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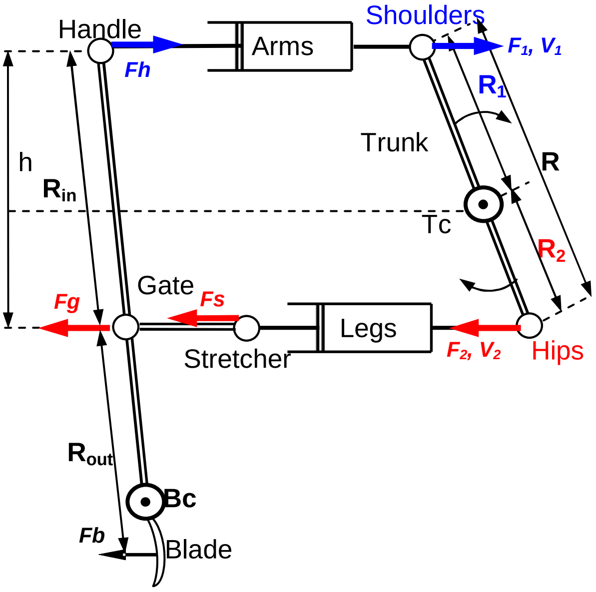
Ideas. What if…

We received a number of replies about the previous Newsletter, which questioned our hypothesis about the torque of the forces relative to the hips. We agreed that it is incorrect to derive the torque from the horizontal components of the forces only. Here we try to analyse this issue from a different point of view.

The question remains: how does a rower manage to vary the ratio of forces applied to the handle and stretcher? This question has implications for deriving trunk power (1, RBN 2004/06) and, further, for rowing styles (RBN 2006/05). The following simplified model can be considered as a development of the Dal-Monte and Komor model (2).



A cricitism of the previous analysis was the assumption that the hips are the fulcrum of the trunk rotation. In fact, the hips are not fixed and move together with the boat and seat. Therefore, power generated by the trunk can be transferred through both ends (shoulders and hips) and, further, through the handle or stretcher (RBN 2008/12). In RBN 2004/06 we expressed an idea that the fulcrum of the trunk rotation is the rower's centre of mass (CM). However, there are no mechanical reasons for it and the fulcrum can be just a virtual point **Tc**. Similarly, the fulcrum of the oar rotation is a virtual point **Bc** on the shaft, the position of which depends on the ratio of the boat velocity and the velocity of the blade slippage in the water.

The position of the fulcrum of the trunk **Tc** is defined by the ratio of the levers R_1 and R_2, which is difficult to determine using the velocities of the shoulders and hips (similarly, with the fulcrum of the blade) because they depend on the choice of the coordinate system. Therefore, it was decided to use a ratio of the forces, assuming they are proportional to the velocities. Ignoring inertia of arms, legs and boat, let us assume that $F_1 = Fh$ and $F_2 = Fs = Fg$. Therefore:

$$R_1 / R_2 = F_2 / F_1 = Fs / Fh = Fg / Fh = k \qquad (1)$$

For a boat, the coefficient **k** is determined by the ratio of the actual oar length **Loar** = **Rin + Rout** to the actual outboard **Rout**:

$$k = (Rin+Rout)/ Rout \sim 1.44 \qquad (2)$$

If the ratio **R1/R2** is expressed in percentages, then in the boat it approximates to 59/41. For an ergo, if again we disregard inertial forces, **R1/R2** = 50/50. The stretcher/handle height **h** is divided in the same proportion, so the difference 9% at h = 22 cm gives the position of the fulcrum of the trunk 2 cm higher for an ergo than for a boat.

Do we really need to adjust the stretcher height to accommodate this difference? It is quite unlikely because of the virtual character of the trunk fulcrum. Muscles always create torques around joints, but geometrical rotation could occur around a virtual point because joints themselves move.

How can we derive the trunk power **Pt** from the measured handle and stretcher forces (***Fh, Fs***) and the linear velocity ***Vt*** between hips and shoulders? This question is difficult to answer strictly and we would be happy if a better method can be found. Currently, we use the following logic. Calculated force and power produced by the trunk depend on what reference point is chosen. If the hips are used as a fulcrum, then $Pt_1 = Vt.Fh$, if the shoulders, then $Pt_2 = Vt.Fs$, which gives about 1.44 times greater power. As the fulcrum is located in between these two points, the force produced by the trunk was estimated as an average of the handle (***Fh)*** and stretcher (***Fs)*** forces, weighted in the proportions stated above, so:

$$Pt \sim Vt\,(0.59\,Fh + 0.41\,Fs) \qquad (3)$$

What could be the practical implications of this analysis of one of the most difficult areas of Rowing Biomechanics? The following very simple idea can be useful for coaches: **in a boat, the trunk should work not only "through the handle", but also "through the stretcher"**. Power transferred through the stretcher can be generated not only by the legs, but also by the trunk. On a stationary ergo, a rower has no choice and must apply power only through the upper end of the trunk, i.e. through the shoulders and handle.

References

1. Kleshnev V., 2000, Power in Rowing. XVIII Symposium of ISBS, Proceedings, Hong-Kong, p. 96-99.
2. Dal Monte A., Komor A. 1989. Rowing and sculling mechanics. Biomechanics of Sport. p. 54-119

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