ELECTROMYOGRAPHIC RESPONSES AND FORCE APPLICATION ASSOCIATED WITH TWO LAND ROWING MODES

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The increasing popularity of the sport of rowing and the complexity of training methods warrant research on the seasonal techniques of land and water conditioning. Research in the sport of rowing has primarily focused on biomechanical and physiological parameters (Hagerman, 1984; Lamb, 1989). Biomechanical investigations (Martindale & Robertson, 1984) indicate that there are differences in rowing techniques between water rowing and rowing on ergometers designed to simulate water rowing. There have been limited investigations on the neuromuscular functions involved with ergometer rowing. The purpose of this investigation was to determine EMG activation patterns during the use of two land rowing ergometers designed to simulate water rowing. The results of this study will be used as a basis for future investigations on the comparison of neuromuscular patterns between land and water rowing.

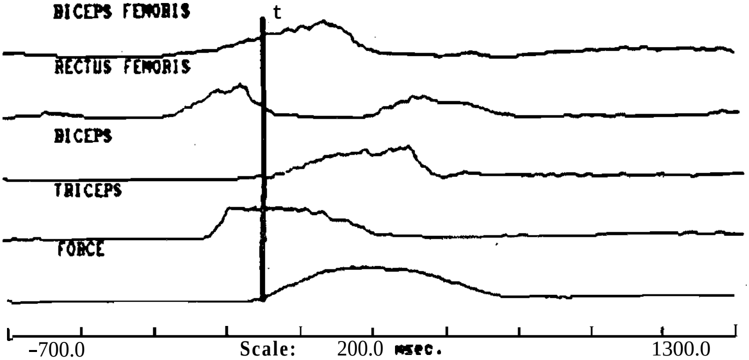
METHODOLOGY

Eleven experienced male lightweight ($\underline{M}$=70.5+ 2.8 kg) collegiate rowers from four universities were tested on two machines designed to simulate water rowing, the Concept II and the Gjessing ergometers. Mean height and age of the subjects were 152.2+5.7 cm and 21.7+1.3 years. During rowing, surface EMG was monitored on four muscle groups: biceps brachii, long head of the triceps, rectus femoris, and biceps femoris. EMG signals were amplified and band passed (10Hz-5kHz) prior to analogue to digital conversion at a sample rate of 1kHz. Force output was measured through a strain gauge transducer located in the draw cable on each machine. Two strain gauges and two fixed resistors were mounted on the transducer completing a full Wheatstone bridge and producing tension sensitivity twice that of a single 11-millimeter gauge. Output was processed through a differential amplifier using high gain (200) and a low pass filter (10 Hz). All data signals were *stored* on a microcomputer. Off-line signal processing produced full wave rectified, linear envelopes (20 ms time constant). Individual subject's data were averaged for each machine with respect to force onset (0.0 ms).

Following a warm-up, subjects randomly began the testing procedure on either machine. Six to eight strokes were used to achieve the designated rate (30-31 stroked minute) and maximal power at a resistance of 29.4 N m (Wilson, Robertson, & Stothart, 1988). Six to eight sets of eight seconds of data collection were accomplished during the ten hard strokes on each machine.

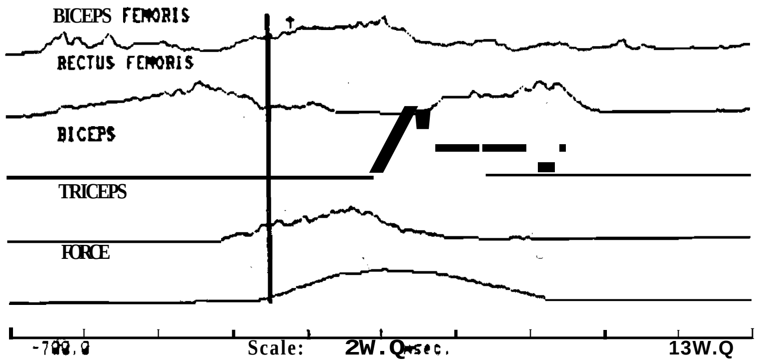
Data collection parameters included burst duration of EMG and force, time of peak activation of EMG and force, and onset time of EMG relative to force onset. Paired t-tests were used to determine the differences in these variables between the two machines. Significance was accepted at the p<.10 level.

(a)



†Note. Force initiation.

(b)



†Note. Force initiation.

Figure 1. Averaged EMG and force records from one subject on the ConceptII (a) and the Gjessing (b) rowing ergometers.

RESULTS

Figure 1 is a representative sample of one subject's data collected on the Concept II (a) and Gjessing (b) ergometers. This figure represents one average stroke cycle on each machine. All subjects displayed a similar EMG onset pattern across machines. The pattern of muscle activation onsets was rectus femoris, triceps, and biceps femoris. The biceps brachii were the last muscles activated. The first three muscles, rectus femoris, triceps, biceps femoris, were activated prior to initiation of force. Force duration on the Concept II was 35.7% of the stroke cycle, while on the Gjessing force duration occupied 37.9% of the stroke cycle. Despite general similarities between the two machines in onset and force duration pattems, careful scrutiny of individual muscle activation patterns between machines indicate differences occurred.

Table 1

Temporal Parameters of EMG Activity and Force on the Concept II and the Gjessing Rowing Ergometers

Parameters	Machine	Duration (ms)		Peak Time (ms)		Onset (ms)	
		M	SD	M	SD	M	SD
Biceps Brachii	Concept II	395	142	390	44	116	142
	Gjessing	390	88	382	60	175	93
Triceps	Concept II	509***	91	91*	78	-156	21
	Gjessing	586***	99	156*	62	-141	70
Rectus Femoris 1	Concept II	401	169	-100	86	-290**	179
	Gjessing	448	127	-48	161	-205**	234
Rectus Femoris 2	Concept II	410	89	507**	110	271*	213
	Gjessing	447	111	677**	175	453*	188
Biceps Femoris	Concept II	375**	115	167	105	-47	128
	Gjessing	435**	93	222	100	-5	120
Force	Concept II	714	45	295**	34	0	0
	Gjessing	757	103	336**	40	0	0

*$p<.10$. **$p<.05$. ***$p<.01$.

Table 1 shows the EMG and force **parameters** of the three variables: **burst** duration, time of **peak** activation and onset time. Triceps and biceps femoris burst durations were significantly longer on the Gjessing ergometer compared **to** the Concept II. Time of peak activation of the **triceps** and **the** second burst of the rectus femoris were significantly greater on the Gjessing. **This** indicates that these variables occurred **later** in the EMG pattern on the Gjessing relative to force activation. The onset time of the **first** burst of the rectus femoris relative to initiation of force application was si cantly less on **the Gjessing** compared **to the Concept** II. This means that the rectus femoris burst on the Gjessing occurred closer **to** the initiation of force. The second burst of the **rectus** femoris during Gjessing rowing was significantly greater **than** the second burst of the rectus **femoris** observed during Concept II rowing. This means that the onset time of the second burst of the rectus femoris on the Gjessing occurred later relative **to** force initiation compared **to** the Concept II. Time of peak force was significantly greater while rowing on the Gjessing compared **to** rowing on **the Concept II.** There were no significant differences in the biceps brachii variables.

DISCUSSION

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While the general muscle activation orders were similar between the two land rowing machines, specific neuromuscular differences occurred. The neuromuscular differences are not surprising and support earlier **biomechanical** studies. **Martindale** & Robertson **(1984)** found significant differences between the movements during water sculling and the movements on the Gjessing land rowing ergometer. They suggested that a rowing ergometer capable of simulating the water rowing motion would be a valuable tool for technique training. **The** results of **the** present study suggest that the design of appropriate land ergometers must also take into account neuromuscular functions involved with the skill of rowing.

Lamb **(1989)** and Daireaux and Pottier **(1983)** found that the **quadriceps** were of primary importance during **the** rowing stroke. The majority of **the** quadriceps' involvement including onset and burst duration **occurred** in the first half of the drive phase. Likewise, this was observed in the present study, the rectus femoris and biceps femoris were active 60% of **the** total stroke time while biceps brachii **were active 45%** of **the** total stroke time. Thus, most of the force production in the rowing stroke came from the legs extending. The biceps brachii activation onset occurred following force initiation in all subjects across both machines. This latency of **the** biceps brachii during land rowing is supported by Daireaux & Pottier **(1983).** although they did not **find** consistent latent biceps brachii onsets between all subjects. Contrary **to** the present study, they found that **the** biceps brachii onsets and durations had substantial variability **between** subjects. The variability found in the Daireaux & Pottier study was probably due to the rowing experience of the subjects. They used both experienced and inexperienced rowers. Inexperienced rowers initiate **the** movement of the handle with their arms as opposed to experienced rowers who initiate movement of the rowing handle with the legs. In the present study, only experienced rowers were subjects, therefore, this may explain the small variability in the biceps brachii onsets and durations.

Olbrecht & Clarys (1983) compared land training techniques versus water training for the sport of swimming. They found that the EMG patterns on dry-land machines did not mimic the patterns observed during swimming in the water. Thus. dry-land training techniques may be questionable as to their effectiveness. In the present study, the dry-land machine that most closely mimics water rowing cannot be determined. Future studies on the EMG patterns during water rowing are necessary.

CONCLUSION

Neuromuscular pattern differences were observed which is in agreement with biomechanical research on land versus water rowing. Experienced rowers use leg muscles as the primary force during the rowing stroke which is in agreement with current rowing literature. The arm muscles are used minimally to initiate force at the beginning of the rowing motion. As a result of this study. insight is available on the differences in EMG and force production during two modes of land rowing. Further data collection of this type is suggested during water rowing to determine the effectiveness of these machines in mimicking water rowing.

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