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☺ **Dear rowing coaches, rowers and all rowing people!**
☺ **We wish you a Merry Christmas and Happy New 2004 Year!**

Facts. Did you know that...

✓ …variation of the boat speed during the race affects performance in rowing? In the last Worlds the most even distribution of efforts was found in W8+AUS and GER (0.01 and 0.03s losses) and the highest variation of the boat speed was found in M4xGER and W2-USA (1.23 and 1.32s losses). The average losses were 0.52±0.38s. Let us explain how we obtained these values.

The data was taken from official 500m splits and 2000m time. Boat speeds V_1-V_4 were produced for each section and on average over the race V_{2000} (e.g. M1x final A):

#	Country	V_1	V_2	V_3	V_4	V_{2000}	Stdev (s)	Var (%)
1	NOR	5.07	4.77	4.92	4.95	4.92	0.12	2.49%
2	GER	5.16	4.77	4.85	4.86	4.91	0.17	3.50%
3	SLO	5.01	4.81	4.90	4.88	4.90	0.08	1.69%
4	CZE	4.98	4.73	4.81	4.77	4.82	0.11	2.32%
5	AUS	5.04	4.69	4.75	4.70	4.79	0.16	3.39%
6	AUT	4.95	4.61	4.61	4.66	4.70	0.16	3.50%

The last two columns in this table are the standard deviation ***Stdev*** of four boat speeds over each 500m and variation ***Var*** of the boat speed, which is ratio of ***Stdev*** to V_{2000}.

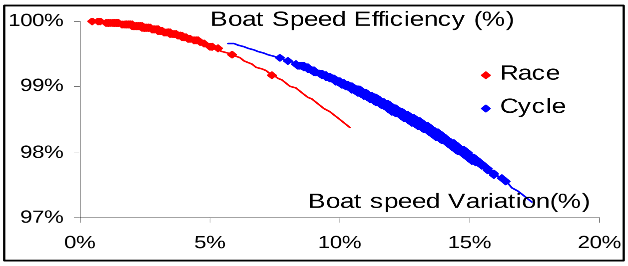
Having boat speed V, the propulsive power P over each 500m can be estimated using the formula $P = k\,V^3$, where k is a drag factor, which depends on boat type and weather (3.22 on average for 1x). The average of these four values is power production over 2000m:

Power (W)					V_{ideal} (m/s)	T_{ideal} (m:s.0)	Loss (s)	Speed Effic.
P_1	P_2	P_3	P_4	P_{2000}.				
419	349	383	391	386	4.93	6:45.77	0.38	99.91%
443	349	368	371	383	4.92	6:46.73	0.74	99.82%
404	358	379	374	379	4.90	6:48.14	0.17	99.96%
398	340	358	350	362	4.82	6:54.53	0.33	99.92%
411	333	345	335	356	4.80	6:56.69	0.71	99.83%
391	316	315	326	337	4.71	7:04.53	0.77	99.82%

Using reverse formula $V = \sqrt[3]{P\ /\ k}$, we can derive ideal boat speed V_{ideal} and time T_{ideal}, which can be achieved with absolute even distribution of given power over the race. The difference of this time and the official race time is the loss in seconds, and ratio of corresponding boat speeds is boat Speed Efficiency in %: $Ev = V_{2000} / V_{ideal}$.

The Speed Efficiency Ev can be derived from the standard mechanical efficiency Ep (which is the ratio of the real and ideal powers) using the formula $Ev = \sqrt[3]{Ep}$. Efficiency does not depend on drag factor and absolute boat speed, but losses do: the slower the speed the higher the losses. The loss L (s) can be derived from the boat speed V and its efficiency Ev: $L = 2000/V - 2000/(V/Ev)$.

✓ … losses caused by variation of the boat speed during the stroke cycle are more significant? They are in the range 3-13s and equal to 6.8±1.8s on average for both training and race speeds. Boat speed variation has moderate positive correlation with the stroke rate (r=0.34) and efficiency has negative correlation (r= -0.39), but the losses do not depend on the stroke rate. Speed efficiency and its variation are very well correlated: the higher the variation, the lower efficiency:



They can be easily converted into one another using the formulae $Ev = 1 - 1.5*Var^2$ for the race and $Ev = 1 - 0.9*Var^2$ in stroke cycle.

Ideas. What if...

? …we try to minimize losses caused by boat speed variation? Analysis of the winning race strategy (RBN 10/2002) has shown that most of the winners have to sacrifice even distribution of efforts in favor of faster boat speed over the first 500m. Example above shows us that the bronze medalist had 0.57s lower losses than silver one, but this was not enough to overtake him.

On the contrary, in-cycle speed efficiency varies quite significantly and depends on technique used by the crew. Three techniques were shown in the previous RBN 11/2003, the first example. The rower 1 with better technique had speed efficiency 98.09% and the rower 3 had only 97.78%, which is equal to 1.6s higher losses over 2000m.

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