Multisensor monitoring cycle ergometer

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Abstract

Cycling ergometers provide a repeatable and controllable test setup to observe the effect that the mechanical (e.g. frame geometry), biomechanical (e.g. position on the bicycle) or biophysical (e.g. effect of rider position on heart rate) variables have over an athlete’s performance, hence their widespread use (Peveler, 2008: Journal of Strength and Conditioning Research, 22(4), 1355-1359) (Wergel-Kolmert, 2002: Clinical Physiology & Functional Imaging, 22(4), 261-265). Although authors have addressed the accuracy of the different types of ergometers available (i.e. air-braked, electromagnetically-braked, friction-braked, mobile) the question of which characteristics apart from accuracy serve as evaluation criteria to determine the quality of an ergometer remains (Paton, 2001: Hopkins Sports Med; 31(7): p489-496) (Mori & Belli , 2004: Journal of Biomechanics, 37, 141-145). A set of evaluation criteria that includes functional, technical and ease of use aspects were proposed. These criteria included input from not only the coaches/biomechanists but also from the system designer, allowing fulfilment of the user’s requirements whilst maintaining enough flexibility to adapt to changes (e.g. integration of new sensors).

A novel, fully automated cycling ergometer with integrated multi-sensor modalities has been designed, enabling cycle geometry setup within 80 seconds for first setup (and 17 seconds for subsequent setups). Built upon a robust industrial data communication protocol (Controller Area Network (CAN)) the ergometer allows (1) integration of multiple sensors (e.g. instrumented cranks) and (2) real-time data acquisition. Instrumented cranks provide right/left torque and force through 360 degrees of crank revolution (as seen in Figure 1B). Inclusion of 3-D motion analysis techniques such as CODA has been used to validate the effect of different rider positions and resistance profiles on the angles of both ankle and hip (ankle angle for three different resistance profiles illustrated by Figure 1A). Variable load profiles (i.e. constant cadence, constant torque) can be implemented using feedback from (1) the left crank, (2) the right crank, (3) both cranks and (4) a torque transducer which is in line with the motor used to provide the pedalling load. The controller strategy allows for fine tuning of its parameters to allow an aspect not considered during ergometer design, that is the perception or ‘feel’ of a bicycle. A set of tests to both construct a vocabulary that can be used to evaluate the perception and establish the controller parameters that provide the best ‘feel’ have been designed.

The presented ergometer supports rapid and precise configuration for athlete setup preferences and inclusion of torque and velocity profiles. By using standard bicycle components changes can be handled quickly. Industrial communications protocol provides not only a robust method for acquisition of sensor signal but also the flexibility to add new functionality if required. The use of different controller feedbacks permits (1) achieving the perception of the ergometer as a real bicycle and (2) inclusion of mathematical models of power to replicate road based cycling.

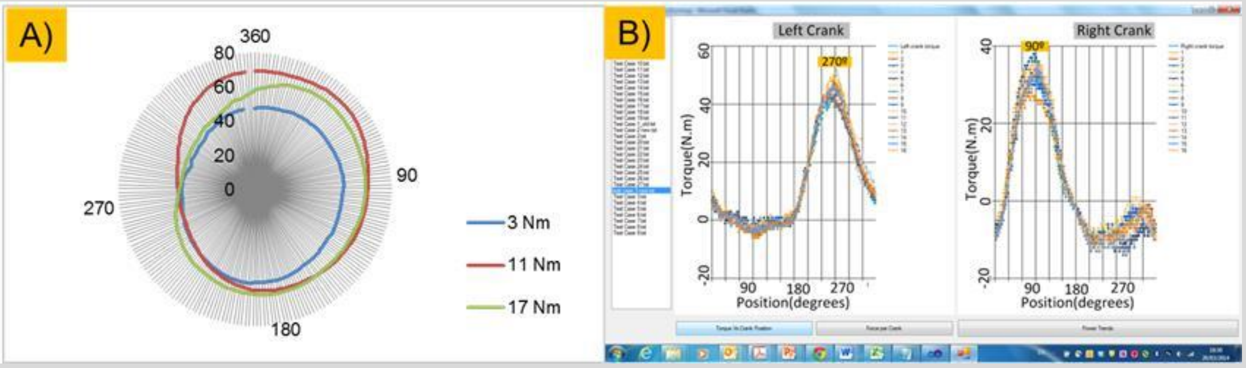

Figure 1A. Variation in ankle angle for different pedalling loads. 1B. Torque produced at left and right cranks through crank motion for a trial.

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