Electromyography and Kinematics of the Trunk during the Rowing Stroke in Elite Female Rowers

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Abstract

The purpose of this study was to explore electromyography (EMG) of eight trunk muscles together with kinematics of the pelvis and spine of elite female rowers during the rowing stroke. Nine female Rowing Canada Aviron national team candidates participated in this study performing a 2000 m race simulation on a rowing ergometer. EMG activity of spinal and pelvic extensor and flexor muscles and kinematic data of the pelvis and spine were collected and reported during the previously described period of peak force production. During this period, pelvic and spinal extensor muscles demonstrated similarities in timing of muscle activity with minimal coactivation of flexors and extensors; minimal excursion of spinal segments at this time suggests a stabilizing effect of the trunk. Minimal coactivation was noted towards late drive as trunk extension is slowed by increasing activity of the flexor muscles. This study provides baseline data of spinal and pelvic rowing kinematics and muscle recruitment strategies of the associated trunk muscles which may assist analysis of technique and rehabilitation of the injured rower.

Rowing is a highly repetitive, cyclical sport which demands efficiency and accurate coordination of the full body to maximize performance. During the rowing stroke the trunk acts as a link in the kinetic chain both generating and transferring forces from the legs and arms to the oar. Baudouin and Hawkins (2) suggest that the ability of the trunk to transfer forces through to the arms and subsequently to the handle is imperative to the resulting force on the oar. Currently there is limited information surrounding the musculature of the pelvis and the trunk as it pertains to the motor patterning responsible for the transfer of forces and the stabilization of the spine during loading.

The rowing stroke consists of drive and recovery phases. The drive phase represents the phase of force application within the stroke. The catch (Fig. 1A) position marks the beginning of the drive phase. The finish position marks the end of the drive phase and leads into the recovery phase of the stroke (Fig. 1C). The recovery phase ends when the catch position is reached. At the catch, the blade of the oar enters the water and is immediately loaded as the rower applies pressure at the fixed foot stops initiating the drive (Fig. 1A, B). The force generated by the legs and the acceleration of the body are the main components of the drive which determine the force developed at the handle (2). The spine is vulnerable during early drive as it is loaded in a flexed position and must, quickly change from a movement of flexion and reaching out, to a highly loaded extension exertion to transfer the large forces generated by the legs.

Within elite female rowers at race pace the period of the drive in which peak force production at the handle was identified occurs at 18.8 ± 1.8% (20). Peak forces estimated at L4/L5 during a 2000 m race simulation on a rowing ergometer were found to be 2694 N of compressive force or 4.6 times the rower's body weight, and 660 N of shear force (21). The cumulative effect of the rowing stroke needs to be considered given the fact that the athlete will load the spine in this way approximately 230-260 times in a single 2000 m race, which may be

A

B

C

Figure 1 Positions during the rowing stroke A: Catch B: Mid-Drive C: Finish.

repeated 3-6 times during training sessions. The most common injuries reported in rowing relate to low back injuries often associated with repetitive strain or cumulative microtrauma (10;26).

Recent studies have focused on establishing the amount of flexion of the lumbar spine during the stroke (3;12;18-20). McGregor et al. (20) found elite rowers demonstrate more subtle changes than non-elite rowers with increasing stroke rates. Changes in kinematics demonstrate a decrease in anterior rotation of the pelvis and flexion of the lumbar spine at the catch as the stroke rate increases and an increase in extension of the lumbar spine and pelvis at the finish (20). These studies, however, do not include the thoracic spine and treat the lumbar spine as one segment, potentially missing the nuances of the lumbar spine and the influence of the thoracic spine along with the pelvis on the lumbar spine.

Measurement of motor control of the spine to maintain a static upright posture has demonstrated varying levels of coactivation of trunk flexor and extensor musculature with increased loads or challenges to postural stability (6;8;9;27). From this research a great deal of attention has been afforded to the concept of coactivation of trunk muscles as a means to stabilize the spine and how levels of coactivation are mediated in varied dynamic conditions. Of the dynamic investigations, those most closely resembling the activity of rowing include lifting and pull tasks (13-15;29;30). The level of coactivation of the trunk flexor and extensor muscles has been demonstrated to increase during asymmetrical versus symmetrical pull tasks (13), within subjects experiencing low back pain (LBP) (15;29) and during lifts with unstable loads (30).

There is a paucity of literature about musculature with regards to motor control and spinal stabilization strategies during rowing and during sport in general. EMG activity of the trunk muscles during rowing has been limited and has not included concurrent investigation of detailed kinematics of the spine and pelvis(3;24). The activity of the trunk musculature, including appropriate muscle recruitment and timing, is essential for maintaining dynamic stability due to the unstable structure of this portion of the spine (7;22). Muscular dysfunction and motor control errors in maintaining spine stability have been suggested as possible factors contributing to low back disorders and chronic back pain (22). Therefore, it is important to establish a baseline of postural control in rowers to allow for further investigation into possible technique or motor control errors in postural control that may predispose rowers to low back injuries.

The goals of this investigation are; 1) to characterize the muscle activation patterns of the trunk and pelvis together with segmental kinematics of the pelvis, lumbar and lower thoracic spine and, 2) to investigate the concept of coactivation amongst the trunk flexors and extensors as a method of stabilization of the spine during the rowing stroke. It is hypothesized that rowing, as studied on the ergometer, will display low levels of coactivation during the drive as forces created are symmetrical, anticipated, and all subjects are currently pain free. Muscle activity of the extensors will predominate in the drive phase, with flexor activity becoming active towards the end of the drive when extension of the trunk must be slowed and eventually reversed into the recovery phase.

Methods

Subjects: National team candidates (open class women) who train at the national training centre for Rowing Canada Aviron were invited to participate in the study. Participation in the study was voluntary and written informed consent was obtained from individuals. The study was approved by the University Ethics Review Board. Twelve of these individuals consented to participate. Nine subjects' data were included for analysis. Data from three of the twelve subjects were excluded because of technical difficulties during collection. The age of the subjects was 25.8 ± 2.6 years, height was 179.2 ± 2.1 cm, and mass was 75.8 ± 5.5 kg. Three subjects had past injuries related to the trunk involving rib stress fractures which required two weeks to two months off rowing, three subjects had a history of LBP, only one of these subjects took one week