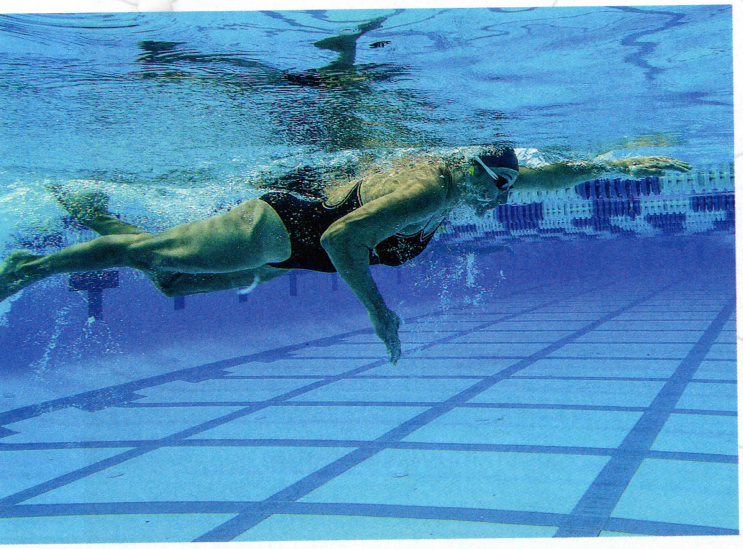
THE SCIENCE OF FRONT CRAWL

Retool your freestyle stroke to increase your speed

BY STUART KAHN

PHOTOS BY PETER H. BICK



Modern science continues to define and direct the future of swimming. Its greatest influences come from underwater motion capture and laboratory studies of biomechanical models and elite athletes.

Brent Rushall, physiologist and founder of USRPT (ultrashort race pace training), suggests technique as the principal factor governing elite swimming success, and an aspect of swimming that should be stressed more than conditioning. This article looks at studies from several other well-known coaches and biomechanics experts identifying current technical trends.

From their research comes a reacceptance of the idea that Newton's third law of motion is the primary physical law governing human swimming propulsion. The third law states that every action (force) produces a reaction (counterforce) of equal magnitude in the opposite direction (i.e., for every action there is an equal and opposite reaction). Therefore, when swimmers use muscular force to push water back, a counterforce is created to propel them forward.

The ability to effectively apply propulsive power is the major determinant of swimming speed. A study by researchers L.J. D'Acquisto and L. Berry of 400-meter freestyle swimmers estimated that up to 57 percent of swimming energy was wasted, mostly because swimmers move the water rather than swim through the water. Increasing propulsion always trumps decreasing resistance as a means of increasing speed. The less drag you experience while swimming, the less energy you need to expend to continue swimming at the same speed. But to become faster, you must increase propulsion.

NBC's coverage of the Rio Olympics provided as much evidence of the new freestyle techniques as any recent medium. There we saw powerful, continuous kicking throughout the shorter races and at the end of the longer races. We saw sprinters holding their breath the entire length of the pool while swimming with minimal hip rotation. And we saw freestylers over all distances racing with higher stroke rates and increased distance per stroke.

But are these observations consistent with the results of research? And should relatively slow swimmers emulate the techniques employed by faster swimmers? According to coach and researcher Rod Havriluk, the answer to both of these questions is yes. Obvious size and strength differences notwithstanding, the primary advantage faster swimmers have over slower swimmers is technique rather than strength.

Kicking

There has been little conclusive research on the extent to which kicking is propulsive in freestyle swimming. However, one study by researcher Kristin Morris in 2015 examined what happens when swimmers don't kick.

At all swimming intensities, whether swimming or pulling only, swimmers who didn't kick were 11 percent slower than when they kicked continuously. Bottom line: We're not sure how much kicking contributes to speed, but we know that not kicking is definitely slower.

Here, Agnese kicks her legs in nearly the same horizontal plane as her torso. Her right knee is locked at the bottom of the downbeat and the sole of her left foot is at the apex of her recovery, ready to begin its downward thrust. A continuous kick provides the sole platform from which to initiate the muscular forces in the hips and core.

Armstroke

Current changes in freestyle technique are most evident in the armstroke. Overall, swimmers are pulling and, especially, pushing longer and more powerfully during both sprints and distance events.

By definition, hand motions coming toward the shoulder plane are pulls and hand motions going away are pushes. However, the terms *pull* and *push* refer to use of muscles against the water, not to the actions of arms and hands in the water. In fact, at the highest levels of skill, the hands and forearms stay nearly still in the water as the body moves past them.

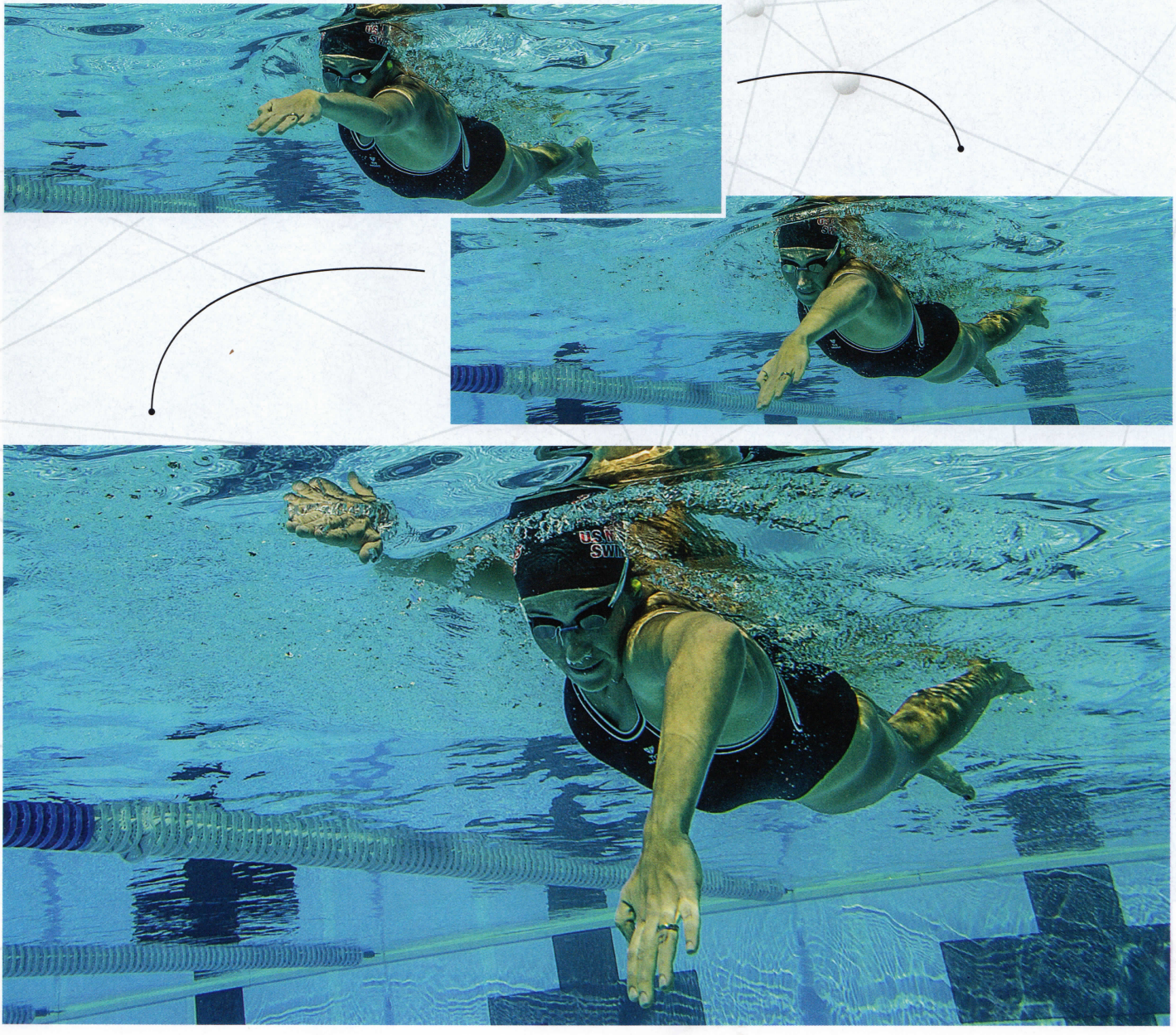
Another way to think of proper arm propulsion is that when the hands stay still (anchored) in the water, then the body moves forward. Conversely, when the hands are moving from front to back (slipping) in the water, then the body is still.

USA Swimming recognizes three biomechanical phases of underwater arm motion: early, mid, and late pull-through.

Early Pull-Through

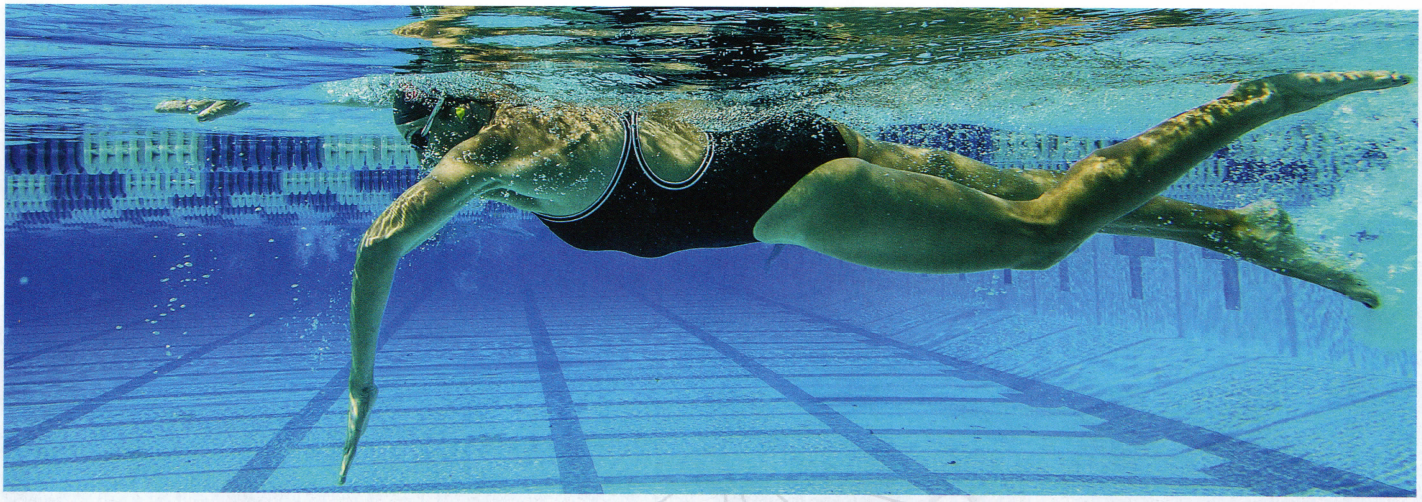
Initiate the early pull-through by applying backward pressure against the water with the palm and forearm. Much attention has been given to this phase of arm motion, which commonly is known as the catch or the early vertical forearm.

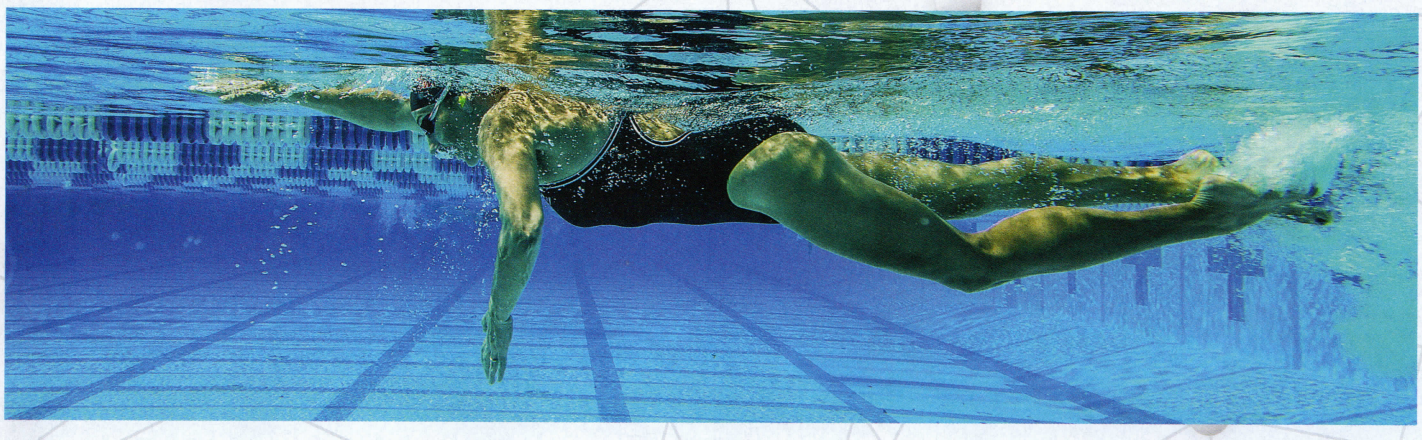
However, this attention might have come at the expense of other, more propulsive phases of arm motion. A 2010 study by Danielle Formosa and others at the Australian Institute of Sport, in which force-time graphs were synchronized to video footage, found that minimum force was produced during the pull phase and maximum force during the push phase. This study contradicts the values that are often claimed for "front-quadrant" swimming. The primary purpose of the early vertical forearm is to initiate backward resistance against the water, allowing for increased propulsion in the following second and third phases of arm motion.

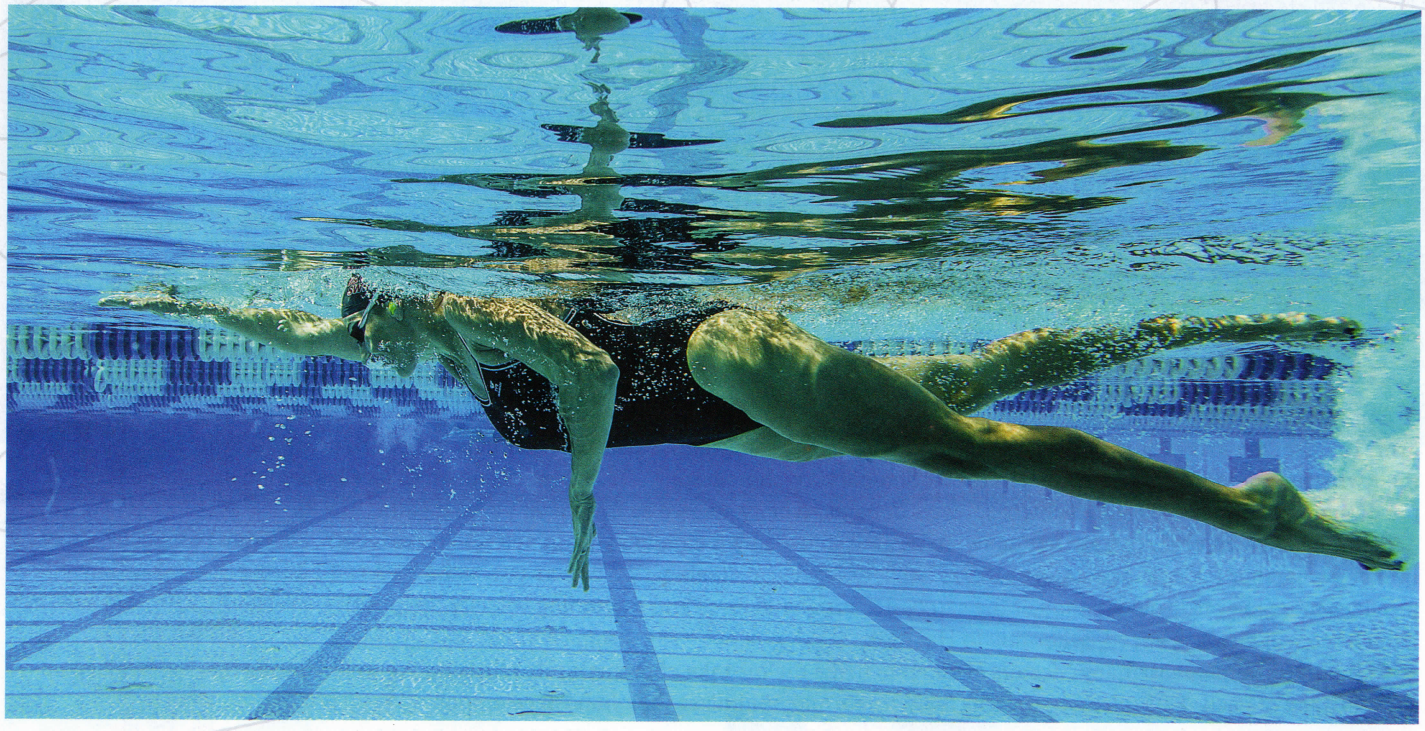


Mid Pull-Through

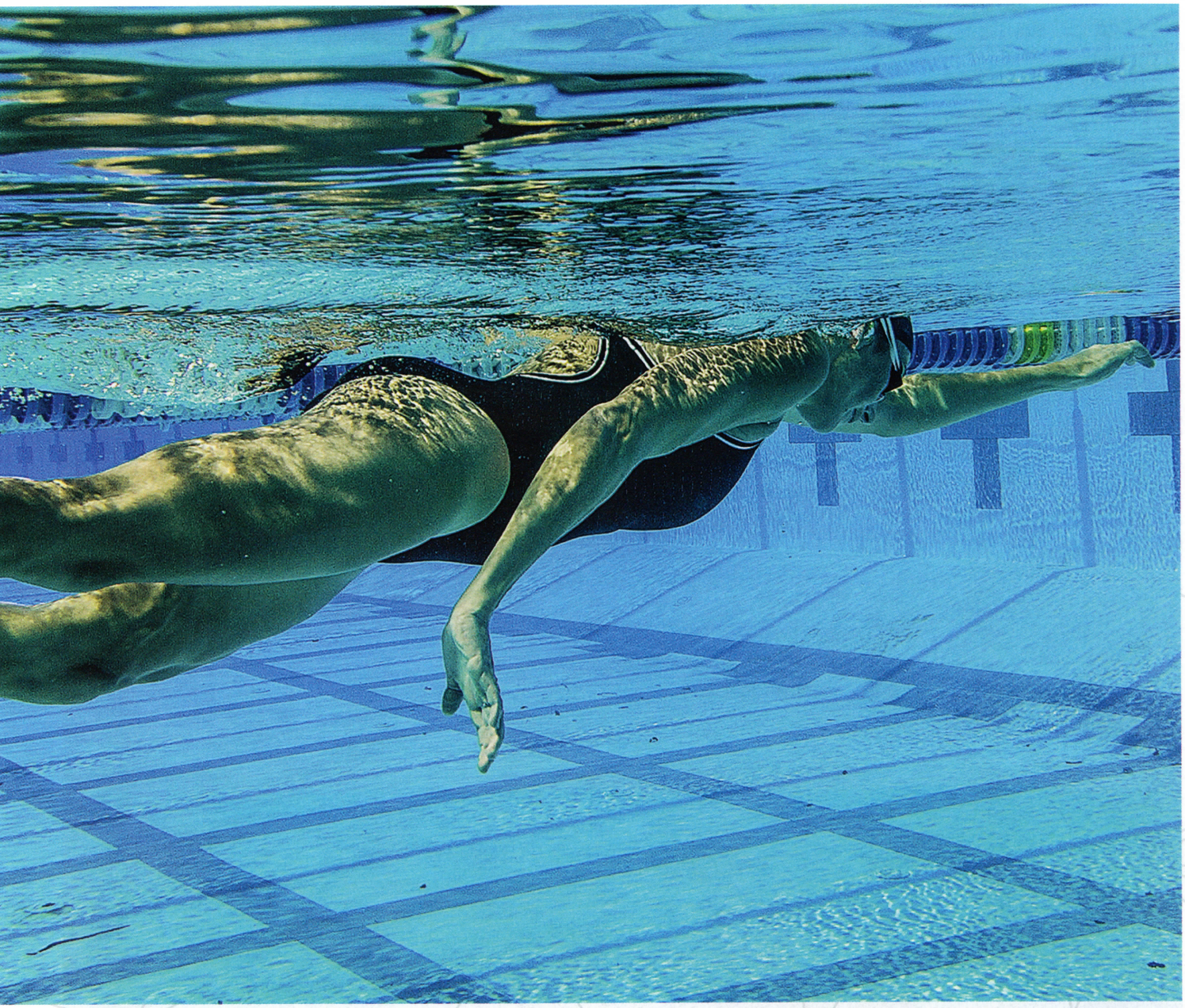
During the mid pull-through, the humerus (upper arm bone) is perpendicular to the body. The mid pull-through is also known as the hold, or as I call it, the late vertical forearm. According to 2012 research by Jan Prins of the University of Hawaii, this arm position presents the largest surface area of the three phases. Therefore, the backward-directed propulsive forces that propel the body forward are greatest during the mid pull-through. The greatest linear hip velocity occurs approximately halfway through the stroke, when the hands pass underneath the vertical line of the shoulder.







U.S. Olympic Committee researchers Scott Riewald and Scott Rodeo stated in 2015 that peak force appears to occur just after the swimmer's hand and forearm are close to vertical position and pushing directly back, meaning focus on this phase of the arm-stroke should be increased. Peak forces continue through this phase until the humerus has moved alongside the torso and the armpit is closed.



Late Pull-Through

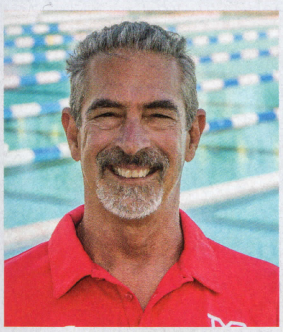
During the late pull-through, when hand forces remain strong, the elbow straightens, reducing the backward-facing angle of the forearm. To offset the loss of surface area at that critical moment, many elite swimmers continue backward pressure by hyperextending their wrists, as demonstrated by underwater motion-capture photography. This allows the palm to face backward and perpendicular to the direction of travel, creating the highest levels of hand velocity, known as even later vertical palm (ELVP).

This higher swim velocity from better swimmers is achieved by maintaining an increased stroke length, according to a 2007 study by French researcher Ludovic Seifert and others. The hand-forearm combination directs less water backward during this phase, but still provides more forward velocity than at the catch. Because hand force and swimming velocity are positively related, these increases in hand force will increase speed, according to Havriluk.

At this precise moment, many Masters swimmers make the mistake of prematurely releasing the water, letting their palms face upward instead of back. This mistake shortens their stroke and minimizes their hand acceleration.

Takeaway

Accelerate your hands from the beginning of the backward motion (EVF), press the water with large surface areas during the middle part (LVF), and finish with small palm pressure during the final part of the underwater armstroke (ELVP). ■



STUART KAHN

Stu Kahn and his wife, Mary Kahn, coach Davis Aquatic Masters, the second largest USMS club in America. He is the 2012 Speedo USMS Coach of the Year, and DAM was awarded the 2011 USMS Club of the Year.

AGNESE BUTLER

Agnese Butler, née Ozolina, 36, competed for the Latvian Olympic team in three Olympic Games—Atlanta, Sydney, and Athens—as a freestyle specialist. She lives in Sarasota, Fla., and is a member of both the Sarasota YMCA Sharks Masters and Sarasota Storm Triathlon Club.