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Coupling athlete force profiles to rowing oar and boat loads simulated using rowing ergometry

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ABSTRACT

The power transfer from a rowing athlete to overcome boat drag is complex. The athlete produced force is transferred through a gearing provided by the oar shaft lengths inboard and outboard of the oarlock pivot point to the blade in the water. The blade position in the water is relatively fixed although there is a small amount of both forward and aft slip during each stroke depending on the hydrodynamic lift and drag forces on the blade (Sliasas and Tullis, 2010). The boat, with its drag loads and effective forces due to the fore-aft accelerating rower mass, is then levered past the blade. If one wants to investigate changes in the blade (shape and size) or oar gearing, the fully coupled nature of the athlete-oar-blade-boat system means that the resistance experienced by the athlete will change, and so the force that the athlete can provide will also change. Similarly, changes to athlete technique will affect the full system so change the loads experienced. One then needs to include a model of athlete force generation in a full system model like one needs to include a motor power curve in the analysis of a motor-gearbox-pump-piping network system.

Here a model of rower power application is developed using measurements of rowers on on-land Concept2 rowing ergometers. The ergometers have a fixed gearing that transfers the rower's handle force and speed to drive a fan flywheel (with an adjustable damper) that emulates boat drag. The ergometers can provide instantaneous torque (i.e. handle force) and power measurements throughout the rowing strokes (i.e. handle position). Rower centre of mass motion is not directly captured but is estimated as a function of handle position. Measurements were made with varying fan resistances and stroke rates which provide a trajectory of the athlete force application as a function of handle speed and handle position. Data from Kleshnev (2006) at a fixed stroke rate was also used. The trajectories found map onto a force-speed-position "force surface" that has a shape like the combination of force-speed (Hill, 1938) and force-extension (Brennan, 2018) relationships. The force surface can then be considered to be the "motor" curve for that rowing athlete which could be used in models of improved equipment design and better matching of athletes and existing or new equipment.

References

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