Swimming Technology Research Position Statement on Catch-up Stroke

Swimming as fast as possible requires a continuous source of propulsion.

Statement of the Problem

Conventional wisdom (CW) submerges the freestyle entry arm at same level as the shoulder and parallel to the surface (Figure 1). At the same time, the opposite arm completes generating propulsion. It takes a fraction of a second for the arm to submerge below the shoulder and generate propulsion. Therefore, for a fraction of a second neither arm is generating propulsion. The arm coordination produces gaps in propulsion and is commonly called “catch-up” stroke.

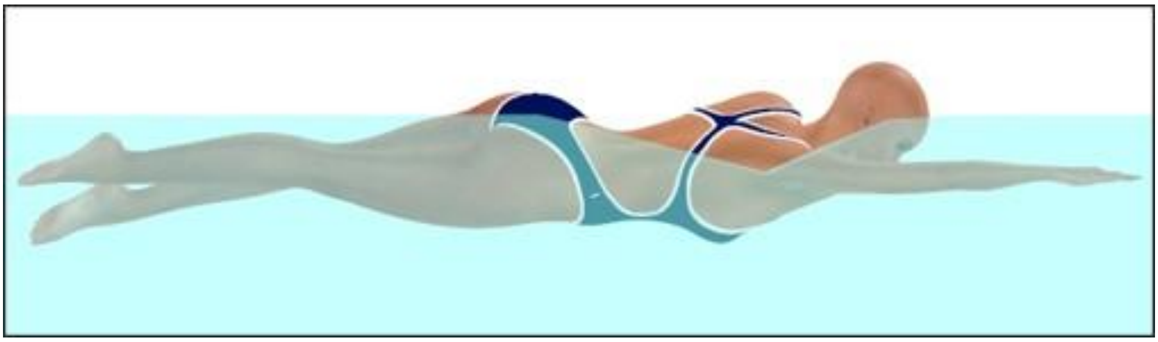


Figure 1. A biomechanical model swimming freestyle with completion of the arm entry at the same level as the shoulder.

To make matters worse, swimmers often maintain the entry arm position and glide as the opposite arm begins recovery. Unfortunately, catch-up is probably the most common drill of competitive swim teams. Even the arm coordination of the current world record holder in the men’s 100-meter freestyle swam with catch-up stroke (Figure 2).

Figure 2. The world record holder in the men’s 100 meter freestyle swimming with catch-up stroke.

The CW arm entry guarantees shoulder stress, wasted motion, and ineffective arm coordination. The likely result is shoulder pain and slower swimming. Evidently, the scientific information (theoretical and practical) has not been successfully disseminated to swim teams.

Theoretical Background

There are at least three reasons for swimming freestyle using an alternative to catch-up stroke: shoulder stress, wasted motion, and arm coordination.

Shoulder Stress

When the upper arm moves above the shoulder, it compresses the soft tissue between the bones (tendon and bursa; Figure 3).

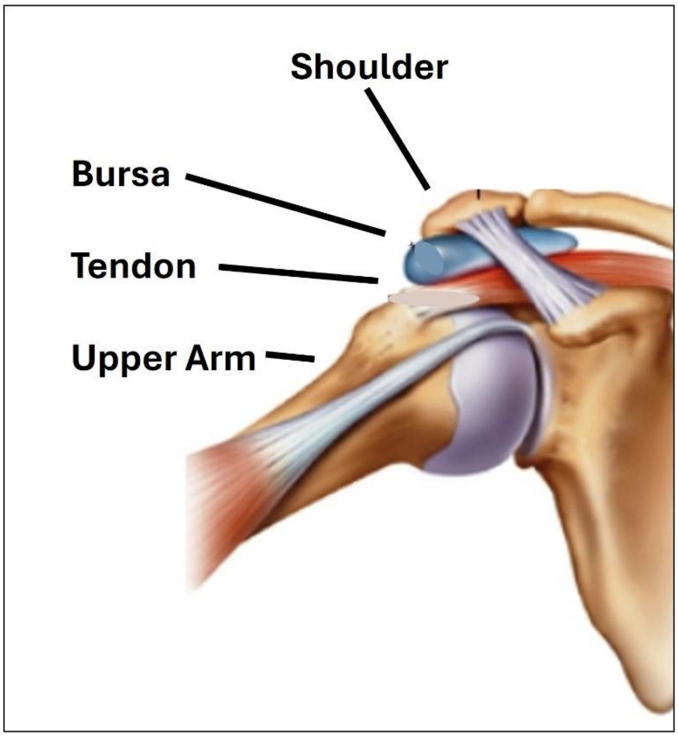
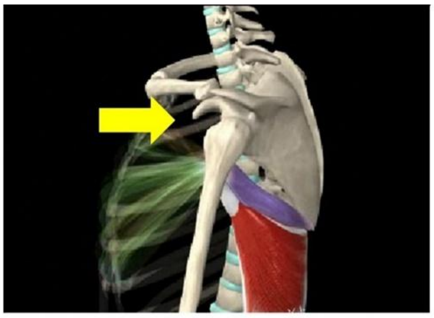
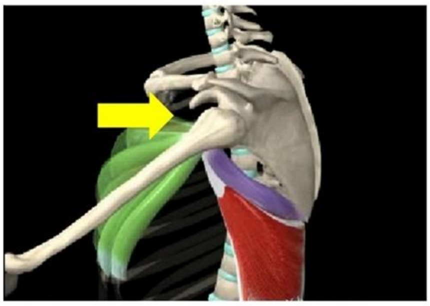


Figure 3. There is soft tissue (tendon and bursa) between the bones of the upper arm and the shoulder.

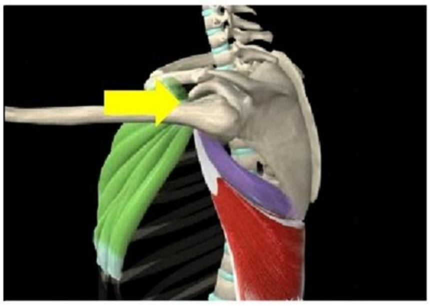
When the entry arm is at the same level as the shoulder, there is maximum stress on the soft tissue. The result is often tendonitis or bursitis (Figure 4).



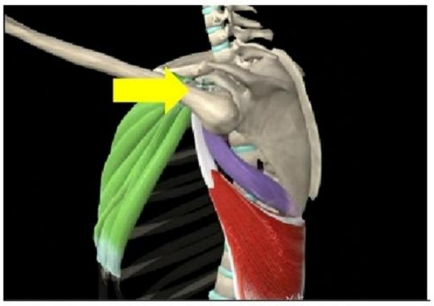
When the arm is alongside the torso, there is considerable room for the soft tissue between the bones of the upper arm and shoulder.



As the arm is elevated, the space between the bones is reduced.



As soon as the arm elevates to the level of the shoulder, the subacromial space is minimal.



As the arm elevates overhead, the soft tissue in the subacromial space is compressed.

Figure 4. Elevation of the upper arm compresses the soft tissue (tendon and bursa).

Wasted Motion

When the entry arm is at the same level as the shoulder (position 1), it must submerge below the shoulder to generate force (position 2). The effort to submerge the arm is wasted motion (Figure 5).

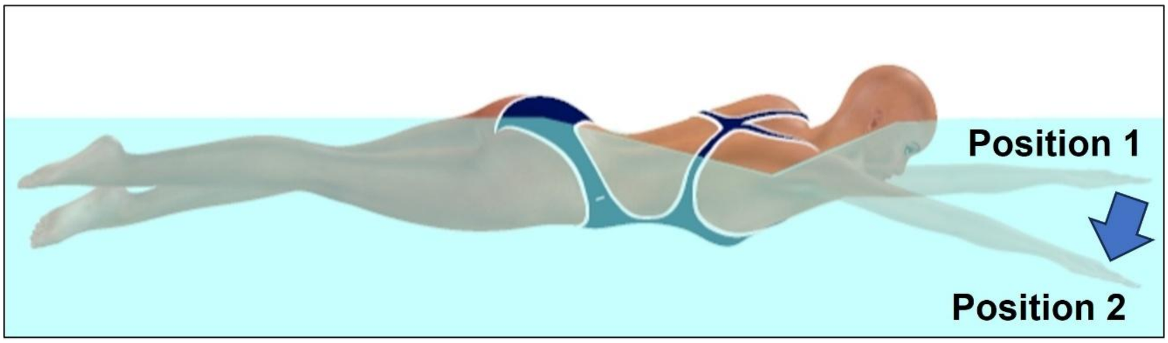


Figure 5. A biomechanical model demonstrating the wasted motion of catch-up stroke.

Completing the arm entry at position 2 would eliminate the wasted motion.

Arm Coordination

Catch-up stroke delays entry arm propulsion. Since the opposite arm is also not generating propulsion, there are gaps in propulsion (Figure 6, top panel). Chollet (2000) quantified arm coordination as the Index of Coordination (IdC).

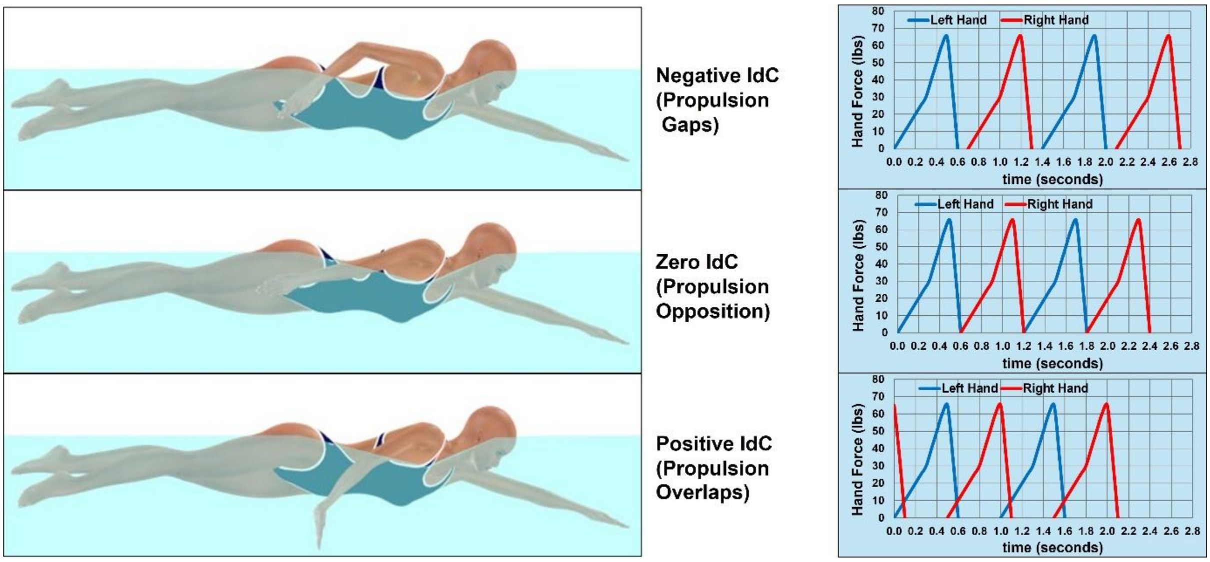


Figure 6. A biomechanical model shows the difference in arm position and hand force for a negative, zero, and positive Index of Coordination.

Swimming with a zero IdC eliminates gaps in propulsion (middle panel). A positive IdC has overlaps in propulsion (bottom panel). Figure 6 also compares force generation for a negative, zero, and positive IdC.

In the above example, each arm generates the same force on each stroke. However, the same total force generation requires 1.4 , 1.2, or 1.0 seconds for a negative (-14%), zero (0%), or positive (+20%) IdC. Therefore, the same total force is generated in considerably less time with a positive IdC. Figure 7 shows another representation of a negative, zero, and positive IdC.

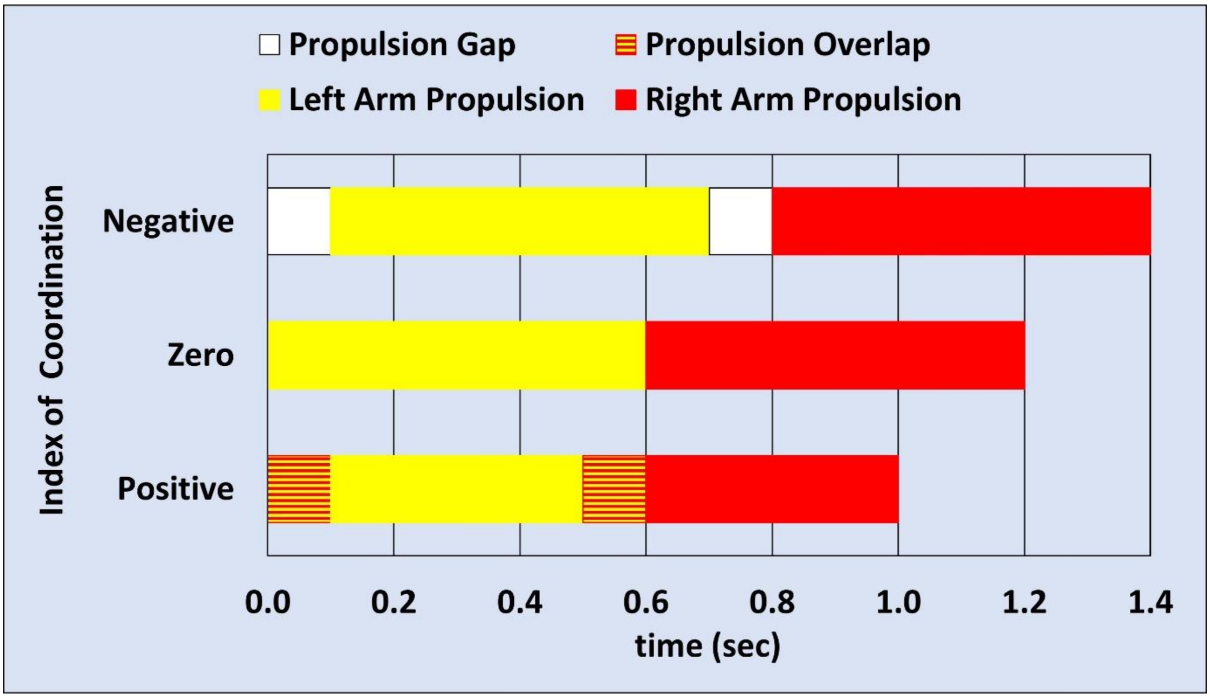


Figure 7. Graphs of a negative, zero, and positive Index of Coordination.

The graph in Figure 8 shows the total force generated for the same hand force per stroke but for different IdCs.

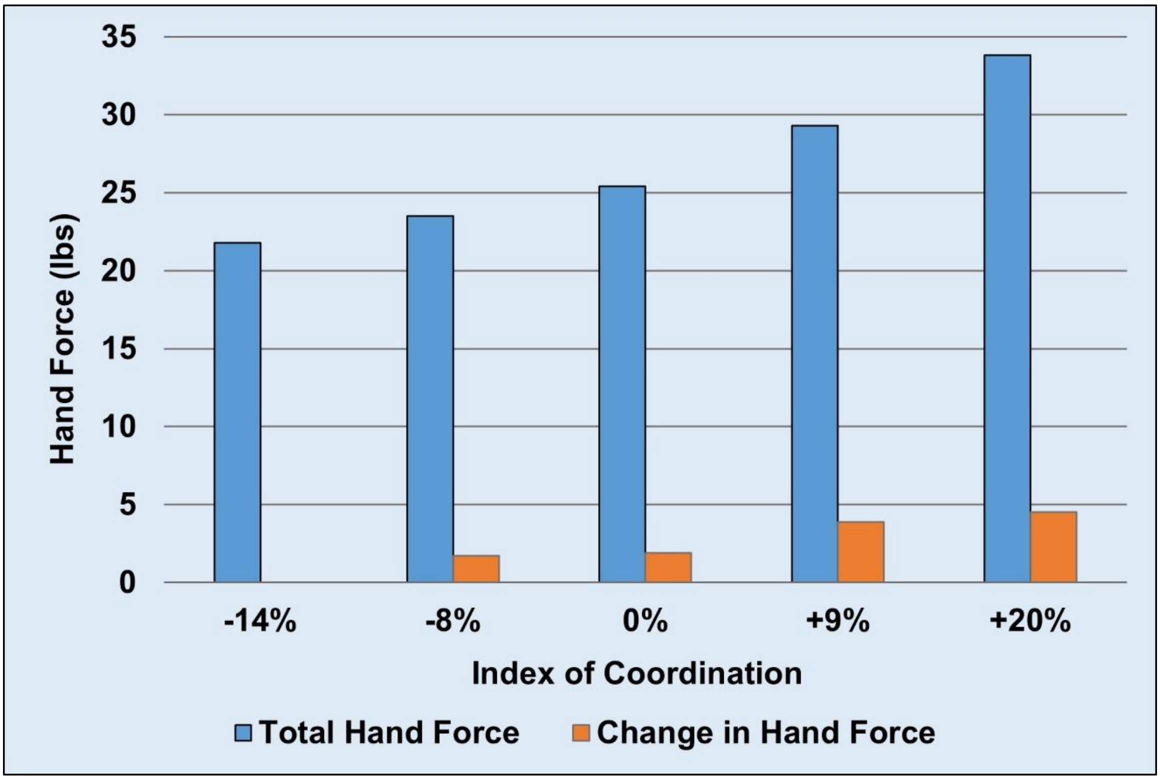


Figure 8. A graph shows the increase in total force per stroke with the same hand force but different IdCs.

Research Background

Studies were conducted on shoulder stress, wasted motion, and arm coordination.

Shoulder Stress

Swimmers generally enter the arm at the same level as the shoulder or above the shoulder, based on results from two studies (Becker, 2014; Figure 9; Havriluk, 2014; Figure 10).

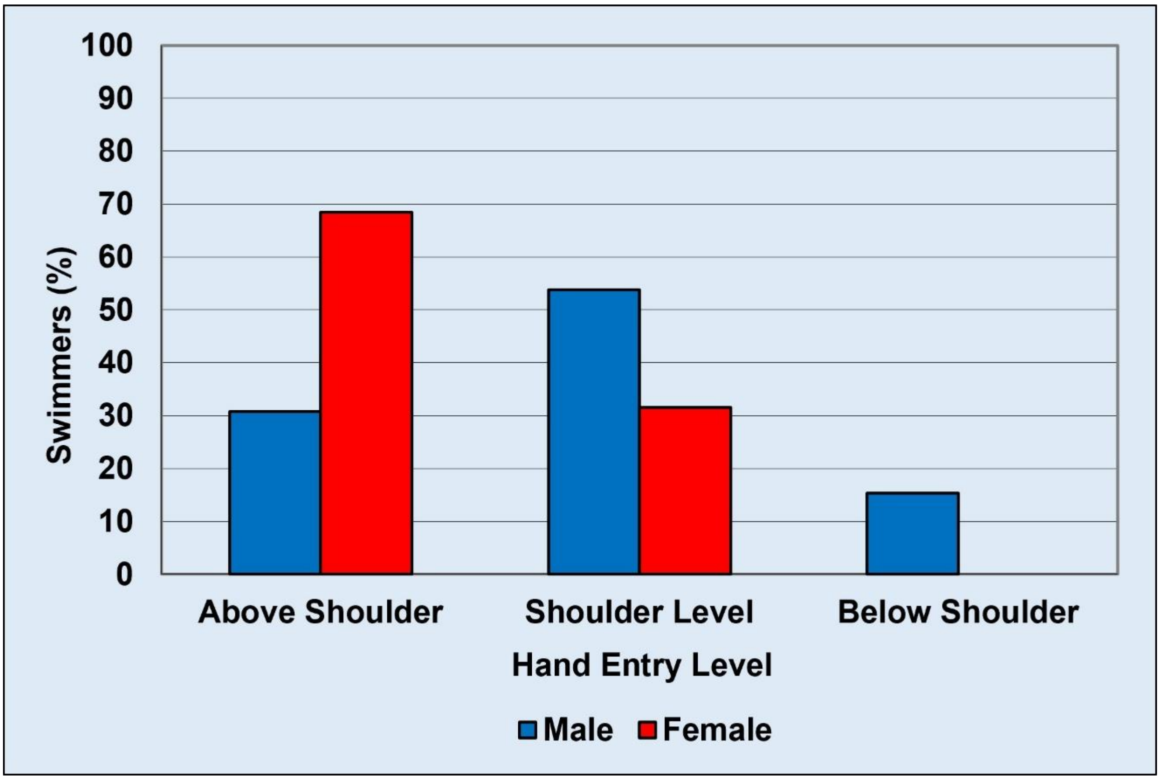


Figure 9. The proportion of freestyle swimmers entering the water above the shoulder, at shoulder level, or below the shoulder in a 2014 study.

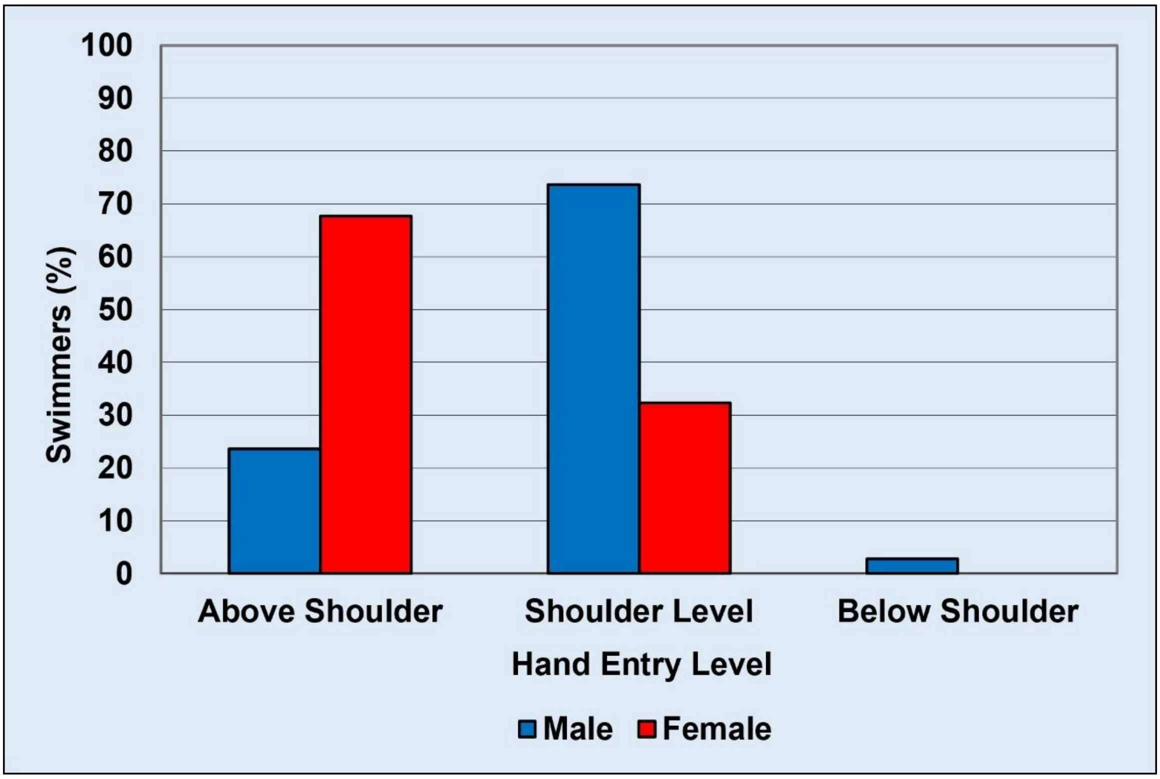


Figure 10. The proportion of freestyle swimmers entering the water above the shoulder, at shoulder level, or below the shoulder in a 2018 study.

Wasted Motion

The time from arm entry until the arm is below the shoulder and ready to generate propulsion is wasted motion and also called exposure time to shoulder stress. The exposure time from the 2014 and 2018 studies are graphed in Figure 11.

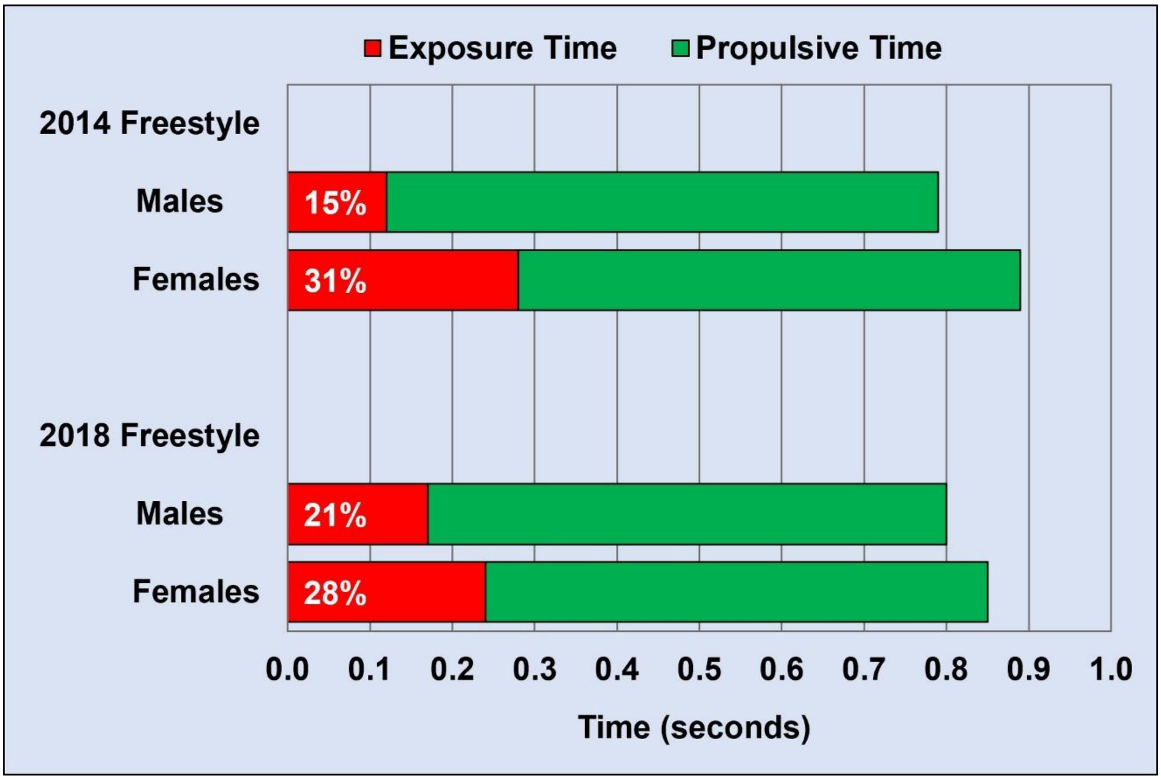


Figure 11. A graph of the wasted time (exposure time to shoulder stress) from the 2014 and 2018 studies.

Arm Coordination

In 1955, Doc Counsilman conducted a study and found that a continuous source of propulsion (caused by overlaps in propulsion) was superior to a non-continuous source of propulsion (i.e., gaps in propulsion). In 2000, Chollet found that a positive IdC (a continuous source of propulsion) was consistent with faster swimming. Many studies by multiple authors confirmed the relationship (Figure 12).

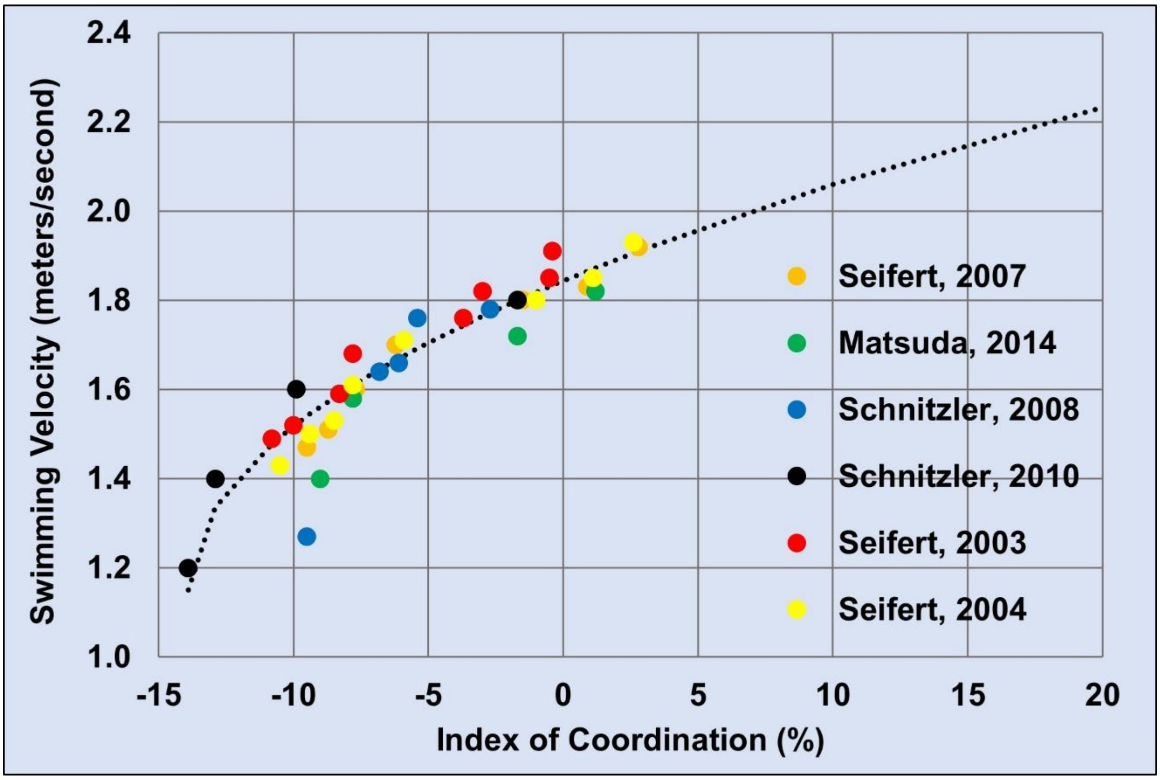


Figure 12. A graph shows the increase in swimming velocity with an increase in IdC from six studies.

Proposed Solution

Fortunately, there is an alternative to catch-up stroke (i.e., gaps in propulsion, a negative IdC). The entry arm can angle downward, so it extends below the shoulder (Figure 13).

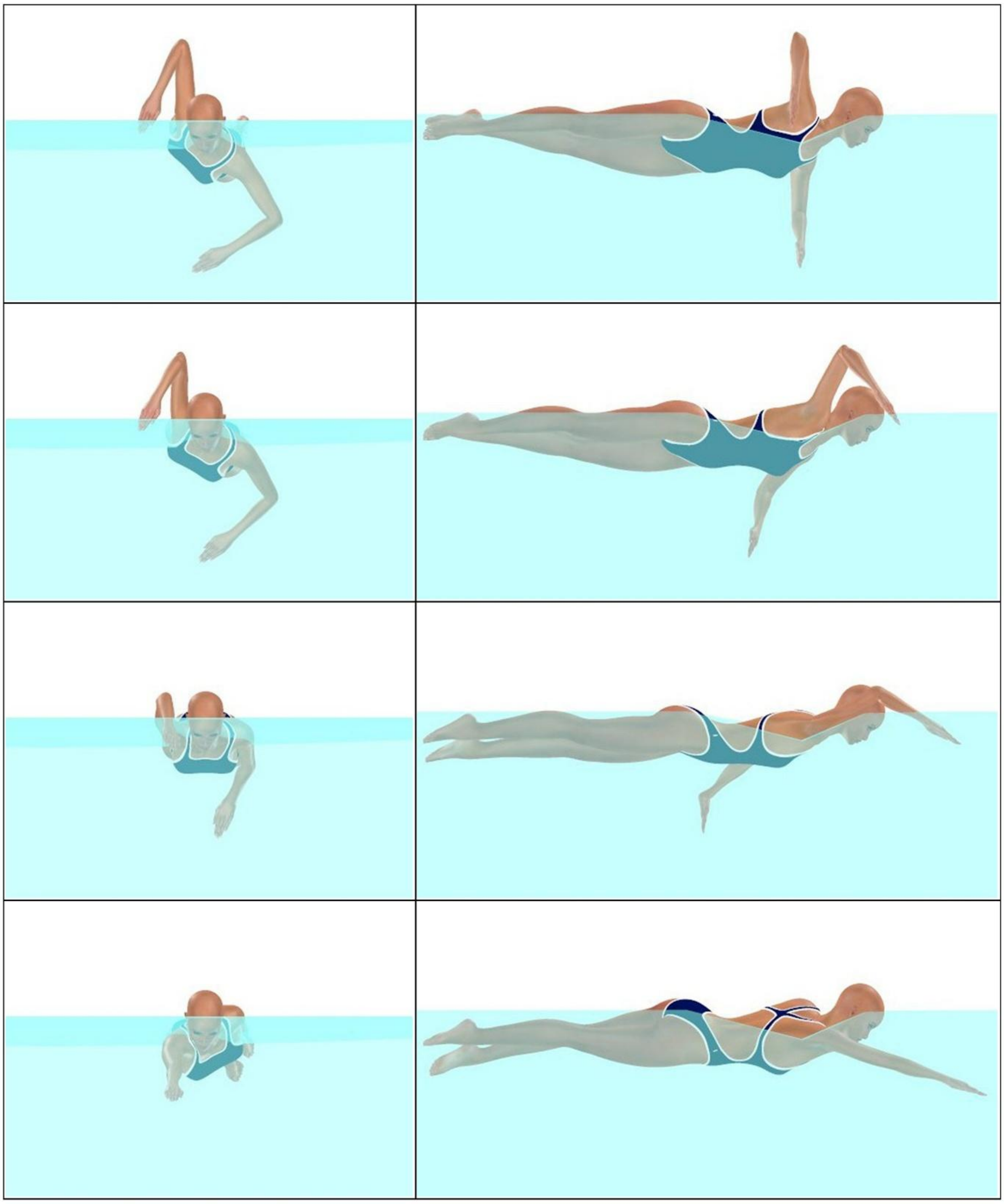


Figure 13. A biomechanical model swimming freestyle with a downward angle on the arm entry and completion of the arm entry below the shoulder.

Increasing Arm Coordination

A swimmer begins to adjust arm coordination by first ensuring that the arms are straight and opposite for an IdC = 0% (Figure 14). At a slow stroke rate, each arm requires about .8 seconds. (The pull and push arm requires .8 seconds. The recovery and entry arm requires .8 seconds.)

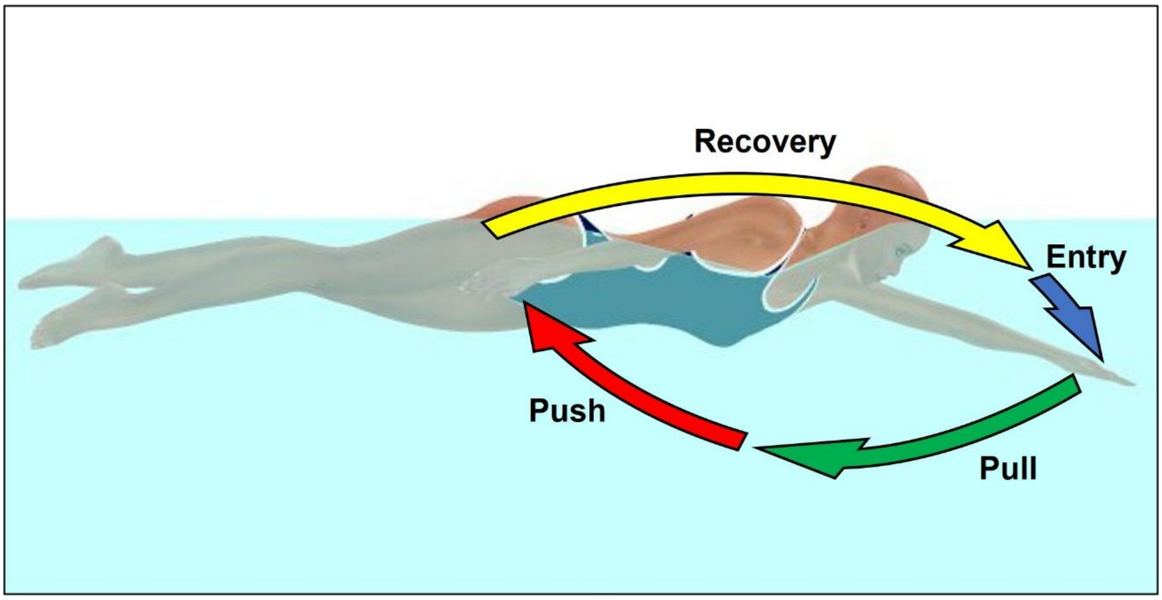


Figure 14. A biomechanical model demonstrating freestyle with an IdC = 0%.

Slightly increasing the stroke rate reduces the time for each arm to .7 seconds. Increasing the stroke rate again reduces the time for each arm to .6 seconds.

Once a swimmer requires only .6 seconds for each arm motion, he/she can begin to reduce the time of the non-propulsive arm, since it is mostly moving through the air. Reducing the non-propulsive arm time to .5 seconds increases the IdC to +9%. Reducing the non-propulsive arm time to .4 seconds increases the IdC to +20% for the fastest swimming (Figures 15 and 16).

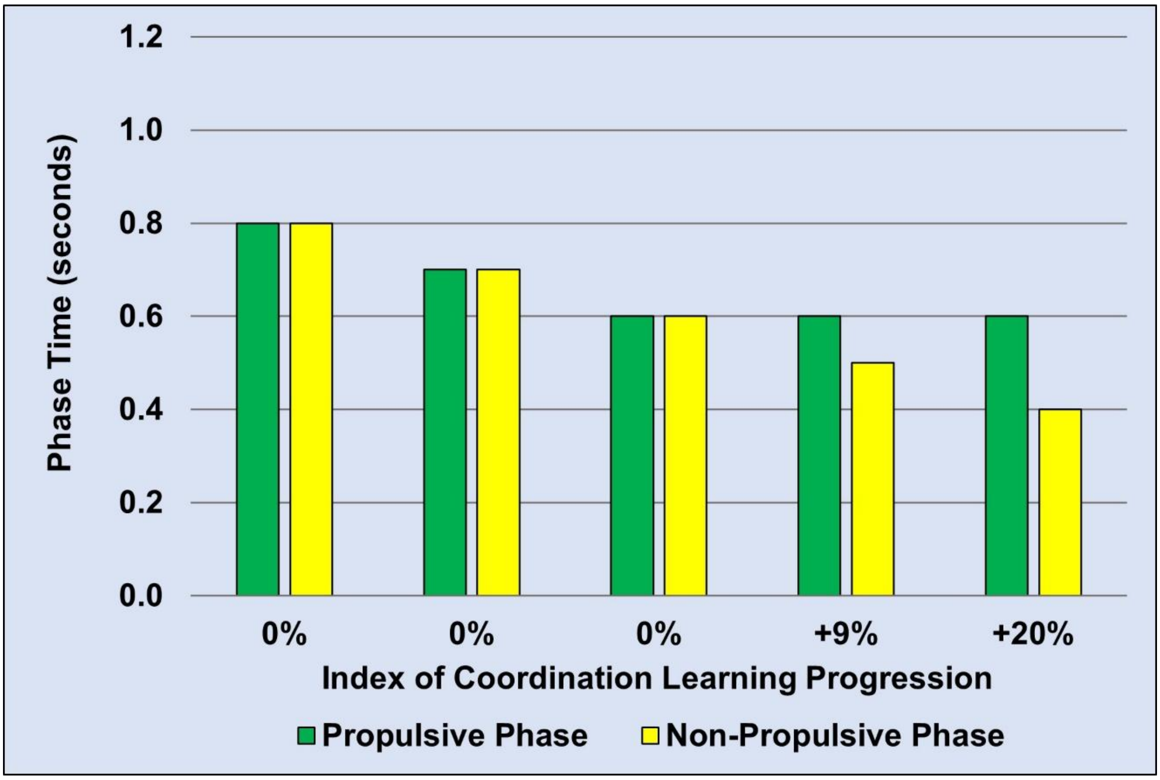


Figure 15. The graph shows the suggested learning progression for increasing the IdC from 0% to +20%.

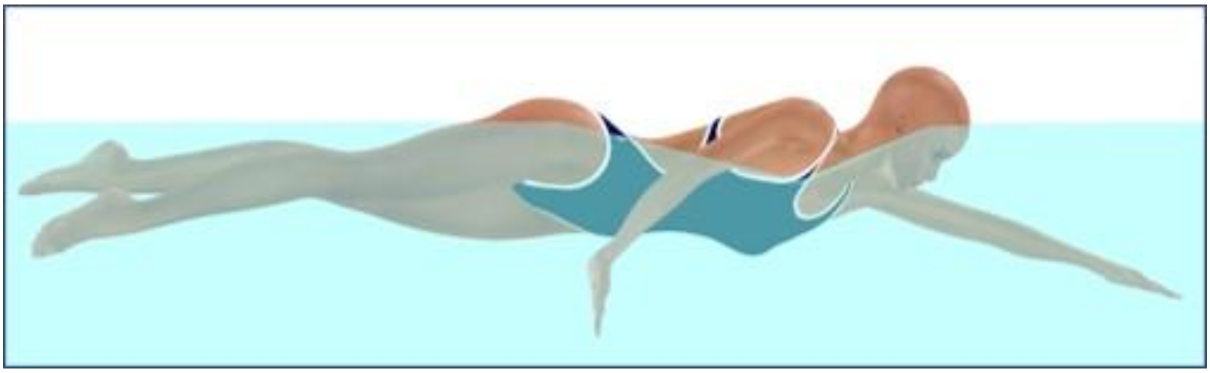


Figure 16. A biomechanical model demonstrating freestyle with an IdC = +20%.

Conclusion

The science-based arm entry reduces shoulder stress, decreases wasted motion, and improves arm coordination (Figure 16). The likely result is the fastest swimming.

References

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Author Notes

Dr. Rod Havriluk is a sport scientist who specializes in swimming technique instruction and analysis. He consults in-person and remotely, year-round and worldwide. His ebooks, courses, software, and videos are available at swimmingtechnology.com. Contact Rod through info@swimmingtechnology.com.