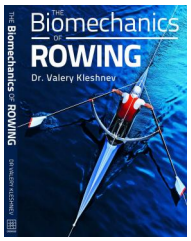


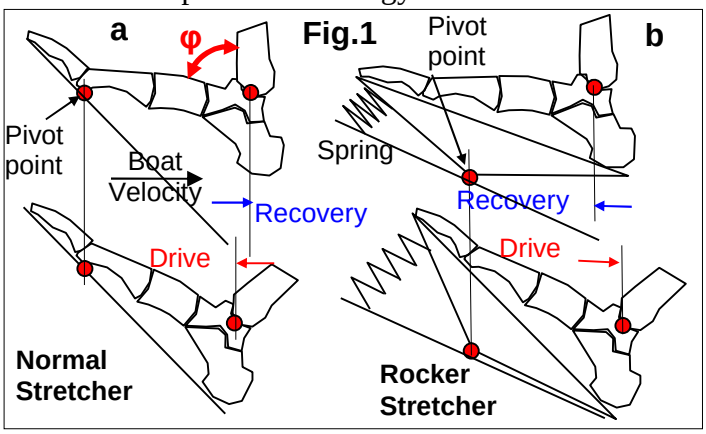
News

A new book titled "The Biomechanics of Rowing" was recently published in Crowood press. Please contact us on www.biorow.com or the publisher on www.crowood.com for further details.

The new Rocker foot stretcher from BioRow/WinTech

The common foot stretcher used in rowing boats has the following disadvantages:

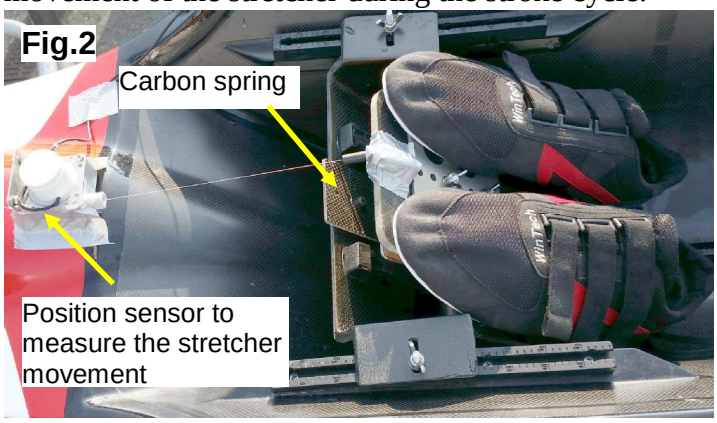
- As the pivot point (centre of rotation) of the foot is located higher than the ankle, during the recovery the centre of the ankle joint moves in the direction of the boat velocity, but during the drive, it moves in the opposite direction (Fig.1, a). This distance is only about 1-2cm, but it is subtracted from the length of the leg drive and the stroke length, and makes it shorter and slower. The higher the pivot point (like in Shimano stretcher, 4), the longer the reverse ankle movement, so the drive could be even shorter.
- At the catch, the angle φ between the tibia and foot bones becomes more acute and the Achilles tendon stretches, so athletes with low ankle flexibility may have difficulty approaching the catch and will therefore spend more energy on it.



To overcome the above problems, a Rocker stretcher was developed (Fig.1 b) in a collaboration of BioRow with WinTech racing boats. The Rocker stretcher could be equipped with a spring, which accumulates the kinetic energy at the catch and returns it during the drive, so it works as a trampoline of sorts.

The idea of pivoting stretcher is not new: it was patented as far back as in 1890 (1, 2). A spring-loaded stretcher was also invented (3), but advantages of a pivoting stretcher were not proved experimentally yet.

Six scullers performed a 1000m race in random a order in three WinTech singles: one boat was with a normal stretcher and two boats were equipped with the Rocker stretcher (Fig.2) with two different positions of the pivot point: high and low. Both Rocker stretchers were with a carbon spring for the recovery of kinetic energy at the catch. All boats were equipped with the BioRow measurement system, which, in addition to its standard variables (RBN 2011/10), measured the movement of the stretcher during the stroke cycle.



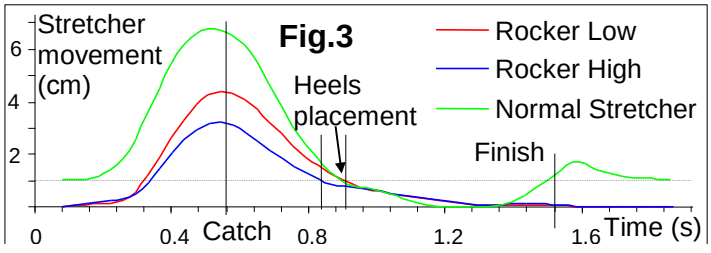
The average boat speed in all six scullers (Table 1 below) was found 0.56% higher with the normal stretcher than with the Rocker High stretcher and 0.85% higher than Rocker Low. These differences were much smaller than variation of the boat speed between scullers (2.05-2.71%, ANOVA $p>0.05$), so the effect of stretcher type could be considered statistically insignificant. The stroke rate (Table 2) was also 0.55 min^{-1} (1.55%) higher with Normal stretcher than with Rocker High and 0.48 min^{-1} (1.42%) higher than with Rocker Low, which partly explains the differences in the boat speed.

Rowing power was the highest with the normal stretcher (Table 3), and it was 2.0% lower with Rocker Low and 5.6% lower with Rocker High stretcher, which could be partly explained by different stroke rate. Work per stroke (Table 4) was very similar with the normal and Rocker Low stretchers (only 0.5% difference), and was 4.0% lower with Rocker High stretcher.

Force production was the highest with the normal stretcher, but it was only 1.1% higher than with Rocker Low stretcher, and 5.0% higher than with Rocker High stretcher (Table 6).

As expected, the stroke length was the longest with both Rocker stretchers: with Rocker Low it was 0.74% longer than with the normal stretcher (Table 5). The length of the leg drive was longest with the Rocker High stretcher, where it was about 1cm (2.3%) longer than with Rocker Low and about 2cm (3.9%) longer than with the Normal stretcher (Table 7). Leg speed was the fastest with Rocker Low stretcher, where it was 1.7% higher than with Rocker High stretcher and 5.5% higher than with the normal stretcher (Table 8).

The amplitude of the stretcher movement was the longest with the normal stretcher (Table 9), which could be related to the longer radius of foot rotation.



The moment of the heels placement onto the foot-board was defined as 1cm from the minimal value of the foot movement (Fig.3), because at lower values the stretcher movement became very slow and could be related to the deforming materials of the shoes. It was assumed that at this moment a part of the foot pressure starts to transmit through the heels.

It was found that the normal stretcher had the earliest moment of heels placement at about -45deg of the oar angle (Table 10). With the Rocker High stretcher, it takes 4deg more oar travel, and with Rocker Low – about 10deg more.

No significant differences were found between the stretchers in Catch Factor (Table 11). Rowing Style Factor was the highest with Rocker Low stretcher: 4.4% higher than with Rocker High stretcher and 8.2% higher than with normal stretcher (Table 12). This means **the Rocker stretcher requires using more legs and less trunk after catch**. Interestingly, two **rowers, which had the highest leg speed, has shown higher boat speed and force-power production with the Rocker stretcher** (Scullers 2 and 6, Table 8).

Contrarily, **the normal stretcher was the best for rowers with the shortest amplitude of the stretcher movement, which was related either to good ankle flexibility**(Sculler 3)**, or to a short legs drive** (Sculler 5). The results of the experiment allow us to conclude the following:

1 The Rocker stretcher has advantages over the normal stretcher in terms of length of the stroke and legs drive.

2 The normal stretcher still appears to be the most comfortable for the most rowers in terms of force / power production and achieving a higher stroke rate. Due to these factors, the average boat speed in the tested group of scullers was slightly higher with the normal stretcher.

3 The effect of the Rocker stretcher appeared to be dependent on specifics of rowing technique: scullers with a dominatingly fast leg drive have achieved higher boat speed, at higher force-power production with the Rocker stretcher.

4 Rowers with good ankle flexibility and/or short and slow legs drive did not benefit from the Rocker stretcher and performed better with the Normal stretcher.

5 Between two types of the Rocker stretcher, the lower position of the pivot point allows slightly higher force/power production and longer stroke length.

References

1. 1890. Kerns E. Rowing apparatus. US patent N 421080.
2. 1927. Long G.E. Foot rest. US patent 1621423.
3. 2006. Kaufer P. Pivoting footrest to rowing boat. Patent pub. US 2006/0183385
4. 2010. Shimano Inc. Rowing boat foot support assembly. Patent pub. US 2006/001850.

Table 1. Boat speed as the time over 1000m race

Sculler ID	Normal Stretcher	Rocker High	Rocker Low	Average
Sculler1	3:29.9	3:33.0	3:34.0	**3:32.3**
Sculler2	3:36.7	3:34.5	3:32.8	**3:34.7**
Sculler3	3:31.2	3:38.7	3:40.3	**3:36.7**
Sculler4	3:39.2	3:36.5	3:45.7	**3:40.4**
Sculler5	3:40.1	3:43.3	3:40.8	**3:41.4**
Sculler6	3:45.7	3:43.7	3:40.0	**3:43.1**
Average	**3:37.0**	**3:38.2**	**3:38.9**	**3:38.0**
±SD	**0:05.9**	**0:04.5**	**0:04.8**	**0:04.2**

Table 2. Stroke rate (1/min)

Sculler ID	Normal Stretcher	Rocker High	Rocker Low	Average
Sculler1	35.2	34.8	34.3	**34.8**
Sculler2	33.5	33.4	34.1	**33.7**
Sculler3	33.9	33.6	33.1	**33.5**
Sculler6	33.4	32.9	33.8	**33.4**
Sculler4	32.5	33.2	32.0	**32.6**
Sculler5	33.7	31.0	31.9	**32.2**
Average	**33.69**	**33.17**	**33.21**	**33.4**
±SD	**0.87**	**1.25**	**1.05**	**1.05**

Table 3. Rowing power (W)

Sculler ID	Normal Stretcher	Rocker High	Rocker Low	Average
Sculler1	359.9	337.6	357.6	**351.7**
Sculler5	346.2	301.3	331.2	**326.2**
Sculler3	350.0	306.1	312.8	**323.0**
Sculler4	321.6	336.9	303.9	**320.8**
Sculler2	311.4	321.7	322.9	**318.7**
Sculler6	260.0	235.7	280.4	**258.7**
Average	**324.8**	**306.6**	**318.1**	**316.5**
±SD	**36.6**	**37.8**	**26.1**	**30.8**

Table 4. Work per Stroke (J)

Sculler ID	Normal Stretcher	Rocker High	Rocker Low	Average
Sculler5	615.2	582.4	623.7	**607.1**
Sculler1	612.2	580.7	625.1	**606.0**
Sculler4	593.0	608.0	568.8	**589.9**
Sculler3	619.5	546.6	565.8	**577.3**
Sculler2	557.7	578.6	568.5	**568.2**
Sculler6	467.0	429.0	496.7	**464.2**
Grand Total	**577.4**	**554.2**	**574.8**	**568.8**
±SD	**58.7**	**64.4**	**47.3**	**53.5**

Table 5. Stroke length as total oar angle (deg)

Sculler ID	Normal Stretcher	Rocker High	Rocker Low	Average
Sculler5	104.1	109.0	107.0	**106.7**
Sculler2	106.0	107.5	106.6	**106.7**
Sculler4	104.1	104.9	103.4	**104.1**
Sculler1	103.2	102.9	104.3	**103.5**
Sculler3	103.4	98.1	102.0	**101.2**
Sculler6	100.6	99.8	102.6	**101.0**
Average	**103.6**	**103.7**	**104.3**	**103.9**
±SD	**1.7**	**4.3**	**2.0**	**2.5**

Table 6. Average force (N)

Sculler ID	Normal Stretcher	Rocker High	Rocker Low	Average
Sculler1	365.5	337.6	364.8	**356.0**
Sculler5	363.5	336.3	357.9	**352.6**
Sculler3	359.2	323.8	332.0	**338.4**
Sculler4	341.3	342.1	327.1	**336.8**
Sculler2	319.1	333.4	337.1	**329.9**
Sculler6	275.4	250.1	283.4	**269.6**
Average	**337.3**	**320.6**	**333.7**	**330.5**
±SD	**35.0**	**35.0**	**28.8**	**31.4**

Table 7. Length of the legs drive (m)

Sculler ID	Normal Stretcher	Rocker High	Rocker Low	Average
Sculler1	0.587	0.594	0.623	**0.601**
Sculler6	0.596	0.590	0.615	**0.600**
Sculler4	0.581	0.612	0.599	**0.597**
Sculler3	0.527	0.535	0.517	**0.526**
Sculler2	0.510	0.508	0.492	**0.503**
Sculler5	0.463	0.548	0.495	**0.502**
Average	**0.544**	**0.565**	**0.557**	**0.555**
±SD	**0.053**	**0.040**	**0.062**	**0.050**

Table 8. Maximal legs velocity (m/s)

Sculler ID	Normal Stretcher	Rocker High	Rocker Low	Average
Sculler6	1.29	1.35	1.41	**1.35**
Sculler2	1.18	1.26	1.27	**1.24**
Sculler1	1.15	1.16	1.26	**1.19**
Sculler3	1.07	1.10	1.10	**1.09**
Sculler5	0.99	1.02	1.02	**1.01**
Sculler4	0.99	1.04	0.98	**1.00**
Average	**1.11**	**1.15**	**1.17**	**1.15**
±SD	**0.12**	**0.13**	**0.17**	**0.14**

Table 9. Amplitude of stretcher movement (cm)

Sculler ID	Normal Stretcher	Rocker High	Rocker Low	Average
Sculler1	6.84	3.31	4.40	**4.85**
Sculler4	6.56	3.41	3.99	**4.65**
Sculler6	6.59	2.53	4.08	**4.40**
Sculler2	6.18	2.18	3.14	**3.83**
Sculler5	2.60	2.00	1.96	**2.19**
Sculler3	1.90	1.10	1.52	**1.50**
Average	**5.11**	**2.42**	**3.18**	**3.57**
±SD	**2.24**	**0.87**	**1.20**	**1.40**

Table 10. Heels placement at oar angle (deg)

Sculler ID	Normal Stretcher	Rocker High	Rocker Low	Average
Sculler1	-37.9	-38.5	-34.0	**-36.8**
Sculler6	-22.4	-32.0	-12.3	**-22.3**
Sculler5	-49.2	-41.1	-34.0	**-41.4**
Sculler3	-57.5	-38.5	-47.4	**-48.8**
Sculler2	-29.6	-57.0	-24.3	**-36.9**
Sculler4	-45.3	-6.3	-26.0	**-25.9**
Average	**-39.6**	**-35.3**	**-29.7**	**-34.8**
±SD	**13.0**	**16.6**	**11.8**	**9.8**

Table 11. Catch Factor (ms)

Sculler ID	Normal Stretcher	Rocker High	Rocker Low	Average
Sculler2	-27.0	-26.4	-27.8	**-27.0**
Sculler4	-29.4	-24.6	-22.4	**-25.5**
Sculler3	-10.6	-15.2	-18.6	**-14.8**
Sculler1	-10.8	-9.9	-8.8	**-9.8**
Sculler6	-7.7	-2.9	-4.6	**-5.1**
Sculler5	0.1	2.0	0.6	**0.9**
Average	**-14.2**	**-12.8**	**-13.6**	**-13.5**
±SD	**11.53**	**11.45**	**11.03**	**11.14**

Table 12. Rowing Style Factor (%)

Sculler ID	Normal Stretcher	Rocker High	Rocker Low	Average
Sculler6	111.4%	111.3%	120.8%	**114.5%**
Sculler2	97.0%	102.7%	103.1%	**100.9%**
Sculler3	91.2%	97.2%	99.6%	**96.0%**
Sculler1	92.1%	92.3%	102.0%	**95.5%**
Sculler4	91.8%	93.5%	100.1%	**95.1%**
Sculler5	80.3%	89.9%	87.5%	**85.9%**
Average	**94.0%**	**97.8%**	**102.2%**	**98.0%**
±SD	**10.2%**	**8.0%**	**10.7%**	**9.4%**