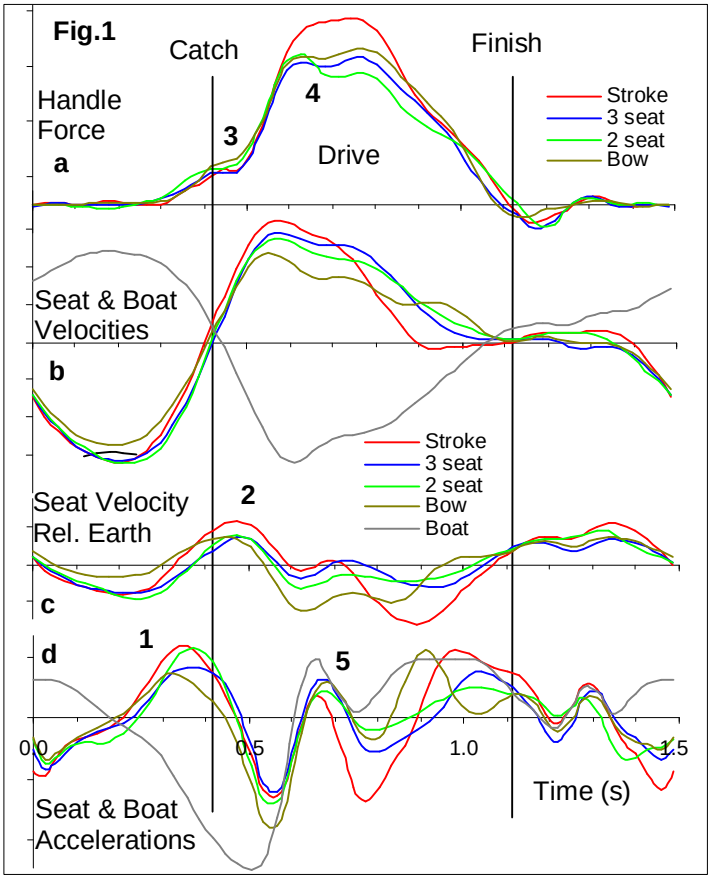
Power transfer between rowers through the boat

During many years of testing, we noticed that rowers on stern seats usually produce more force/power than rowers in bow seats, especially in pairs, fours and eights. Coaches usually put the strongest rowers at stroke, but this doesn't explain all of observed differences in power of up to 30%. Recently, we obtained data, which allows enlightening this phenomenon. A top international level four conducted the same 6x5min step-test both on Concept2 stationary erg and on-water with power (***P***) and heart rate (***HR***) measurements. Because HR was slightly different during these two tests, second-order polynomial trends (R^2>0.99) were derived using ***P*** and ***HR*** data on erg for each rower:

$$P = a\,HR^2 + b\,HR + c \qquad (1)$$

Values of power were calculated for each rower using individual coefficients of above function, where the argument was HR on-water in each sample. These values were compared with on-water power and ratios were derived. Simply speaking, ratios of power on-erg/on-water at the same heart rate were derived for each rower. This ratio was 85.8% for the stroke, 79.3% for 3 seat, 82.2% for 2 seat and 77.7% for bow, so the rowers in the middle of the boat apply 3-6% less power than on erg compared to stroke rower, and for the bow this difference was 8%.

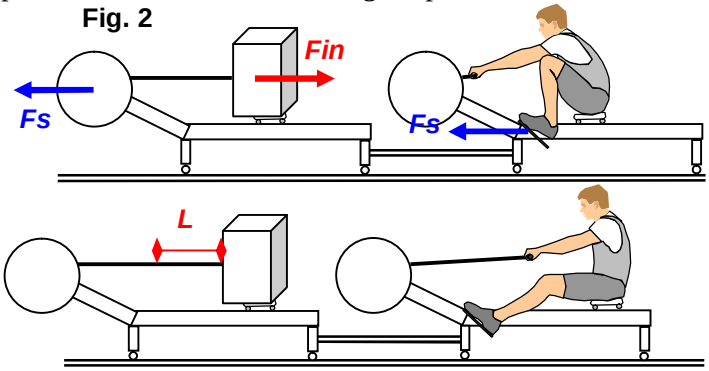


To find reasons of this phenomenon, measured patterns of handle force (Fig.1, a), seat and boat velocities (b) were analysed. Seat velocities for each rower (measured relative to the boat) were summed up with the boat velocity, so seat velocities relative Earth coordinate system were derived (c) and differentiated into accelerations (d). We assume that these seat variables were quite close to velocities and accelerations of centre of mass (CM) of each rower.

At the catch, stroke rower accelerates his seat/CM earlier (1) and achieves faster velocity (2) than teammates. As the blades are at the entry stage and forces are low (3), it is quite easy for the stroke to do. When blades go deeper into the water and forces increase to their maxima (4), it is a turn for other rowers to accelerate their masses (5). Therefore, they have to push the stretcher harder than the stroke, who already moves fast. This extra force is transferred through the stretcher-hull-rigger-pin and applied to the gate of the stroke rower, so his measured handle/blade force became higher. In other words, **one rower can transfer power through the stretcher, boat and rigger to the gate and oar of other rower**.

Notice, that acceleration of CM plays the only role in this effect, not position of the rower in the boat. Bow rowers usually accelerate their CM later, probably, because they focus on synchronisation of handle movement and pay less attention to work through the stretcher. Also, higher efficiency of the stroke rower could be explained by better utilisation of large legs muscles and faster single-motion movement, which is called "rowing using the mass".

We received anecdotal evidence that similar phenomenon also occurs on ergs: when a number of them are connected on slides, the "stern" rower usually shows higher score than normal. This gives us an idea to illustrate the phenomenon with the following simple model.



Imagine two connected ergs on slides (Fig.2). A rower sits on one of them, but the seat of another erg is occupied by a box, which mass is similar to the rower's mass. The box is connected to the handle of the erg. When the rower starts the drive and pushes the stretcher, this force ***Fs*** moves both ergs backwards. It creates reaction force of inertia at the box, which pulls the handle, increases the distance L between the box and erg and rotates flywheel. So, the box produces some erg "score", which is explained by force/power transfer from the rower through the ergs.

Is this effect is negative and should be avoided? Not necessary. **The power transferred from bow rower to the blade of the stern rower could help to keep the boat straight in pairs and fours** (RBN 2008/01). The only problem for the bow rower is lower measured force and power. Therefore, the method 3 with power detection at the stretcher (RBN 2004/06) should be used for accurate rower's testing.

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