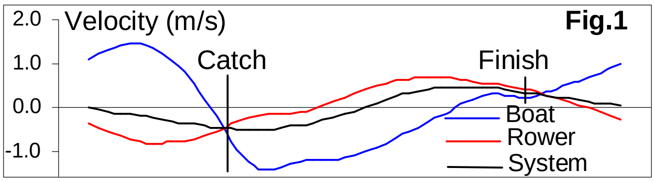
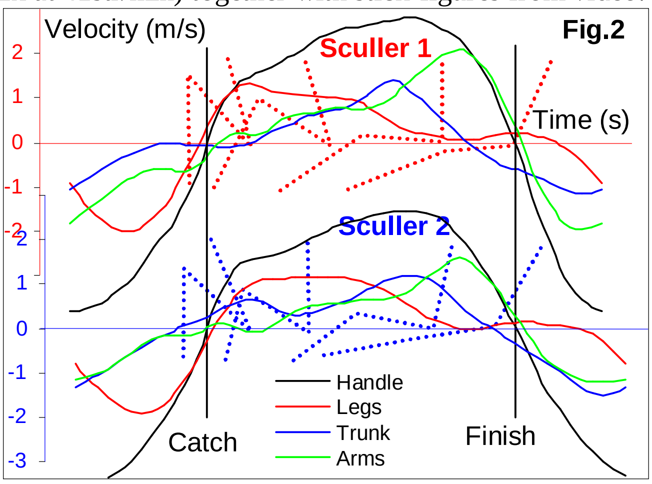
Ideas

We received very positive feedback on the previous Newsletter and continue discussing inertial losses, now in on-water rowing. We used a similar model: inertial losses equal to amount of kinetic energy, which has to be spent to accelerate the boat and rower's centre of mass (CM) up to a certain maximal velocity during the drive and recovery. We do not take into account the energy required for deceleration, because it can be partially stored in elastic energy at the catch and recycled into propulsive power at the finish (RBN 2006/10). Here we used a reference frame, which moves with a constant velocity equal to the average velocity of the rower-boat system during the stroke cycle. Fig.1 shows velocities of the rower's CM, boat and whole system in this reference frame:



Contrarily to ergo rowing, on water, the whole system accelerates during the drive and decelerates during recovery. A rower can shift emphasis either on acceleration of his CM, pushing the stretcher harder and using legs more or on the acceleration of the boat, pulling the handle stronger and using upper body more. To compare inertial efficiency of these rowing styles, Fig.2 shows two samples of data (two M1x at 41str/min) together with stick-figures from video:

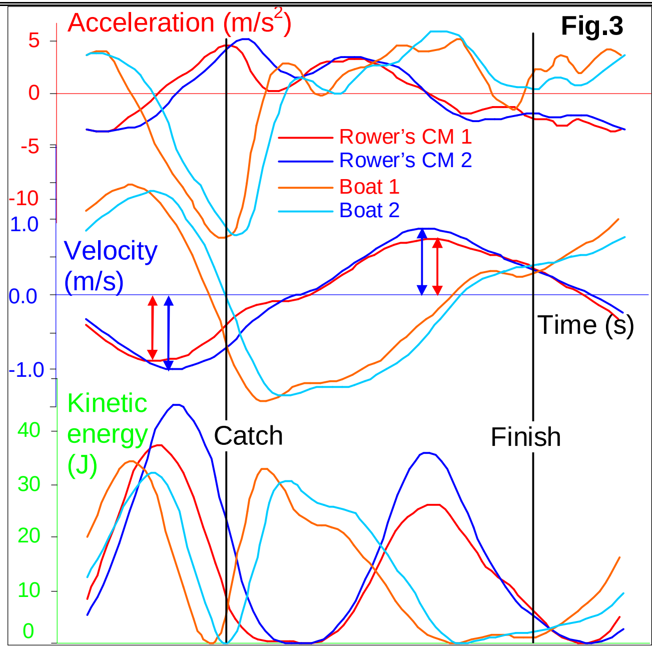


At the catch, velocity of sculler's 1 legs grows faster, earlier than the handle velocity. Sculler 2 use his trunk for the same purpose: for initial acceleration at the blade entry.

At the middle of the drive and finish, sculler 1 is using the trunk more actively and returning it earlier (negative trunk velocity) by means of fast arms pull.

Fig. 3 shows acceleration, velocity and kinetic energy of the boat (measured) and rower's CM (calculated using a method described in 1) for these two scullers.

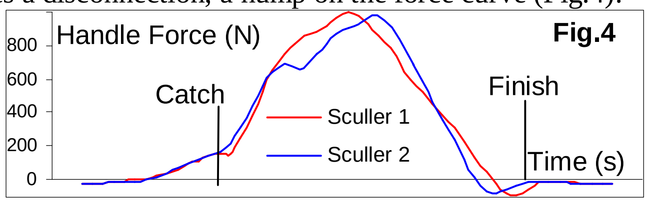
At the catch, sculler 1 developed both accelerations of the boat and his CM earlier, which lead to a smaller magnitude of negative velocity of his CM. During the drive, maximal positive velocity of his CM also has smaller magnitude because of more active utilization of his upper body at that moment. As a result, peaks of kinetic energy and, therefore, his inertial losses are lower than in sculler 2.



The table below shows amounts of kinetic energy of the boat and rower's CM, inertial losses and efficiency (ratio of the rowing power to its sum with the inertial losses).

	Rower' Inertia			Inertia of the Boat			Total	
Rower	Ekin Recovery (J)	Ekin Drive (J)	Inertial Power (W)	Ekin Recovery (J)	Ekin Drive (J)	Inertial Power (W)	Total Inertial Losses (W)	Inertial Efficiency (%)
1	37.4	26.2	44.2	34.6	33.0	47.0	91.1	**88.0%**
2	45.1	36.1	56.1	32.1	30.5	43.2	99.3	**86.3%**

Sculler 2 has to spend 9% more power to overcome inertia of his CM, being 3kg lighter than sculler 1. The inertial efficiency is 1.7% lower, which alone would decrease speed by 0.43% or by 1.7s over a 2000m race. This is not the only problem, which creates the style of sculler 2: it also makes the catch much less effective (RBN 2006/07, 09), ineffectively utilises muscles-antagonists (RBN 2008/07) and creates a disconnection, a hump on the force curve (Fig.4):



As a result, at the same average force and even higher force per kg of body weight, the speed of sculler 2 was 8.3% slower than sculler 1 (30s per 2k, this could also be affected by weather and 8deg shorter length of the stroke).

Some rowing coaches still believe that the target of efficient rowing technique is maintenance of the most even boat velocity, avoiding of the boat "check" or "disturbing". However, it appeared to be that even velocity of the rower's CM is more efficient and important.

References

1. Kleshnev V. 2010. Boat acceleration, temporal structure of the stroke cycle, and effectiveness in rowing. Journal of Sports Engineering and Technology, 224, 1, pp.63-74

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