New Research

Recently, we conducted a study with the following hypothesis: **can shorter rowers really benefit from using shorter oars?** Four lightweight single scullers (height 1.68-1.84m, weight 55-73kg) performed four trials each with various rigs (Oar Length/Inboard/Span): Rig1 289/89/159 cm, Rig2 279/86/153, Rig3 269/82.5/147 and Rig4 259/79/141, so the actual gearing ratio (RBN 2006/11) was kept roughly constant at 2.07-2.08. Each trial was 1 km long and the stroke rate increased every 250m (20, 24, 28 and 32 str/min). WinTech Club Racer boat and four sets of Concept2 Smoothie2 Vortex sculls were used together with BioRowTel system (1) to collect the following data:

- Boat velocity, acceleration, tilt and pitch,
- Horizontal and vertical oar angles,
- Forces at the handle and gate (normal and axial),
- Positions of the seat and trunk,
- Wind speed and direction.

As it was expected, using shorter sculls enables bigger angles: shortening the inboard by 10cm increased the total angle by 12deg, when the handle arc length shortened by 3 cm. Tables 1 and 2 present average data for all athletes.

Table 1	Drive Time (s)	Catch (deg)	Finish (deg)	Total Angle (deg)	Arc Length (m)
Rig 1	1.093	-64.4	44.2	108.7	1.612
Rig 2	1.118	-64.7	47.3	111.9	1.602
Rig 3	1.145	-70.7	44.9	115.6	1.584
Rig 4	1.198	-73.6	47.3	120.9	1.582

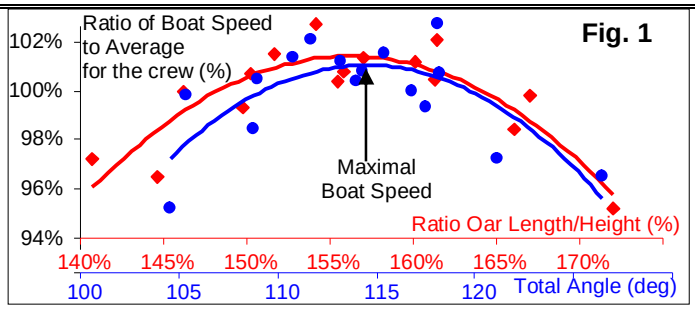
Increase of the angles happened mainly by means of longer catch angles (9 deg on average), where values of more than 80 deg were recorded in the tallest sculler. Longer catch angles increased actual gearing ratio (RBN 2007/03), gave 10% longer drive time and similar slower average handle velocity (Table 2).

Table 2	Aver. Handle Velocity (m/s)	Average Force (N)	Rowing Power (W)	Boat Speed (m/s)	Blade Efficiency (%)
Rig 1	1.49	285.2	249.7	3.85	74.3%
Rig 2	1.44	272.1	233.8	3.79	75.3%
Rig 3	1.39	278.0	233.1	3.80	75.5%
Rig 4	1.33	275.6	223.2	3.73	76.3%

The average forces were quite similar in all rigging settings (3% difference), but slower handle velocity caused a proportionally 10% lower power production. This resulted in a 3.5% slower boat speed, even though the blade efficiency was 2% higher at the shortest rigging.

To find out the optimal rig, the boat speed was corrected using wind speed and direction data (RBN 2009/12) and a prognostic boat speed for absolutely calm conditions was derived. Ratios of prognostic speed in each trial to the average for this sculler in all four trials were derived. Then, two methods could be used:

1. A ratio of the oar length to the athlete's height was related to the boat speed and second order polynomial trend was added (Fig 1, red line). It was found that the maximal boat speed can be achieved at 157% of this ratio.

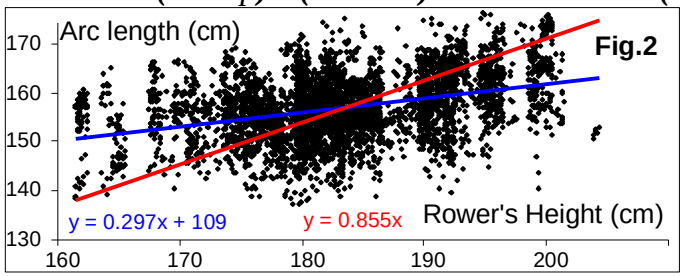


This method leads to very radical rigging dimensions:

Rower's Height (cm)	160	170	180	190	200
Oar Length (cm)	250	265	281	296	312
Inboard (cm)	77	82	86	91	96
Span (cm)	137	146	156	165	175

2. Using similar analysis, it was found that the maximal boat speed was achieved at the total oar angle ***A*** = 114 deg. Using our database (n=4600), ratio of the arc length ***Larc*** to rowers' height was calculated with a linear trend (Fig.2, blue line) and then actual inboard ***Linb.a*** was derived using an equation:

$$Linb.a = (180 / p) * (Larc / A) \quad (1)$$



Oar length and span were derived using above gearing ratio leading to more realistic dimensions:

Rower's Height (cm)	**160**	**170**	**180**	**190**	**200**
Arc Length (cm)	**157**	**160**	**163**	**166**	**169**
Oar Length (cm)	**272**	**277**	**281**	**286**	**291**
Inboard (cm)	**83.0**	**84.5**	**86.0**	**87.5**	**89.0**
Span (cm)	**149**	**152**	**155**	**158**	**161**

The used linear trend ***y=0.297x+109*** means that every 1cm of extra rower's height increases the arc only by about 0.3cm and the arc has a length 109 m at zero rower's height. If we assume zero arc length at zero height and use the equation ***y=0.855x*** (Fig.2 red line), then the rigging will be similar to radical method 1.

Conclusions:

- **Total angle of 114 deg (catch 68-70 deg, finish 44-46 deg) appears to be the optimal for achieving the maximal boat speed in sculling.**
- **Rigging dimensions should be adjusted based on the rower's height and actual length of the arc to obtain the optimal rowing angles (2).**

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References

1. BioRowTel system www.biorow.com/PS_tel.htm
2. Rigging Chart http://www.biorow.com/RigChart.aspx