The effect of load and target height on muscle EMG activation of the abdominals and paraspinals in multi-joint reaching tasks

James S. Thomas, Candace E. Kochman, Sarah E. Clagg, Daohang Sha, and Christopher R. France
School of Physical Therapy, Ohio University, Athens, OH

Introduction
Low back pain is a major health concern in today’s society. Recent research has focused on spinal stability and its potential to prevent low back pain. Without muscle activation, the ligamentous spine fails under minor loads of back (Bergmark, 1989). Activation of trunk muscles is to stiffen the spine which leads to increased spinal stability (MaIi and Cholewicki, 2001, Bergmark, 1989). It has been suggested that during conditions of decreased spinal stability an increase in abdominal and paraspinal muscle activation would be necessary to increase stiffness of the spine thereby increasing spinal stability. scanena and Orishimo had subjects perform a bilateral reach task to two targets located in the mid-sagittal plane while holding a load of 0 or 3.6 kg. Target heights were set so subjects could reach the targets by extending the trunk 30 degrees for the high target and flexing 30 degrees for the low target. The order of the reaching task was randomized. Muscle activity of the left and right rectus abdominis, external oblique, internal oblique, iliocostalis lumborum, and multifidus were recorded using a 16 channel DelSys Bagnoli system. EMG signals were sampled at 1000 Hz. The EMG data were rectified and low pass filtered using a 4th order zero lag Butterworth filter with a cut-off frequency of 5Hz. Next, the EMG data were integrated from 100ms prior to target contact to the time of target contact. The times series EMG data for the deltoid, external abdominal oblique, rectus abdominis, internal abdominal oblique, erector spinae, and multifidus muscles during a bilateral reach to the high target with a 3.6 kg load are shown in Figure 1.

Methods
Twenty healthy participants (12 females and 8 males) performed a series of bilateral reaching tasks to two targets located in the mid-sagittal plane while holding a load of 0 or 3.6 kg. Target heights were set so subjects could, in theory, reach the targets by extending the trunk 30 degrees for the high target and flexing 30 degrees for the low target. The order of the reaching task was randomized. Muscle activity of the left and right rectus abdominis, external oblique, internal oblique, iliocostalis lumborum, and multifidus were recorded using a 16 channel DelSys Bagnoli system. EMG signals were sampled at 1000 Hz. The EMG data were rectified and low pass filtered using a 4th order zero lag Butterworth filter with a cut-off frequency of 5Hz. Next, the smooth EMG data were time normalized to 100 points and the integral from 100ms prior to the initiation of arm movement to target contact was calculated for the 6 abdominal muscles. The 6 integrals were then averaged to provide a measure of abdominal activity for the reaching task. The same procedure was repeated for the paraspinal EMG data.

Data Analysis
Repeated measured ANOVAs were used to determine the effects of target height, load, and trial on the averaged muscle activity of the abdominals and paraspinals along with changes in AP and vertical COM.

Results
Subjects had increased activity of the abdominal muscles when reaching to the high target in the loaded condition compared to the no load reaches (F=519.77, p<.05). However, there was no effect of load on abdominal activity for reaches to the low target. As expected, paraspinal muscle activity increased with load for both the high (F=31.53, p<.05) and low target (F=71.9, p<.05). There was no effect of target height on abdominal or paraspinal EMG activity for the no load condition. However, for the 3.6 kg load condition, both abdominal (F=43.03, p<.05) and paraspinal (F=14.68, p<.05) muscle activity was increased for the high target compared to the low target (Figure 3).

Conclusions
Based on the manipulation of target height and load we predicted an increase in abdominal and paraspinal muscle activity at the high target in both the loaded and unloaded conditions to increased spinal stability under these conditions. However, abdominal and paraspinal activity increased at the low target during the loaded condition only. We also expected to see increased abdominal and paraspinal activity during reaches for both target heights due to the effect of load on the stability of the system. The results only partially supported this assumption. However, after examining the vertical COM data these results could be expected. The vertical COM had a significant increase at the high target with an increase in load condition. The vertical COM at the low target for the unloaded condition increased at both load conditions compared to the loaded condition. However, abdominal and paraspinal activity at the high target in both the loaded and unloaded conditions was increased due to the increased demand on spinal stability during these specific reaching tasks.

Results cont.
Subjects vertical COM was found to be greater at the high target during the loaded condition compared to the no load condition (F=519.77, p<.05). However, there was no effect of load on vertical AP COM at the high target. AP COM was found to be between the high (F=33.33, p<.05) and low target (F=71.9, p<.05) for the loaded condition only (Figure 4).

Figure 1. Time series EMG data for the deltoid, external abdominal oblique, rectus abdominis, internal abdominal oblique, erector spinae, and multifidus muscles during a bilateral reach to the high target with a 3.6 kg load.

Figure 2. High target reach 3.6 kg load.

Figure 3. A) Abdominal EMG muscle activity for the both the high load and low target in the loaded and unloaded conditions. B) Paraspinal EMG muscle activity for both the high and low target in the loaded and unloaded condition.

Figure 4. A) Whole body vertical Δ COM for the high and low target during the loaded and unloaded condition. B) Whole body AP Δ COM for the high and low target during the loaded and unloaded condition.