Margins of Stability in Children with Cerebral Palsy Diplegia: Barefoot versus AFO Comparison

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INTRODUCTION

Research of children with Cerebral Palsy (CP) indicates poorer balance than normal (Hsue 2009). Ankle-foot orthoses (AFOs) are often prescribed to improve balance, but little research confirms their effectiveness. The use of the extrapolated center of mass in calculating the margin of stability (MoS) provides a more accurate measure of dynamic balance (Hof 2005). No studies have used this method to determine the effect of AFOs on the dynamic balance of children with CP diplegia using AFOs. This study attempts to do this.

METHOD

Subjects: Gait data from 191 children (129 male, 62 female) with CP diplegia were analyzed. These children were tested using their own bilateral custom molded thermoplastic AFOs, which were hinged, posterior leafspring (PLS) or solid ankle style.

Apparatus: Marker trajectory data were used to calculate the extrapolated center of mass (XCoM). The average normalized mediolateral (ML) and backward (BW) MoS were calculated at midstance and initial contact, respectively. Four pendulum lengths (calculated and measured leg length, maximum and midstance center of mass (COM) height) were compared to determine measure sensitivity. Normalization by leg length was examined.

Procedures: This is a retrospective analysis of gait data collected between 1994-2012 at Gillette Children's Specialty Healthcare Center for Gait and Motion Analysis as part of routine clinical care. This study received IRB approval.

Data Analysis: Data were analyzed using MATLAB. ANOVA with post hoc Tukey-Kramer test for significance, paired t-tests, and linear regressions were used for statistical analysis with significance level of $p < 0.05$.

RESULTS

Pairwise comparisons for each combination of MoS, pendulum, and AFO type were completed. Pendulum lengths differed from each other, but the resultant MoS did not. The MoS increased with subject height, but not when normalized by leg length. Comparisons of all subjects' AFO and barefoot normalized MoS indicated that the ML MoS was significantly smaller and BW MoS significantly greater with AFO use for all subjects. When repeated for each AFO type, similar results were found for BW, but not ML, MoS.

DISCUSSION

The MoS is a robust measurement that is not sensitive to the pendulum length used. This indicates that studies are comparable. Although previous studies of adults did not normalize the MoS, this study found that it was necessary for children.

Smaller ML and larger BW MoS were observed. Since a significant difference was found for all subjects', but no AFO subgroups', ML MoS and because the order of magnitude was millimeters, this is not likely a clinically meaningful result. The difference is likely due to the large subject pool. The increase in BW MoS with AFO use is considered clinically significant as the effect was seen for all comparisons and the order of magnitude is centimeters. The BW Mos is important when transitioning weight from one limb to the other for fall avoidance. A future prospective study that standardizes the AFO prescription and fabrication, as well as footwear is necessary to determine the cause of this change. The authors are currently examining the barefoot MoS for typically developing children to deterine whether or not the increase in BW MoS is bringing the children with CP closer to normal.

CONCLUSION

The MoS is resilient to pendulum type used and requires normalization. An increase in BW, but not ML, MoS was observed with the use of AFOs for children with CP diplegia.

CLINICAL APPLICATIONS

AFOs appear to increase the BW MoS or room for error that children have in the anterior-posterior direction, which may allow them to better adapt to perturbations while walking and thereby reduce falls.

REFERENCES

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