MONITORING BALANCE IN ROWING USING A MODIFIED DYNAMIC ERGOMETER

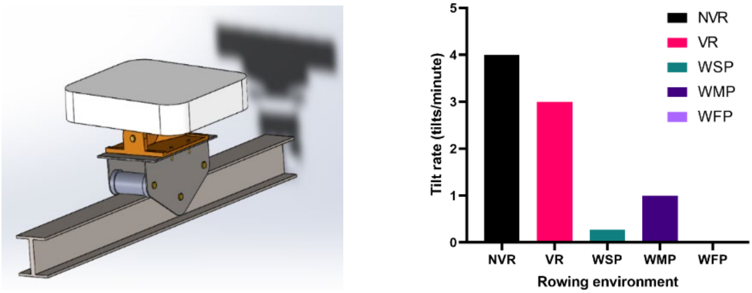
Matthew T.O. Worsey[1,3], Regina Arias[1], David V. Thiel[1], Jonathan Shepherd[1,2], Allan G. Hahn[3] and Hugo G. Espinosa[1]
[1] School of Engineering and Built Environment, Griffith University, QLD 4111, Australia
[2] PING Inc., 2201 W. Desert Cove, Phoenix, AZ 85029, USA
[3] Centre of Excellence for Applied Sport Science Research, QAS, QLD 4111, Australia

Postural balance in rowing is of great importance for performance and injury prevention. A rowing machine system to measure the stability of a rower in the mediolateral axis is reported. A Concept 2™ dynamic ergometer (Length: 193 cm, Width: 62 cm, Seat height: 55 cm, Weight: 42 kg), was modified to allow the seat to tilt in the mediolateral plane, mimicking boat (shell) movement on water. The system was used in conjunction with a virtual reality (VR) headset with a built-in modelled rowing course. This system closely resembles on-water training for rowing athletes, and is intended to be used as a training tool for elite athletes to improve balance, and to train the activation of key muscles when rowing [1]. The system can also be used as a training tool for athletes transferring from machine rowing to on-water rowing with more confidence, and for novice rowers to become accustomed to the unstable nature of the boat on water without the hazard of falling.

A mechanical insert was designed and implemented for mediolateral seat movement. The seat of the dynamic rowing machine already moves in the anterior-posterior direction. Based around a polyoxymethylene (nylon) axle (diameter 20 mm), aluminium plates on the top and bottom of the pivot ensured that no changes to original screw fasteners of the seat were required. The assembly was designed to accommodate weights of up to 150 kg (see Fig. 1a). The maximum angle of tilt is ± 15° from the horizontal plane. A 360° full range of view was scanned at the Penrith Olympic rowing course (regattacentre.nsw.gov.au) built for the Australian Olympic Games in 2000. From this image database, a VR display was integrated into the ergometer.

Measures of stability of an elite rower (Ethics approval Ref No: 2017/587) were monitored using an inertial measurement unit (IMU) [2] when rowing in three different environments: on-water, on the modified rowing ergometer with no VR headset, and with VR headset. The IMU (SABELSense, 250Hz, ±16g, ±2000°/s, ±7 Gauss, 23 grams [3]) was placed on the bottom of the sliding seat of the boat, and under the modified seat of the ergometer.

Corresponding author email: h.espinosa@griffith.edu.au



(a) (b)

Fig. 1: (a) Design of the mediolateral axis between the seat frame and the seat to allow mediolateral movement, (b) Tilt rate for an elite rower in different rowing environments.

On water, the athlete performed a 68 min circuit on the Brisbane River, Australia, rowing at three different paces, slow (WSP), medium (WMP) and fast (WFP). On the ergometer, the athlete rowed for 6 min at one pace.

A tilt-detection algorithm based on the IMU orientation in terms of Euler angles (roll, pitch and yaw), was developed to count the frequency of tilts experienced by the athlete. The roll signal describes the angular tilt about the anterior-posterior axis of the rowing system. The tilt rate in different environments is shown in Fig. 1b, it suggests that rowing with a VR headset marginally improves mediolateral stability on the modified ergometer for this participant. It also further reinforces evidence that the participant was more stable on water, particularly at a fast pace, than on the modified ergometer (an average of 3.5 tilts per minute on the ergometer compared to 0.42 on water). Of course, differences in efficiency of the vestibular system across different participants will affect how users respond to the VR environment. The rower did not demonstrate any significant bias to tilts on either the left or right sides ($p=0.6597$, $\alpha=0.05$). Qualitative feedback from the athlete indicated that the tilting seat was comfortable and stable, with a resemblance closer to on-water rowing. The stability increased at higher speeds. Future versions of the modified ergometer will include a frictional system to account for the damping effects of the water.

1. Arol P, Eroglu KI (2018) The effect of 8 week balance training on the kayaking performance of the beginners. Pedag, Psych, Medical-Biological Problems of Physical Training and Sports 22:170-176.
2. Worsey MTO, Espinosa HG, Shepherd JB, Thiel DV (2019) A systematic review of performance analysis in rowing using inertial sensors. Electronics 8:1-20.
3. Espinosa HG, Shepherd JB, Thiel DV, Worsey MTO (2019) Anytime, anywhere! Inertial sensors monitor sports performance. IEEE Potentials 38:11-16.

Corresponding author email: h.espinosa@griffith.edu.au