ANALYSIS OF FOOT MOTION AND LOADING IN HEALTHY CHILDREN DURING GAIT

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INTRODUCTION

The foot is a complex structure with movement occurring at 23 joints, as well as within the toes. At present, most locomotor models consider the foot to be one rigid structure, with no relative movement within it. This simplified model is inadequate when examining the effect of surgical treatment within the foot. Ninety percent of children with cerebral palsy develop some form of foot deformity. An understanding of normal foot motion is vital in planning treatment and rehabilitation for these patients, in order to determine objectively whether the treatment has been successful or not. This study examined 10 healthy children to define normal movement within the foot and assess repeatability of measurement, using 3D motion capture, force plate and pressure platform measurements.

METHODS

Ten healthy children (mean age 9.1, SD 1.7 years) were examined on 3 occasions, at either 6 monthly or 2 weekly intervals (to assess the effect of time). Each subject had 14 markers placed on the foot and shank at specific anatomical landmarks, according to the model developed by Carson et al. (2001). This allowed motion during gait to be measured in 3 segments: the tibia, hind foot and fore foot. Data was also collected from a pressure platform mounted on, and time synchronized with an AMTI force plate. The footprint was divided into 5 sub-sections using a novel approach, which utilised the position of markers on the foot, Giacomozzi et al (2000) (Figure 1). Data from 3 trials for each visit were averaged, and then compared for repeatability. Normal ranges for each variable were established. Peak pressure and time to peak pressure were recorded for the total foot and each of the sub areas. Data from patients with hemiplegic cerebral palsy were also collected and compared to healthy data.

RESULTS AND DISCUSSION

Initial results (based on 7 subjects) show variables extracted from kinematic traces of foot motion have good repeatability between visits, with 95% confidence ranges between 5^0 and 15^0 in the sagittal and coronal planes. This was found to be adequate to distinguish common CP foot deformities from normal foot motion and to detect abnormal alignment within the foot (Figure 2).

There has been some work to date on modelling the foot, but very little to establish the validity and precision of such measurements. Carson et al (2001) performed repeatability analysis on foot kinematics, however, the study included only 2 adult subjects. The current research includes a population of 10 subjects. The model was tested for its accuracy in testing children (both healthy, and with various forms of foot deformity). A number of adaptations were made to Carson's model, to improve accuracy in measurement.

More subjects are currently being assessed to verify the repeatability of the results and to determine which variables are the most reliable in order to assess the effects of treatment. The approach to dividing the foot into sub-areas (to assess pressure distribution) based on marker position was found to be effective across the healthy population.

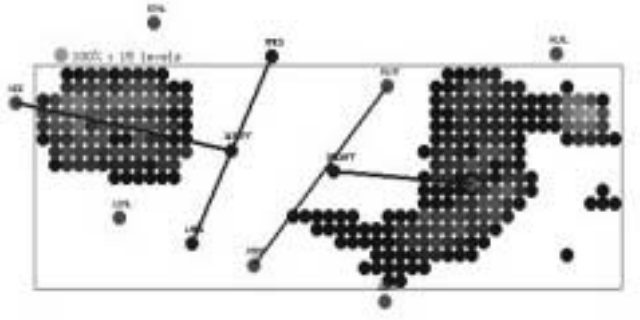

Figure 1: Plantar pressure distribution, with subdivision of the foot into 5 areas based on the position of foot markers.

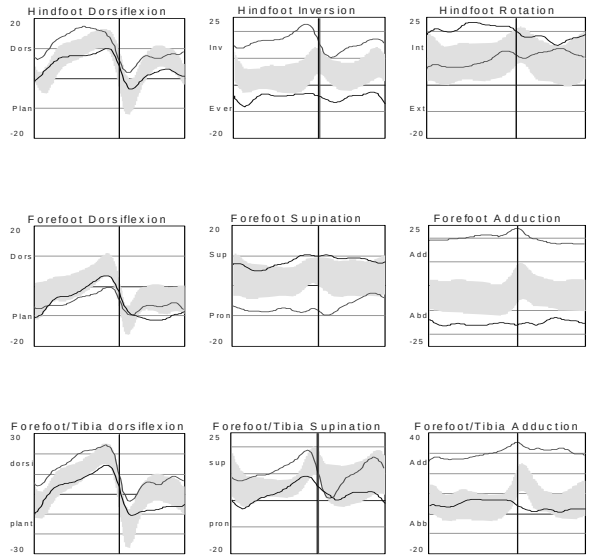

Figure 2: Comparison of normal foot motion, defined from healthy children (grey band), and typical CP foot deformities. The dashed line shows data from a child with a cavo-varus foot deformity, while the solid line is for a child with a planovalgus foot.

SUMMARY

This study focused on evaluating a model for measuring motion within the foot that may be applied to children with foot deformity. The integrated kinematic, kinetic and plantar pressure information provides a detailed description of healthy patterns of foot mechanics.

REFERENCES

Carson M.C., et al (1998). *J. Biomechanics*, **34**, 1299-1307.
Giacomozzi C. et al. (2000) *Med Biol Eng Comp*, **38**, 156-163.