ACCELEROMETRY FOR PADDLING AND ROWING

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INTRODUCTION

The influence of sport biomechanics over the past 20 years has steadily increased. Its impact includes designing of conditioning programs, the evaluation and improvement of sport performance, and the prevention of sport injury. The need for biomechanical intervention is evident in aquatic sports, particularly where the athlete is required to use equipment. Olympic flatwater paddling (canoeing and kayaking) and competitive rowing (sweep and sculling) are major aquatic sports where proper integration of equipment and technique are vital to success.

In paddling and rowing, average boat velocity over a required distance will dictate winning and losing. In these sports, an effective propulsive phase, and an efficient recovery phase of the stroke are critical to the maintenance of an optimal average boat velocity. Technique and equipment play major roles during both phases of the stroke. Analysis of the acceleration, velocity and impulse of the system (equipment and athlete) can aid in the appraisal of the stroke (technique) and the usefulness of equipment as it relates to each performer. In addition, this approach can be used in matching athletes for multiple person crafts.

Cinematography has been the primary method of choice while investigating the boat motion of canoeists or kayakers. In past years, much of the investigation has concentrated on the biomechanical features of the propulsive phase. In these studies, the propulsive phase of the canoe or kayak stroke has been described in terms of motion of the joint centers and paddle patterns (Plagenhoef, 1979), velocity and acceleration of the upper extremities (Mann and Kearney, 1980), while Logan and Holt (1985) and Pelham et al. (1992) studied the electromyographic and force-time characteristics in both laboratory and on-water. These studies were useful to the scientist, however the use of high speed film or video has limited interpretability (indirect method) in profiling the dynamics of the canoe or kayak system and is essentially limited to kinematic analysis.

In rowing, with the exception of Duchesnes et al. (1987) cinema and video have been used as the primary source of analysis. This is consistent with virtually all sporting activities. Although there is much to be learned from these optical methods, identifying the effects of the athletes movements on the craft/athlete system would be a most useful tool. Presently, work in the Sport Science Laboratory at Dalhousie University has shown that the g-analyst has great potential for this type of analysis. With this in mind, the purpose of this paper is to introduce a convenient method of obtaining on-water acceleration data that can be useful to both coach and athlete.

METHODOLOGY

The triaxial g-analyst (Valentine Research Inc.) was originally designed for use in high performance land vehicles. The g-analyst is three electromagnetic force-balance accelerometers with flexure suspension in an orthogonal alignment. While in motion, horizontal linear acceleration, horizontal lateral acceleration and a friction profile of the moving vehicle are recorded by the apparatus. Measurement resolution is ± 0.10 g (g=9.8

m/s^2). The data sampling rate is 10 samples per second with a memory capacity of 4800 samples. A 12V DC battery is required to power the system. Three Duracell LR44 batteries are required to maintain electronic memory.

The method of calibration of the machine is clearly described in the operating instructions manual. To correct for roll and pitch a setting must be selected as described in the operating instructions manual. The range of data magnification is 0.25 g to 2.00 g.

Positioning of the device is critical in obtaining precise data. The g-analyst must be mounted on a stable, horizontal wood support fixed to the hull of the craft. To obtain horizontal linear and lateral acceleration data, the horizontal axis of the g-analyst must be parallel to the long axis of the boat. To correct for roll and pitch in paddling and rowing shells, a roll rate of 8.5°/g and a pitch rate of 2.5°/g is recommended. Data magnification is recommended at 0.25 g. For comparison of lateral axis data, distance of the g-analyst from the center of mass of the craft should be controlled.

Video is also recommended while using the accelerometer. Views from the rear, front and side (in powerboat) permit the analysis of the entire stroke cycle of the athlete(s). The camera should be mounted on a tripod for stability. Markings should be placed on the boat, and the subject(s) should be wearing a minimum amount of clothing in order to identify movement patterns of athlete and boat. For test trials, ideally the subject should simulate actual racing (2,000 m for rowing, 1,000 m or 500 m for paddling). Race simulation should be performed on a measured and marked (race lanes markers) course. The camera should be approximately 6 m from the subject and in the aforementioned motor boat. The subject(s) should be fresh and environmental conditions should be comfortable for testing. The subject(s) should be instructed to race with the same effort and stroke rate as they would in race conditions. For these purposes, a stroke rate monitor (strokecoach, Nielsen-Kellerman) may be used by the subject to maintain the same stroke. Total time and stroke rates should be recorded by the test administrators.

Synchronization of film to acceleration is vital for the analysis of the data which may include one stroke, a series of strokes, or an entire race. After viewing the video, the strokes selected should closely represent typical strokes for the subject(s) during a race condition. Acceleration data from the g-analyst can be transferred to virtually any PC, in our case a Macintosh Plus using the g-Logger I-MAC software package (Valentine Research Inc.). Further data analysis programs have been designed to convert the acceleration data to velocity, distance and impulse.

Other methods of analysis of boat motion were found to be either indirect or expensive and sophisticated (acceleration telemetry) in measuring acceleration of the paddling and rowing craft. On the other hand, the g-analyst and power source apparatus is light (1 kg), easy to handle, and relatively inexpensive. Little room is required to house the apparatus and it does not interfere with the athletes in the canoe, kayak, rowing shell, or scull.

An example of its use can be seen in Figure 1 and 2 where it is evident that the boat acceleration dynamics are quite different with subject #1 affecting the boat more dramatically both positively and negatively than subject #2. The velocity profiles show that an average difference of 0.24 m/s results from their respective strokes.

Only horizontal linear and lateral accelerations of the boat were identified as collectable. Unlike other methods, precise information pertaining to the acceleration of the stern and bow of the craft (either horizontally or vertically) can be obtained by positioning the accelerometer on the stern or bow and arranging the machine perpendicular to the surface of the water.

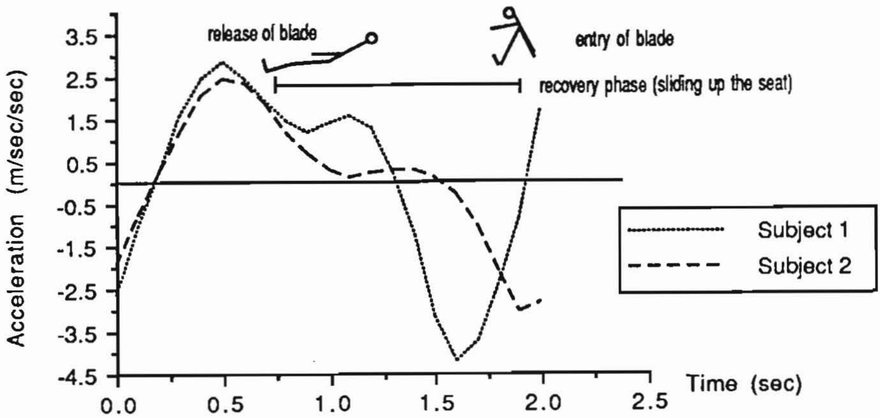

Figure 1. Comparison of stroke acceleration of two rowers (subject #1 - 6' 5", 225 lbs, subject #2 - 5' 9", 145 lbs).

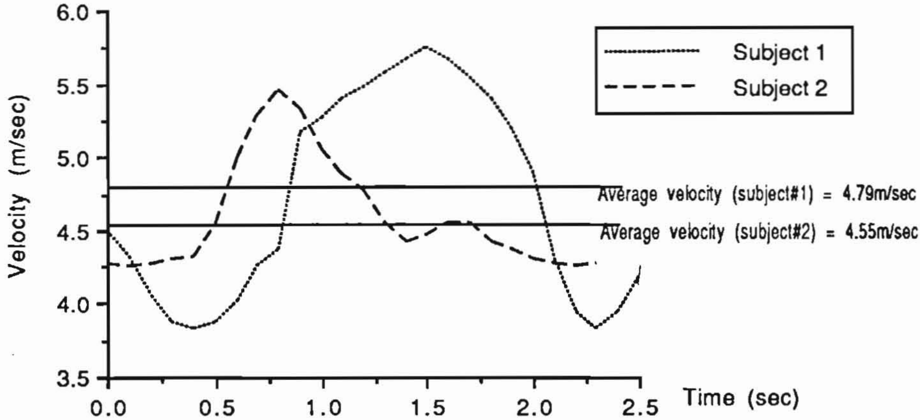

Figure 2. Comparison of the stroke velocity of two rowers.

CONCLUSIONS

On-water accelerometry using the g-analyst may prove to be an important analytical tool for detection of movement faults and for matching equipment to athlete(s) in paddling and rowing.

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