Volume 8 No 93 **Rowing Biomechanics Newsletter** December 2008

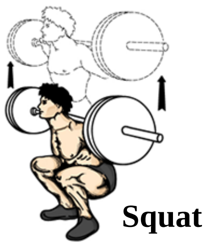
Merry Christmas and Happy New Year to all rowers and coaches!

Q&A

We had interesting discussions with Marinus van Holst, Dutch mechanical engineer and professor emeritus of the Delft University of Technology. Marinus has been active in rowing since 1957, done vast research in Rowing Biomechanics and published results on his web site http://home.hccnet.nl/m.holst/RoeiWeb.htmll

MvH: *"The force/energy/power approach in the RBN 2008/10 is to my opinion unnecessary complicated and confusing. I have great difficulty with the concept "power transferred by the foot stretcher"… Power is not generated, not transferred and not applied at the foot stretcher. The term 'leg power' much better describes what happens. The legs are a power-generating device and the foot stretcher is its foundation. The device generates power by extending and its speed equals the seat speed (with respect to the hull) because legs connect foot stretcher and seat. Power generation by the legs stops when the seat stops."*

VK: Power transmission can be understood better with the examples of two exercises below:



Squat

Leg press

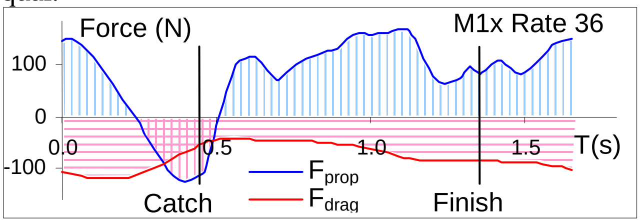
In the case of the squat, the feet are unmovable, so the velocity and power transfer through it are zero, because power is the product of force and velocity. The energy is transferred to the moving athlete's body and to the weight on his shoulders.

In the case of the leg press, the body is fixed, so its kinetic energy cannot be increased. Power is transferred through the feet and the stretcher to the weight.

In rowing on water or on a mobile ergo, both body and feet are mobile, and <u>power is transferred through both the stretcher/boat and rower/handle</u>. Contrarily, in rowing on a stationary ergo or in a tank the stretcher is fixed and power can be transferred only through the rower's body to the handle.

MvH: *"When we disconnect the hull from the rest of the system, we introduce a pin force and a stretcher force. When we consider the equilibrium of the hull, we find that the algebraic sum of these forces constitutes equilibrium with the hull resistance force F_{drag} (at constant hull speed)."*

VK: The <u>impulses</u> of the propulsive force $F_{prop} = F_{pin} - F_{stretcher}$ and drag force F_{drag} have equal magnitude and opposite direction during the stroke cycle (in steady state rowing), but <u>instantaneous forces are different</u>. If they were always equal, the resultant force would always be zero and the boat would not be able to accelerate or decelerate at all. On the chart below the impulses are represented by the area between the curve and the X axis; sums of the areas below and above the axis are equal.



Recently, Marinus have sent us the correct version of the equation: $F_{pin} - F_{str} = F_{drag} + m_{hull}\, a_{hull}$

MvH: *"The power outflow (on the hull) is* $P_{out} = F_{drag}\, v_{hull}$. *The power input is* $P_{in} = (F_{pin} - F_{stretcher}).v_{hull}$ *"*

VK: Definition of the power input P_{in} is another quite common mistake, so we will explain it in more detail. <u>When we define power, it is always very important to define the interacting objects.</u> Imagine two pairs of objects, A_1-B_1 and A_2-B_2, which mechanically interact with a certain force and velocity, so that they transfer power:

A_1	F_1, v_1 →	B_1	B_2	← F_2, v_2	A_2

We can write: $P_1 = F_1\, v_1$ and $P_2 = F_2\, v_2$. This is correct. We can NOT write either $P = F_1\, v_2$ or $P = F_2\, v_1$, which would be incorrect, without physical meaning and misleading. Now, imagine that one of the objects in the two couples is combined. That, however, doesn't change the power equations above:

A	F_1, v_1 →	B	← F_2, v_2	C

In the case of rowing, A is the rower, B is the boat and C is the water. The equation $P_{in} = (F_{pin} - F_{stretcher}).v_{hull}$ would mean $P = F_1\, v_2$ the product of force applied by the rower and velocity relative to the water, which is incorrect. Both rower and water objects can interact with the boat; water constantly consumes power through the drag. (We completely agree with Marinus's first equation, $P_{out} = F_{drag}\, v_{hull}$.) The rower can transfer power through the handle-oar-gate during the drive phase and directly through the stretcher throughout the stroke cycle. Therefore, we have to define P_{in} separately for the drive and recovery. The recovery is the simpler, because the rower can transfer a part of his kinetic energy to the hull only through the stretcher: $P_{in} = F_{stretcher}\, v_{rower\text{-}boat}$, where $v_{rower\text{-}boat}$ is the velocity of the rower's CM relative to the boat. During the drive, the picture is more complicated, as the power can be supplied to the hull by both propulsion through the oar and transfer of kinetic energy from the rower's mass. We may give a more complete analysis later.

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