A REAL-TIME BIOMECHANICAL FEEDBACK SYSTEM FOR TRAINING ROWERS

Paul Page and David Hawkins

Human Performance Laboratory, University of California, Davis, CA, USA
E-mail: dahawkins@ucdavis.edu

INTRODUCTION

Successful competitive rowing requires cardiovascular fitness, anaerobic power, and proper technique to move the boat as rapidly as possible over the course of a race. Researchers have studied both rowing kinematics (Nelson and Widule, 1983) and kinetics (Macfarlane et al., 1997) on rowing ergometers. Recently, kinematic and kinetic analyses have been combined, but not in real-time (Torres-Moreno et al., 2000; Hawkins, 2000). While rowers can benefit from objective visual feedback during training (Henry et al., 1995), no system to-date provides real time kinematic and kinetic feedback.

An ergometer-based biomechanical feedback system was developed to provide integrated kinematic and kinetic data in real-time. While the athlete rows, a two-dimensional stick figure of the rower is displayed above the power profile produced during the drive (power-producing) portion of the stroke. Joint kinematic data are displayed and a file save and replay capability allows further stroke analysis following a training session.

METHODS

A Concept II Model C rowing ergometer was modified with the following hardware (Figure 1):

A) A 10-turn potentiometer coupled to the flywheel sprocket via a plastic chain and sprocket assembly to measure handle distance from the flywheel hub;

B) A spring-return linear position transducer mounted between the ergometer foot stretchers, and connected to the ergometer handle via a radial bearing;

C) A 10-turn potentiometer mounted to the seat and coupled to the seat track via a rack and pinion mechanism;

D) A shoulder-position measurement system mounted to the seat and consisting of three single-turn potentiometers interconnected with aluminum bars;

E) A single-turn potentiometer mounted to the flexible foot stretcher;

F) A 2224 N load cell mounted in line with the ergometer handle.

The instrumentation was wired to a data acquisition computer via a National Instruments data acquisition card.

Two computer programs were written using National Instruments LabView™ software. The RowTrainer program provides real-time data collection and display. The ReRow program allows for replay and analysis of previously saved data. Calibration data for the system components are entered into the

Figure 1. Modified rowing ergometer.
RowTrainer program along with the rower’s anthropometric data. Assuming simple hinge joints and motion in the sagittal plane, a real-time stick figure is generated while the athlete rows. Handle position data are numerically differentiated and combined with the load cell force to generate a power profile over the course of the stroke. Other parameters of interest, such as stroke rate, slide ratio (the ratio of time spent on the recovery phase to time spent during the power phase of the stroke), and hip and knee angles over the course of the stroke, are also provided in real-time. Data can be saved for subsequent detailed analysis using the ReRow program.

Static and dynamic error analyses were performed to determine the accuracy and limitations of the system. Static measurements compared joint locations predicted by the RowTrainer system with values measured directly. Three-dimensional motion analysis was utilized to perform both dynamic and static error analyses. Joint locations predicted by the RowTrainer system were compared to values determined using the video system.

RESULTS AND DISCUSSION

Average static joint position errors ranged from 0.2 cm to -2.5 cm, with a typical joint location error being 1 cm. Average dynamic joint errors ranged from ±0.1 cm to -4.4 cm, with typical errors on the order of ±1 cm. Joint position errors were more pronounced at the extremes of the stroke. Errors in joint positions resulted in average knee and hip joint angle errors of 9.6° and 5.8°, respectively. Additionally, the average handle horizontal velocity error during the drive phase was –1.8%. Figure 2 provides a visual comparison of the effect that the typical errors have on the RowTrainer stick figure (compared to videography). Two experienced rowing coaches evaluated the system and concluded that the accuracy was sufficient to provide beneficial feedback.

Figure 2. RowTrainer vs. Videography stick figures.

SUMMARY

A rowing ergometer biomechanical feedback system was developed to provide athletes and coaches with real-time kinematic and kinetic information during dry land training. While system accuracy is limited at the extremes of the stroke, coaches believe the system to be a useful training tool.

REFERENCES