Effects of simulated healthy gait patters in children with idiopathic torsion deformities

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Introduction: Femoral and tibial torsional deformities are a common cause of pain even in individuals with otherwise healthy (i.e. idiopathic torsion deformities) [1]. Individuals with idiopathic torsion deformities often present with abnormal gait patters and increased joint contact forces (JCF) compared to controls [2]. However, it remains unclear if the increased JCF are a result of bone deformities or altered gait patterns.

Research question: (1) How does pathological gait patter affect joint contact forces in children with idiopathic bone deformities?

Methods: Magnetic resonance imaging scans, three-dimensional gait kinematics, and ground reaction forces were recorded from 5 children idiopathic femoral and tibial deformities and 5 age, weight, and height matched children with normal bone morphologies. We created patient specific musculoskeletal models for the partictipants with torsion deformities [3]. For each model, joint kinematics, net joint moments, muscle forces, and JCF during self-paced overground walking were calculated in OpenSim [6] using two input datasets: 1) the patient-specific gait data, and 2) the matching control gait data. Resultant peak hip and knee JCF were compared between the patient-specific and control gait patterns.

Results: Fig. 1 shows the mean and individual peak hip and knee JCF during walking for each participant. The simulation of healthy gait did not change peak hip JCF when compared to those during pathological gait (mean difference = 2% (95% CI: -24%to 28%). Simulating healthy gait resulted in a decrease in knee JCF in 4 of the 5 participants (mean difference = -14% (95%CI -41 to 12). Mean walking speed differed from pathological gait when healthy gait was simulated (-34% to 50%).

Fig. 1. Mean peak hip (left) and knee (right = . Peak values for individual trials are represented as grey dots. P01 and P02 walked with pathological in-toe gait and P03, P04, and P05 walked with a pathological out-toe gait.

Discussion: In this study we evaluated how a healthy gait pattern would change hip and knee contact forces in children with idiopathic torsion deformities. Results from this exploratory study showed an increase in hip JCF in 3 children and a decrease in knee JCF in 4 children. These preliminary results suggest that the larger JCF previously reported in individuals with idiopathic bone deformities [2] may be a result of the bone deformities and the altered gait pattern may not reduce joint loading. However, differences in JCF could be a result of different gait speeds between pathological and simulated healthy gait, and results warrant further investigations.

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Smart technology intervention to retrain gait in children with idiopathic toe walking

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Introduction: Approximately 5% of 6-year-old children demonstrate idiopathic toe walking (ITW). Children with ITW demonstrate limitations in balance and function.[1,2] Currently, there are no interventions for ITW harnessing feedback during rehearsal of a heel strike in the natural environment.

Research question: Could immediate and summary feedback in the natural environment retrain heel strike in children with ITW?

Methods: Fourteen participants (mean age = 10.3 years (SD 2.9), 10 M/4 F) diagnosed with ITW were evaluated prior to intervention (W0), following 12 weeks of intervention (W12) and 10 weeks-post intervention (P10) on parent report of toe walking (TW%), maximum dorsiflexion range (maxDF), sensory organization test (SOT), and 3D gait analysis. During a 12-week intervention phase, each child used a smart system which included a shoe insert with a haptic vibrator providing immediate feedback after toe strikes and a phone App which provided summary feedback for the user and parent on frequency of toe versus heel steps. A mixed effects linear model was used for analysis.

Results: Thirteen of 14 participants logged a mean of 229,491 steps (range 107,041-396,967 steps) over 57 mean days (range 30-81 days). One participant logged 3 days (6851 steps) use secondary to limitations in shoe fit. All 14 participants were included in the analysis. Parents reported % toe walking significantly decreased ($p < .001$), while MaxDF significantly increased ($p = 0.004$). SOT total scores demonstrated a non-significant increase ($p = 0.11$). Significant differences were observed in the gait analysis between measurements at W0 and W12 with no significant difference between W12 and P10, including increase toe clearance ($p < 0.001$), increased ankle dorsiflexion at heel strike ($p = 0.006$), increased dorsiflexion during swing ($p = 0.005$), and an increase in height of the lateral 5th metatarsal compared to the heel ($p = .009$). No significant differences were found in stride length, stride time or