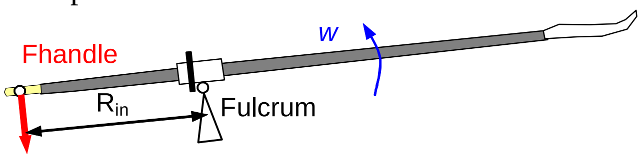
Facts. Did you know that...

✓ …the method of power calculation in rowing is quite complicated issue? It is very important because power production is the main characteristic of a rower's performance and the main component for calculation of the rowing efficiency. We can calculate power in rowing in three ways:

1. Traditional method of the power calculation in rowing is based on the assumption that the rower applies power to the handle only. Oar works as a lever with a pivot point (fulcrum) at the pin:

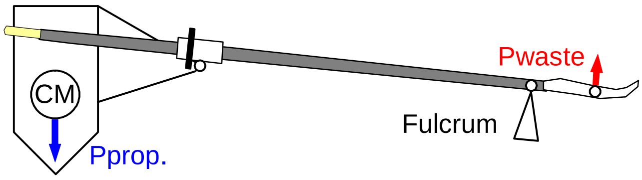


In this case power equates to a product of the torque τ and angular velocity ω, or to a product of the force applied to the handle ***Fh*** and the linear velocity of the handle ***Vh***:

$$P = \tau \omega = (\tau / R_{in}) (\omega R_{in}) = Fh\ Vh \qquad (1)$$

, where R_{in} is the inboard length. To be more accurate, R_{in} is the distance from the pin (+2cm = half of the gate width) to the middle of the handle (-6cm for sculling, -15cm for sweep).

2. Propulsive-waste power. Why we assume that the pin is the fulcrum? In fact, pin moves with the boat with quite irregular acceleration. Therefore, the boat is not an inertial reference frame in Newton mechanics. If we set the reference frame based on Earth (or water), we will find the oar fulcrum somewhere close to the blade:



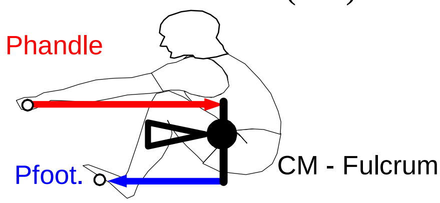
There are two components of the power here: propulsive power **Pprop** on the inboard side from the fulcrum and waste power **Pwaste** on the blade side. Propulsive power equates to the scalar product of the force vector acting on the rower-boat system ***Fprop*** and velocity of the system centre of mass ***Vcm***: $Pprop = Fprop\ Vcm \quad (2)$

Waste power equates to the scalar product of the blade force vector ***Fblade*** and velocity of the centre of pressure on the blade (slippage of the blade through the water) ***Vslip***.

$$Pwaste = Fblade\ Vslip \qquad (3)$$

This method is not very practical, because velocity of the system centre of mass ***Vcm*** can not be determined accurately and easily. The position of the centre of pressure on the blade affected by the blade hydrodynamics, boat speed and oar angle and also can't be determined easily.

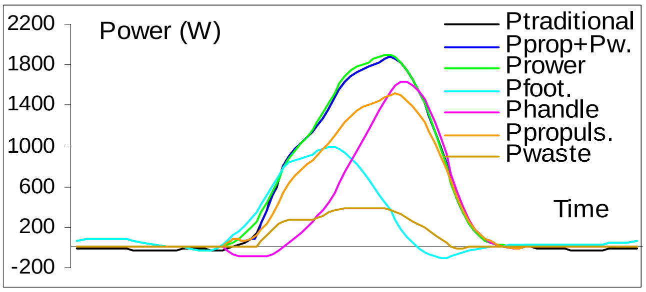
3. Rower's power. In fact, the rower is the only source of mechanical energy in rowing. The rower applies force (i.e. power) only at two points: the handle and the foot-stretcher. The fulcrum here is the rower's centre of mass (CM):



The power can be calculated as a sum of the handle and foot-stretcher powers and each of them equates to a scalar product of correspondent force and velocity vectors:

$$P = Ph + Pf = Fh\ Vh + Ff\ Vf \qquad (4)$$

✓ Graphs below show the power calculated using all three methods, and also their components: propulsive, waste, handle and foot-stretcher powers (M1x, rate 32str\min)



You can see a very good correspondence between the traditional and the propulsive-waste power curves. The average rowing powers were P_1 = 462.9W, P_2 = 465.5W and P_3 = 494.4W. The reason of the difference between the first two and the rower's power is that the last includes inertial component, which is necessary to move the boat relative to the rower. In this case inertial losses were 6.4% of the total rower's power. The blade propulsive efficiency equates to a ratio of the propulsive to the total power, which was 80.4% in this case. The handle/foot-stretcher power ratio was 60%/40% in this case. It depends on the shape of the force curve: foot-stretcher share increases at force emphasis at catch.

References

Kleshnev V. 2000. Power in rowing. *Proceedings of XVIII Congress of ISBS*, (2) Chinese University of Hong Kong, 662-666

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