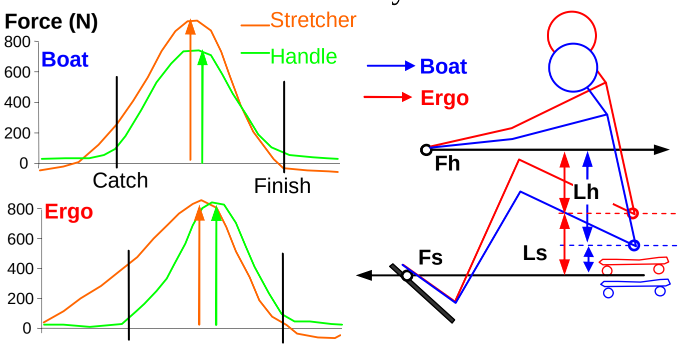
Ideas. What if…

In RBN 2003/10 and 2005/03 we explained that during rowing in a boat the stretcher force is about 40% higher than the handle force but that on an ergo the forces are nearly equal. How do rowers adjust their efforts to produce such different forces? We used the model of Einar Gjessing (RBN 2008/07) to explain this phenomenon. We modified the model and derived levers from the horizontal components of the force vectors relative to the hip joint, because this is the way that forces move the rower-boat system, and we measured them in this direction only:



If we neglect forces due to inertia, which are low in the middle of the drive, then:

$$Fh\, Lh = Fs\, Ls \quad \text{or} \quad Fh / Fs = Ls / Lh$$

The magnitudes of the handle force (***Fh***) and stretcher (***Fs***) forces are inversely proportional to their corresponding levers, relative to the hip joint, ***Lh*** and ***Ls***. This means that on an ergo the levers must be equal, whilst in a boat the lever of the handle force ***Lh*** must be longer than the lever of the stretcher force ***Ls***.

The practical implication of this finding is that the height of the hips in a boat must be closer to the stretcher than to the handle, whilst on an ergo the hips must be equidistant between the points of application of the handle and stretcher forces. If we assume that the stretcher-handle height is the same in both cases, then the seat height must be lower in a boat and higher on an ergo. If the seat heights were the same, then the rower would have to apply force differently, pushing more with the toes in a boat or more with the heels on an ergo, and pulling the handle higher in a boat or lower on an ergo.

How high should the seat be if we want rowing on an ergo most closely to simulate rowing in a boat? Calculations were made for a height of hip joint above seat of 10 cm and a height of gate above seat of 15 cm (with the same handle height in the boat and on the ergo of 22 cm). It was found that, in the boat, the seat must be 1.5cm **lower** than the point of application of the stretcher force, but 1.5cm **higher** on an ergo, which means **the seat height relative to the stretcher on an ergo must be about 3cm higher than in the boat**.

Obviously, the real picture is not so simple. During the drive, the ratio of handle to stretcher forces changes significantly owing to inertia forces. At the catch, on a stationary ergo the stretcher force is much higher, so rowers have to push the stretcher more with the toes. In contrast, at the finish, more stretcher force should go through heels.

How can our findings be related to previous studies? Caplan and Gardner (3) found that a higher position of the stretcher on an ergo allows greater power production. They suggested: "this improvement in effectiveness is due to a reduction in the active downward vertical forces applied to the foot stretchers which does not contribute to forward propulsion, and thus a reduction in energy waste during each stroke". However, vertical forces do not produce any energy in this case because there is no significant vertical movement in the stretcher, in the handle, or in the rower's CM. Contrarily, our model explains this fact perfectly; a higher position of the stretcher reduces the levers ***Ls*** and ***Lh*** which must be equal on an ergo and allows the application of higher stretcher and handle forces for the same muscular torque.

Soper and Hume (4) found that "Ergometer rowing performance improves over 2000 m when using a steeper foot stretcher angle". They also explain this fact by vertical forces and stated that "It is unclear why the male rowers benefited more from a steeper foot-stretcher angle than the female rowers." Our model explains this improvement in performance; a steeper stretcher angle creates a higher point of application of the stretcher force which shortens the lever ***Ls*** and allows the application of greater force for the same muscular torque. The difference between male and female rowers can be explained by invoking the concept of the force that lifts the rower's weight from the seat (RBN 2002/05). This force is lower at steeper stretcher angles. The lower lift force increases the limit of force application and allows physically stronger male rowers to produce more power. For physically less strong females, the limit is less achievable anyway, so the steeper stretcher affects their performance less.

References

1. Kleshnev V. (2005) Comparison of on-water rowing with its simulation on Concept2 and Rowperfect machines. XXII International Symposium on Biomechanics in Sports, Beijing. p 130-133.
2. Gjessing E. (1979) Kraft, Arbeids og Bevegelsesfordeling I Roing en Analysemodell. Presented during FISA seminar in Tata, Hungary.
3. Caplan N., Gardner T.N., (2005) The Influence of Stretcher Height on the Mechanical Effectiveness of Rowing. Journal of Applied Biomechanics, 21, 286-296
4. Soper C., Hume P.A. (2005) Ergometer rowing 'performance improves over 2000 m when using a steeper foot·stretcher angle. XXII International Symposium on Biomechanics in Sports, Beijing. p 326-329

Contact Us:

✉ *©2009: Dr. Valery Kleshnev,*
kleval@btinternet.com , www.biorow.com