Biomechanical evaluation of boats and oars

"Which boats and which oars are faster?" Questions like this are very often asked by rowers and coaches in an attempt to improve the performance of their crews. Usually the differences are very small and simple trials cannot reveal them, because much more significant effects of rowing power variation and weather conditions hide them. The power factor could be controlled with instrumentation, and an indoor tank could be used to avoid the weather factor (RBN 2015/04). An alternative method is side-by-side trials, where the wind conditions are the same for both boats.

Two mid-weight quads: a Hudson Super Predator – 2016 for 75-88kg and WinTech Cobra – 2015 for 80-90kg, both with bow mounted wing riggers, were equipped with BioRowTel systems, which measured oar angles, handle force, seat movement, boat speed, hull accelerations and 3D rotations. Two sets of sculls were instrumented and used: WinTech RDS and Concept2 normal shaft, both with the "Smoothie" blade shape of the same area.

Two junior male crews rowed these boats: **A** crew (average height 1.86m, weigh 81kg), and **B** crew (1.88m, 78kg). Four 1000m full-effort trials were performed by these crews side-by side using all possible combinations of crew-boat- oars:

Trial N	Crew A	Crew B
1	WinTech - RDS	Hudson – C2
2	Hudson – C2	WinTech - RDS
3	Hudson - RDS	WinTech – C2
4	WinTech – C2	Hudson - RDS

This method allows separate evaluation of effects of 1) the boat hull, 2) oars and 3) crew performance. The weather conditions were good and consistent (+16°C, cross-tail wind 2-3m/s).

Boat Speed (m/s)		Oars		
Boat	Crew	C2	RDS	Total
Hudson	A	5.473	5.409	5.441
	B	5.414	5.330	5.372
Hudson Total		**5.443**	**5.370**	**5.407**
WinTech	A	5.412	5.634	5.523
	B	5.409	5.363	5.386
WinTech Total		**5.410**	**5.498**	**5.454**

The average boat speed was 0.88% faster in the WinTech boat than in the Hudson boat, and 0.13% faster with RDS oars than with C2 oars. Though the stroke rate was very similar in all trials, measured rowing power was 1.4% higher in the WinTech boat than in the Hudson, and 1.7% higher with RDS than with C2 oars. This means the **WinTech boat and RDS blades were more comfortable for the rowers**.

Power per rower (W)		Oars		
Boat	Crew	C2	RDS	Total
Hudson	A	319.3	326.8	323.1
	B	309.3	310.1	309.7
Hudson Total		**314.3**	**318.5**	**316.4**
WinTech	A	320.3	348.8	334.5
	B	315.0	299.4	307.2
WinTech Total		**317.6**	**324.1**	**320.9**

Gross and Net Drag Factors (***DFg*** and ***DFn***) were calculated using the method described in RBN 2015/04, which was proven to be reliable and valid.

Gross DF		Oars		
Boat	Crew	C2	RDS	Total
Hudson	A	7.780	8.249	8.015
	B	7.795	8.180	7.988
Hudson Total		**7.788**	**8.215**	**8.001**
WinTech	A	8.067	7.782	7.925
	B	7.949	7.747	7.848
WinTech Total		**8.008**	**7.765**	**7.886**
Grand Total		7.898	7.990	7.944

It was found that **Gross DF was 1.45% lower in the WinTech boat, which equates to a 0.48% faster boat speed at the same rowing power: at the given 320W power (6m over 2k), the WinTech boat would have a 1.77s advantage over the Hudson boat**. Similar results were obtained using Net DF: 1.46% lower ***DFn*** in the WinTech boat, which gives a 1.68s gain over a 2km race. Average ***DFg*** of the **A** crew was 0.65% higher than in **B** crew, which adequately reflects the 3.8% heavier average rower's weight in the **A** crew (RBN 2007/07).

Measured boat roll and yaw (RBN 2012/03) were very similar in both boats, but **the boat pitch amplitude was 7.3% lower in the WinTech boat** (0.92deg) compare to the Hudson boat (0.99 deg). This fact was quite surprising, because the shape of Hudson hull looks much "fuller" at the ends, which should decrease the boat pitching during the stroke cycle.

In spite of smaller shaft diameter of the RDS oars (24mm at the blade) compared to C2 oars (34mm), RDS showed a slightly higher average ***DF***. With the WinTech boat, RDS had lower ***DF***, but in Hudson they had significantly higher ***DF***, which could be related to rigging specifics. The tail wind during the trials reduced aerodynamic resistance and may have diminished the advantage of thinner RDS oar shafts.

With the BioRowTel system, every oar is calibrated using a dedicated load cell, so we always obtain information, which may help to answer another common question about the stiffness of the oar shafts. It is usually thought that thinner oar shafts are more flexible, but in this experiment, it was found that, on average, **RDS oars were 8.1% stiffer than the standard Concept2 oar shafts**.

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