Part I: Is the Breaststroke arm stroke a "Pull" or a "Scull"?

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Abstract. *At the present time swimmers seem to be moving away from using sculling motions in their arm strokes. The trend is back toward the use of drag-dominated propulsion where the hand and arm operate more like a paddle than a foil. While this is true in three of the competitive strokes, a great number of coaches still think breaststroke should be the exception to this trend. They believe swimmers in this stroke should be sculling their hands out and in. In this paper I want to present a case for breaststrokers using drag-dominated propulsion during their arm stroke. My rationale for suggesting this will be given early in the paper, followed by the presentation of visual and graphic data that support that rationale. In the final section, I will describe how I believe the arm stroke should be performed together with a short video showing an Olympic Gold Medalist swimming this way.*

Introduction:

The debate continues, are swimmers pulling or sculling? Is lift the dominant propulsive force in swimming or is it drag? In Part I of this paper I will describe why I think drag is the dominant propulsive force. The use of drag-dominated propulsion in the breaststroke will be described in Part II.

Because Newton's Third Law of Motion is now being reconsidered as the basis for human swimming propulsion, many coaches are advocating a more straight-line pulling motion, at least in the freestyle, backstroke and butterfly strokes with swimmers using their hands and arms like paddles to push water back instead of foils that scull through it. However, a considerable number of persons still believe that sculling is the preferred method of propulsion in the breaststroke.

Despite the predominance of lateral and vertical hand movements in this stroke, it has never seemed logical to me that breaststrokers would rely on lift-dominated propulsion when drag seems to be the dominant propulsive force in the other three competitive strokes. I believe there should be commonalities to the way athletes propel their bodies through the water. That is, the same motions and forces that produce propulsion from the arms in the freestyle, backstroke and butterfly should also be employed in the breaststroke.

I will make a case for drag-dominated propulsion in the breaststroke arm stroke later in this paper, but first, let me describe how I believe swimmers in the other competitive strokes are using drag-dominated propulsion in their arm strokes. The

mechanism I believe they are using is an anatomical movement called *shoulder adduction*.

What is shoulder adduction and, how is it performed in freestyle, backstroke and butterfly?

In swimming, shoulder adduction is performed as a sideward, sweep of the arm from a position overhead to one at the side. In other words, the arm is *added* to the body. Charles Silvia first described shoulder adduction as a major propulsive movement in competitive swimming in 1970. However, his advice was largely ignored during the next three decades when most swimming coaches and swimming researchers, including this writer, became convinced that lift, the Bernoulli Principle, and sculling were the principle mechanisms for swimming propulsion. Now that this belief is in doubt, it may be time to reconsider Silvia's teachings.

The drawing in figure 1 is of a freestyle swimmer, from an underneath view, completing what most refer to as the pull, while I call it the "insweep." The pull has traditionally been taught as a down and in sweep of a swimmer's hand and arm, that begins with the arm extended straight ahead of his shoulder and just under the surface. From there, the swimmer gradually flexes his arm at the elbow as he pulls it down and in, until, at the end, it (his arm), is flexed nearly 90 degrees and under his chest.

In actuality, swimmers use a very different pattern of motion during the "insweep" than the one I just described. They do begin by pressing down with their hand and flexing their arm at the elbow, but this is not the start of the propulsive phase of that arm stroke. Instead, the downward motion and gradual flexion of their arm is used to place their hand and arm in position to apply propulsive force during the insweep that follows. The correct placement should be with their upper arm, forearm, and hand in a backward facing position that some refer to as a "high-elbow catch" and others call an "early vertical forearm". The swimmer's un-shaded arm is in that position in figure 5. Once that position is achieved, the swimmer accelerates his body forward by pressing his flexed arm back with a sideward, semi-circular sweep like the one shown in figure 5. The pull/insweep ends when his upper arm and elbow are coming in toward his ribs and his flexed arm is somewhere under his body (see the position of his shaded arm in figure 1).

It is my contention that swimmers are not sculling during this semicircular movement, even though their hand-paths are curvilinear. Instead, they are using their upper arm, forearm, and hand like a paddle to push back against the resistance of the water, at least during the first two thirds of the insweep.

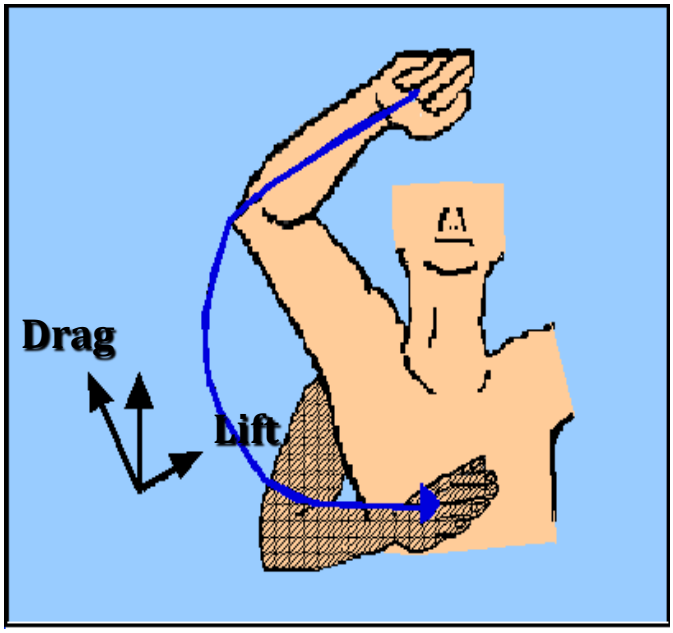

Figure 1. *Shoulder adduction during the insweep of the freestyle as viewed from underneath.*

Far from pulling the water down and in under the body with his hand while gradually flexing his elbow, the swimmer starts the insweep with his elbow already flexed and pushes back against the water with his entire arm by means of a sideward, semi-circular sweep. The side views of a multiple Short Course World Champion freestyle sprinter, in figure 2, demonstrate two important aspects of shoulder adduction. They are, (1) that swimmers should not push their upper

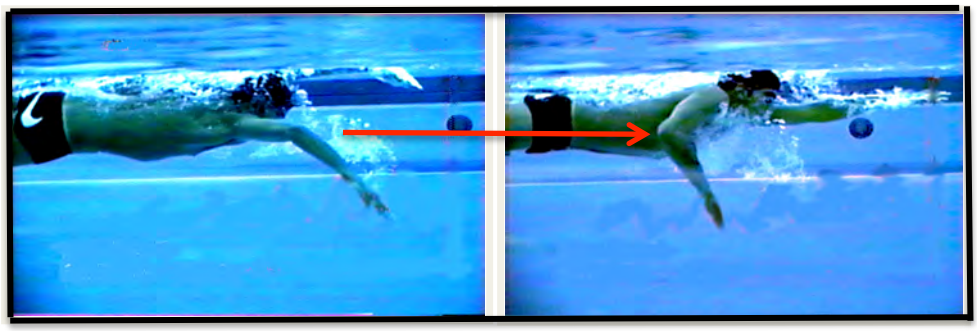

Figure 2. *The insweep in the freestyle from a side view (L to R). The swimmer is Francisco Sanchez; twice World Short Course Champion in the 50 m freestyle and once World short course Champion in the 100 m freestyle.*

arm(s)down through the water any more than necessary while they are moving their arm(s) into position for the catch (see photo on left, in figure 2), and, (2) they press their arm horizontally backward during the insweep. The red arrow at the level of the swimmer's elbow in figure 2 has been used to demonstrate that his arm

travels horizontally backward when he presses it back against the water. He could not stroke this way unless his arm was traveling around to the side, not down, in, and up during the insweep.

The three underneath views of a former Olympic Silver Medalist in the 100 m butterfly in figure 3, show that her arms move in a similar shoulder-adducting manner during the insweep of this stroke. They are flexed and positioned backward *before* she begins the pull/insweep, (see photo at extreme left in figure 3), after which they are swept out, back and in under her body with a sideward, semi-circular and horizontal movement of her hands and arms (see the middle and right photos in figure 3).

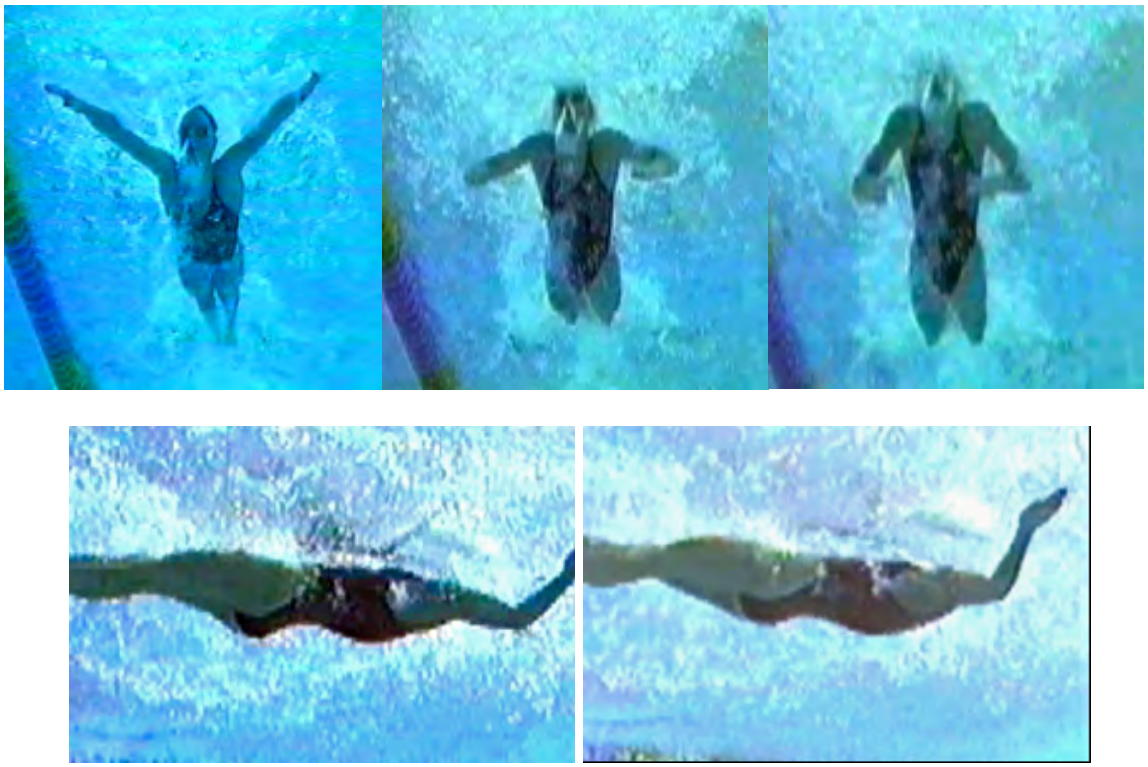

Figure 3. *Shoulder adduction in the butterfly and backstroke. The butterfly swimmer is Chrissie Ahmann, former Olympic Silver Medalist in the 100 m Butterfly. The backstroke swimmer is Multiple Olympic Gold Medalist and former World Record Holder in the backstrokes, Kristina Egerszegi.*

Also in figure 3, the two side views of a multiple Olympic Gold Medalist and former World Record Holder in both backstroke events, show that she uses a similar shoulder adducting motion during her pull. (Because she is in a supine position, I call this movement an upsweep rather than an insweep). Nevertheless it performs the same function in a slightly different way in the backstroke that the pull/insweep performs in the other strokes. It is the first propulsive sweep following the catch and it is a semi-circular, shoulder-adducting motion. Notice in the picture on the

left, that she is in the catch position with her arm down in the water and flexed at the elbow. From there she pushes back against the water with her entire arm and hand, moving them through a somewhat semi-circular backward arc that ends when her arm is approaching her ribs (see right-side photo in figure 3).

Why is this same shoulder adducting motion used in each of the three competitive strokes? I believe it is because it is the most effective way to apply propulsive force during the pull/insweep. The undersides of the upper arm and forearm, as well as the palm of swimmer's hands can be used to form a paddle to push back against the resistance of the water in a largely horizontal direction. In several studies, combined hand and forearm models have been shown to increase propulsive force when compared to the hand alone. In one of these (Cappert, 1992), propulsive force was increased by nearly 38%, and it was increased by 27% in another (Riewald and Bixler, 2001a).

To my knowledge, no one has attempted to quantify the contribution of the upper arm to propulsion. I believe, however, that it will, in time, be found to contribute substantially to propulsive force during the insweep.

A second reason for using shoulder adduction is the large amount of trunk musculature swimmers activate when they perform the insweeping this way, (the "upsweep" in backstroke). The muscles primarily responsible for shoulder adduction are the large and powerful pectoralis major, and latissimus dorsi. I will discuss how, I believe, breaststroke swimmers use shoulder adduction during their arm stroke in Part II of this paper.

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