“shoulder” and the “elbow” set the arm in motion. Walcott gave the stick-figure limb a fixed amount of energy to expend and then let the computer search for the arm motion that produced the longest throw.

If the computer program allowed the arm to work against itself, it threw the object farther. The design of the arm doesn’t allow it to chuck the object at any old angle and speed, Walcott explains, but “doing this negative work somehow allows us to get closer” to the optimal angle and speed.

It’s an interesting argument, says Michele LeBlanc, a biomechanist at California Lutheran University in Thousand Oaks, but the abstract analysis probably isn’t the entire explanation of countermovement. The details of how specific muscles, bones, and sinews interact will also play a role, she says. Jill McNitt-Gray, a biomechanist at the University of Southern California in Los Angeles, says that the precise function of countermovement will probably vary even from person to person: “You and I can jump together, and how you get your vertical impulse and how I get my vertical impulse might be different.”

Pulling Straight to the End of the Pool

For decades, competitive freestyle swimmers have been taught to make an S-shaped path when pulling their hands through the water. But measurements and calculations now show that to generate the maximum thrust, swimmers should pull their hands straight back through the water, reports a mechanical engineer whose research was inspired by his previous study of turtles.

Swimmers have been purposely doing the “S-pull” since the early 1970s, when famed swimming coach James (“Doc”) Counsilman used underwater cameras to film elite swimmers and found that they were moving their hand first out to the side and then back under their bodies. By moving side to side, hands acted like little airplane wings or propeller blades, Counsilman argued, generating hydrodynamic lift that pulled the swimmer through the water. That lift would supplement the force generated by simply pushing against the water with the palms. In recent years, researchers have questioned just how large and important the lift forces are, but the S-pull has remained a standard technique among competitive swimmers.

However, the S-pull may not be the best pull for all races and circumstances, says Shinichiro Ito of Japan’s National Defense Academy in Yokosuka. Using measurements of the lift and drag coefficients of manikin hands and a computer model of a swimmer, he found that the S-pull makes the most efficient use of energy, as it maximizes the ratio of lift to drag. It does not, however, generate the most thrust. Instead, Ito found, a straight “I-pull” yields more pure power.

Ito had already observed something similar in his study of freshwater turtles. When paddling about leisurely, turtles wave their feet in flourishes, doing a reptilian version of the S-pull. When frightened, however, terrifed terrapins pull their feet straight back to swim away as fast as possible. Analysis showed that for turtles, the sinuous movement was more efficient, Ito says, but the straight movement produced greater thrust.

Other familiar creatures also provide living examples of the advantages of the I-pull. Underwater video shows that Australian swimming sensation Ian Thorpe snaps his elbow and pulls his hand straight through the water, Ito says. Other swimmers are following the nine-time Olympic medalist’s lead, says Yuji Ohgi, a professor of physical education at Keio University in Fujisawa, Japan. “At the Sydney Olympics [in 2000], only Ian Thorpe had the I-shaped pull,” he says. But now, “many, many Australian swimmers do it.”

Switching from S-pull to I-pull isn’t easy, says Ohgi, who is also a swimmer. Good swimmers generate power by rolling from one side of their bodies to the other, he says, and that makes their hands move side to side almost automatically.

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