OAR BLADE POWER OUTPUT AND BOAT VELOCITY IN CONTEXT OF ROWER LEG, KNEE AND TRUNK COORDINATION IN SCULLING

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The purpose of this study was to test the feasibility of a method estimating oar power output and boat velocity in relation to rower coordination in terms of kinematics of knee, trunk and elbow, derived from a set of 17 wireless Inertial Magnetic Measurement Units (IMMUs) positioned on rower body segments, oars and boat, recorded in actual on water varsity rowing at competition speed. Although in these experiments no 2nd method was present for absolute validation, the practical feasibility, the repeatability within bouts, between similar bouts as well as the consistencies in similarities and differences between different bouts and different rowers support the feasibility of a future coach supporting tool based on this technology.

KEY WORDS: rowing, oar power, 3D kinematics, knee, back, elbow, IMMU.

INTRODUCTION: In varsity rowing results are obtained by skilfully delivering power to the water through the oar blades, optimally in amplitude and pattern. This paper describes a method estimating blade power output and its application to actual on water rowing in 6 rowers in repeated sessions of multiple bouts at competition speed. The power profiles are discussed in the context of the 3D kinematics of the oar, boat and rower knee joint, trunk and elbow joint of the rower.

METHODS: 6 rowers performed two 4 hour measurement sessions of 3 sets of 400m rowing on 2k competition speed and tempo, followed by 600m of light rowing before starting the next set. Experiments were conducted on the Twente Kanaal under mostly clear weather conditions with a slight downwind. Sessions were divided in part A and part B with 1.5 hour resting period in between. Before, in between and after each session body segment calibrations were performed to estimate and test and/or confirm the relative orientation between the IMMU coordinate frames and the body segment coordinate frames. This was also done for the sensors on oars and boat. 17 wireless IMMUs (Xsens MTw) were placed on boat (1), oars (2 each), upper and lower legs, pelvis, thorax, upper and lower arms and feet (1). Also a bow and stern camera was mounted (GoPro) and a recording tablet and wireless IMMU receiver/commander dongle were mounted in a box on the boat just behind the rower. Oar output power was estimated from data from 2 IMMUs on each oar. The recorded relative angle between both IMMUs was statically calibrated against the force to the oar on the section where the blade attaches to the oar. For this a separate calibration session was performed. In this session the oar was horizontally fixated at 2 points representing hands and rig contact and different weights were applied at a point just before the blade attachment. Oar absolute inclination and angle around the vertical axis of the boat were taking into account when deriving a power component related to force components in 'forward' direction and one related to lateral force components lateral direction.

RESULTS: The force to bending angle α calibration procedure yielded a linear relationships (typically R^2 = 0.99, no significance in second order term). Figure 1 shows pictures of the physical setup and part of the recording and analysis software. Figure 2 shows an example data of a few strokes of rowing data. Shown are from top to bottom: oar bend angle, oar forward force, forward velocity, oar angle, work, forward power and power versus knee, trunk and elbow flexion. This example illustrates clearly the consistency of amplitude and detail in the estimated entities on a similar level in power estimates as in knee, trunk and elbow kinematics estimates. This was observed throughout all experiments. Groupwise (statistical) evaluation of the rower 3D kinematics data revealed consistent high repeatability within subjects over sessions, consistent rower knee, trunk elbow coordination styles characteristics and consistent fatigue induced effects. This data behavior, together with the consistency observed in the power data details as described above, suggests that similar observations can be made for the power data on a group level. This information is however not yet available at the moment of submission of this abstract.

Figure 1: Details of the setup and recording and analysis software. Recording tablet and wireless dongle are mounted in a box on deck behind the rower. Camera's on both decks.

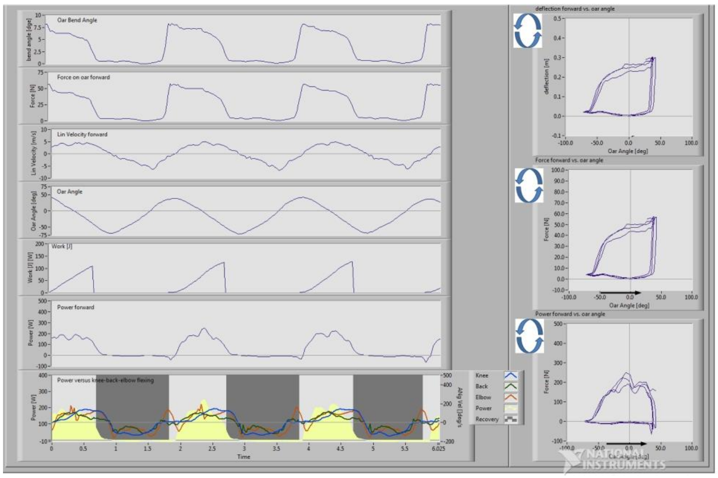

Figure 2: Example of data obtained during actual on water rowing. Left, top down: estimates of oar bend angle, oar forward force, forward velocity, oar angle, work, forward power and power versus knee, trunk and elbow flexion. Right, top down: Deflection forward, forward force, and estimated 'forward' power respectively, all vs. oar angle.

DISCUSSION: It appeared feasible to record 3D kinematics of 13 body segments, boat and 2 oars with wireless IMMUs synchronously with 2 video streams in actual on water rowing. Recording of oar bending effects from data of 2 IMMUs on each oar combined with a static calibration of oar bending to force seemed possible in such a detail and consistency that consistent and feasible oar output power profiles could be estimated in relation with the knee, trunk and elbow flexion details. In absence of a method absolute validation of the power estimator, still the consistency of the data suggests future useful application in studying relation between rower coordination (variations) and power output and boat velocity profiles.

CONCLUSION: Although no absolute validation of power data is performed yet, studying these output power profiles in the context of the coordination details, the practical feasibility, the repeatability within bouts, between similar bouts as well as the consistencies in similarities and differences between different bouts and different rowers support the feasibility of a future coach supporting tool based on this technology. Group level effects related to oar power are still under study at the submission of this abstract. A new series of on water rowing experiments is started adding several force sensors and an independent velocity estimate.

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