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Sitting Force Monitoring System on Rowing Ergometer

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Introduction

Real-time feedback system has become widely used in daily training and testing. It provides quantitative performance parameters to coaches and athletes for scientific analyses. A sensor, visual and sound feedback integrated system will help coaches provide immediate feedback to athletes about their performance. The suspension of body weight plays a role in contributing to power output during the drive phase of the rowing stroke. Rowers may increase their driving power by actively reducing their vertical seat force, “hanging” or “suspending” their body, and then passively lowering the weight back without disturbing the flow. Some rowers however do not know how to make use of their body weight to generate effective driving power due to skill imperfection or individual fatigue during competition or training. A sitting force real-time feedback monitoring system therefore could provide direct and real-time feedback to the coaches and rowers during training. By making use of the feedback information, rowers could learn how to control their body weight during the drive phase.

Objective

The study objective is to develop and install a sitting force real-time feedback monitoring system on a rowing ergometer for determining rower body normal force on the seat and to provide real-time feedback during training.

Methodology

Fourteen rowers were invited to perform a submaximal stroke technique quantification using four stroke rate (20, 24, 28 and 32 stroke/min) on a Rowperfect rowing ergometer. This rowing ergometer (Figure 1) was modified and fitted with 4 Futek LTH300 thru-hole compression load cells beneath the seat, a Transducer Technology SBO-1K S-Beam transducer on the handle and a Micro-epsilon WDS-1500-P96-SR-U draw wire displacement sensor between the seat and foot stretcher to determine the normal sitting force, handle pulling force, and seat position respectively. The electrical signals from these sensors were collected by a Intel i5 1.8GHz CPU notebook computer at 100Hz sampling rate via an Arduino MCU evaluation board with built-in 10-bits Analogue to Digital Converter (ADC) input ports. At the same time, instant video footage (320x240, 30fps) was captured by a USB web camera. The processed numerical data was re-phrased to be visualized by coaches instantly using a Processing2+ software.

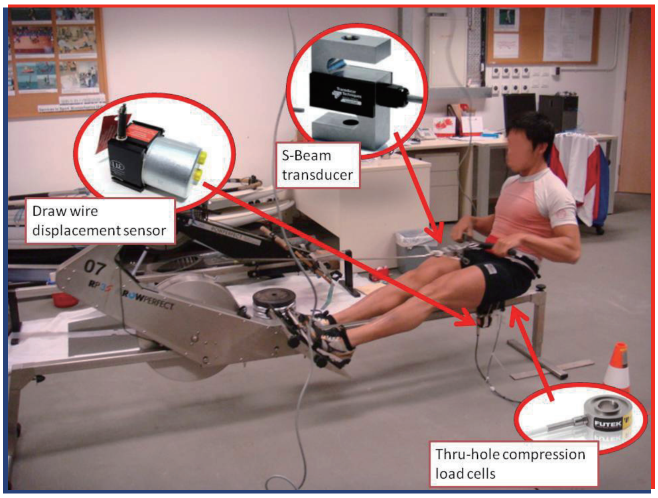

Figure 1. Real-time feedback system

Results and Discussion

It was assumed that the installation of various sensors onto the rowing ergometer did not affect its intrinsic functions. With the aid of the rowing ergometer sitting force monitoring system, four kinds of information were displayed in real-time on the interface (Figure 2), including 1) video footage synchronized with graphical data displayed on the interface, 2) vertical sitting force, 3) body mass centre on seat and 4) pulling force of rower were measured. Within the rowing stroke cycle, athletes may increase their driving power by actively reducing their vertical seat force, “hanging” or “suspending” their body, and then passively lowering the weight back without disturbing the flow. The vertical sitting force, represented in black line, was shown on the top right corner of Figure 2 and the "hanging" technique of the rowers were revealed from the curve. At the same time, the body mass centre on seat (black dot) was displayed on the bottom left of Figure 1. By judging the front-back and left-right range of movements of the black dot, the trunk stability was quantified and may provide a cue on the flow of the stroke especially at the driving phase.

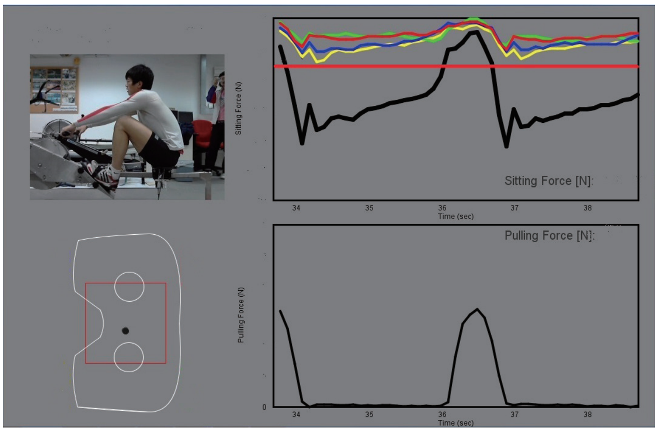

Figure 2. Layout of information on computer screen

Conclusion and Recommendation

The sitting force monitoring system could provide real-time quantitative measurement to rowers in different training phases. The rowing team may make use of the rowers' technique similarity in vertical sitting force and pulling force patterns to help crew boat rower selection. The system may be further improved by 1) enhancing the performance of data and video recording at a high frame rate; 2) addition of a foot reaction force device to help identify the exact start of stroke cycle and foot extension force; and 3) implementation of an offline play-back mode for after test review purpose.

Reference

1. *Caplan, N., & Gardner, T.N. (2005). The influence of stretcher height on the mechanical effectiveness of rowing. Journal of Applied Biomechanics, 21, 286-296.*
2. *Kleshnev, V. (2011). Five factors affecting force at the seat. Rowing Biomechanics Newsletter. Vol.11: 120.*
3. *Kleshnev, V. (2013). Vertical seat force. Rowing Biomechanics Newsletter. Vol.13:145.*
4. *Kleshnev, V. (2013). Rower’s mass suspension. Rowing Biomechanics Newsletter. Vol.13: 149.*
5. *van Soest, A.J. “Knoek” & Hofmijster, M.(2009). Strapping rowers to their sliding seat improves performance during the start of ergometer rowing. Journal of Sports Sciences, 27(3): 283-289.*
6. *張清，葉國雄（1999）。《中國體育教練員崗位培訓教材 - 賽艇》；中國國家體育總局。*