New Approach for Boat Motion Analysis in Rowing

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INTRODUCTION

In rowing, the study of the movement of the boat and of the rower in the boat is difficult. Indeed, the shell is quite narrow and fragile and it is impossible to use the classical apparatus for physiological and biomechanical analysis.

For this reason, the physiological studies of rowers (cardiac and pulmonary parameters) have been more easily realised on specific and non specific ergometers (see Hagerman for an extensive review 1984): it is well known now, that rowers have exceptional aerobic possibilities and also use anaerobiosis for the start and the final part of the race (Hagerman 1984).

In contrast, only a few publications deal with the movement of the boat and the rower. The velocity of the boat at different stroke rates (Martin and Bernfield 1980), the angular velocities of various articulations of the rowers (Nelson and Widule 1983) were studied by kinematic analysis.

Though this technique is very useful, it does not catch the movements behind the subjects and is of no use to record physiological and mechanical parameters (Ishiko 1967).

Some authors used DC recorder placed in a motor boat following the racing shell to record different parameters (Baird and Soroka 1952; Di Prampero 1971; Celentano 1974). But, this technique is not practical because of the need of a second operator to keep the cables out of the water.

With the miniaturization, Ishiko proposed and used multichannel-telemetry to record the force of the rower and the acceleration of the boat (Ishiko 1967; Ishiko 1971). Schneider also used the same technique to record the force of the rower in the boat (Schneider 1978).

Though this technique is excellent and powerful, it is also very expensive and quite sophisticated.

Our goal was thus to take advantage of the miniaturization of the elements and to build and use a recorder and transducers that can be placed into the boat to record the acceleration of the boat and the propulsive force of the rower.

MATERIALS

To record the acceleration of the boat, we used a piezoelectric monoaxial Kistler[R] accelerometer (PIEZOTRON ACCELEROMETER model 8612B5).

The calibration done by the facturor was the following:

— sensitivity at 100 Hz: 996 mV/g till 10 g
— transverse sensitivity: 1.2% max
— deviation of the signal with frequency:

−0.5% at 20 Hz, +0.6% at 500 Hz } compared with the measures at 100 Hz.

Alimentation is furnished by a Piezotron Coupler Kistler type 5112, containing 3 batteries of 9 volts and providing a constant current of 2 mA.

The mounting was accomplished with a screw, furnished by the facturor, on a metal piece fixed on the boat, the axis of the accelerometer being parallel to the axis of the boat.

To measure the composant of the force useful to progression, we glued strain gages on the axis of the oarlock as described by Baird and Soroka (1952). New Stämpfli oarlocks with an axis were bought. The axis was removed and a new one was designed with two flat surfaces on which we glued four strain gages to realise a Wheatstone bridge. The flat surfaces were placed perpendicularly to the axis of the progression. The calibration was performed in laboratory, hanging different weights to the axis placed horizontally. The response of the gages was 31.18 mV/kg ± 0.42 mV/kg.

A 10 kOhms potentiometer was fixed on the axis of the oarlock to follow the position of the oar. The signal was of 400 mV for each deviation of 45°.

The recorder was a battery-powered two channel audio-recorder Tandy[R]. It correctly recorded and reproduced a square wave between 300 and 12,000 Hz. We decided to use it between 500 and 10,500 Hz. As we have to measure very slow variations of the signal, we added a voltage to frequency converter for both channels.
100 mV was converted in 500 Hz and 2,100 mV in 10,500 Hz.
We adjusted the amplification gain of our signals to be in the range of 2 V. The signals were reproduced in laboratory, through frequency to voltage converters.
The total weight of the apparatus placed in the boat (coupler, alimentations, amplifiers, converter and recorder) was about 1,3 kg.

RESULTS

The presented curves were obtained with a female rower that was asked to pull lightly and regularly.
They are the average of 8 consecutive strokes.

As the curve of the potentiometer, i.e., the position of the oar invariable for this rower at the same stroke rate, we took it as a reference. The angle covered was about 90° and the stroke rate was about 20 per minute. The ascending slope of the curve is the pulling phase. (Figure 1).

The second channel received the signal either from the accelerometer or from the gages (Figure 2).

During the pulling phase, the acceleration increased. During the recovery phase, acceleration was still positive but just before the next stroke, there was an important decceleration (Figure 3).

During the pulling phase, the force increased till a maximum and presented a second peak at the end of the pulling phase. A remaining force was observed during the recovery phase.

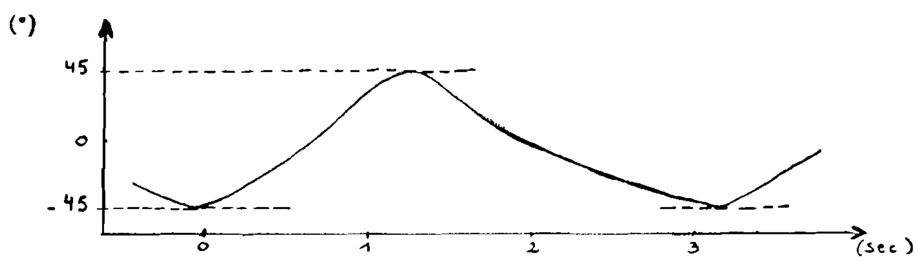

Fig. 1: Potentiometer.

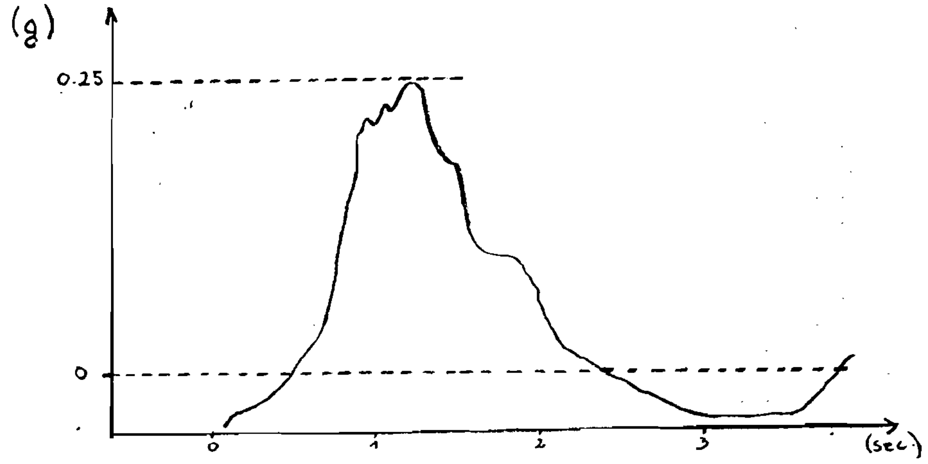

Fig. 2: Accelerometer.

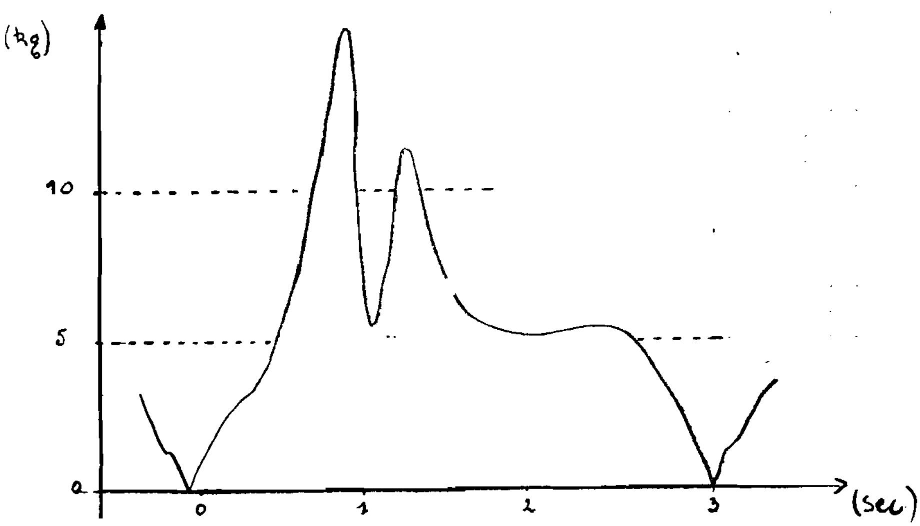

Fig. 3: Strain gages.

DISCUSSION

Our devices were easy to handle. The little room needed in the boat to place the instruments does not disturb the rower nor does the weight of the material. It is quickly removed from the boat too.
The most important problem is the humidity that must be avoided in all the electronic composants.

The protentiometer gives the position of the oar so that we know the phase of the stroke we observe. It could be done by film analysis too. The pulling phase is about one third of the whole stroke, in agreement with Celentano (1974). During this phase, a peak of force and its result, the acceleration of the boat, were observed. The positive acceleration of the boat during the recovery phase is due to the counter-movement of the rower in the boat. Then the resistance of the water overcomes this movement and the boat deccelerates. The second peak of the force is not yet explained. It is probably a defect of the tested rower that pulls in two times developping the force with the legs too late comparatively to the trunk. We must investigate other subjects to confirm this hypothesis.

These preliminary qualitative results are in agreement with those of Ishiko using telemetry (Ishiko 1967). Investigations of more rowers are necessary to collect quantitative results.

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