Biomechanical Analysis of Streamline and the Breakout of a Butterfly Stroke

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Introduction

Since the 1970's, there has been consistent research of the kinetics, kinematics, and neuromuscular contributions to competitive swimming. According to Barbosa, Marinho, Costa, & Silva (2011), each of the four strokes require specific stroke cycle kinematics, limb kinematics and hip and center of mass kinematics to create the most efficient stroke. The highest neuromuscular activation from swimming comes from the butterfly stroke (Barbosa et al., 2011).

The butterfly stroke requires proper technique in order to improve speed, thus improve overall performance. Speed is simply the distance covered over the time it took to cover that distance, which can be enhanced by maximizing propulsive forces and minimizing underwater drag resistance. A substantial amount of energy is lost trying to overcome these forces; so, by improving a swimmer's techniques and underwater form, they can make themselves faster regardless of anthropometric measurements such as height (Marinho et al., 2011).

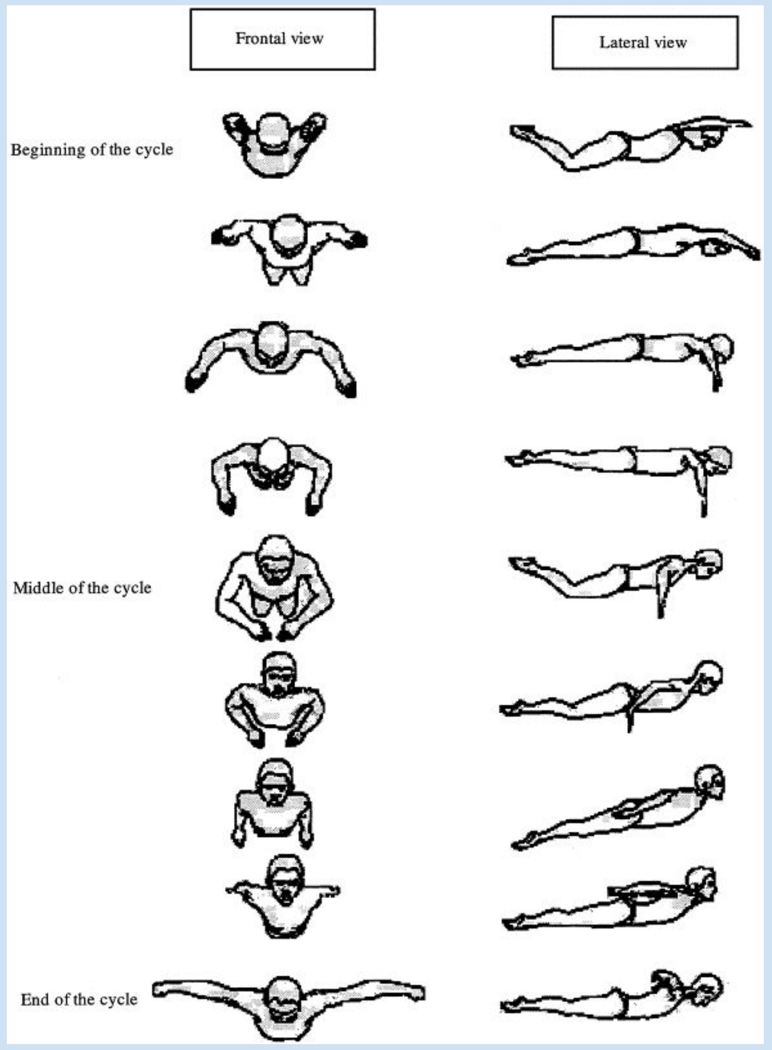


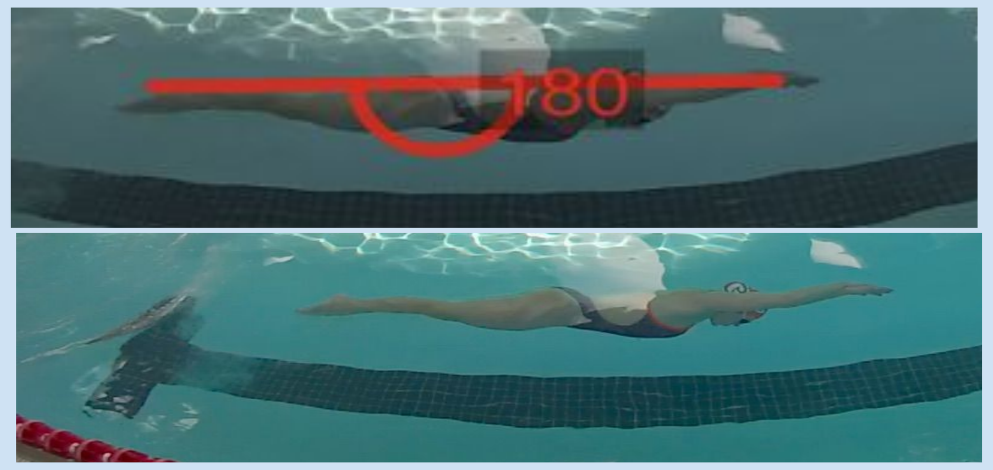
Figure 1. The image shows the frontal and lateral view of the various swimming strokes beginning with the kicking phase and ending with the recovery phase. Retrieved from https://doi.org/10.1016/S0021-9290(99)00066-4

The butterfly stroke can be broken down into five main components: the initial glide phase, kicking phase, catch phase, front and back sweep phase, and recovery phase. The subject is a 20-year-old female collegiate swimmer. The purpose of this analysis is to differentiate the various stages streamline and the initiation of the butterfly stroke, and evaluate each step using kinematics.

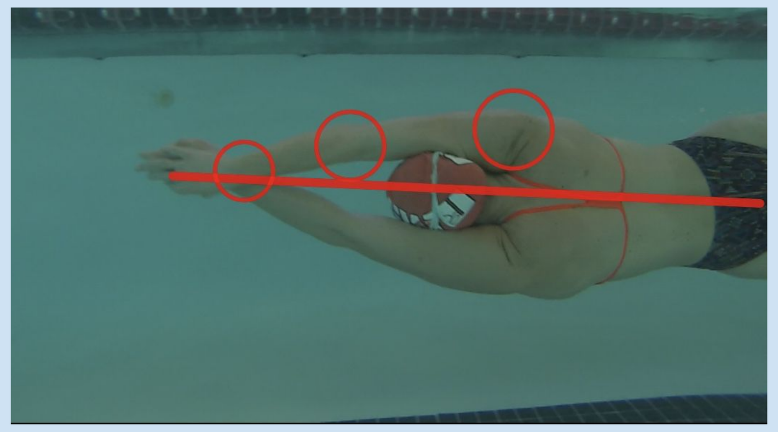
Initial Glide Phase

The initial glide phase and kicking phase only occur after the first block or push off the wall. According to Vantorre, Chollet, & Seifert (2014), the initial glide phase begins when the head enters the water and ends when the head breaks out. It is important for the swimmer to remain in a streamlined, horizontal position for as long as possible in order to maintain a high velocity. When the swimmer is not in a straight position parallel to the ground, there is a greater hydrodynamic resistance and drag from the water.

It has also been shown that placing one hand on top of the other, as opposed to positioning the hands in shoulder alignment, caused a 7% decrease in water resistance (Vantorre, Chollet, & Seifert, 2014). This requires core stability to keep the trunk in a 180 degree line with the other extremities, including the arms and legs.



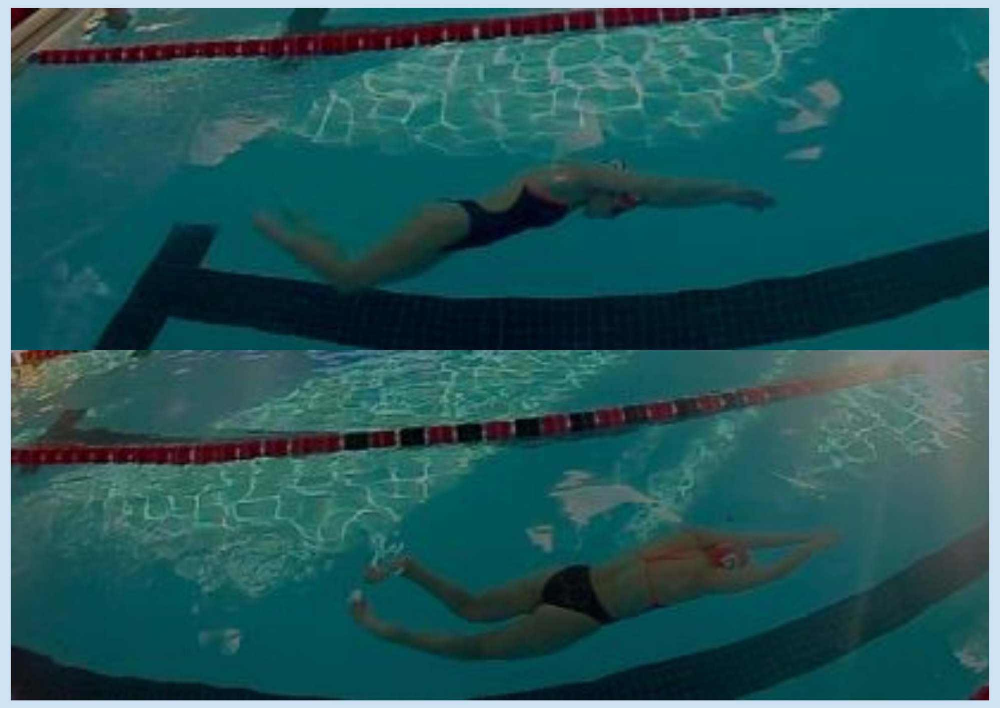
As seen in the image above, the subject being assessed maintained a perfect 180 degree line, enhancing the forward movement and minimizing drag resistance. This movement involves anterior and posterior core stiffness (Vantorre, Chollet, & Seifert, 2014).



In the image on the left, the subject has triple extension of the shoulder, elbow and wrist. The subject also has one hand placed on top of the other to minimize resistance (Vantorre, Chollet, & Seifert, 2014). .

Kicking Phase

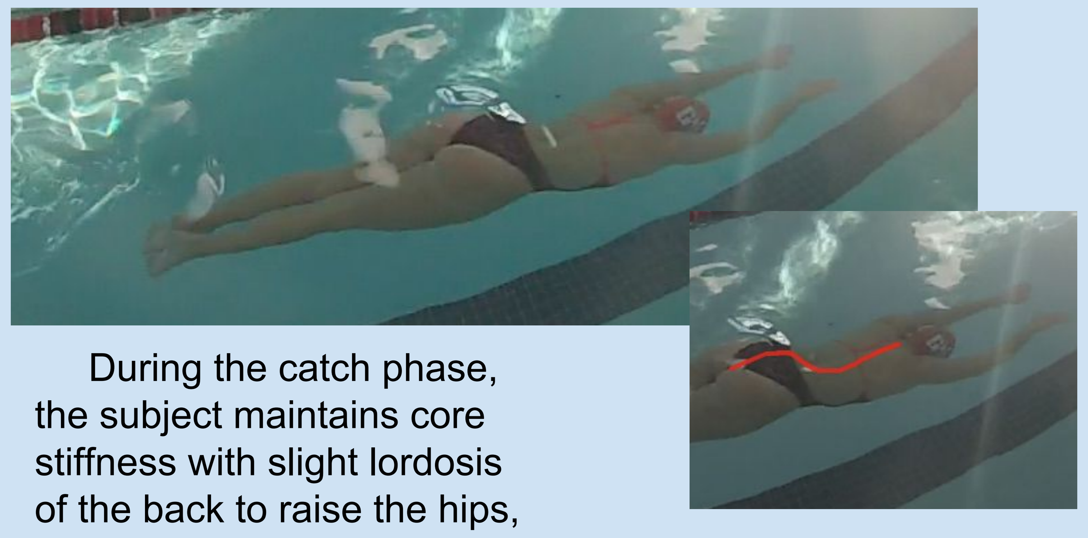
According to Houel et al. (2012), swimmers should ideally start dolphin kicks after approximately 6-m of glide and need to be efficient, with a high rate of kicking (p. 225). When the swimmer's feet are plantar flexed and knees begin to bend, the downbeat of the dolphin kick is occurring. It serves to set the hips high in the water so water flowing along the body is smooth and unbroken (Richards, n.d.). According to Barbosa et al. (2011), the increase of the knee angle during the downbeat will increase velocity.



The image above shows both a lateral (top photo) and aerial (bottom photo) view. The subject's ankles show inversion and the thighs, knees and ankles are not together. The feet are plantar flexed; however, they are not kicking simultaneously. This makes the kick less powerful and the overall movement less efficient.

Catch Phase

According to Wang & Liu (2011), the catch phase is from the point of fingers entering into water to the moment where both arms sweeping outward to the widest point. The pull phase starts at the end of catch phase to the minimum angles of the elbow joints under the chest, the push phase was from the end of pull phase to the fingers exiting water and the recovery phase was from the fingers exiting water to the beginning of the catch phase. According to Richards (n.d.), the arms are positioned to deliver maximum drag propulsion and the legs are stretched toward the surface to level the trunk. In order to perform this, strength in the lower back and abdominal muscles are required, along with flexibility.

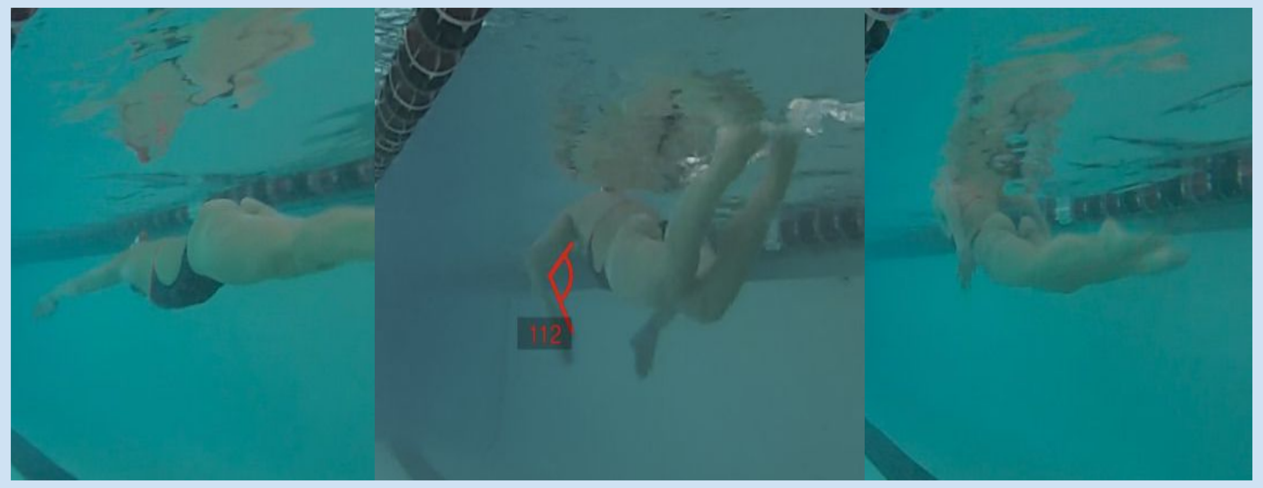


During the catch phase, the subject maintains core stiffness with slight lordosis of the back to raise the hips, which counterbalance the raising of shoulder and head.

As seen in the two images above, the subject's hand are rotated internally to "catch" the maximum amount of water.

Front and Back Sweep

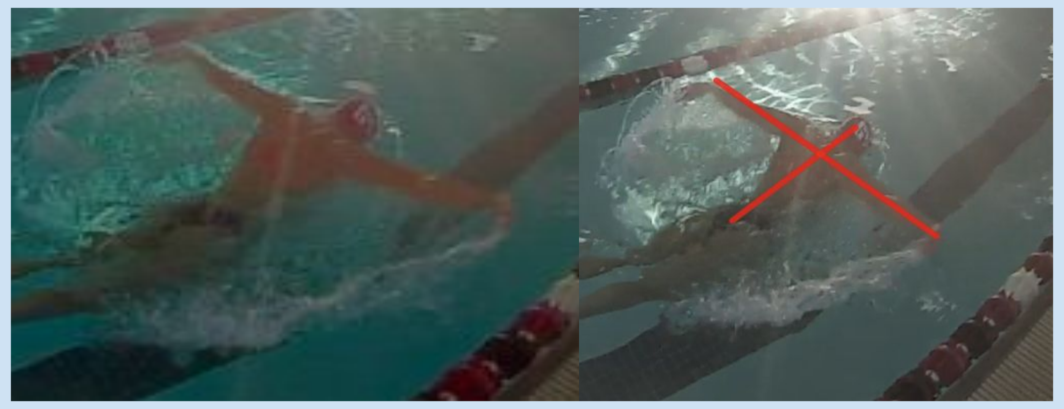
During the midpart of the pull, the biceps brachii and brachialis are activated as the elbow moves from being fully extended to approximately 40 degrees of flexion (McLeod, 2010). According to Barbosa et al. (2011), during the front and back sweep, the primary muscles activated are the latissimus dorsi and pectoralis major This phase generates the most drive through the water as the swimmer pushes the water back and propels forward swiftly. The arms extend at the shoulder, then begin to adduct. As the hands are brought towards the abdomen, the arms circumduct backwards. After the arms and hands pass under the body, the forearms quickly extend and the arms abduct and hyperextend at the shoulder. At the same time, the hips and knees go from being in a flexed position to extending rapidly to complete the second leg kick (Rushall, 2016).



In the images above, the front and back sweep are demonstrated in sequence from left to right. The middle photo shows the elbow being at a 112 degree angle instead of a 40 degree angle between the biceps brachii and brachialis. The larger angle creates a less powerful sweep, thus reducing the speed of the athlete (McLoad, 2010).

Recovery Phase

In the recovery phase, the swimmer's arms should stretch out in front of the body above the water surface and be led into the water by the thumb. Then, the hands should enter about shoulder width apart with elbows bend and slightly higher than the hands. The swimmer's hands then sweep down and out to form a Y-shape in front of the body. Afterwards, the hands should turn and sweep towards each other while keeping the elbows higher (Swim England Masters, 2014). During this phase, both the rotator cuff and deltoid are responsible for moving the arm. The entire upper torso is brought out of the water to aid in the recovery process. According to Barbosa et al. (2011), there is high activation of the supraspinatus, infraspinatus, middle deltoid, and serratus anterior during the recovery phase.



In the image above, the subject is retracting their scapula in order to drive their arms forward. The arms temporarily form a T-shape as they momentarily remain perpendicular to the spine. Internal rotation of the shoulders is also evident as the arms prepare to hyperflex and dive back into the water.

Conclusion

The butterfly stroke is made up of the initial glide phase, the kicking phase, the catch, the front and back sweep, and the recovery phase. During the initial phase, the subject maintained an absolute 180 degree line when compared to the bottom of the pool. During the kicking phase, the subject maintained plantar flexion to increase surface area to move more water. In the catch phase, lordosis of the subject's spine was noted which helps to raise the hips and counterbalance the raising of the head and shoulders. Shoulder, hip, and core stability and mobility are vital to performing. In the middle of the front and back sweep, the most efficient angle between the biceps brachii and brachialis is 40 degrees, however the subject was measure at 112 degrees. There is significant loss of power and speed when the swimmer's form is incorrect. Incorrect form separates the elite athletes from the average individual. During the recovery phase, the subject used the rotator cuff and deltoid to rotate the shoulders back to the front of the body, where the cycle begins with another catch phase. This cycle continues until the swimmer ceases to perform the butterfly stroke.

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