Q&A

Q: *Roger Moore a senior boys coach at Pembroke School, Adelaide, South Australia asked: "Do you have any figures regarding coxswains weight and the effect on boat speed, in particular an the eight? I have an important race in a few weeks and my coxswain is 11kg overweight. Our recent races have been decided by only 1-2s."*

Another coach asked a similar question: "Would it be possible to use the formula for determining the effect of dead weight on boat speed … to calculate the expected time for a coxed four based on their 2000m time in the coxless fours. In other words: Is a coxed four nothing more than a coxless four with 55 kg of excess baggage in terms of drag factor?"

A: There are three components of the influence of extra dead weight on the speed, which affect it in different directions:

1. Higher drag resistance force caused by higher mass of the system and consequently greater water displacement;
2. Higher inertial losses, which decrease propulsive power because the rowers have to move a heavier mass back and forth;
3. Lower energy losses caused by reduced fluctuations of the hull velocity in the water.

The first component can be estimated using empirical equations for the dependence of the drag factor on the rower's mass (RBN 2007/07). The drag factor depends on the amount of water displaced by the hull, which equal to the total mass of the system. Therefore, we can add the dead weight to the rower's mass. We need to calculate two values (DF_1 and DF_2) for the drag factor for each mass (without and with deadweight) using equations in Table 1 of RBN 2007/07. Then using the equation $P = DF * V^3$ and assuming that power production P is constant we can derive the equation for the ratio of the speeds:

$$V_1 / V_2 = (DF_1 / DF_2)^{1/3}$$

Drag caused by 1kg of extra dead weight per rower decreases the boat speed by 0.061% or 0.21s over a 2k race in a time of 5min 40s.

The second component (inertial losses) can be derived using mathematical modelling with sinusoidal movement of two known masses relative to each other. We found that at a rate 36 str/min and relative displacement 0.6m, each 1kg of extra dead weight per rower decreased the boat speed by 0.33% or 1.13s over a 2k race. This value depends on rowing technique and can be decreased by means of transferring kinetic energy to blade propulsion at the finish of the drive (RBN 2006/10). Using the measured data analysis we took it as 0.24% or 0.81s over a 2k race.

We modelled the third component in a similar way and found that each 1kg of extra dead weight per rower would make the boat speed smoother and increase its average value by 0.11% or 0.37s over a 2k race. We think this is a maximal value; if, with poor technique, the rowers rush the recovery increasing fluctuations in hull velocity, then this value will be reduced (RBN 2007/10).

The table below summarises these values, assuming that rowing technique is good:

1kg per rower extra DW	Speed losses (%)	2k race in 5:20	2k race in 7:10
Drag factor	-0.061%	+0.20s	+0.26s
Inertial losses	-0.240%	+0.77s	+1.03s
Speed fluctuations	+0.110%	-0.35s	-0.47s
Sum	**-0.191%**	**+0.61s**	**+0.82s**

Every 1kg of extra dead weight per rower can decrease the boat speed by 0.19% or about 0.7s slower over a 2k race in 6:00.

If we refer to the second question about coxed and coxless fours, we find that 55kg of extra dead weight (EDW) in a four (13.75 kg per rower) would make the boat 9.5s slower over a 2k race in 6:00. Similar analysis for a pair (27.5kg of EDW per rower) gives us 21.3s slower over 2k in 6:40.

We compared these values with the results of Olympics-92, where the coxed four and pair events were last contested. The difference in results between M4- and M4+ for the winners was 4.3s and the average for the finalists was 6.4s, which is lower than the above value. In M2+ and M2- these differences were 22.1s and 20.5s respectively, which is very close to the predicted value.

Biomechanical conditions are also quite different; in heavier coxed boats, it is more difficult to transfer power through the stretcher (RBN 2008/12). The leg drive is slower and more load is applied to the upper body, and so rowing in coxed boats more closely resembles ergo rowing. In coxless boats, a fast leg drive and work though the stretcher are more important.

Our summed factor -0.19% corresponds quite well with findings of other authors (1, 2). However, they analysed only the drag factor component, which represents only 30% of the total value in our analysis. Probably, a further discussion is required.

References

1. Atkinson B. 2001. The Effect of Deadweight. http://www.atkinsopht.com/row/deadwght.htm
2. Dudhia A. 2008. Effect of Weight in Rowing. http://www-atm.atm.ox.ac.uk/rowing/physics/weight.html#section7

Contact Us:

✉ *©2008: Dr. Valery Kleshnev,*
kleval@btinternet.com , *www.biorow.com*