke pull.

If one were to examine the velocity of the body in relation to each individual hand position (as that relates to the body), one could easily come to the wrong conclusion about where the greatest power is derived. The reason is that the highest velocity is achieved when the trailing hand is releasing from the water, leaving one to think that the power is generated from the end of the stroke. But one must also consider that by the time the trailing hand is exiting the water, the leading hand is now in front in the ‘catch’ position and that is where most of the power is coming from, not the trailing hand.

Brett Hawke, sprint coach at Auburn University, describes the derivation of power, when the hand is out in front of us, as originating from the core and extending through the back, chest, shoulder and down the front arm.5 I agree with him, as this is part of the fundamental of swimming with the entire body, not just the arms. If you agree with us that the bulk of propulsive power is generated at the beginning of the stroke cycle, not in the middle, when the arms are in a very disadvantageous position from a streamline perspective, nor at the end, where frankly, about the only muscle left working is the tricep muscle, leaving little source of power, then how does this help us understand how to best sustain our body speed while swimming? How does this help us take advantage of inertia?

The answer is to keep one arm in the 'power position' in front at all times. Since we have only two arms and the only path to get back to the 'power position' is by going through the stroke cycle, there will always be some delay in getting the hand back to the 'power position'. Too bad we don't have three arms which could work more like a propeller, allowing one arm to remain in the 'power position' at all times. Unfortunately, since we are bricks, the moment we leave the power position, we immediately begin to slow down. Therefore, the quicker we can get the hand back to the 'power position' in front (higher stroke rate), the less time we will have to slow down and the better we will maintain our speed. Now there is a catch to this (no pun intended). If we turn over too fast and lose our catch or hold of the water, then we lose more than we gain and begin to slow down again. The secret is to be able to turn over fast, yet stay in control of 'holding ' the water; easier said than done.

Finally, we must not forget our legs, arguably the most neglected part of our stroke. Depending on how strong they are, the legs not only provide propulsive power, but in free and backstroke, assuming a 6 beat kick is used, they provide the power more continuously (faster stroke rate) than the arms, contributing significantly to a more sustained speed. This fact is particularly true with hip-driven freestylers, like Michael Phelps and Ian Thorpe, who use a slower stroke rate, holding longer in front, but depend on massive leg strength to sustain their speed and stay on the freeway. The legs not only provide this important consistent propulsion, but also provide significant lift to the body, reducing drag and making us less like bricks in the water. Legs are crucial to a swimmer and provide propulsion, lift and sustained speed. Train your legs hard.

The challenge for a coach is how to get the swimmer out of stop-and-go traffic and onto the freeway? The best drill I have found to accomplish this is to incorporate the dolphin kick with freestyle or backstroke. The trick is to swim with a one kick to one pull ratio. By having to keep up with the legs with this drill, the swimmer will get into a much faster stroke rate than he or she customarily uses. Once they get accustomed to the stroke rate they can then switch back to a flutter kick without slowing the arm rate down. Michael Klim of Australia actually converted to dolphin kick with his freestyle in the last 10 meters or so of his world-record 100 m. leadoff in the 4 x 100 freestyle relay in the Sydney Olympics. The purpose was to keep up his stroke rate at a time when it would normally slow in the race. In other words, instead of getting on the off-ramp at the end of the race, the dolphin kick kept him on the freeway.

In conclusion, just remember that even though we may not be ideally designed to move fast through the water, with training and attention to details, we can get pretty darned good at it. As a coach or a swimmer, just remember the three fundamentals of fast swimming and practice, practice, practice.

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