A KAYAK TRAINING SYSTEM FOR FORCE MEASUREMENT ON-WATER

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INTRODUCTION: Kayaking is a very competitive sport and represented in the Olympic context with two disciplines: slalom and flatwater. The main forces that propel the boat are paddle and foot stretcher force (Mann & Kearney, 1980). Anecdotal evidence collected from coaches involved in the research suggests varying theories on the best profile and synchronisation of paddle and foot stretcher force. It should be extremely helpful for athletes, coaches and researchers to measure these forces in real-time on-water with an unobtrusive, wireless sensor system such as is presented here. Thereby athletes are provided the possibility to perform their training with knowledge of performance (KP), which leads to superior training effects compared to knowledge of results (KR) only. The authors have not been able to identify any previous studies examining paddle and foot stretcher forces simultaneously although previous work has suggested doing so (Michael et al. 2009, Petrone et al., 1998).

METHOD: The developed system is made up by four units: three waterproof sensor units that link via Bluetooth to a central unit, e.g. a mobile phone, that runs custom software written in Java ME. This central unit accounts for the synchronisation of the data streams and logs performance data with the option to add further functionality in the future. The mechanical loads are sensed with strain gauge (HBM 1-LZ-48-6/350, Darmstadt Germany) setups, which can be screwed onto the paddle, and a modified footrest with four force sensitive resistors (TekScan A201-100, Boston USA) per foot, which replaces the original wooden plate. Each of the three sensor nodes hosts a microcontroller module (EISTEC Mulle V3.2, Luleå Sweden) that converts the analogue signal into 10bit digital data and communicates via, and controls, the Bluetooth radio. Figure 1 visualises the forces that are recorded. The sampling frequency is 150Hz for the paddle sensors and 100Hz for the foot stretcher.

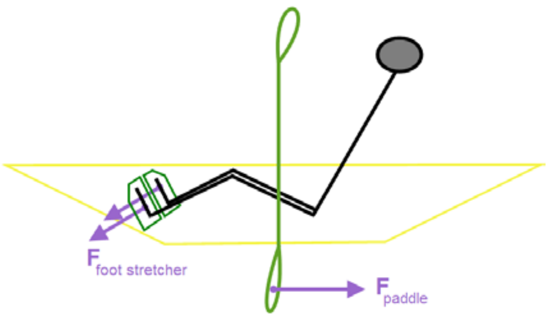

Figure 1. Forces measured by the training system.

Beside the technical aspects usability and compliance with an athlete's expectations were prioritised in the design process. For this reason the sensors can easily be attached to and detached from a kayak requiring no other alteration to the sports equipment. There are no cables between the sensors and they are one-button (power button) operated. A light emitting diode indicates the status of each sensor.

Calibration of the foot stretcher load sensor cells was performed with an electromechanical testing system (Instron 5567, Norwood USA). The foot stretcher unit only has to be calibrated once as it replaces the original wooden plate. The paddle sensors, on the other hand, clamp onto the paddle an athlete chooses to use. They therefore have to be calibrated before every trial by means of loading the paddle with weights at one gripping area while supporting it in the centre and at the other gripping area. The process has to be repeated for the other side.

The system was tested on a kayak ergometer (Dansprint, Hvidovre Denmark) equipped with a rowing computer. Time, total distance, stroke distance, stroke rate and stroke power, amongst other things, can be stored on a personal computer from the ergometer. The ergometer is widely used among Scandinavian elite athletes for indoor training. Non-elite athletes provided data for the evaluation of the system by paddling a distance of 250m.

RESULTS: Force data from each side of the paddle and the footrest were recorded; Figure 2 shows the force profile of a recreational kayak athlete for two strokes, one left and one right. The paddle force profile differs for each side and relates to the associated footrest force. Furthermore, it was found that peak paddle force values and the measured paddle power from the ergometer correlated well (93.6%).

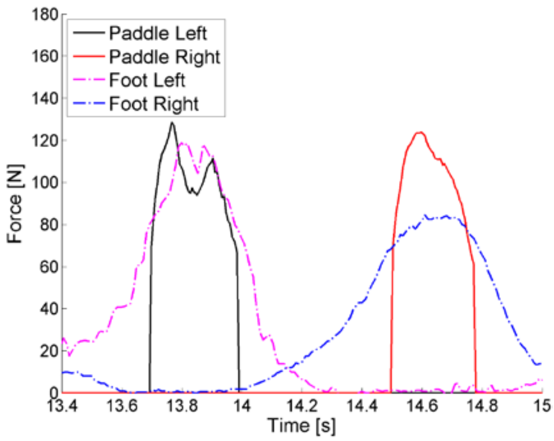

Figure 2. Force profile of two strokes by a recreational kayak athlete.

DISCUSSION: Even though the introduced measuring system has been designed for use on water it was first used on an ergometer because of the machine's possibility to retrieve quantitative data for comparison. The ergometer uses a theoretical model to calculate stroke distance that was not revealed in full to the authors, hence only stroke power data from the ergometer was compared. The results are very promising and motivate the system's use in a study with elite athletes exploring on-water biomechanics from a new perspective.

CONCLUSION: This study presents a novel kayak force measurement system that has been verified in the laboratory and complies with all requirements to be used on-water. The system provides mechanical data with a high temporal resolution for a more thorough analysis and understanding of the kinetics in a kayak.

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