Matching Technology to Coaching Needs: On-water Rowing Analysis

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INTRODUCTION

As with any other motor skill, it is essential that the rower obtain appropriate feedback at each stage of the rower's development (Yelon, Hoban and Perles, 1980). The observational techniques currently used by coaches may not be totally adequate for this purpose (Angst, 1980) and, further, Newell and Walter (1981) maintain that provision of kinematic and kinetic parameters as information feedback is preferable to mere knowledge of results and that the feedback should occur as soon after the performance of the skill as possible. The development of the on-water rowing data collection system described here was guided by these principles. The present format of the system reflects a cyclical process of design, construction, trailing, feedback from coaches, redesign and so on. The paper will list the design goals, note their implications for the instrumentation, describe the hardware and the software system thus determined, and discuss some sample results.

Formulation of Design Goals

The following list of design goals were considered important in the design of an effective on-water data collection system.

1. At least two oar forces, oar angles and the boat velocity need to be measured.

The ultimate **performance** criterion for rowing is the time for the **2000m.** distance. Thus it is important to measure the velocity of the shell. From the force and angle variables can be derived work, power output, stroke length, shape of **force/angle** profile, stroke rating, effectiveness, consistency, smoothness and relative timing (Smith and Spinks, 1988). Two oar forces and angles would be the minimum configuration for the measurement of a **sculler's** performance.

2. The transducers, signal conditioners, telemetry equipment and power supplies must not interfere with the normal operation of the rowing shell.

This is necessary if the'"natural" movement of the rower and shell is to be recorded.

3. The transducers must be quickly mountable on any oar gate or shell.

4. The system should allow flexibility of operating mode, adjustable at the data collection site, in terms of the type and number of variables measured and the frequency of sampling and in the way the data is presented.

5. The final version of the equipment must be affordable by rowing clubs.

6. The range of the telemetry equipment must be at least 2 kilometers.

The ideal arrangement is to have a laptop computer with the coach in the coach's boat. If a suitable laptop is not available or if the conditions on the coach's boat are a threat to the continued operation of the computer then the telemetry device must have a range of at least 2 kilometers to enable coverage of a **2000m. "event".**

7. The data must be graphed at the receiving terminal in real time to allow the association of objective data with subjective perception and to reduce the amount of time delay between performance of the rower and feedback from the coach.

8. It must be possible to synchronise video with the force, angle and velocity data to improve the objectivity and illustrative power of post **hoc** discussions.

The capacity to replay a video of the rower with the rower's force-angle profile and the velocity profile superimposed on the video image would be a valuable coaching aid.

9. The equipment must be accurate and reliable.

Each of these goals place their particular technical requirements on the total system. These are discussed in the next section.

TECHNICAL IMPLICATIONS

Figure 1. shows that the total system is made up of transducers, signal conditioners, computer, modem, transceiver (for the boat) and transceiver, modem, computer for the coach. The present configuration of each of these elements will be discussed in turn.

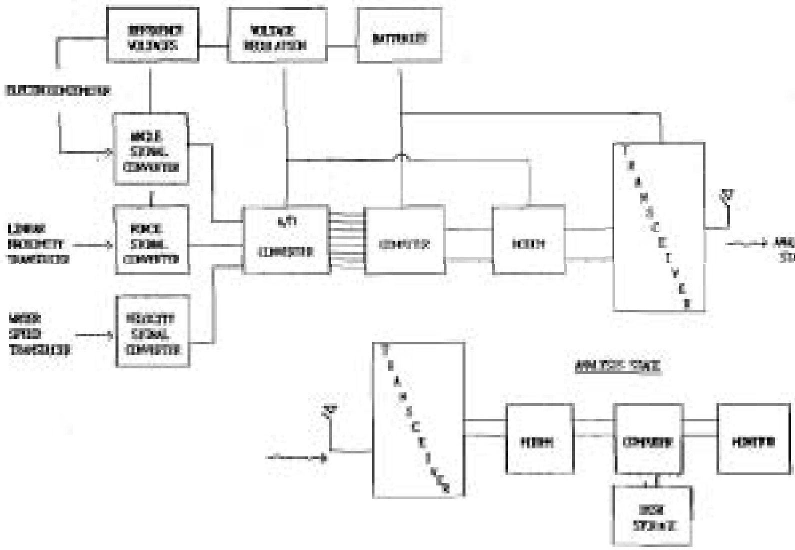

Figure 1: Structure of the on-water analysis system

BOAT INSTRUMENTATION

The Transducers (Figure 2)

Force

The force applied to the oar by the rower is obtained by measuring the strain produced in the oar with a linear proximity transducer (Honeywell 924AB3W-12P) in a similar way to Gerber, Jenny, Sudan and Stussi(1985) mounted in-board on the sternward surface of the oar using worm drive hose clips. This method of mounting ensures that the transducer can be slipped onto the oar from the handle end and the rower can readily disconnect the transducer and ship the oar. The dynamic linearity of this ar-

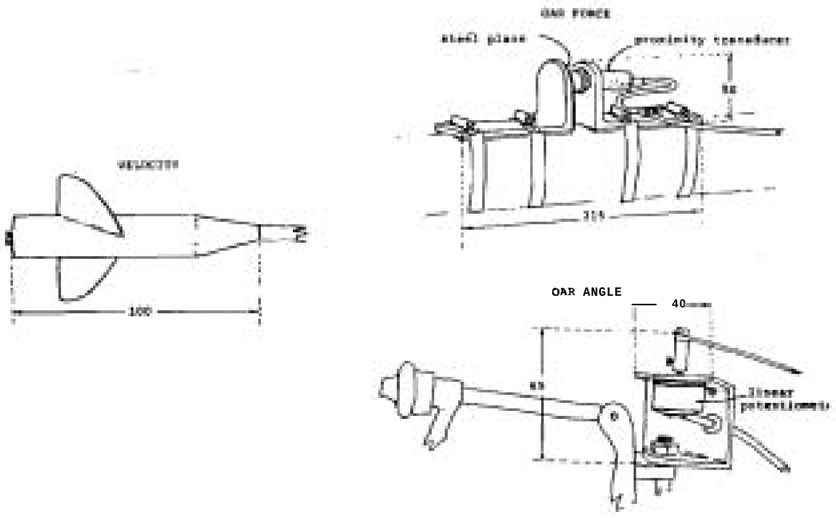

Figure 2: Transducers (all dimensions are in mm)

rangement was found (Smith, Spinks and Moncrieff, 1988) to be better than 0.3% (RMS deviation from linear). The weight of the transducer is 264gm. and has dimensions of 50X50X215mm.

Oar Angle

Oar angle is measured using a rubber band electrogoniometer (Neukomm 1974). This consisted of a Radiospares rotary potentiometer (173-580) with a 10k plastic element with guaranteed linearity of 0.5%. The potentiometer is mounted on an aluminum bracket with a 9mm. clearance hole for fitting to the gate pin. The shaft of the potentiometer is attached to the rower's side of the handle of the oar via a lever arm and elastic a rubber band in such a way as to allow for the rotation of the oar around its longitudinal axis during the feathering movement without affecting the angle subtended to the pin and leaving the handle free of obstruction to the hands of the rower. The weight of the angle transducer is 45g and 65 x 40 x 30mm approximately in size.

Velocity

A trailing turbine is used to monitor the boat velocity. The particular turbine used produced five pulses per metre. This resolution was doubled by using a digital doubler. The transducer is trailed from the stroke's rigger. The transducer weighs 95g and is 100 mm long.

Signal conditioning

The signal conditioner provides gain and offset adjustments and filtering for each of the two force and angle channels. Most times the angle does not have to be adjusted but both off set and gain controls are used in the calibration of the oar force particularly on the change from timber to carbon fibre oars. The filter has a 6db per octave slope and a -3db point of 10Hz consistent with a maximum frequency of 5 Hz for the rowing movement (Martindale and Robertson, 1984) and a sampling frequency of 20Hz.

The computer

The computer, a single board STD-800, controls the sampling of transducer output, the digitizing, the counting of pulses from the velocity transducer and the serialisation of the output stream. The advantages of using a computer on the shell are the noise immunity of telemetered digital data, flexibility of data collection mode by switching to alternative programs and reasonable weight, cost and power consumption characteristics.

The Modem

The '7910 FSK modem chip is used for the lightweight, low volume, low power, low component count single chip design, the intrinsic reliability of the digital signal processing and filtering used by this chip. The maximum baud rate of 1200 places a limitation on the number of channels and the amplitude and time resolution of the system.

The Transceiver

The Philips SPX portable transceiver is used because it is a lightweight, off the shelf, authority approved transceiver with adequate range. No interference problems have been encountered using this transceiver. The receiving transceiver is a Philps FM828, which is connected, via the same type of modem as used on the boat, to the coach's computer.

The ***coach's computer***

A Zenith 286 laptop computer is used for the receipt, display and analysis of data. This type of computer is fast enough to graph the data in real time, is battery driven and compact enough to be taken on the chase boat.

Software

The data collection, display and analysis software structure is shown diagramatically in Figure 3. The language used to compile the program was ASYST (1987). This can provide menu driven operation as well as the

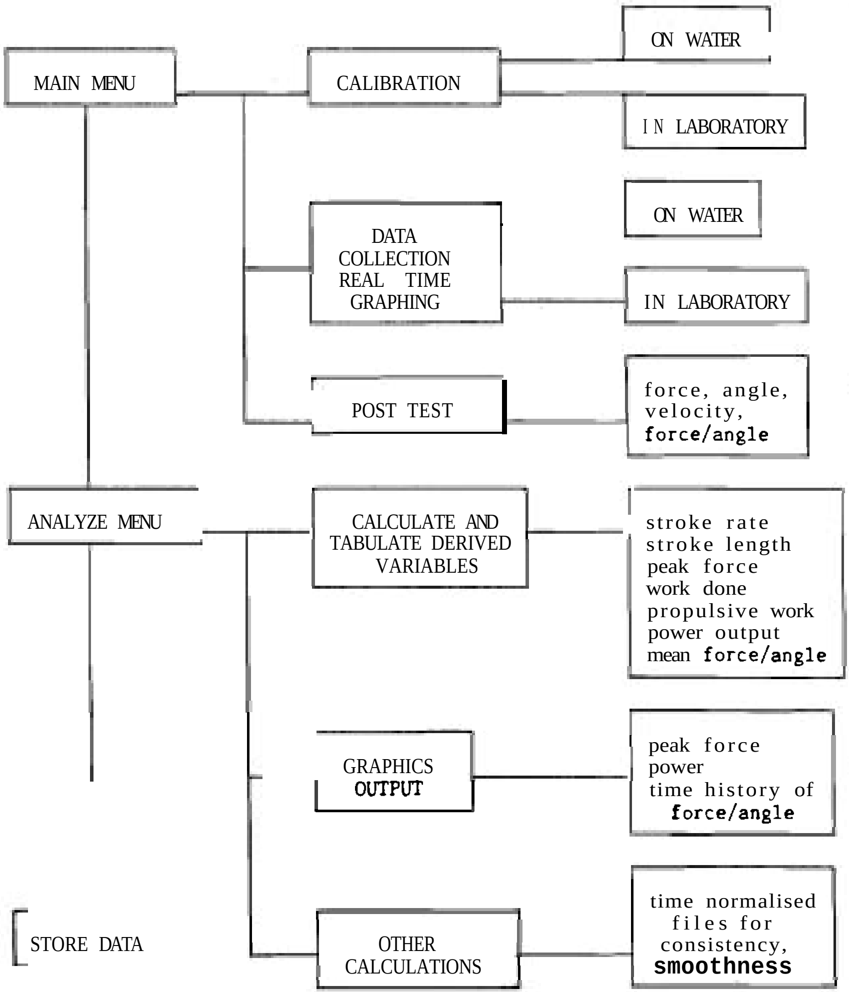

Figure 3: Software options

capacity to revert to interactive mode allowing access to the whole range of powerful ASYST words.

Data Collection

A data collection session consists of setting up equipment on site and on the boat, calibration of oar force and angle, disconnection of the oars and transport of the shell to the water. On the water, the oars are reconnected and the boat is ready for the conduct of data collection. Force, angle and velocity are graphed in real time while data is being collected on the water. Using this facility, the coach can observe the kinetic data, ask a rower to change their style and observe the effect of the style change on the biomechanical variables graphed on the screen. On the water or back at the boatshed the data can be further processed and reports produced as shown in Figures 5, 6 and 7.

RESULTS

The range of parameters which are revealed by the force/angle profile are illustrated in Figure 4.

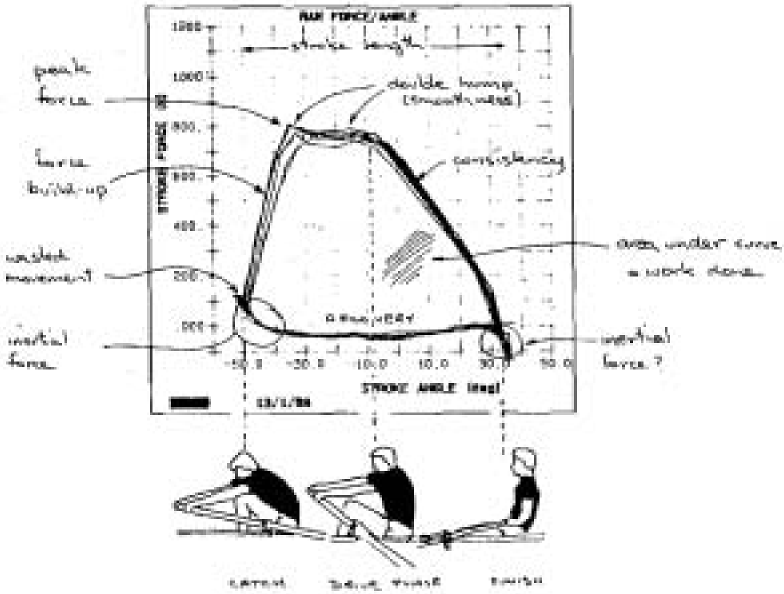

Figure 4: Features of the force/angle profile

Many other forms of data presentation are available in interactive mode through the use of the variables propulsive power, stroke-to-stroke consistency are described elsewhere (Smith and Spinks, 1988). The sample results shown in Figures 5 and 6 display various aspects of a few second segment at the beginning of a 2000m race pace effort by an under 21

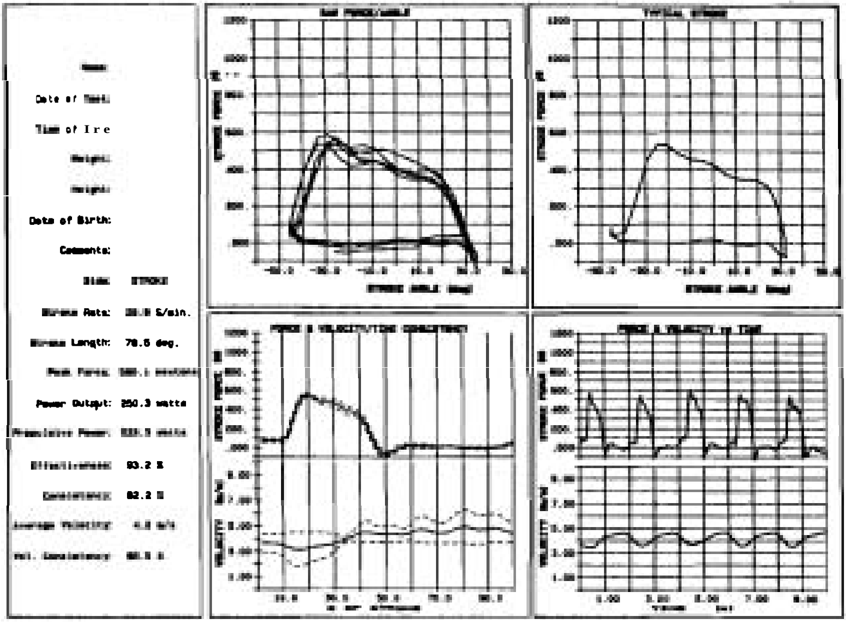

Figure 5: Stroke Side Report

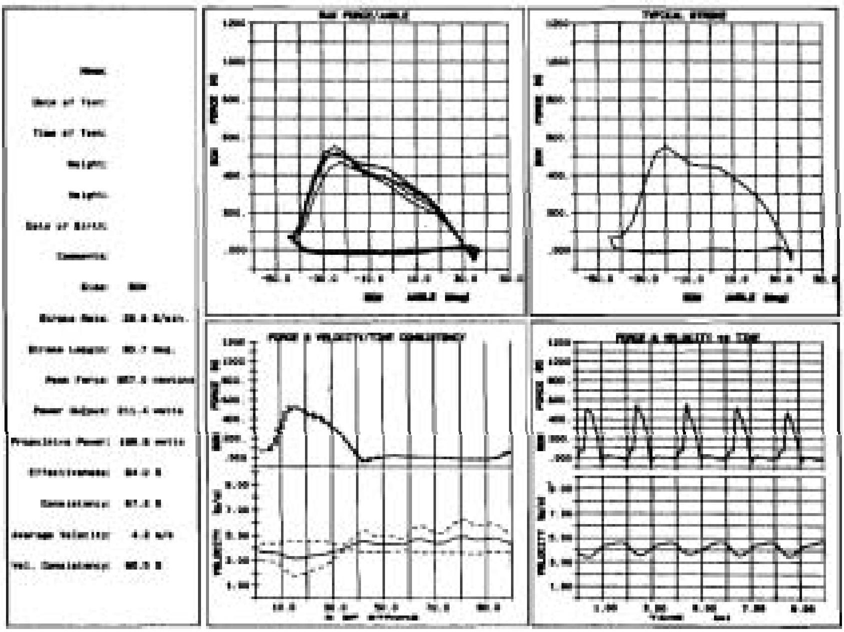

Figure 6: Bow Side Report

lightweight coxless four. The force, angle and velocity measures were taken simultaneously for the stroke and bow-side number three rower, the sternward pair of the four. The graphs can be examined alone or together held up to the light to compare the differences in force application of the two rowers.

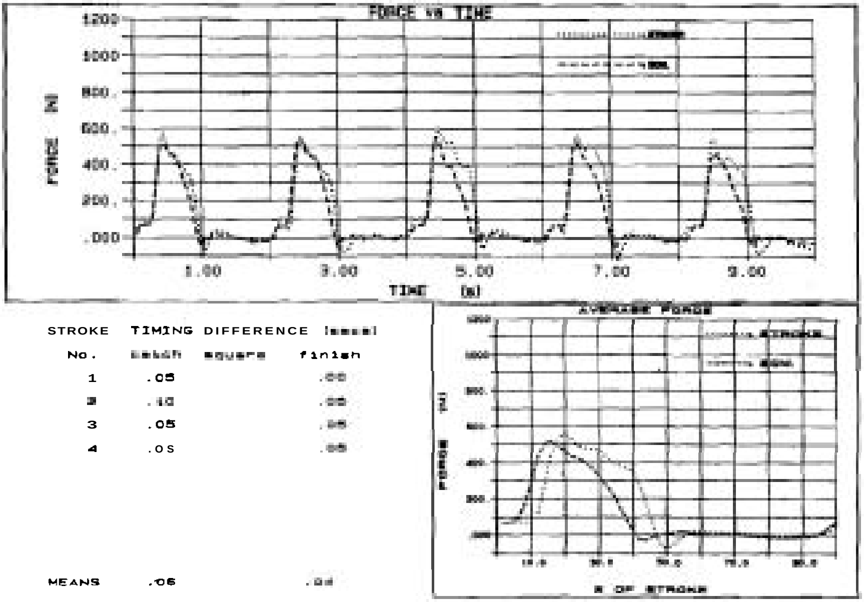

Figure 7: Relative Timing

CONCLUSION

A comprehensive on-water rowing analysis system has been developed which allows the simultaneous collection of oar force and angle and velocity data simultaneously for two rowers. The results can be presented graphically to the coach in real time, facilitating the immediate feedback to the rower with objective kineticinformation. Thus the system meets the major design goals listed at the beginning of this paper. Improvements to the system already under way include increasing the number of channels, the resolution in both amplitude and time domains and decreasing the weight and volume of the on-shell instrumentation.

ACKNOWLEDGMENTS

The authors would like to thank Ray Patton, Technical Officer and Tim Turner, Scientific Officer, of Cumberland College for their invaluable help in this project and the Australian Sports Commission National Sports Research Program and the Cumberland College Research Grants Scheme for their support.

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