Elist Discussion about Resistance

10-16-12 from William:
This is a late question to this post, but, what are "units of measure" for the various components of the formula? (Eg; is frontal area in centimeters ?) I really like the formula. I just need to be able to explain it to others at times.

From Connie:
Hi William,
I am a math-challenged exercise physiologist, not an engineer so this is my attempt for you. I suggest you talk to your engineering department about fluid dynamics and this equation in general. They can give you a more complete answer, I'm sure, but here goes:

Where **Resistance = C of D x density of water x SOM squared x frontal area**

C of D - Coefficient of Drag has no units. It is an experimentally determined number, knowing the units and quantities of the other variables.

Density of water = The SI units for density are kg/m^3. The imperial (U.S.) units are lb/ft^3 ($slugs/ft^3$).

Multiply that by **speed of motion** (ft or inches / sec) ***squared***. Speed of motion / velocity is more complicated than this, since it is rarely constant in the water. People accelerate and decelerate as they move. Their movement is rarely in a straight line. This makes calculation difficult to impossible, reinforcing the challenges of determining resistance in the water.

Frontal area meeting the water in the direction of movement = cubic inches or feet of surface area. Since we are talking about body parts (even if equipment is attached), and since movement is rarely strictly linear, this variable is also difficult to pin down.

Background from previous email:
Resistance in water = coefficient of drag (an experimentally determined number based on how streamlined the object passing through the water is - i.e.: a cupped hand has a different C of D (coefficient of drag) than a flat hand; a ball has a different C of D than a stick, etc. Lab testing will tell you what the C of D is for an object, hence all the flow studies for new car shapes.)

From Bruce:
Unfortunately, it is even more complex than this already complicated formula, as the speed issue is very much in play as movement of water around an object as it moves through water changes from laminar flow to turbulent flow, and from turbulent flow to producing turbulence in the boundary layer around the moving object (or the stationary object in a moving river.) These forces are pretty extensively discussed in Chapter 2 of Comprehensive Aquatic Therapy, 3rd Ed. The calculations are based upon a derived

dimensionless number called a Reynold's number driven by viscosity, density, velocity and frontal area.

So if you want to, you can baffle your clients with abstruse science, or you can just encourage them to push as hard as they can without having pain, knowing that as soon as they stop pushing, the viscosity of water will halt that movement and resultant pain.

From Connie:
Yahoo Dr. B. That gets my vote!

From William:
Thank you! That works.