Analyzing Hand Force in Swimming: Bilateral Symmetry

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Since hand force is directly related to swimming velocity (Havriluk, 2004, 2006a), it is important to exert a maximal amount of force. Bilateral symmetry in hand force (i.e., an equal force with both hands throughout the range of motion) will not only help to maximize propulsion, but also minimize resistance. As obvious as this may seem, only a small proportion of swimmers have bilateral symmetry in hand force.

Since there is no rule requirement for symmetry in the unilateral strokes (freestyle and backstroke), it is not surprising that there are bilateral differences. However, substantial bilateral differences have been detected in the bilateral strokes (butterfly and breaststroke) of even the world's fastest swimmers (Havriluk, 2006a). Reference axes are useful for evaluating body symmetry.

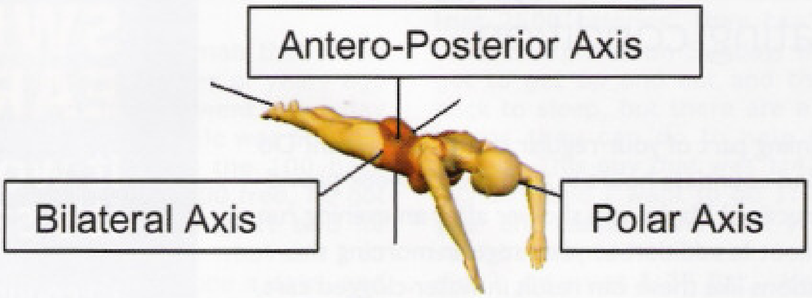

Figure 1. Reference axes of the body

REFERENCE AXES FOR EVALUATING SYMMETRY

Three axes (Figure 1) pass through the center of mass of the body (approximately the level of the navel). The polar (or longitudinal) axis runs the length of the body from head to feet. The bilateral axis passes through the body from one side to the other. The antero-posterior axis enters the front of the body and exits at the back.

In the bilateral strokes, a difference in hand force can cause unwanted rotation or twist about the antero-posterior axis and produce excess resistance. In the unilateral strokes unequal rotation about the polar axis can position one arm so that it generates less propulsion. Either asymmetry is undesirable, as less force results in slower swimming.

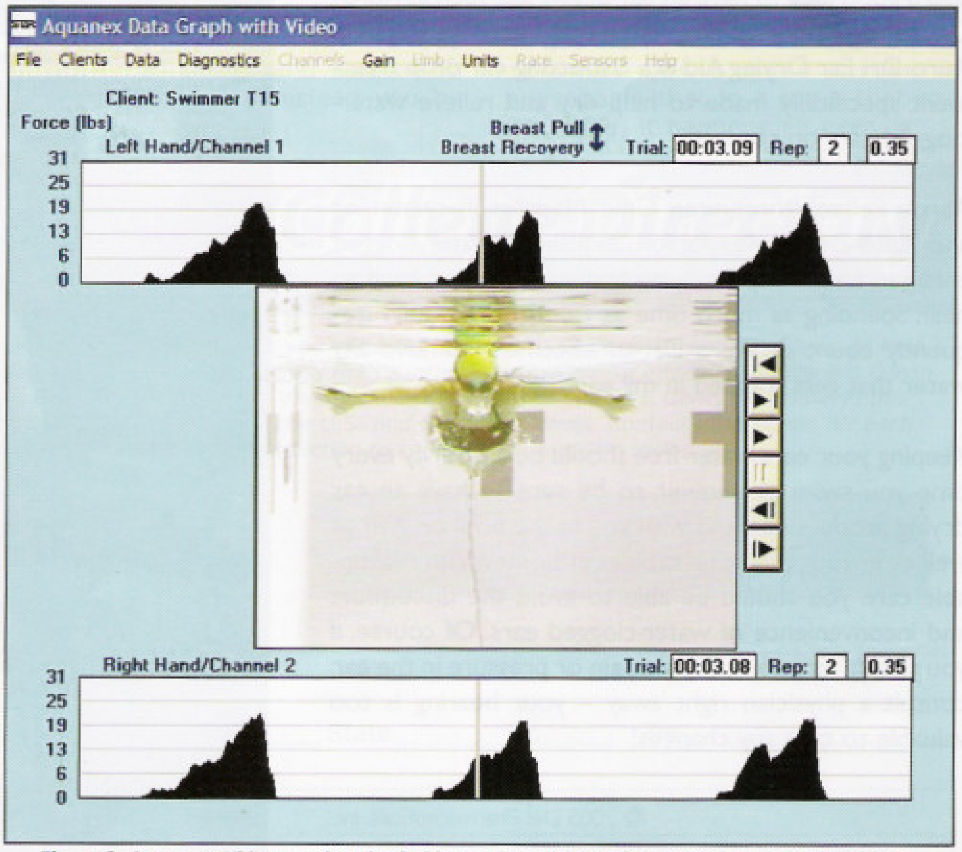

Figure 2. Aquanex+Video synchronized video and hand force data for a female breaststroker.

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BILATERAL SYMMETRY IN THE BILATERAL STROKES

The swimmer in Figure 2 has a very symmetrical hand force pattern. The force value for both hands at each point in the stroke cycle is almost identical. (The vertical lines on the force curves are synchronized with the video image at .35 sec into the second stroke.) She has less than a 7% bilateral difference in peak hand force and only a 9% difference in average hand force. In addition, the force pattern between strokes is very similar. The shape of the curves varies only slightly from one stroke to the next. This is about the most symmetry that can be expected from a human.

An example of bilateral asymmetry is shown in Figure 3. There is a slight amount of counter-clockwise rotation about the polar axis. More pronounced is the difference in the angle at the shoulder. Since the right elbow is a little below the shoulder, that arm is in a stronger (more mechanically advantageous) position. The right hand force value at that point (marked by the vertical line) is almost 50% higher than the left. This example shows how a seemingly small asymmetry can make a considerable difference in force.

Asymmetries of this magnitude are very difficult to identify from above the surface. As a minimum, underwater video with a single frame advance feature is necessary. However, force data that is synchronized with video is required to quantify the difference and determine the potential impact on performance.

BILATERAL SYMMETRY IN THE UNILATERAL STROKES

In the unilateral strokes, symmetrical rotation about the polar axis is important for generating equal force with both hands. Asymmetrical torso rotation is often obvious on freestyle breathing strokes, but also occurs on nonbreathing strokes. It is also possible for a swimmer to have symmetrical polar axis rotation, but still have a bilateral difference in hand force because of differences in hand path, pitch, or speed.

Whatever the cause of the asymmetry, correction can improve performance. The swimmer in Figure 4 is a prime example, as he was already international caliber at the time of his first analysis. The pretest force curves are from the beginning of his collegiate career. The peak force for his left hand was consistently close to 50 lbs. However, all of the peaks for his right hand were less than 37 lbs.

The vertical line on the first left hand stroke marks the peak force. At the same point in his right hand stroke, the swimmer does not have an increase in force. The force pattern shows that the swimmer was taking advantage of his strength on the push phase of his left hand, but not his right.

After the swimmer had considerable time to work on this asymmetry, a retest was conducted. The left hand still peaked at about 50 lbs, but now the right hand peak was about the same. The force patterns show a distinct peak during the push phase of both hands (at .62 sec into the stroke). By this point in his career, this swimmer had achieved one of the fastest 50 m freestyle times in history.

MINIMIZING BILATERAL DIFFERENCES

Although bilateral differences are prevalent in competitive swimmers, there are basic strategies that swimmers can use to minimize these differences:

1. In the bilateral strokes, avoid any polar axis rotation. Although this asymmetry is usually undetectable from an above water view, it is seen surprisingly often with underwater video.

2. Make the path and pitch of the hands mirror each other. Naturally, this is easier to monitor in the bilateral strokes, but it requires focusing on the visual information within the field of view.

3. In the unilateral strokes, rotate the body about the polar axis equally in both directions during breathing and nonbreathing strokes. Rotation is often greater during breathing strokes in freestyle.

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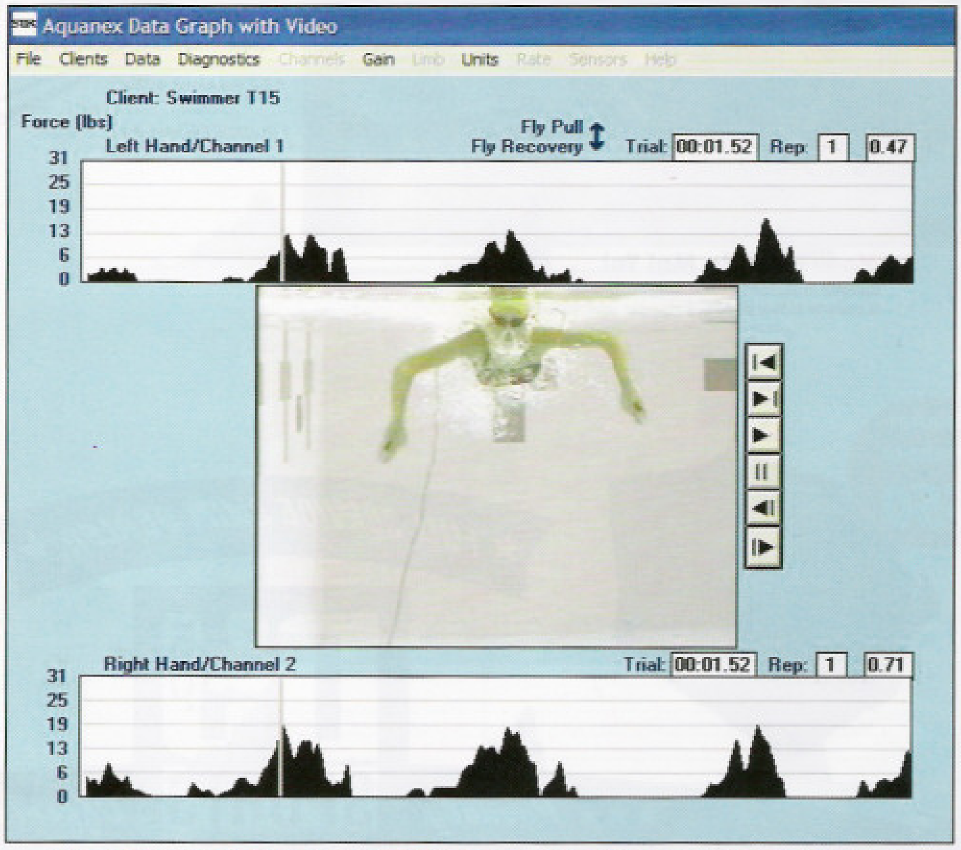

Figure 3. Aquanex+Video synchronized video and hand force data for a female butterflyer.

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4. Train both arms with equal force. This is particularly important for swimmers who only breathe on one side and requires that swimmers feel their arm effort.

Handedness (the inherent preference to use one side of the body instead of the other) is an issue in all the above strategies. Since humans usually favor one side of the body, there is a natural tendency to exert more force with the preferential side. Swimming workouts allow a swimmer to train each side equally. However, a swimmer must consciously take advantage of this opportunity, particularly with the unilateral strokes.

Using visual and kinesthetic input is a way for swimmers to monitor bilateral differences (Havriluk, 2006b). It is important to use visual information to check that the hands mirror each other in path and pitch. When the hands move out of the field of view, a swimmer must rely on feeling that the hands are moving symmetrically. Use of this kinesthetic feedback is generally not as effective as visual information and requires much practice.

Limiting the number of breathing strokes can make it easier for a swimmer to focus on bilateral symmetry. Nonbreathing strokes give swimmers a better opportunity to visually track their arm motions. Kinesthetic input is also improved with the elimination of head motion. Consequently, practicing a limited number of stroke cycles without breathing can help achieve bilateral symmetry. It is important that training sessions include short swims at a low intensity level so swimmers can breathe less often and track their arm movements.

SUMMARY

Hand force is a key factor in swimming fast. Bilateral symmetry in hand force is important to maximize propulsion and minimize resistance. A synchronized underwater video and force analysis is necessary to quantify asymmetries. The use of visual and kinesthetic cues can help swimmers minimize these differences. Improving bilateral symmetry in hand force will improve performance.

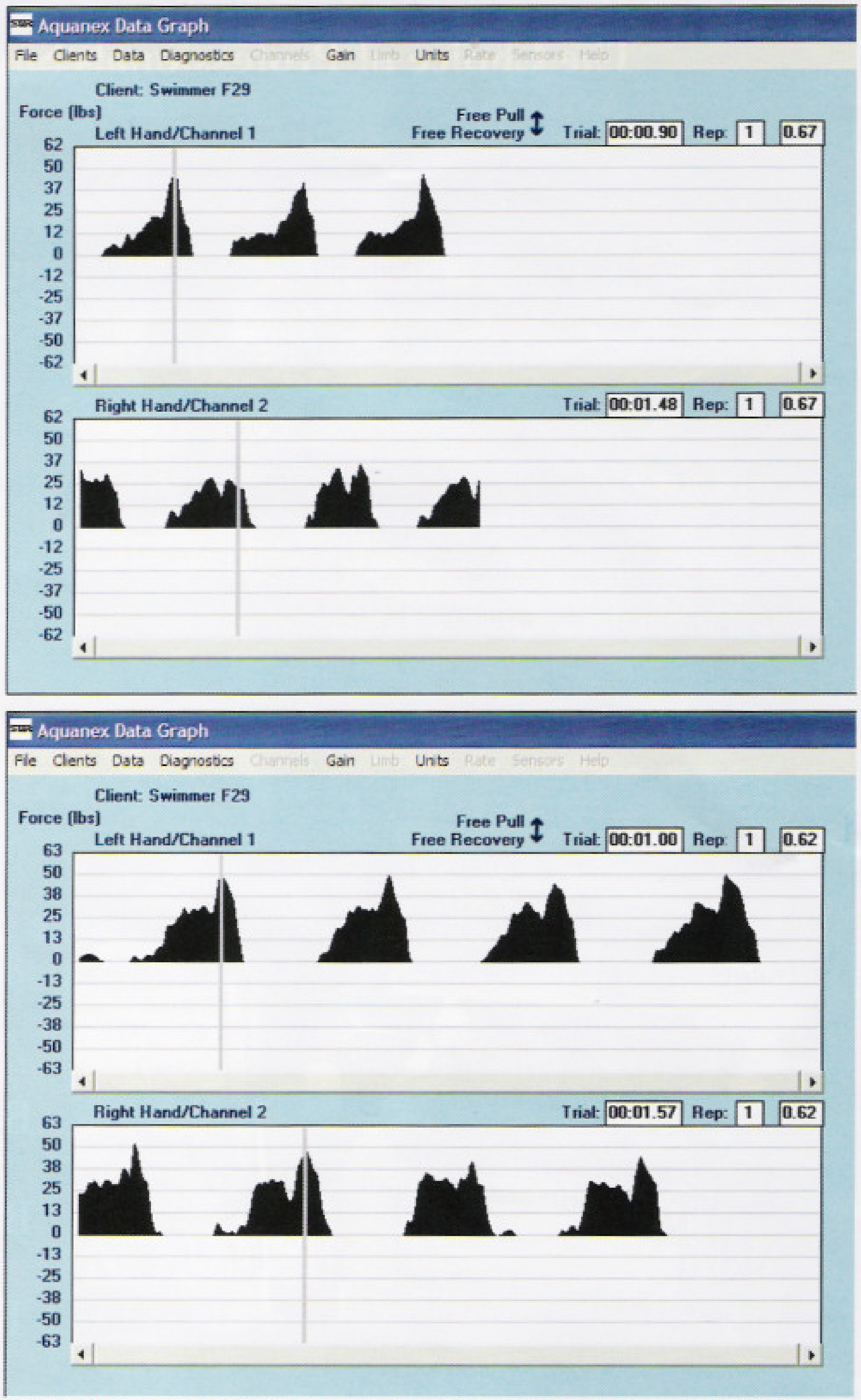

Figure 4. Aquanex pretest (left) and posttest (right) for one of the fastest sprinters in history.

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AUTHOR NOTES

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