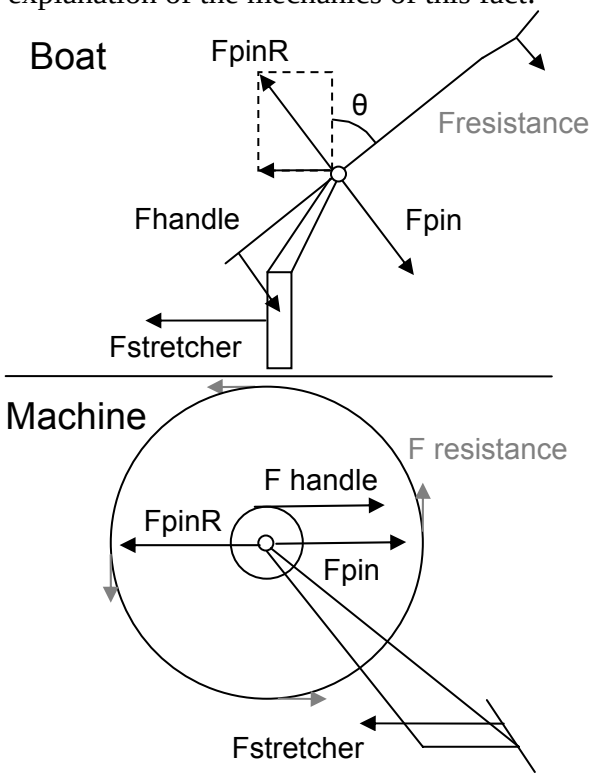
Facts. Did You Know That…

✓ …a comparison of on-water rowing with Rowperfect and Concept2 machines was done recently. Biomechanical parameters were measured in five female rowers during two 90s pieces: at training stroke rate around 20 spm and at racing rate around 32 spm. Average curves and derivative values are presented in Appendix 1.

Maximal force applied to the handle on both rowing machines was 27-30% higher at the training stroke rate (Rowperfect-Concept2, respectively) and 34-40% higher at racing stroke rate. Average force on machines was 22-19% and 25-26% higher, respectively. This confirms our previous considerations (RBN 2005/1). Below is an explanation of the mechanics of this fact:



In the boat, the handle force ***Fhandle*** equal to the pin force ***Fpin*** multiplied by the gearing ratio:

Fhandle = Fpin (Rout / Roar)

where ***Rout*** is the actual outboard, ***Roar*** is the actual oar length. The pin reaction force ***FpinR*** relates to the stretcher force ***Fstretcher*** as:

$$FpinR = -(Fstretcher + m_b a_b) / \cos\theta$$

where $m_b a_b$ is inertia force of the boat shell (relatively small), θ is the oar angle. So:

$$Fhandle = (Fstretcher + Finert.)\ (Rout / Roar) / \cos\theta$$

In simple terms, if the rower applies a certain force to the stretcher, then the corresponding handle force depends on gearing ratio and oar angle.

On the machines, the handle and the pin reaction forces create a couple, i.e. they have the same magnitude and opposite direction: ***Fhandle*** = ***-FpinR*** The difference between the pin and stretcher forces is equal to the inertia force of the mobile unit on Rowperfect ($m_u a_u$, smaller) or the rowers mass on Concept2 ($m_r a_r$, larger):

$$Fhandle = Fstretcher + ma$$

So, if the rower applies a certain force to the stretcher of the machine, then he/she has to apply a similar force to its handle.

In our case the approximate gearing ratio in the single was 2.00m/2.88m = 0.695, which explains 30% difference in the maximal forces. In the boat the handle/stretcher forces ratio depends on the oar angle. For example, at 50^o in catch it is $0.695/\cos(50^o) = 1.08$, i.e. the handle and stretcher forces are nearly equal. This explains the smaller difference in the handle force at the catch and finish between on-water and on-machines rowing. It affects the difference in average forces, which is lower, than the difference in the maximal forces.

The gearing ratio in the boat varies during the drive, because it depends on the oar angle. In both machines it is constant. This explains difference in the handle velocities profiles. This difference significantly affects the rower's perceptions.

Rowers executed 11-12% longer stroke on-water than on both machines, which mainly occurred by means of 30% longer arms pull. This can be explained by curvilinear geometry of the movement of the arms in the boat and the linear handle path on machines.

Faster increase of the handle force and leg speed in the boat and on the RowPerfect can be explained by the different magnitude of inertial forces caused by interaction of the rower with mobile or stationary point of support. For the same reason, leg drive was 4-6% longer on Concept2.

The RowPerfect machine accurately simulates negative acceleration of the boat shell at the catch. During the drive, acceleration of the single was significantly (20-30%) higher than acceleration of the mobile unit of the RowPerfect. The latter exceeded the boat acceleration during recovery phase. This also can affect rower's sensations.

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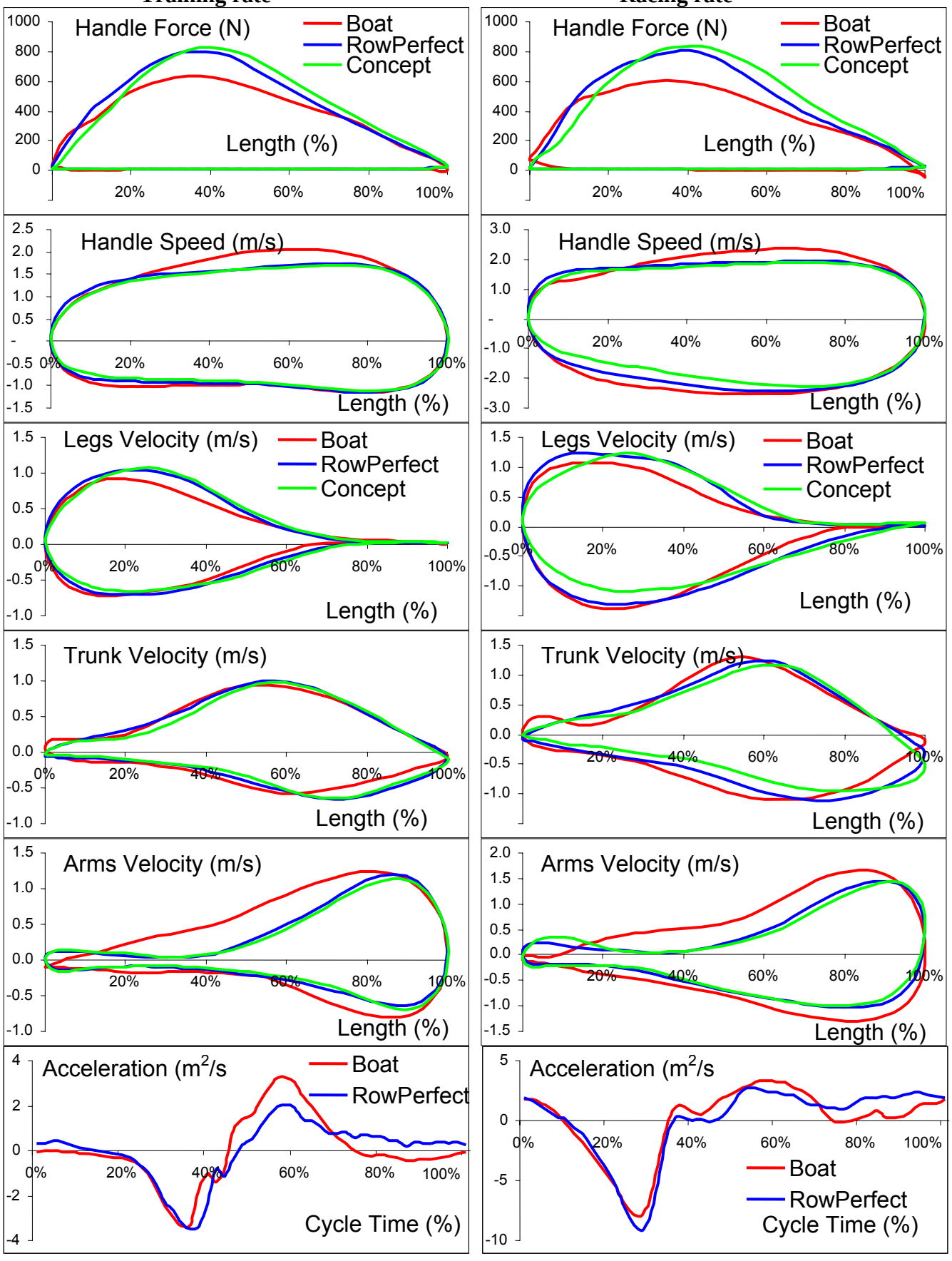
Appendix 1 to the Rowing Biomechanics Newsletter 3(5), March 2005.

Average biomechanical parameters in five female rowers during rowing in single scull, on Rowperfect and Concept2 rowing machines.

Training rate | **Racing rate**



Derivative numerical values of rowing at training and racing stroke rates

	Parameters	Boat		RowPerfect		Concept2	
	Rate	Training	Racing	Training	Racing	Training	Racing
1	Average Rate (str/min)	20.1	32.3	22.3	35.2	20.7	32.1
2	Rowing Power (W)	247	391	247	401	237	375
3	Drive Time (s)	1.26	1.00	1.13	0.92	1.21	0.97
4	Rhythm (%)	42.0%	54.0%	42.0%	53.9%	41.7%	51.9%
5	Drive Length (m)	1.60	1.59	1.42	1.43	1.44	1.41
6	Maximal Force (N)	634	602	803	806	826	840
7	Average Force (N)	331	342	404	427	394	430
8	Ratio Aver/Max Forces (%)	52.3%	56.9%	50.4%	53.0%	47.7%	51.2%
9	Position of Max. Force (%)	37.6%	34.7%	36.3%	40.5%	37.2%	40.8%
10	Catch Slip (m)	0.04	0.04	0.07	0.09	0.12	0.13
11	Release Slip (m)	0.22	0.20	0.24	0.25	0.22	0.21
12	Max.Handle Velocity (m/s)	2.06	2.36	1.73	1.94	1.70	1.89
13	Average Velocity (m/s)	1.28	1.59	1.26	1.55	1.19	1.45
14	Position of Max.Velocity (%)	59.4%	65.2%	73.5%	71.4%	76.4%	74.1%
15	Min. Acceleration (m/s^2):	-3.35	-7.92	-3.46	-9.13	0	0
16	Max. Acceleration (m/s^2):	3.23	3.39	2.01	2.78	0	0
17	Legs Travel (m)	0.52	0.51	0.52	0.52	0.55	0.53
18	Trunk Travel (m)	0.50	0.48	0.48	0.48	0.47	0.46
19	Arms Travel (m)	0.61	0.62	0.43	0.43	0.44	0.43