LOWER EXTREMITY MUSCLE ACTIVATION DURING BAREFOOT, MINIMALIST AND SHOD RUNNING

1Tyler Standifird, 2Ulrike Mitchell, 2Iain Hunter, 2Wayne Johnson and 2Sarah Ridge

1University of Tennessee, Knoxville, TN, USA
2Brigham Young University, Provo, UT, USA
email: tstandif@utk.edu

INTRODUCTION

Research on running mechanics is a common area of biomechanical research. It is important to understand how varying running strategies may contribute to or decrease the risk of injury. At this time, barefoot and other minimalist running has gained popularity among many runners. Prior research has shown that barefoot running can be beneficial at reducing the amount of impact forces during running (1). Minimalist running shoes, like the Vibram FiveFingers (VF®), have been created to mimic barefoot running, though little is known about the specific mechanics used when wearing these types of running shoes.

EMG is a biomechanical tool that can compare muscle activations of different motor tasks. Lower extremity EMG has been measured and reported as a measure of muscle activation during a variety of activities including running. Although EMG has been compared previously for barefoot and shod conditions (2, 3), little research has looked at muscle activation during minimalist running.

One study which compared muscle activity during barefoot running and shod running reported increased tibialis anterior activation prior to foot strike during shod running (2), though this was the only muscle analyzed. Other research has looked at the tibialis anterior muscle along with the soleus, gastrocnemius and peroneus longus (3). This study reported no differences for pre-activation for the tibialis anterior or peroneus longus between shod and barefoot conditions, but did report pre-activation levels to be greater for the plantar flexor muscles during barefoot running when compared with shod. The weight acceptance and push-off phases showed no differences between muscles.

The purpose of this project was to compare muscle activation during barefoot, shod and VF® running during three distinct time periods. It was hypothesized that the barefoot and VF® conditions would exhibit similar muscle activations and that both would be different than the shod condition.

METHODS

Ten injury free recreational runners with no barefoot/minimalist running experience were included in this study. Four wireless surface electrodes (Delsys Trigno, Boston, MA) were placed on the subjects’ right leg at the following locations: tibialis anterior, soleus, gastrocnemius and peroneus longus. Prior to placement skin was prepped by shaving the area as well as cleansing with an alcohol wipe. Electrodes were placed according to the SENIAM recommendations (www.seniam.org). Prior to data collection electrodes were tested for proper location and cross talk. Once placement was deemed correct, the electrodes were secured using tape and wraps.

Following a warm-up of running the length of the Lab (15 m) a few times, subjects ran in VF®, barefoot and shoes (Nike Air Pegasus) in a randomized order at a speed of 3.84 m/s, controlled with timing lights. Subjects were required to meet this speed three times for each condition while making complete foot contact with the force platform. Visual 3d was used to analyze all EMG data. Data were filtered using a band-pass filter at 10-450 Hz, full-wave rectified and a moving RMS with a window size of 100 ms was applied. The max EMG value for each muscle was calculated as the overall max during all running trials. Each muscle’s EMG signal during running trials was normalized to its max EMG value. Three different periods were identified during the gait cycle. The pre-activation
period was calculated as the 50 ms prior to foot strike. The stance phase was split into two periods, by creating an event when the A/P ground reaction force moved from negative to positive. The first part of stance was labeled as impact phase and the last part was labeled as push-off phase. Normalized EMG signals were integrated for each time period and reported as $I_{EMG}$. ANOVA analysis was performed using mixed models and least square means were compared for the three conditions using Tukey adjustments.

**RESULTS AND DISCUSSION**

The tibialis anterior muscle showed differences between conditions during the pre-activation time period. The $I_{EMG}$ value during the 50 ms prior to foot strike was the greatest during shod running and the smallest during barefoot running (the Vibram condition was not significantly different from either condition). The peroneus longus was found to be significantly less activated during push-off during the shod condition when compared with both the barefoot and Vibram condition. No other muscles had $I_{EMG}$ values that were significantly different for any periods between conditions.

Our findings support the findings of some of the previous literature that have suggested that pre-activation of the tibialis anterior is greater in the shod condition when compared with barefoot running (2). Other studies have reported varying results, showing no difference in pre-activation levels of the tibialis anterior when comparing barefoot and shod running (3). With respect to pre-activation muscle activity in the gastrocnemius and soleus, our study found conflicting results to a previous study, as we found no differences in activation of these muscles (3). Additionally our findings on the differences in push-off activation of the peroneus longus muscles did not support previous literature (3). Differences between testing protocols may partially explain some of the discrepancies. The study reporting plantarflexor differences (3) instructed runners to run with a heel strike pattern. Our subjects were free to contact the ground in any manner.

**CONCLUSIONS**

We hypothesized that the EMG patterns during Vibram running would mimic those seen with barefoot running. We further suggested that both of these conditions would lead to different activation patterns when compared with shod running. The tibialis anterior during pre-activation differed between barefoot and shod conditions and the peroneus longus was less activated at push-off during shod when compared with the other two conditions. Muscle activation differences between shod and barefoot/minimalist running may be greater for runners with minimalist running experience. Our runners had no previous barefoot or minimalist running experience, an aspect similar to previous research (2,3). It may take time to alter running form including muscle activation patterns. In order to fully understand this effect it would be important to carry out similar studies on individuals with barefoot/minimalist running experience.

**REFERENCES**


| Table 1: $I_{EMG}$ values (%Max*) for the tibialis anterior (TA), gastrocnemius (GAS), soleus (SOL) and peroneus longus (PL)
<table>
<thead>
<tr>
<th>Condition</th>
<th>Pre-Activation</th>
<th>Impact</th>
<th>Push-Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shod</td>
<td>TA</td>
<td>.881 (.10)</td>
<td>.189 (.05)</td>
</tr>
<tr>
<td>Barefoot</td>
<td>TA</td>
<td>.637 (.10)*</td>
<td>.262 (.05)</td>
</tr>
<tr>
<td>Vibram</td>
<td>TA</td>
<td>.778 (.10)</td>
<td>.270 (.05)</td>
</tr>
</tbody>
</table>

Means (standard errors) *denotes significant difference from shod condition ($p<.05$)