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Estimation of pedal force variation from pedal motion in cycling

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Background

Pedal forces in cycling are of interest for several applications: correction of asymmetry between left and right leg motion, training for an even distribution of pedal force during the pedaling cycle, etc. Direct measurement of pedal forces along a full pedaling cycle requires sophisticated sensor technology. We propose to derive pedal force variation from pedal motion that can be acquired in the lab using motion capturing or optical motion tracking.

Materials and Methods

The torque at the pedal of an ergometer is the sum of the torque (TR) to overcome all resistance forces and the torque required for any changes of angular momentum of the ergometer flywheel (both multiplied by the transmission ratio). The latter torque is proportional to the angular pedal acceleration. For constant speed cycling the torque TR is almost constant, we may assume that variations of pedal force depending on the phase of the crank position can be extracted from pedal motion alone. The key problem is to reliably estimate the angular pedal acceleration from noisy motion data. We project the positional data onto a least squares fitting circle, then filter the resulting angular time sequence by local polynomial regression. Finally, we solve the equation of torque equilibrium for the pedal torque. For validation we used motion capturing and direct pedal torque measurements.

Results

We applied and validated the method for ergometer cycling corresponding to pedal forces of 60, 100, 150, and 200 N, and with cadences of 60, 80, and 100 rpm. The accuracy of the pedal torque results was good for 60 rpm, acceptable for 80 rpm, but deviated significantly for fast pedaling at 100 rpm.

Discussion and Conclusion

We have reconstructed pedal force variations for all crank phases based on pedal motion data. To improve the accuracy the filtering technique should be improved.