The Mechanics of Modern BUTTERFLY Swimming

by Dr Ralph Richards

Traditionally, butterfly has been perceived as more ‘difficult’, requiring greater strength and stamina than the other three stroke disciplines. Scientific evidence has never fully supported this notion; the effort required to swim ‘fast’ butterfly is not significantly greater than the effort required to swim ‘fast’ freestyle, backstroke, or breaststroke. Naturally the top speed of elite butterfly swimmers (in terms of peak speed and time over a competitive distance) is different to that of elite freestylers, backstrokers, and breaststrokers because of stroke efficiency and potential power application differences. Butterfly is currently our second fastest stroke. One important trend in the emergence of the ‘modern’ butterfly swimmer is the earlier introduction of butterfly stroke development during the learn-to-swim stage. Most coaches or teachers of swimming judiciously use fins as one method of developing a complete butterfly stroke. Coaches have also adapted more variety into their butterfly training sets to parallel training principles used with the other strokes.

Swimming skills essential to fast butterfly swimming, principally the use of the dolphin kick and body streamlining techniques, are now universally accepted as part of the teaching and stroke development process. When junior swimmers begin to train and compete, butterfly racing should be the same as training / racing in the other strokes. Fast butterfly swimming remains a blend of power and precise timing; it is not simply an application of strength. The general coaching emphasis on core stability (of the trunk) as a platform for the application of propulsive power helps to support the essential elements of great butterfly swimming technique.

Efficient butterfly technique relies on timing to maximize propulsion while minimizing resistance. Correct timing of the kick is used to position the body so the large surface area of the trunk is streamlined at both the least and most propulsive aspects of the armstroke. The large power impulse generated by the simultaneous double-arm pulling pattern yields great propulsive potential; however, during the arm recovery phase there is no propulsion generated. This creates a minor ‘dead space’ in the stroke. Reducing resistance at key points during the stroke cycle is a major objective of ideal butterfly technique. The simultaneous and symmetric arm and leg actions mean the body’s centre of gravity (COG) will naturally tend to rise and fall slightly. Correct timing of the kick and positioning of the head (to facilitate breathing as well as balance the body) allows the COG to move forward in a pattern that resembles a smooth ‘wave action’. This helps to smoothly deflect water over and around the body to maintain greater forward momentum.

Before detailing the arm and leg action it's important to note how timing can be used to help streamline the body. Turbulence is minimized by positioning the body so that water flows over / under / and around with a gradual, rather than a sharp, deviation from horizontal flow. The first streamlining technique occurs as the hands enter the water. The downbeat of the dolphin kick serves to set the body position with hips high in the water. At this point the propulsive force generated by the arms is almost nil; thus, its' important that the hips remain high so water flowing along the body (while not perfectly horizontal) is smooth and unbroken.

First streamlining technique – enter with hands at shoulder width
(or slightly inside) as the first kick is executed.

A second streamlining technique occurs during the first-half of the propulsive stroke cycle, when the arms are positioned to deliver maximum drag propulsion. The legs are stretched toward the surface to level the trunk. This requires strength in abdominal and lower back muscles, as well as flexibility. This action also helps to counterbalance the downward force created as the head begins to lift during mid-stroke.

Second streamlining technique – stretch legs up during propulsive phase.

A third application of streamlining occurs when the arms are being recovered over the water. By stretching the legs to bring the soles of the feet toward the surface, the trunk is positioned closer to horizontal. Streamlining at this point is one way of conserving forward momentum generated during the powerful finish of the underwater armstroke. The second dolphin kick also serves to support the hips and allow the arm recovery to be initiated smoothly. At the finish of the underwater armstroke the swimmer actually slides forward on top of the wave created by the body's forward motion.

Third streamlining technique – recover legs during the arm recovery.

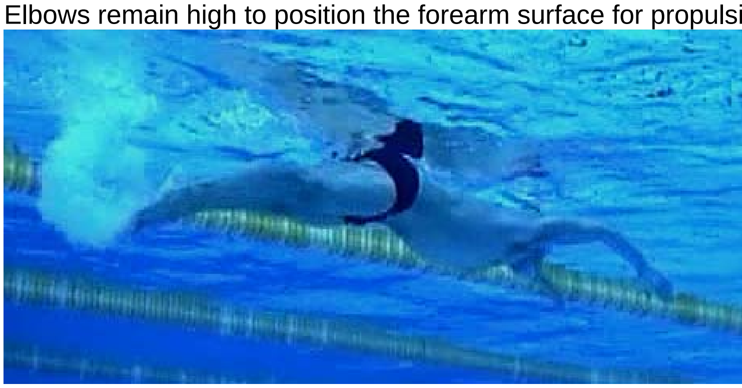
One of the greatest difficulties encountered by 'less skilled' butterflyers is successfully completing a strong second kick. If the second kick is weak, or poorly timed, the hips will be too low as the hands exit the water. This will encourage the swimmer to pull the hands sharply outward-upward, instead of pushing back to achieve maximum stroke length. A poor second kick usually means the arm recovery begins too soon. Once the timing is delayed, it's increasingly difficult to lift the soles of the feet to the surface in preparation for the next stroke; thus, the first kick gradually becomes less effective. The end result of this series of timing and streamlining problems is a rapid deterioration of body position. The swimmer becomes more vertical in the water and performance suffers.

Dolphin kicking is used exclusively during butterfly swimming, as well as during specific parts of freestyle and backstroke races. Therefore, it's a useful crossover skill and should encourage good backstrokers to try butterfly, and vice versa. Two kicking cycles fit nicely within each complete butterfly stroke cycle. Although some swimmers may attempt to use only one kick per stroke cycle, this is a mistake because of the streamlining influence of the kick. Conversely, a faster kicking tempo (i.e. three or more kicks) is likely to disrupt the overall timing of the stroke components. There is some difference of opinion among coaches regarding the relative contribution of each kick. Some believe the second kick should be stronger than the first. This belief is supported by the observation that over racing distances of 50m and 100m, swimmers tend to accentuate the second kick as a result of the great acceleration in hand speed during the second-half of the armstroke. Other coaches feel that each of the two kicks should be the same depth and intensity; this is usually the case for most 200m swimmers. There is general agreement that all butterfly swimmers should attempt to get the most out of each kick by timing the downbeat precisely at certain phases of the armstroke.

In the previous article on Backstroke the point was made that 'fast' dolphin kicking off the start and each turn is an essential part of current swimming technique. Butterflyers must develop this skill as well as maintaining an effective dolphin kicking rhythm during swimming. Extension (or hyperextension) at the hip is an asset, as it helps to lift the feet to the surface. Once the feet are correctly positioned, the knees begin to flex while the heels stay close to the surface; propulsive thrust of the legs is accomplished by forceful extension of the knees and simultaneous flexion of the hips to create a ‘whip like’ downward movement of the legs. During this propulsive thrust the abdominal muscles must remain tight to stabilize the pelvis and allow the large muscles of the legs and buttocks to contract strongly. The backward-downward push from the legs will drive the hips upward and forward.

The pattern traced by the hands (relative to the body) is sometimes referred to as an ‘hour-glass’ shape. However, many top butterfly swimmers actually exhibit much less inward-outward movement of the hands than generally conceptualized as part of an ‘ideal’ stroke pattern. There are three or four sequences of sweeping movements, and these may result in only moderate variation in lateral position of the hands. Hands enter the water at shoulder width, or slightly inside, with palms pitched slightly outward (i.e. thumb edge slicing into the water first). The angled hand entry allows a smooth transfer of momentum developed during the arm recovery. Hands move symmetrically outward with the elbows held high to position the forearm as a propulsive surface.

Elbows remain high to position the forearm surface for propulsion.



The hands then sweep inward as they move under the trunk, drag propulsion is generated on the hand / arm surface. The amount of elbow bend is determined by the depth of the hands – this is determined by shoulder and upper back strength (i.e. effective transfer of force through the kinetic chain linking arms and trunk). The final propulsive sweep, or push, moves the hands from a position under the chest or stomach to a position past the hips. The hands slide out of the water and into the recovery phase in one smooth motion. Because hand movements are rounded, rather than changing direction sharply, hand speed continues to accelerate during the length of the stroke. There is a large amount of drag propulsion generated during the butterfly armstroke because the surface of the hand-forearm can be positioned at right angles to the directional movement of the body.

Hands and forearms positioned for maximum drag propulsion.

The arm recovery phase begins as the elbows lift slightly and the hands slide out of the water. At this point the downbeat of the second kick assists by positioning the hips close to the surface. The arms remain comfortably extended as they begin to swing forward. Once the hands lift sufficiently to clear the water the forward swing of the arms becomes a ballistic movement. Lateral forces created by the wide swing of right and left arms during the recovery act to cancel each other and this keeps the shoulder position stable. The shoulders tend to lift at the completion of the propulsive phase and stay high in the water during the start of the arm recovery due to the body's forward momentum.

Most butterfly swimmers breathe on every second stroke cycle. If the stroke-rate is low, or the swimmer needs to breathe more frequently because of the race distance (i.e. 200m event), taking a breath every stroke cycle may be required. Swimmers who develop correct timing and have a strong kick should not worry about reducing their stroke efficiency if they breathe during every stroke cycle. Conversely, during sprint events of 50-100m the swimmer may want to limit breathing for 3 or more strokes to achieve a faster stroke-rate. The breath is always taken in conjunction with the natural rise of the shoulders created by the strong propulsive force generated during the middle of the armstroke. The head is generally lifted with the face positioned forward, chin just clear of the bow-wave. However, some swimmers may prefer to turn the head to the side, similar to the movements used in freestyle. Side breathing may be an advantage to some swimmers because it requires less lifting of the head and shoulders.

Most butterflyers breathe with face forward, chin just above the surface.

As mentioned, timing is an important part of efficient application of butterfly technique. The action of dropping the head during the arm recovery serves two purposes: (1) it allows the muscles of the upper back to complete the forward swing of the arms without restriction, and (2) it lowers the body's centre of gravity to assist in creating the wave action. Swimmers who keep their head up too long will eventually disrupt their body position by causing downward force on the legs; once the legs drop frontal resistance will increase.

As we have seen, correct butterfly technique is all about timing rather than brute strength. Each stroke contains periods of accelerating movement that provide the ‘power’ signature of each swimmer’s style. Top butterfly swimmers produce tremendous bursts of power, but more importantly (as compared to less efficient swimmers) they apply their power through a long, smooth stroke pattern. Combining efficient power application with effective streamlining allows butterflyers to achieve speeds only exceeded by freestylers (because of the continuous power application advantage that freestylers enjoy).