

COORDINATION PATTERNS IN CHILDREN WITH SPASTIC DIPLEGIA: PRE-, 1- AND 5-YEARS POST-OPERATIVE

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INTRODUCTION

Spastic diplegic cerebral palsy (CP) is often characterized by excessive hip and knee flexion and ankle plantar flexion. This leads to impaired coordination and coupled lower extremity motion patterns known as the "extension synergy", which can negatively influence gait and stability (Thelen, *et al.*, 2003). Surgical lengthening of the affected biarticular muscles can produce joint angle profiles similar to those in healthy children. However, over time post-surgery, CP children tend to revert back to a crouched gait with increased knee flexion due to spasticity in the hamstrings and the constant pull from gravity. The majority of literature on CP gait focuses on the kinematics of the hip, knee and ankle and not the interactions between the joints. The purpose of this study was to examine intra-limb coordination patterns pre-operatively and approximately one- and five-years post-operatively.

METHODS AND PROCEDURES

Five (4 males, 1 female; age 7.33 (1.86) years at first surgery) children with spastic diplegia all underwent surgical procedures bilaterally to transfer the rectus to the sartorius and lengthen the hamstrings and heel cords. Surgeries were not limited to these three procedures; however, no orthopaedic surgeries were performed. Three-dimensional kinematic gait analyses were collected pre-operatively and approximately one- (1.17

(0.79) years) and five-years (6.19 (1.75) years) post-operatively as subjects walked through the collection area without assistive devices and at their preferred speed. Sagittal plane hip, knee and ankle joint angles for the right and left legs were calculated during the stance phase of gait, normalized to 100 data points and averaged within a subject. The angular position of the hip relative to the knee, and the knee relative to the ankle were graphed and a vector coding approach (Heiderscheit, *et al.*, 2002) was applied to assess frame-by-frame changes in coordination. Vector angles (γ) were grouped in bins in Table 1 to classify coordination.

Proximal	$0^\circ \leq \gamma \leq 22.5^\circ$; $157.5^\circ < \gamma \leq 180^\circ$
Distal	$67.5^\circ < \gamma \leq 112.5^\circ$
In-phase	$22.5^\circ < \gamma \leq 67.5^\circ$
Anti-phase	$112.5^\circ < \gamma \leq 157.5^\circ$

Table 1. In-phase is flexion/extension of both joints; anti-phase is flexion of one joint and concurrent extension of the other; proximal signifies change in the proximal joint angle relative to a stationary distal joint angle; distal signifies the distal joint changing angle relative to a stationary proximal joint angle.

RESULTS

Surgical lengthening of biarticular muscles crossing the hip, knee and ankle did not show a major change in the coordination between the hip and knee during stance but a clear shift in the coordination pattern is seen between the knee and ankle (see Figures 1 &

2). The angle between two points can be grouped into the bins in Table 1 to quantify coordination.

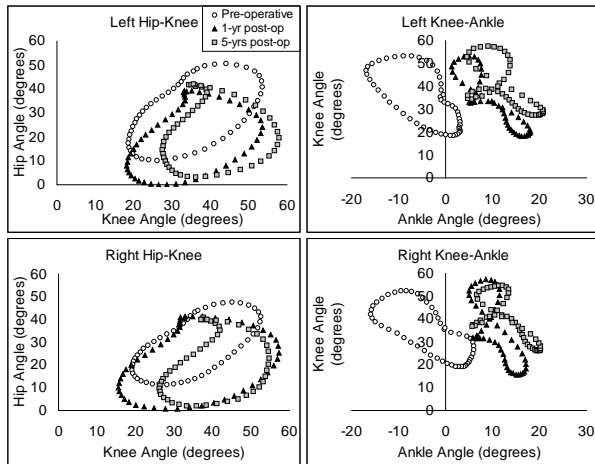


Figure 1. Mean intra-limb coordination patterns pre-operatively, 1- and 5-years post-operatively in children with spastic diplegia.

Subjects did not show a major shift post-surgery in percent stance spent in each coordination pattern. Figure 2 displays that no single pattern predominated between the hip and knee but the knee spent almost half of stance either flexing or extending while the ankle joint did not change.

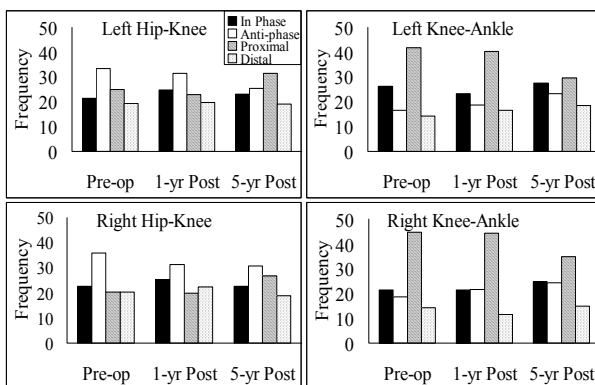


Figure 2. Frequency of occurrence of the different coordination patterns during stance.

DISCUSSION

Previous studies have found changes in coordination patterns post-operatively in children with spastic diplegia using

correlations between joint actions as the coupling parameter (Baddar, *et al.*, 2002). Analysis using vector coding showed a clear change in the shape of the coordination patterns, particularly between the knee and ankle, post-operatively. We expected that the improvements post-surgery towards a more “normal” gait pattern would decrease the amount of concurrent hip and knee flexion and ankle plantar flexion; however, the percentage of in-phase coupling across the stance phase remained stable after surgery. The “in-phase” coordination characteristic of CP gait is actually a combination of all four different types of coordination. The type of coordination did not change with surgery or over time and no single pattern was preferred post-surgery.

SUMMARY

A vector coding approach quantified coordination changes in children with spastic diplegia, one- and five-years post-surgery. Surgical lengthening of the hamstrings, rectus femoris and gastrocnemius improved range of motion and altered the shape of the coupling pattern between the knee and angle, in particular. Future clinical treatments for CP may establish procedures to remedy the synergistic activity of the lower extremity musculature while maintaining healthy joint motion.

REFERENCES

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