“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.

Thorpedo away! Olympic champion Ian Thorpe pulls his hands straight through the water.

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, terrified 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.

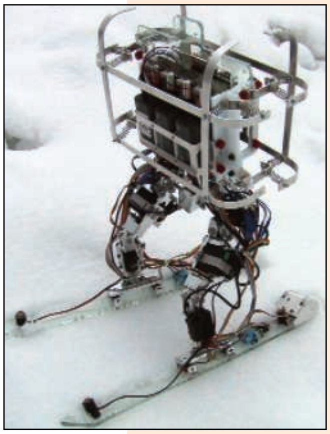
Other familiar creatures also provide living examples of the advantages of the I-pull. Underwater video shows that Australian swimming sensation Ian Thorpe snaps his elbow and pulls his hand straight through the water, Ito says. Other swimmers are following the nine-time Olympic medalist’s lead, says 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. “The I-shaped pull is rather more difficult than the S-shaped pull because of the rolling motion” of the body, Ohgi says. Still, to shave every fraction of a second from their times, more swimmers are tackling the challenging technique and learning to swim like a frightened turtle.

–ADRIAN CHO

Snapshots From the Meeting

R2D2 meets K2. A robot standing 45 centimeters tall and weighing 3 kilograms swishes down a 10-meter artificial ski slope much like a human skier, report engineer Takeshi Yoneyama of Kanazawa University in Japan and colleagues. The mechanical downhiller isn’t completely lifelike, because it doesn’t generate nearly as much force with its legs as humans do. Still, the robot has already provided insights into why skiers move their joints the way they do.



A swell new wetsuit. A high-tech wetsuit automatically adjusts to keep divers warmer in cold water, reports engineer Alec Jessiman of Midé Technology Corp. in Medford, Massachusetts. As water flows in and out of a conventional wetsuit, it carries away a diver’s body heat. But when temperatures dip, the suit made of SmartSkin absorbs water and swells to fill in the gaps between diver and suit. That shuts off the flow within minutes and reduces heat loss by as much as 70%.

The camber of least resistance. The tops of the wheels of racing wheelchairs are tilted toward each other to make them more stable. But such “camber” also reduces the amount of rolling friction, reports Nick Hamilton, a sports engineer at the University of Sheffield, U.K. Hamilton figured that the friction must be least when the wheels are perpendicular to the ground. To his surprise, his measurements showed that the friction was smallest when the wheels leaned by 8 to 14 degrees, presumably because the tires deform to reduce the amount of contact with the ground.

–A.C.

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