Background: Ankle braces are commonly utilized in ambulatory children with cerebral palsy (CP) to restrict excessive ankle plantarflexion during gait so as to improve toe clearance in swing, foot strike at initial contact and tibial translation throughout stance. Some active plantarflexion is desirable in late stance for propulsion. However, current “passive” ankle bracing strategies tend to totally block plantarflexion beyond neutral with some including a hinge to allow some ankle dorsiflexion during stance. It is being increasingly recognized that traditional bracing approaches may be too restrictive by blocking wanted as well as unwanted motions and thereby limiting functional capabilities and potentially exacerbating weakness over time. These also do not provide dynamic assistance to desired motions, such as ankle dorsiflexion during swing, when the patient lacks strength or motor control to accomplish this without assistance. The Adjustable Dynamic Response (ADR) ankle orthosis was designed to address previous limitations by “actively” augmenting dorsiflexion as needed in swing while restricting plantarflexion through variable resistance rather than a mechanical block.

Objective: To comprehensively and objectively evaluate performance of the ADR ankle orthosis during gait and balance tasks compared to barefoot, shoe inserts, and locked brace conditions.

Methods: A 12 year old boy with right spastic hemiplegia participated in this pilot investigation. He was given a custom-designed ADR ankle orthosis for daytime use and a nighttime dynamic stretching device. 3D kinematic, kinetic and EMG analyses and the Limits of Stability Test on the Neurocom were performed after he had worn the brace for several weeks.

Results: His fast gait speed improved by 0.2-0.3 m/sec in all brace conditions compared to barefoot with no appreciable differences among brace conditions. Both the locked and ADR braces improved sagittal plane kinematics by improving toe clearance and foot positioning for contact but the ankle curve was notably “flatter” in the locked brace. By allowing more dorsiflexion in stance, the ADR brace allowed better tibial progression, leading to greater knee and hip extension at mid-stance. Increased dorsiflexion in swing further educated compensatory ipsilateral hip flexion and contralateral hip abduction -circumduction. The first of two ankle peak moments in stance was markedly reduced with the ADR orthosis. However, the second peak did not increase as desired. Since plantarflexion resistance was set fairly high, no motion occurred at self-selected speed with slight motion at fast speed. Tibialis anterior EMG magnitude decreased during swing in the ADR brace, suggesting that assistance was more than was required. Instrumented balance parameters of reaction time, movement extent and velocity were best in the ADR compared to other conditions.

Conclusions: The ADR showed improvements over the traditional brace in this patient, consistent with design goals. Even though some adjustable parameters were not optimized here to encourage greater active dorsiflexion in swing and plantarflexion in stance, the concept of actively versus passively restraining and segmenting muscle actions is a promising approach that warrants greater study, development and implementation. Quantitative evaluation techniques may prove increasingly valuable when evaluating and modifying more dynamic bracing strategies, especially for more subtle or invisible effects (such as muscle activation).

Acknowledgment: The ADR and stretching brace were provided to the patient by Ultraflex. This research was funded by the Intramural Research Program at the National Institutes of Health Clinical Center.