GENDER DIFFERENCES IN MOTOR CONTROL OF THE TRUNK DURING PROLONGED ERGOMETER ROWING

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The aim of the study was to compare the temporal kinematics of a stroke, spino-pelvic kinematics, trunk and quadriceps muscle activation in prolonged ergometer rowing between males and female rowers. Twelve adolescent rowers performed a 20 minute rowing ergometer trial at a high self perceived rate of exertion. Spino-pelvic kinematics, muscle activity and temporal kinematics data were compared in the 1st, 10th and 20th minute. The results from this study indicate there is a difference in temporal kinematics of a rowing stroke between adolescent males and females. Furthermore, males row with a more flexed thoracic spine and a posteriorly rotated sacrum compared to females at the catch and the finish positions.

KEY WORDS: adolescent, rowing, gender differences, motor control, posture

INTRODUCTION:

Rowing is perceived to have a lower risk of injury when compared to contact sports while still providing physical and mental health benefits. However, a recent study by Perich et al. (2006) found the point prevalence of low back pain (LBP) in a large group of adolescent female rowers was 47.5%. This was approximately three times the prevalence of a matched control group.

In a study examining elite rowers, 25.0% of all injuries reported by male rowers were of the lumbar spine when compared to 15.2% for females (Hickey et al., 1997). Hosea et al. (1989) speculated that such a difference in the incidence of LBP between males and female rowers may be due to increased forces on the lumbar spine in male rowers. Further, differences in usual sitting posture between males and females have also been reported. Specifically, males displayed a more flexed lumbar spine and a more posteriorly tilted pelvis compared to females in sitting (Dunk and Callaghan, 2005). As rowing is a seated sport and sitting is known to be a major exacerbating factor in LBP, this raises the question whether differences exist in spino-pelvic posture in adolescent male and female athletes whilst rowing.

To date, no study has examined whether between-gender differences exist in spino-pelvic kinematics and trunk muscle activation in rowers. Therefore, the aim of this study was to compare spino-pelvic kinematics and trunk and quadriceps muscle activation in adolescent male and female rowers whilst performing a prolonged rowing trial on a rowing ergometer.

METHODS:

Data Collection: In this study, 12 rowers between the ages of 14-17 years with no history of LBP were recruited. Six males and six females mean (SD) age; 16.5 (0.8) and 15.1 (0.8) years, height; 1.82 (0.08) m and 1.71 (0.05) m and mass; 72.7 (11.3) and 66.2 (12.2) kg respectively participated in this study. All rowers were performing rowing training at least three times a week and competing in rowing regattas at the time of testing.

Subjects were asked to perform a warm-up that included ergometer rowing and stretching. During actual testing, subjects were requested to row for a maximum of 20 minutes at a stroke rate of 22 strokes per minute (spm) at an exertion of greater than 17 on the Borg scale. Synchronised spino-pelvic kinematics and trunk and quadriceps muscle activation were collected whilst rowing for a period of 15 seconds every minute.

Prior to undertaking the testing protocol, a validation study was conducted to determine whether collecting kinematic data using a 3-Space Fastrak^{TM} (Polhemus Navigation Science Division, Kaiser Aerospace, Vermont) was feasible. The Fastrak^{TM} is an electromagnetic tracking device and this may be problematic as a standard rowing ergometer contains a large amount of ferrous material. A Concept II rowing ergometer was modified so that it's beam and footings were precisely replaced with non-ferrous components (wood).

Four electromagnetic sensors were placed on a wooden model that replicated a typical static lumbar posture. For both the standard and modified ergometers, this model was secured to the ergometer's seat and moved forward and backwards five times simulating five rowing cycles. Three cycles were completed and elevation angles (angles about the Y-axis-flexion/extension) were recorded from the Fastrak^{TM} and compared to angles previously measured from the spine model using an inclinometer. Data were analysed so that two measures of accuracy and variability were obtained. Accuracy was determined by comparing values measured by the Fastrak^{TM} to angles directly measured by the inclinometer whilst variability was assessed by measuring the standard deviation of the data throughout the simulated rowing strokes (ie. three trials and five strokes/ trial). Mean flexion/extension angles (from four sensors) recorded by the Fastrak^{TM} were -5.4º for the standard ergometer and 1.4º for the modified ergometer. This was compared to a value of 1º from the inclinometer. With respect to variability, the average of the standard deviation values obtained was less for the modified ergometer (0.8º) when compared to the standard ergometer (3.4º). On the basis of the pilot study, spino-pelvic kinematic data was collected using the modified ergometer.

During the rowing trials, four sensors were affixed to the skin overlying the spinous processes of T6, T12, L3 and S2. Prior to these trials, subjects' spinal range of motion in sitting was obtained by subject's slumping their spine towards maximum flexion. The subjects were then positioned into a neutral spinal posture. Three trials for flexion ROM and neutral spine position were captured and a mean value was then obtained. The following spino-pelvic angles were defined: *Pelvis* – S2 relative to the magnetic source; *Lower Lumbar* – L3 relative to S2; *Upper Lumbar* – T12 relative to L3*; Lower Thoracic* – T6 relative to T12.

Muscle activation was recorded bilaterally from three muscles (vastus lateralis (VL), superficial lumbar multifidus (SLM) and the erector spinae at the level of T9 (EST9)) at 1000Hz (bandwidth 10-500 Hz and the common mode rejection ratio >115 db at 60 Hz). These data were collected using an Octopus Cable Telemetric system (Bortec Electronics Inc., Calgary, Canada). Two silver/silver chloride disposable surface electrodes (inter-electrode distance - 20mm) were placed on the skin after the skin was abraded and cleaned with ethanol so that the resistance was less than 5Ω. A ground electrode was placed over the left anterior superior iliac crest. EMG data were full wave rectified and low pass filtered at 4 Hz to generate a linear envelope. Data was then amplitude normalised using sub-maximal voluntary isometric contractions (sub-MVIC). To generate the sub-MVIC for SLM and EST9, subjects where asked to lie prone with knees flexed 90 degrees and lift their knees off the plinth for 3 seconds (Dankaerts et al., 2004). For VL, the MVIC values were taken as the maximum value recorded over an average of 100ms in the first minute of the rowing trial.

Data Analysis: EMG and spino-pelvic kinematic data were simultaneously collected and synchronised using the length of chain on the ergometer. Chain length (and thus drive and recovery phases) was derived via a rotary encoder attached to the flywheel. On the basis of this data, drive phase duration, stroke rate and stroke length were calculated. Muscle activation data calculated using Root Mean Square (RMS) with a window length of 50ms. All data were time normalized (0-100%) using an interpolative spline and ensemble averages were obtained from five completed rowing cycles within the 15-second window. All kinematic and EMG muscle activation variables at the catch and finish positions were screened for normality (Shapiro-Wilks test) and data were deemed to be normally distributed. Hence, a two-way ANOVA with one between-subjects variable (gender) and one with-subjects variable (time) was conducted. Paired t-tests were used to determine whether muscle activation differed between the left and right paired muscles. All statistical procedures were conducted using SPSS V13.0 and the level of significance was set at $p<0.05$.

RESULTS AND DISCUSSION:
With respect to temporal and kinematic features of the stroke, males spent 35.5(1.1)%, 37.3(1.6)% and 38.2(3.1)% in the drive phase during the first minute, the tenth minute and the twentieth minute respectively. This was significantly less (p=0.005) than recorded for females (42.5(3.1)%, 41.2(3.3)% and 42.6(3.7)%). No significant differences were found in stroke rate (males= 22.9 (1.3) spm, females = 22.7 (2.2) spm) or stroke length (males = 1.53 (0.10) m and females (1.48 (0.10) m).
For spino-pelvic kinematic data, significant differences were found in the sacral angle at the finish (p=0.002) (Figure 1) and also the thoracic angle at the catch (p=0.002) and finish (p=0.02) (Figure 2). Differences were seen in the sacral angle at catch, but statistical significance was not achieved (p=0.08). No differences were observed in the lower lumbar or upper lumbar spinal angles. A greater posterior pelvic tilt angle and a greater flexion angle in the thoracic spine reported in this study indicates a more slouched thoracic rowing posture in males when compared to females and this supports previous findings in normal sitting (Dunk and Callaghan, 2005). Posterior pelvic tilt reflects a change in hip and/or lumbar spine angles. Given that the lumbar spine angles were not different between gender, these findings are likely to reflect a difference in the functional hip range during rowing i.e. less hip flexion in males, although this was not formally measured.

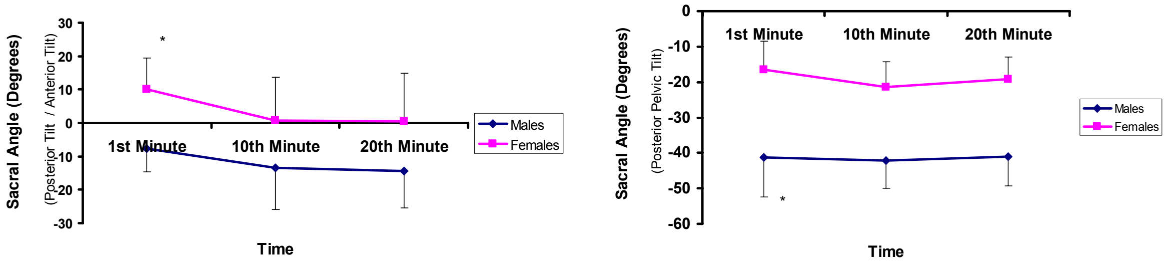

Figure 1. Sacral angle at the catch (left) and finish (right). (* Denotes differences in angle between gender of P<0.05 at specified time.)

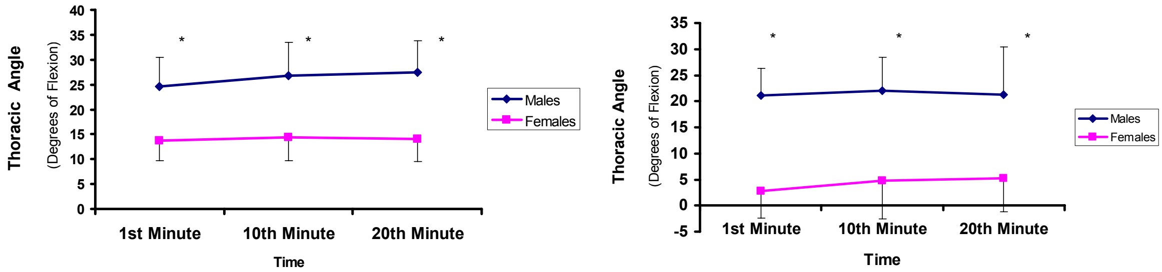

Figure 2. Thoracic angle at the catch (left) and finish (right). (* Denotes differences in angle between gender of P<0.05 at the allocated time.)

For EMG data, no significant differences in muscle activation were found between the left and right sides so data were averaged to represent activation of one muscle group. Further, no differences in muscle activation existed between gender over time (Figures 3 and 4).

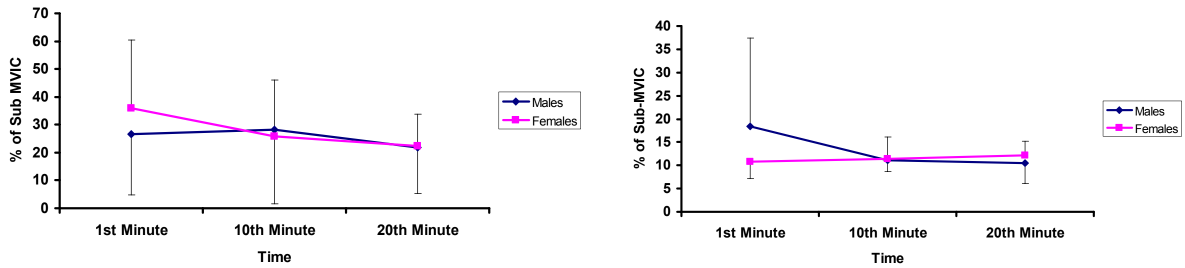

Figure 3. Muscle activation of the EST9 at the catch (left) and finish (right).

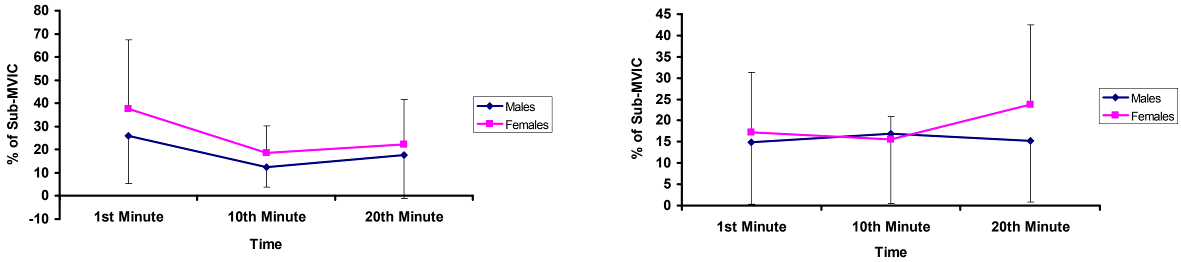

Figure 4. Muscle activation of the SLM at the catch (left) and finish (right).

CONCLUSIONS:

From the results of this study there is evidence to suggest that spino-pelvic kinematics differ between gender. Specifically, males tend to row with a more ‘slouched’ thoracic posture in addition to a greater posterior tilt. No differences were found in EMG data to support differences in muscle activation of superficial spinal muscles or the quadriceps, although insufficient statistical power may have limited these findings. Further study with a greater sample size is required.

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