PADDLING ERGOMETER KINEMATICS OF ELITE KAYAKERS

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Physical work capacity assessments of athletes have for many years provided researchers with information fundamental to our understanding of physical performance. In an effort to control work loads in repeated tests in the laboratory, this has invariably lead to the employment of one kind of ergometer or another but usually a bicycle ergometer or a treadmill. These "general" ergometers have been used to assess athletes from a wide variety of sporting activities on the premise that the movements involved are common to all sports and that the O_2 transport system will be stressed in essentially the same way by any sport. However, most modern researchers have accepted that the unique circumstances of skeletal muscle and motor unit recruitment for a given activity have created a need for the development of ergometers which are specific to the particular sporting activities in which the athletes train and compete. An early contribution in applying this approach to measuring work capacity of canoers and kayakers was made by Pike et al., (1973) who modified a Monark bicycle ergometer to create ergometers for both canoeing and kayaking. The pike ergometer has subsequently been shown by Holt et al. (1980) to compare favorably on physiological parameters ($\dot{V}E$ and $\dot{V}O_2$) with on-water canoeing performance. However the comparison with biomechanical parameters of stroke pattern was not favorable.

Two other kayak paddling ergometers have been noted in the literature (Dal Monte and Leonardi, 1976; and Campagna et al., 1982). The Dal Monte ergometer was developed in Italy through the adaptation of a Elema-Schönander constant power mechanism. Dal Monte and Leonardi report test results of physiological parameters to be in agreement with results from tests on a bicycle ergometer. Cinematographic sequences were shown for both the kayak ergometer and on-water kayaking; however, without quantitative information meaningful conclusions regarding biomechanical comparisons would be rather difficult. The most recently developed ergometer to simulate on-water kayaking was reported by Campagna et al. (1982). This ergometer is based on the adaptation of a Biokinetic Swim Bench. Kinematic analysis of the ergometer and on-water kayaking has shown similar stroke patterns, and Campagna et al. have concluded that the ergometer is suitable for both assessment and training of flatwater kayakers.

INSTRUMENTATION

The ergometer system presented here is modelled after the device described by Campagna et al., 1982. The University of Ottawa system is composed of four basic components: (1) a biokinetic ergometer, (2) a bench, (3) a modified "paddle", and (4) a computerized signal processing/analysis

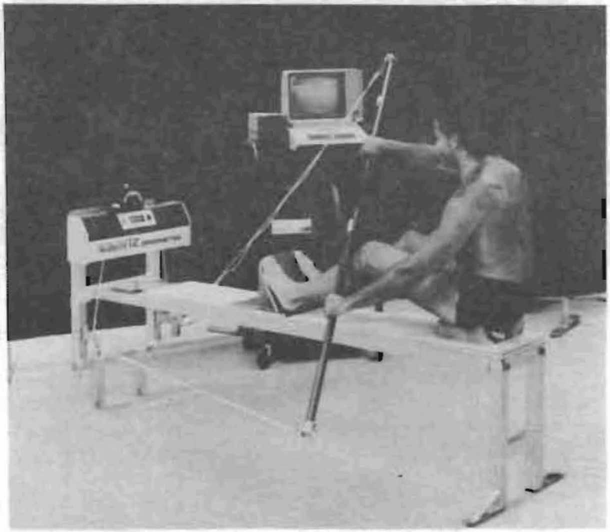

Figure 1. Paddling ergometer system: modified "paddle", bench, biokinetic ergometer, computer interface, microprocessor.

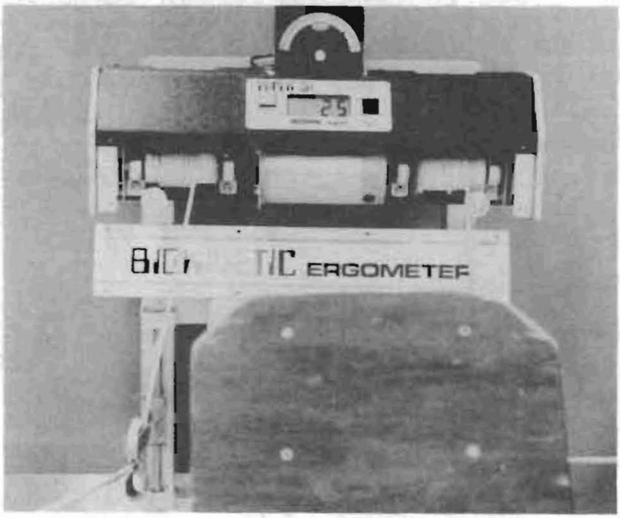

Figure 2. Biokinetic ergometer.

unit (figure 1). The biokinetic ergometer (manufactured by Isokinetics Inc., Albany California) which was originally designed as a swimming ergometer, has been adapted for the kayaking motion (figure 2). Movement velocity is controlled through electronic circuitry and a generator whose variable loading control permits paddle movements equivalent to velocities up to 7.43 meters per second. A digital display exhibits cummulative work done in kilopond-meters.

The bench is a heavy metal frame with a kayak seat and adjustable foot stretcher arranged to provide body position and angle of pull which are very similar to boat conditions. The biokinetic ergometer is bolted firmly to the frame at one end. The bench may be disassembled into four pieces for easy portability to a remote testing site.

The modified "paddle" is actually a carbon fiber paddle shaft which is constructed very much like the instrumented paddles used for on-water measurement (as reported earlier, Stothart et al., 1986) with the exception that it has no blades and the shaft has been extended to permit the resistance to be applied at a point corresponding to the estimated centre of pressure of the blade in a normal paddle. The paddle is adjustable for length and twist and is instrumented with strain gauges. Electronics are built into the hollow core of the shaft.

The signal processing/analysis unit is made up of an Apple IIe computer with A to D hardware and hardwire connections from the paddle and the ergometer. In addition the paddle can also be linked through the telemetric system used on-water.

METHODS, APPLICATIONS AND DISCUSSION

The ergometer has two distinct but related fundamental roles to play. First, it may function as a tool to measure the physical working capacity of athletes by allowing control of paddling frequency and paddle velocity and therefore of work rates patterned on field data collected as described earlier. Second, it may function as an instrument to investigate the nature of the kayak stroke--to learn more about the relationship between technique and mechanics. The methodologies currently being developed are predicated by these two fundamental roles.

The determination of appropriate methodology for the measurement of physiological parameters is based on the variation of one or more of paddling rate, stroke speed and total working time. These paddling variables are manipulated according to the characteristics of on-water kayaking as determined through the telemetric system already described.

The biomechanical parameters which may be examined with the ergometer, parallel those which are examined with the on-water telemetric system and include stroke timing, force rate, peak force, and impulse. Additionally the ergometer provides data on work output and power. (Inter-individual comparisons are possible for all parameters). Intra-individual comparisons over time as well as bilateral symmetry may be examined for all of the variables measured.

It is conceived that paddlers whose competitive performances have been recorded as paddling frequency, force and velocity in the field can be similarly examined in the laboratory for analysis of metabolic circumstances from which physiological training programs can be extrapolated in conjunction with quantitative and qualitative information on inter and intra paddle force characteristics.

At this point it is useful to reiterate the conclusion of Campagna et al., (1982) that a further appropriate application would include the ergometer as a fitness training device.

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