ELECTROMYOGRAPHIC (EMG) ACTIVITY OF LOWER EXTREMITY MUSCULATURE DURING DROP JUMPING FROM DIFFERENT HEIGHTS

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The purpose of this study was to determine EMG activation patterns of the lower extremity musculature during drop jumping from different heights. Ten subjects participated in the study. EMG activity of the rectus femoris, biceps femoris, and gastrocnemious muscles as well as ground reaction forces were simultaneously recorded during drop jumping from 20, 30, and 40cm. Sagittal video data were also recorded and synchronized to the analog data. Results show similar jump height and EMG activation patterns for the 20 and 40cm drop jumps, but not for the 60cm. It was concluded that activation patterns of the lower extremity musculature varies when the drop height exceeds certain limits. The activation pattern of gastrocnemious deviated from the one described in the literature.

KEY WORDS: drop jumping, plyometric, electromyography

INTRODUCTION: The rapid eccentric/concentric cycle of muscular contraction found in many physical activities has been the subject of investigation. In addition, the ability of muscles to develop more force when pre-stretched, has led to the development of specific “plyometric” training programs to increase performance. Drop jumping has been utilized to investigate the neuromuscular adaptations and muscular coordination used by subjects during the short time interval of landing/rebounding. Previous studies have reported reduction of the gastrocnemious muscle electromyographic (EMG) activity during the early phases of drop jumping. The coordination of gastrocnemious and rectus femoris muscles, and/or selective relationships between dropping height and biomechanical variables has also been investigated (Bobbert, Huijing, and van Ingen Schenau, 1987; Gollhofer, A., 1993; Schmidtbleicher and Gollhofer, 1997; Neubert, Schwirtz, and Buehrle, 1998; Gkantiraga, Papadopoulos, Kosmis, and Simeonidou, 2000). However, EMG activation patterns during different drop heights and the question of whether or not knee joint flexors have a specific role to play, is a topic not yet investigated. Therefore, it was the purpose of this study to investigate the EMG activation patterns of selective lower extremity musculature including the biceps femoris muscle during drop jumps from 20, 40, and 60cm.

METHODS: Ten physical education students participated in the study. All subjects were highly skilled athletes. They performed maximum drop jumps from 20, 40, and 60cm. EMG activity of the rectus femoris, (short head of) biceps femoris, and gastrocnemious muscles was recorded. Force and sagittal video data were simultaneously recorded. EMG and force data were recorded at 500 Hz, video data at 60 Hz. All data were synchronized. An Ariel Performance Analysis System (APAS) with propriety software was utilized to collect and process the analog data and to analyze the video data. In this study, the following variables were examined: (1) maximum height jumped, calculated from the (KISTLER) force plate data.(2) onset of muscle activity in relation to contact, where onset was defined as the instant prior to impact where muscle EMG activity began to continuously increase; (3) instant of maximum EMG activity after impact; (4) duration of ground contact; and (5) knee joint angular history.

RESULTS AND DISCUSSION: There were no statistical differences between jump heights from 20 and 40cm drop jumps (p>.05). Therefore, only the 40 and 60cm drop jump data are presented. Representative EMG activity for the three muscles and knee joint angle data are presented in Figures 1, 2, and 3, respectively. Height jumped, ground contact time, temporal EMG results, and knee joint angular data is presented in Table one. As illustrated, ground contact time decreased from 200ms to 189ms for the 40 and 60cm drop jumps, respectively.

In addition to the increase in EMG amplitude when the drop height increased from 40 to 60cm, some changes in the timing and/or pattern was observed. In the 40cm drop jump, the onset of gastrocnemious EMG activity was 152ms prior to contact, followed by the activation of rectus femoris and then of the biceps femoris.

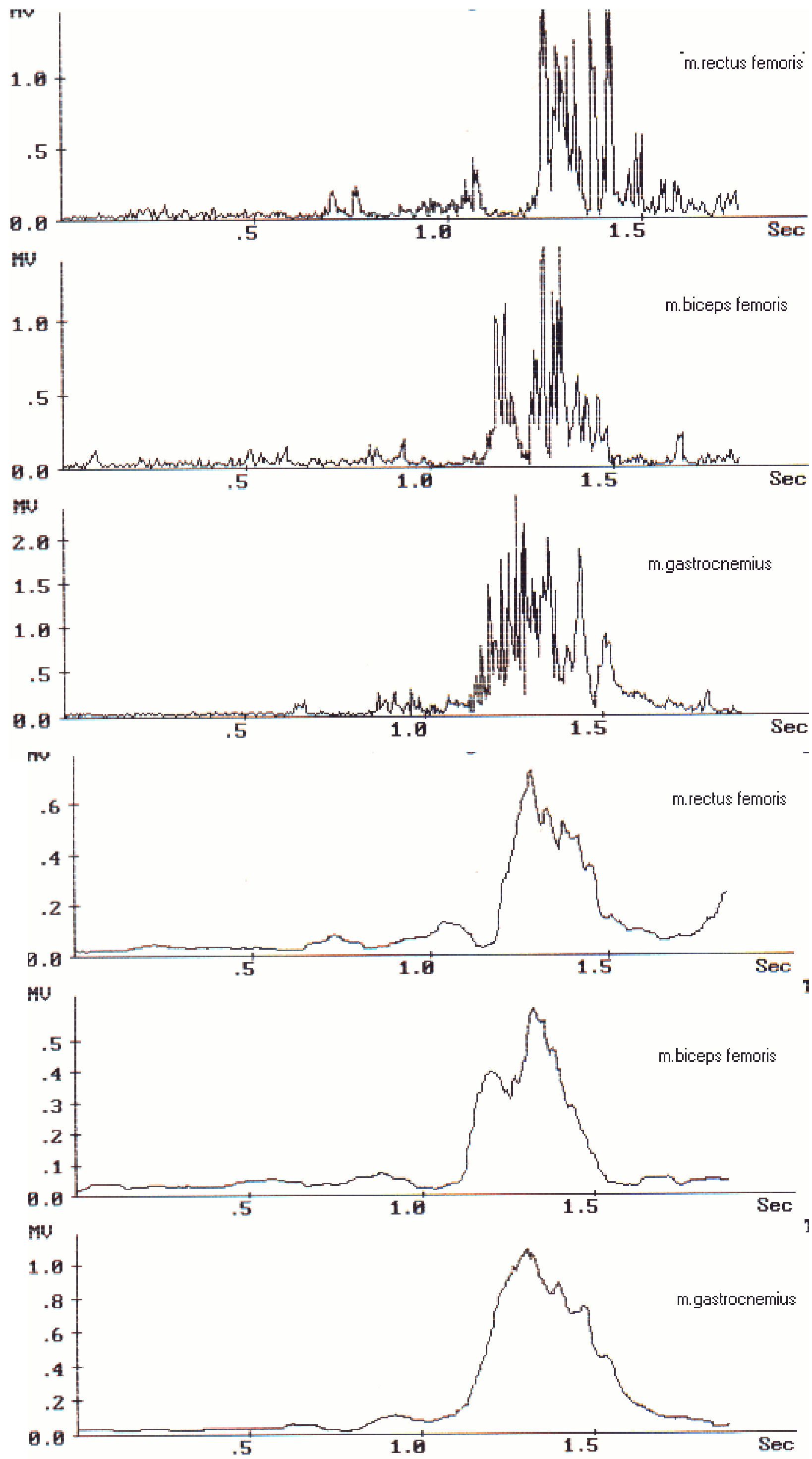

Figure 1 - Representative rectified and integrated EMG activity for the 40cm drop jump for the rectus femoris, biceps femoris , and gastrocnemious muscles. Note: ground contact is between 1.28 and 1.41 seconds.

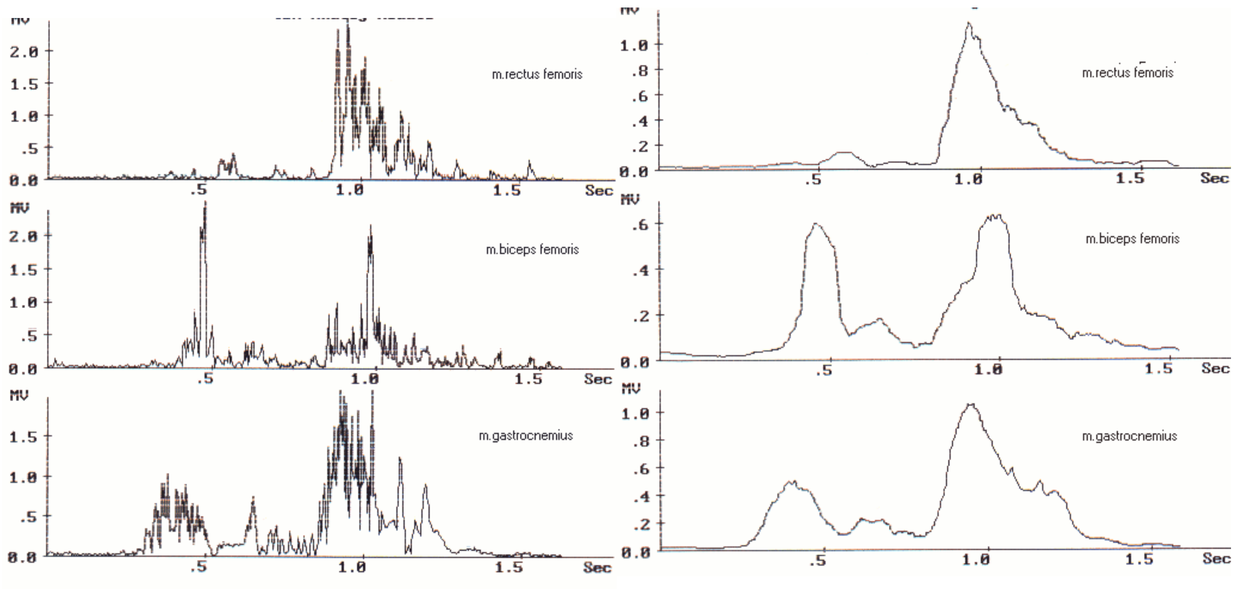

Figure 2 - Representative rectified and integrated EMG activity for the 60cm drop jump for the rectus femoris, biceps femoris, and gastrocnemious muscles. Note: ground contact is between 1.24 and 1.42 seconds.

The EMG activation pattern was different when the drop height increased to 60cm, with the gastrocnemious activated earlier (174ms), but the rectus femoris and biceps femoris later, closer to touchdown. During ground contact, results for both drop heights showed continuous gastrocnemious activity until 72ms after contact and a gradual declining thereafter until takeoff.

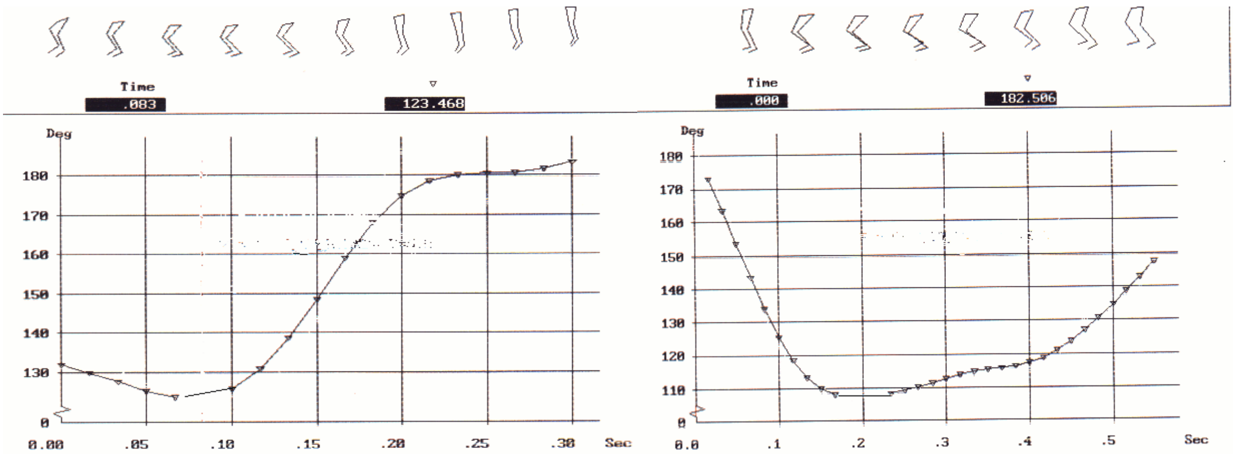

Figure 3 - Knee joint angle during the 40cm (left) and 60cm (right) drop jumping.

Rectus femoris EMG results showed high levels of activity immediately after touchdown, eccentric activity to slow down knee joint flexion, followed by concentric activity during extension. Maximum biceps femoris EMG activity was observed during the later phase of knee joint extension, when rectus femoris activity was declining, with eccentric contraction to reduce the rate of knee joint (terminal) extension. However, substantial biceps femoris activity was noted prior to flexing of the knee joint in preparation for landing. As Figure 2 indicates, this early firing of the biceps femoris was more pronounced when the drop height increased.

Table 1 Temporal EMG and Knee Joint Angular Results (n=10)

	Drop jump height	
Variable	40 cm	60 cm
Rectus femoris onset (ms)	-92±30	-87±32
Biceps femoris max. (ms)	79±28	104±20
Biceps femoris onset (ms)	-131±45	-116±37
Gastrocnemious max. (ms)	72±25	72±11
Gastrocnemious onset (ms)	-152±62	-174±58
Ground contact time (ms)	200±10	189±12
Jumped height (cm)	30.5±4	26.3±5
Knee joint angle at contact (deg.)	140±3	134±4
Knee joint angle range of motion (deg.)	17±4	27±3
Rectus femoris max. (ms)	65±20	43±7

Note: negative times denote time before impact, positive time denotes time after impact.

INTERPRETATION AND CONCLUSION: The results of this study showed that, during drop jumping, the gastrocnemious muscle is activated initially, followed by the biceps femoris, followed by the rectus femoris muscles. When drop height increased from 40 to 60cm, the gastrocnemious was activated earlier, stabilizing the ankle joint in anticipation of greater impact forces and “shifting” rectus femoris and biceps femoris activity closer to touchdown to compensate and “protect” the knee joint. In contrast to previous studies, the results of this study showed no reduction in gastrocnemious EMG activity during contact in highly skilled subjects. This could be explained as an impact absorption eccentric function followed by a propulsive concentric function. These results may have implications in designing training programs.

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