Transmission of a Floor-Based, High-Frequency, Low-Magnitude Vibration Stimulus to the Distal Tibia and Distal Femur of Children With Spastic Cerebral Palsy

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Abstract
Individuals with physical disabilities such as cerebral palsy (CP) have been shown to have decreased bone mass and an increased risk for fracture in the lower extremities. A floor-based, high-frequency, low-magnitude vibration (HLV) stimulus has been shown to have anabolic properties on bone. It is plausible that the effect of HLV on bone is dictated, at least in part, by the degree of HLV signal transmission to a particular bone site. The aim of this study was to determine the degree to which an HLV signal emitted by a floor-based platform transmits to the distal tibia and the distal femur of children with spastic CP. Participants were children aged 7-11 years with spastic CP and a gross motor function classification of I or II determined using the Gross Motor Function Classification System. All testing took place in a pediatric hospital and a university setting. Triaxial accelerometers (PCB Piezotronics Inc., Depew, NY) were strapped to the skin over the lateral condyle of the distal tibia and immediately above the medial malleolus of the distal tibia. A uniaxial accelerometer was secured to the center of a plate (Juvent Inc., Palm Beach Gardens, FL) that was programmed to emit an HLV signal. As the children stood on the plate, accelerations were sampled at 2 kHz at the platform, distal tibia and distal femur for 30 seconds while the plate was at rest and for 30 seconds while the plate was vibrating. The HLV plate generated a vertical acceleration of 0.32 ± 0.01 g at a frequency of 33.4 ± 1.7 Hz. Compared to the vertical acceleration measured at the plate, the resultant accelerations were greater at the distal tibia (0.41 ± 0.01 g, p < 0.001) and lower at the distal femur (0.24 ± 0.02 g, p < 0.001). The low-magnitude plate evaluated in this study transmitted slightly higher signal to the distal tibia but only ~80% of the signal to the distal femur in ambulatory children with spastic CP. The findings suggest that the potential benefits of HLV for bone health in children with CP may be site-specific and influenced by transmission of the HLV signal.

Introduction
Children with physical disabilities such as cerebral palsy (CP) have compromised muscle [1] and bone [2,3] mass and quality, especially in the lower extremities. Studies have shown that a floor-based, high-frequency, low-magnitude vibration (HLV) stimulus has an anabolic effect on bone in various populations, including children with disabling conditions such CP [4]. Despite the potential of HLV as a treatment to promote musculoskeletal health, the degree to which the HLV signal is transmitted to a particular bone site may dictate its effectiveness. Other types of mechanical loading, such as exercise, have a site-specific influence on bone with the greatest effects at the site that experiences the load [5]. In addition, a previous study done in children showed an amplification of HLV stimulus at the distal tibia and distal femur at 33 Hz [6]. Unfortunately, the transmission of HLV to key bone sites in children with CP has not been studied.

Methods
• 14 children with spastic CP (4-11 y) with a gross motor function classification between I and II were recruited from pediatric hospitals in the Mid-Atlantic region of the U.S. 14 children with spastic CP (4-11 y) with a gross motor function classification between I and II were recruited from pediatric hospitals in the Mid-Atlantic region of the U.S.
• Children stood on a platform (Juvent Inc., Palm Beach Gardens, FL) that emits an HLV (~0.3 g and ~30 Hz).
• Triaxial accelerometers (PCB Piezotronics., Depew, NY) were strapped to the skin over the lateral condyle of the distal tibia and over the medial malleolus of the distal tibia. A uniaxial accelerometer was secured to the center of the HLV platform.
• As the children stood on the platform, accelerations were sampled at 2 kHz at the platform, the distal tibia, and the distal femur for 30 seconds while the platform was at rest and for 30 seconds while the platform was vibrating.
• DASYLAB® software was used to collect all the data from 7 channels. Spike 2 software was used to analyze the data after it was filtered using the MATLAB coding.

Results
• Table 1 shows the physical characteristics of the participants.
• Sinusoidal waveform at each site was well-maintained (Figure 2).
• Compared to the vertical acceleration measured at the plate (0.32 ± 0.01 g, 33.4 ± 1.7 Hz), the resultant accelerations were greater at the distal tibia (0.41 ± 0.01 g, p < 0.001) and lower at the distal femur (0.24 ± 0.02 g, p < 0.001) (Figure 3).

Table 1. Physical characteristics of children with CP (n = 14)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD</th>
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</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>7.3 ± 2.0</td>
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<tr>
<td>Height (m)</td>
<td>1.2 ± 0.1</td>
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<tr>
<td>Height (%)</td>
<td>17.6 ± 22.8</td>
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<tr>
<td>Body mass (kg)</td>
<td>24.4 ± 9.4</td>
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<tr>
<td>Body mass (%)</td>
<td>35.4 ± 34.0</td>
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<tr>
<td>Leg percent fat</td>
<td>40.9 ± 11.0</td>
</tr>
</tbody>
</table>

Figure 1: Accelerometers at a) the distal femur, b) the distal tibia and c) the HLV platform.

Figure 2: Waveforms showing vibration acceleration at the HLV platform, distal tibia, and distal femur.

Figure 3: The graph on the left shows that the accelerations were significantly higher at the distal tibia and lower at the distal femur compared to the platform (*p < 0.001) when the platform was in the on condition.

Conclusion
The preliminary findings suggest that an HLV signal transmitted by a floor-based platform was amplified at the distal tibia and attenuated at the distal femur of children with mild spastic CP. The data from this study will be helpful in determining if the adaptation of bone in the lower extremity of children with CP to HLV is related to the amount of signal transmitted.

Reference

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