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 amounts of load (Bergmark, 1989). Activation of trunk musculature acts to stiffen the spine which leads to increased spinal stability (McGill 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. Granata and Orishimo had subjects participate in static reaching tasks with varying demands on spinal stability by manipulating target height and load (Granata and Orishimo, 2001). They found an increase in abdominal and paraspinal activity during static reaches to a high target and increases in abdominal activity during static reaches performed with an increased load. These findings suggest that the increases in muscle activation were due to the increased demand on spinal stability during these specific reaching tasks.

The purpose of this study was to determine the response of the abdominal and paraspinal muscles to conditions of decreased stability during a dynamic, bilateral reaching task. By manipulating target height and loading condition we created reaching tasks that increased demands on spinal stability.

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 trials was randomized. Muscle activity of the left and right rectus abdominis, external oblique, internal oblique, iliocostalis lumborum, and multifidis 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 smoothed 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 each of 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.

Location of the whole body center of mass (COM) was calculated using regression equations based on subject's weight, sex, and measured segment lengths provided by Plagenhoef et al. (1983).

Data Analysis

Repeated-measures 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=24.60, p<.05). However, there was no effect of load on abdominal EMG activity for reaches to the low target. As expected, paraspinal muscle activity increased with load for both the high (F=31.63, p<.05) and low target reaches (F=54.04, p<.05). There was no effect of target height on abdominal or paraspinal EMG activity for the no load conditions. However, for the 3.6 kg load condition, both abdominal (F=9.92, p<.05) and para spinal (F=14.88, p<.05), muscles EMG activity was increased for the high target compared to the low target (Figure 3).

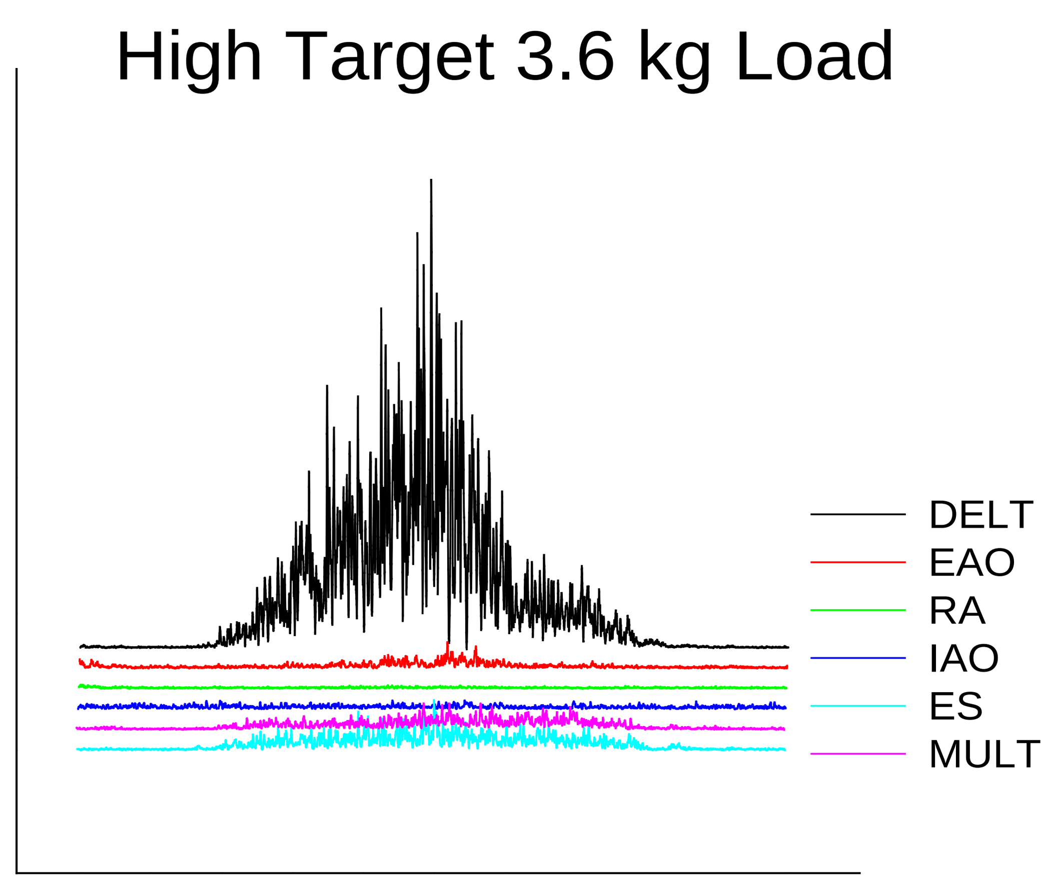

Figure 1. **Time series EMG data for the deltoid, external abdominal oblique, rectus abdominis, internal abdominal oblique, erector spinae, and multifidus muscles during a bilateral reach to the high target with a 3.6 kg load.**

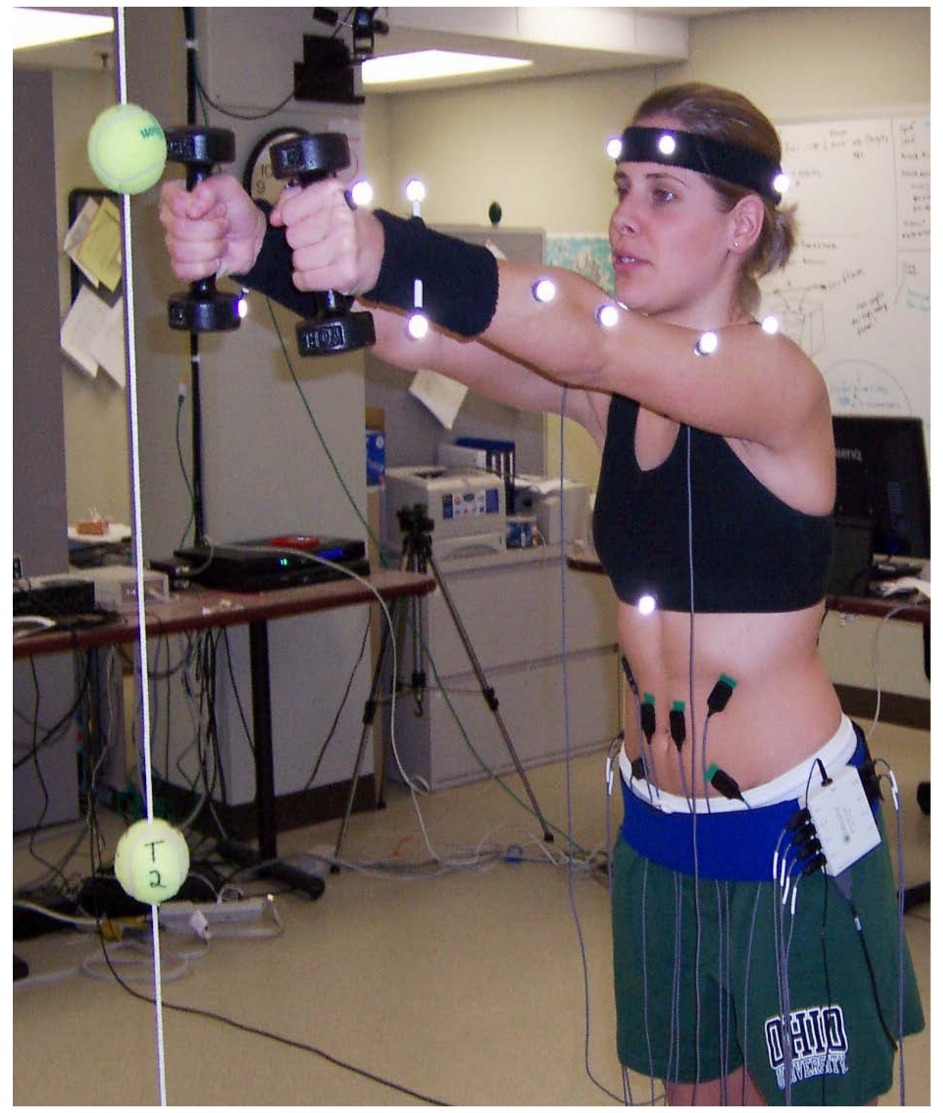

Figure 2. **High target reach 3.6 kg load.**

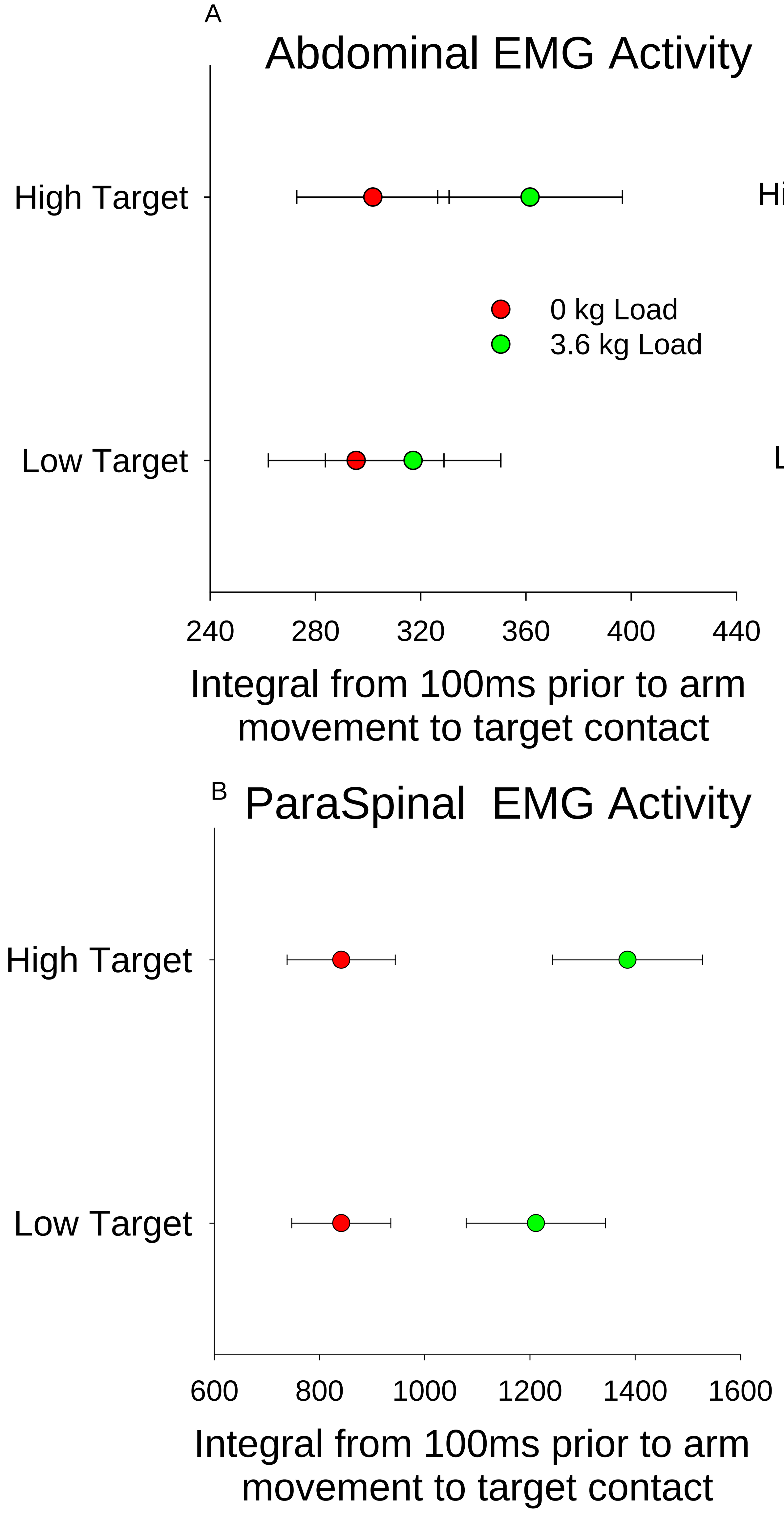

Figure 3. **A) Abdominal EMG muscle activity for the both the high and low target in the loaded and unloaded conditions. B) Paraspinal EMG muscle activity for both the high and low target in the loaded and unloaded condition.**

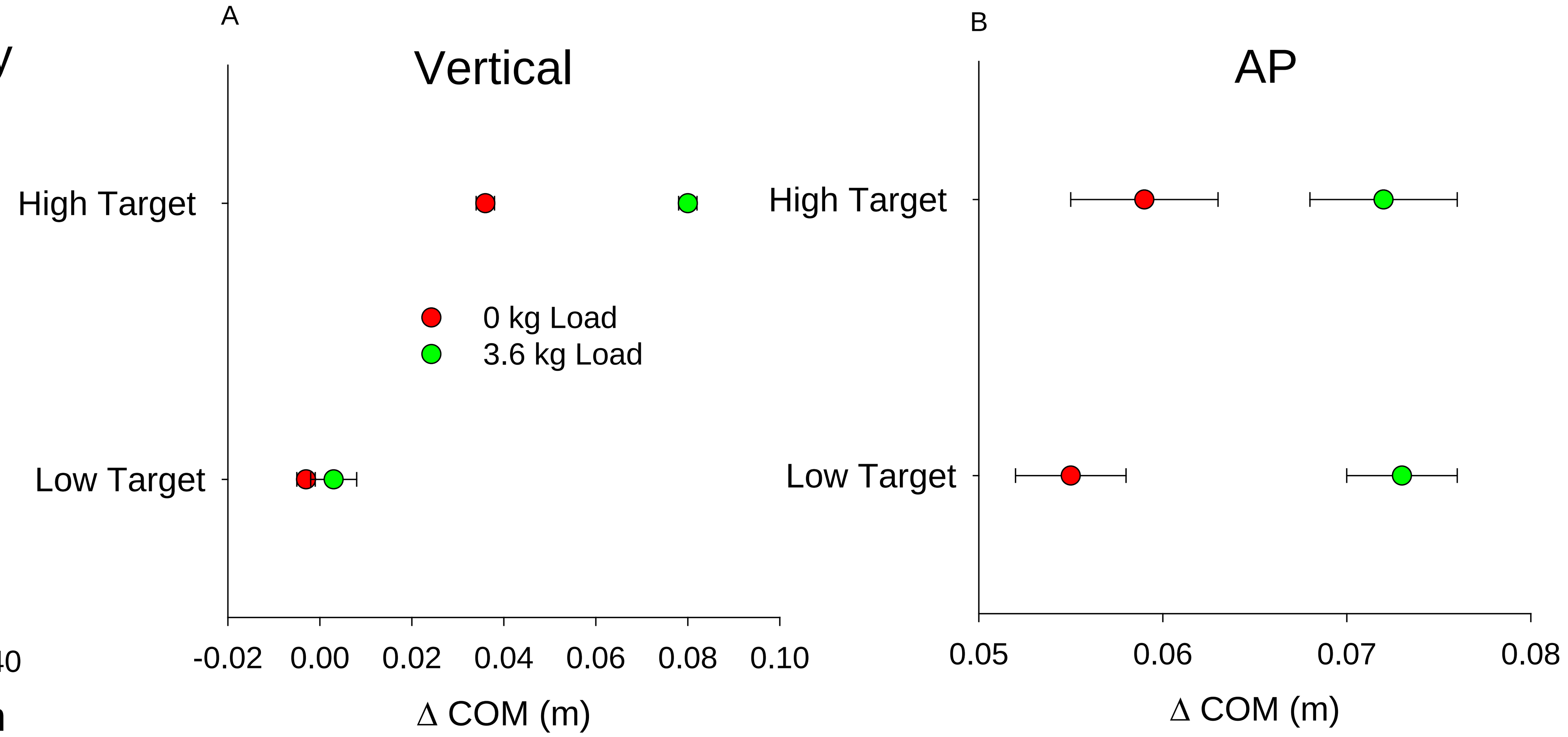

Figure 4. **A) Whole body vertical Δ COM for the high and low target during the loaded and unloaded condition. B) Whole body AP ΔCOM for the high and low target during the loaded and unloaded condition.**

Results cont.

Subjects vertical Δ 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 affect of load on vertical Δ COM at the low target. AP Δ COM was found to increase at both the high (F=31.53, p=<.05) and low target (F=71.9, p=<.05) for the loaded condition only (Figure 4.).

Conclusions

Based on the manipulation of target height and load we predicted an increase in abdominal and paraspinal activity at the high target in both the loaded and unloaded conditions due to decreased spinal stability under these conditions. However, abdominal and paraspinal activity increased at the high target during the loaded condition only. We also expected to see increased abdominal and paraspinal activity during loaded 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 Δ COM data these results could be expected. The vertical Δ COM had a significant increase at the high target with load demonstrating that the stability of the system was challenged more in the loaded condition than in the unloaded condition for the high target, requiring increased muscle activation to stabilize the system. Due to the lack of a significant change in vertical Δ COM at the low target for the loaded condition, you would not expect an increase in abdominal activation because spinal stability was not challenged enough to require increased stiffness from abdominal and paraspinal muscle cocontraction. Paraspinal activity increased with load at both target heights, but increases in abdominal muscle activity in the loaded condition was found only at the high target. Further testing in clinical populations is necessary to determine the role of abdominal bracing on spinal stability.

This research was supported by The National Institutes of Health Grant R01-HD045512 to J.S. Thomas