Effect of heel-up shoes upon gait of children with spastic diplegic cerebral palsy
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Introduction
Ankle foot orthoses are prescribed in children with spastic diplegia to improve ambulatory function. But sometimes wearing such orthoses is not comfortable for them while playing in school or kindergarten. It is very important for them to wear such orthoses fast and easily. So we use heel-up shoes to improve ambulatory function and they can be wore very easily. The purpose of this study was to determine the effect of heel-up shoes for children with spastic diplegic cerebral palsy. The clinical significance of study is the objective assessment of heel-up shoes effect upon gait performance using gait analysis.

Methods
Two children with spastic diplegic cerebral palsy (two females, age 5 and 7 years) participated in the study. Both patients were ambulatory. The subjects were asked to wear heel-up shoes with 3 cm wedge shaped wolletane board (Fig. 1). The data collection system was a five-camera Vicon 370 system, a Kistler force plates. Gait analysis tools were performed during initial normal shoes baseline and after heel-up shoes. Each subject walked at a comfortable and natural speed on the gait laboratory walkway.

Results
Heel-up shoes increased walking speed and decreased vertical excursion of COG and medial-lateral shear of GRF (Table 1 and Fig. 2). Moment analysis calculations revealed that there were differences at the knee, and the ankle during early and mid stance phase. A decrease was observed in the extensor moment at the knee and in the plantar flexion moment at the ankle, while wearing heel-up shoes (Fig. 3).

Discussion
The findings suggest that there is an improvement of balance control, during walking when using heel-up shoes. This may be responsible for increase of walking speed. It is not surprising children with cerebral palsy exhibit a mean center of pressure more anterior than healthy children, because of the propensity of the spastic condition to plantar flex the ankle and create more weight bearing on the forefoot. It might be expected that heel-up shoes would shift the position of the center of pressure posteriorly and the direction of the vector of GRF more anteriorly (Fig. 4). This may be attribute to decrease of these moment in the sagittal plane during early stance. Decrease of these moments leads to a reduction of spasticity generated by quadriceps, and ankle plantar flexors, which have commonly hyperaction during spastic gait.
Fig. 1

heel-up shoes with 3 cm wedge shaped wolletane board

Table 1

<table>
<thead>
<tr>
<th></th>
<th>case 1</th>
<th>normal shoes 1.045</th>
<th>heel-up shoes 1.054</th>
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<tbody>
<tr>
<td></td>
<td>case 2</td>
<td>normal shoes 1.133</td>
<td>heel-up shoes 1.151</td>
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<td>walking speed (meter per second)</td>
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<tr>
<td>vertical excursion of COG (cm)</td>
<td>case 1</td>
<td>normal shoes 3.6</td>
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<tr>
<td></td>
<td>case 2</td>
<td>normal shoes 3.9</td>
<td>heel-up shoes 2.5</td>
</tr>
</tbody>
</table>

Fig. 2

Black lines show medial-lateral shear of the GRF. Heel-up shoes decreased their excursion in both cases.
Fig. 3

**Case 1**

- **Normal shoes**
- **Heel-up shoes**

Yellow lines show ankle moments (plus direction - plantar flexion moment, minus direction - dorsiflexion moment). Red lines show knee moments (plus direction - flexion moment, minus direction - extension moment).

**Case 2**

- **Normal shoes**
- **Heel-up shoes**

Fig. 4

**Case 1**

- **Normal shoes**
- **Heel-up shoes**

**Case 2**

- **Normal shoes**
- **Heel-up shoes**

Yellow line shows the vector of GRF.