Variability of Muscle Activity During Off-Road Cycling
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Introduction

With the rapidly evolving technology of bicycle frame designs, empirical research that investigates their affects on rider safety and control is needed. Few studies have investigated the mechanical characteristics of hardtail (HT) versus full-suspension (FS) mountain bikes (Pritlove et al. 1998; Roy and Robertson, 2000). While these studies focused on the frames abilities to passively attenuate shock, the active contribution of the cyclist is unknown. Studies show that muscles can actively attenuate impact shock (Mahar et al., 1997; Derrick et al., 1998).

The purpose of this study was to determine the ability of axial and lower extremity muscles to actively attenuate shock during rear wheel impacts with a HT bike and a FS bike.

Methodology

The study consisted of 20 trials performed by each of the subjects. Subjects were equipped with surface (EMG) electrodes taped to the skin using athletic tape to reduce data artifacts. Electrodes were placed at the muscle bellies of the erector spinae (ES, T12 level), vastus lateralis (VL), and biceps femoris (BF). A ground was placed on the anterior superior iliac spine (ASIS) (Eisner, 1999; Mahar 1997).

EMG data were collected via a bioamplifier (Noraxon, U.S.A., Inc.) set at an amplification of 1000 gain and sampled at 1000 Hz (Merletti and di Torino, 1999). Force data were collected using a Kistler force plate equipped with a “bump” (see Figure 1) (Pritlove et al. 1998). EMG data were synchronized to force plate data using the BioWare software package. Force plate data were used to indicate rear wheel impact.

A ramp was used to have each subject achieve the same velocity at impact. The ramp was 2.27 m long and had a 10.2° rise from the horizontal. It was placed 0.985 m from the center of the force plate. The center of the force plate corresponded with the center of the bump (see Figure 1).

Results and Discussion

For all trials, the average muscle activity of ES was lower during HT as compared to FS riding. It was found that heightened ES activity during FS riding coincided with heightened VL and BF activity during HT riding. Maximum ES activity (1.163 mV) was recorded at 43% of the trial, shortly after the rear wheel contacted the ground after descending from the bump (Table1). Maximal VL and BF activation (0.207 mV and 0.207 mV) in HT trials occurred at 53% of the trial, approximately when the rear wheel rolled off the force platform (Table 1). Table 1 also shows that maximal ES activity during HT trials occurred after the rear wheel had cleared the force plate (59% of trial). Similarly maximal activation of VL and BF during FS trials occurred quite late in the trial (56% and 67%).

After initial rear wheel impact, the ES, muscle group exhibited more activity during FS riding; the VL and BF showed greater activity during HT trials than FS riding (see Figure 2 and Table 1). Upon rear wheel decent off the bump onto the force plate ES showed relatively higher activation during FS riding. Again this coincided with an increase in VL and BF activity during HT trials. The increase in ES activity during FS may be in reaction to the dampening action of the suspension; rear shock rebound is
controlled; the rate of rebound is less than the rate of compression. The relatively lower ES activity after wheel decent coincides with an increase in VL and BF during HT riding. This may be attributed to the active contraction of the VL and BF to slow the trunks return to the seat after being displaced vertically due to initial impact. In addition, this decrease in ES activity may be caused by a lack of reaction to rapid vertical displacements. FS bikes are designed to control this occurrence. According to these data, it appears that it is the actions of the VL and BF that contribute to active shock attenuation. This is necessary for stabilizing the cyclist while riding a HT mountain bicycle.

The data suggest that the forces experienced by the body after rear wheel impact are less with the use of a FS mountain bike frame. This finding is comparable to that of Roy and Robertson (2000). The relatively higher post impact forces experienced during HT riding may lead to unwanted sheer forces experienced between vertebrae. The possibility of such sheer forces may be facilitated by the angle at which a rider places their torso (forward lean). However, the magnitude of erector spine activity upon post rear wheel impact is greater during FS riding. This increased ES activity may initially be perceived in a negative manner, however, the activation of erector spinae muscles may be beneficial. Since one of the roles of ES is to stabilize the spine, its activity may contribute to countering the sheer forces experienced between vertebrae post-rear wheel impact. A reduction of sheer forces between vertebrae may help decrease the possibility of lower back pain over repetitive rear wheel impacts. Although a Fourier analysis was not conducted, the authors assume that this condition would lead to muscle fatigue in a relatively lesser time than a HT bike. To verify this question further study is necessary.

![Figure 2. Ensemble averaged linear envelope EMG and vertical force during trial](image-url)
<table>
<thead>
<tr>
<th>Muscle Activity (mV)</th>
<th></th>
<th></th>
<th></th>
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<tr>
<td>ES FS</td>
<td>0.878</td>
<td>0.883</td>
<td>0.685</td>
<td>0.758</td>
<td>1.163</td>
<td>1.091</td>
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<td>VL FS</td>
<td>0.054</td>
<td>0.080</td>
<td>0.069</td>
<td>0.061</td>
<td>0.088</td>
<td>0.107</td>
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<td>BF FS</td>
<td>0.044</td>
<td>0.052</td>
<td>0.053</td>
<td>0.050</td>
<td>0.086</td>
<td>0.086</td>
<td>0.088</td>
<td>0.088</td>
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<tr>
<td>ES HT</td>
<td>0.615</td>
<td>0.659</td>
<td>0.573</td>
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<td>VL HT</td>
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<td>0.098</td>
<td>0.095</td>
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<td>0.198</td>
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<tr>
<td>BF HT</td>
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<table>
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<tr>
<th>Events</th>
<th>Initial BI</th>
<th>Peak BI</th>
<th>Initial GI</th>
<th>Peak GI</th>
<th>Off Plate</th>
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<tr>
<td>% of Trial</td>
<td>5%</td>
<td>17%</td>
<td>35%</td>
<td>40%</td>
<td>48%</td>
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<tr>
<td></td>
<td>53%</td>
<td>56%</td>
<td>59%</td>
<td>67%</td>
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</table>

BI – Bump Impact  
GI – Ground Impact  
Off Plate – rear wheel rolling off of force plate

ES - Erector Spinae  
VL - Vastus Lateralis  
BF - Biceps Femoris  
HT - Hardtail  
FS - Full Suspension

Table 1

References


