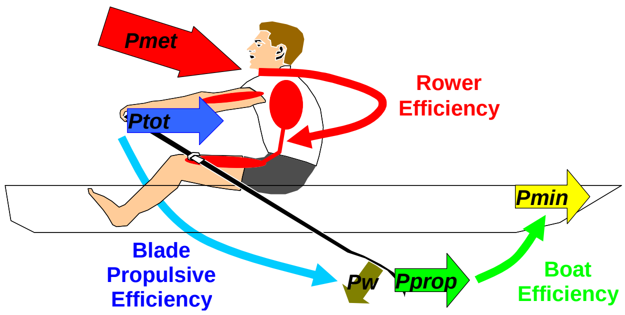
News

Congratulations to British rowers, who were the best performers on the Olympic Games in Beijing with two gold, two silver and two bronze medals! Well done! Australians also performed well with two golds and one silver.

Q&A

Q: *We have received a number of questions with the following meaning: "How can rowing efficiency be defined?"*

A: The standard definition of the efficiency of any mechanism is the ratio of output to input power: ***E = Pout / Pin***. In rowing we can define the following chain of components, which the energy is transfered from the previous to the next: rower - oar - boat. The figure below shows schematically the process of the energy transformation:



Efficiency of the rower ***Erow*** can be measured as the ratio of the total mechanical power ***Ptot*** applied at the handle (and the stretcher, RBN 2004/06) to the consumed metabolic power ***Pmet***, which can be evaluated using physiological gas-analysis methods.

Erow = Ptot / Pmet

The "delta" rower efficiency was measured at **22.8±2.2%** (mean±SD) (1).

Blade propulsive efficiency ***Ebl*** is the ratio of the propulsive power at the blade ***Pprop*** to ***Ptot*** (RBN 2007/12). ***Pprop*** can be calculated as a difference between ***Ptot*** and waste power ***Pw***, which is spent on moving the water:

Ebl = Pprop / Ptot = (Ptot – Pw) / Ptot

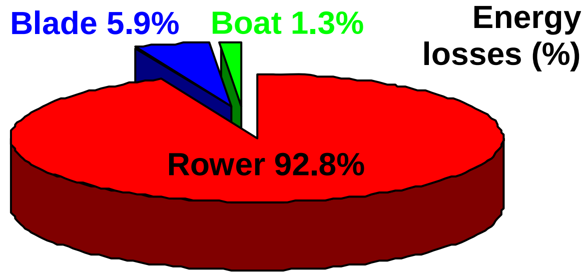
We determined ***Ebl*** as equal to **78.5%±3.1%** (2) for a single, which has a high SD owing to variation in weather conditions.

Boat efficiency ***Eboat*** can be defined (RBN 2003/12) as:

Eboat = Pmin / Pprop

where ***Pmin*** is the minimal power required for propelling the boat and rower with a constant speed equal to the average boat velocity. We calculate ***Eboat*** using the variation of the boat velocity only and found it equal to **93.8±0.8%** (2) (in fact, it is affected by other factors such as vertical oscillation of the shell, but this is included in ***Pmin***). The standard deviation in ***Eboat*** is quite small and mainly affected by the stroke rate.

It is interesting to estimate the energy losses caused by each of the three components of efficiency above. Let's take a single sculler, who sculls at 5.06m/s (6:35 for 2000m), so we can estimate ***Ptot*** as about 544W (RBN 2007/08). In this case ***Pmet*** must be about 2386W, which requires 7.1 l/min of O_2 (consumption plus debt). ***Pprop*** in this case is 427W and ***Pmin*** is 400W. We can calculate the absolute energy losses by subtracting each value from the previous in the chain. Then we can determine the proportion of the losses by dividing the three absolute values by their sum:



From the chart above you can see that the most of the energy losses, 92.8%, occurred inside the rower's body. Blade slippage contributes 5.9% and the boat speed variation – only 1.3%. These numbers suggest that the greatest scope for performance gain can be found inside the rower's body.

Obviously, no component can have an efficiency of 100%. However, we can use standard deviation as a measure of the variability between rowers, boats and various conditions, i.e. as a measure for changing the component. To model a possible gain in the boat speed, we increase efficiency of a component by its SD. In this case we can gain **12.0s** from ***Erow*** improvement by 2.2%, **4.9s** from ***Ebl*** increase by 3.1% and only **1.1s** from ***Eboat*** increase by 0.8%. Moreover, variation in ***Ebl*** and ***Eboat*** depends mainly on wind resistance and stroke rate, and the rower cannot improve them significantly. This means we should focus our attention on improvement of the rower's efficiency, which depends on many factors such as:

- use of the most powerful muscle groups,
- optimum muscle contraction velocities,
- single-motion movement;
- proper relaxation of the antagonist muscles.

Some of these points have already been discussed, the others we will discuss later.

References

1. Fukunaga T., Matsuo A., Yamamoto K., Asami T. 1986. Mechanical efficiency in rowing. European Journal of Applied Physiology. 55/5, 471-475.

2. Kleshnev V. 1999. Propulsive efficiency of rowing. In: Proceedings of XVII International Symposium on Biomechanics in Sports, Perth, 224-228.

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