

FUNCTIONAL DEFICITS IN THE NON-OPERATIVELY TREATED SKELETALLY MATURE CHILD WITH CLUBFOOT: MOVEMENT QUALITY ASSESSMENT USING ACCELEROMETRY DATA

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INTRODUCTION

A nonoperative treatment paradigm for children with clubfoot is widely accepted as a standard course of care. Functional outcome assessments of children treated primarily nonoperatively have been performed using various technologies including three-dimensional gait analysis, pedobarography, objective strength measures and community ambulation [1]. Advancements in technology, including highly sensitive accelerometers, have broadened the capabilities of researchers to further investigate functional outcomes and gather in-depth assessments on sided differences and overall movement mechanics (quality) in both healthy children and those with a physical disability [2]. When utilizing a dynamic agility test to assess movements and overall function, integrating accelerometry data in these assessments could be a useful tool to researchers. Children with clubfoot who remained non-operative at 10 years of age have been shown to have deficits in sagittal plane ankle ROM and push-off power during gait [1]. The question remains whether these non-operatively treated children at skeletal maturity have sided differences when asked to perform a dynamic agility task and whether ankle plantarflexion/dorsiflexion strength influences the quality of movement during the task.

CLINICAL SIGNIFICANCE

At skeletal maturity, children treated nonoperatively for clubfoot may show deficits in ankle strength which may translate to poorer movement quality during a sport specific dynamic agility task.

METHODS

As part of this prospective IRB approved study, isokinetic strength and performance during the Edgren Side Step Test (modified) were collected at 16 years of age in unilateral patients treated nonoperative (NO) for idiopathic CF (surgically treated and bilateral patients were excluded). Isokinetic dorsi- and plantar-flexion strength were collected in the prone position (Biodex, NY, USA). Five consecutive trials were collected and the maximum effort on each side (peak torque, N-m/kg) was used for analysis. Each child performed a modified version of the Edgren Side Step Test (mESST) which incorporates lateral coordination, power, speed and agility. This modified protocol allows for time-based assessments of the functional demand on the leg rather than a singular distance-based evaluation. At the “go” command subjects side stepped laterally across 4-meters toward the opposite end-line, quickly gathered themselves and side stepped laterally in the opposite direction. “Down-and-back” was counted as one repetition and this was performed three times. If the individual did not touch the end lines, did not maintain their trunk and pelvis positions parallel to the path, or crossed their legs during the test, the trial was deemed unsuccessful. Subjects were given three attempts and the fastest successful trial was used for analysis. To determine time based metrics and sided movement patterns, an Actigraph GT3X accelerometer (Pensacola, FL, USA), sampled at 100 Hz, was worn above the lateral malleolus of each ankle. The acceleration signals were plotted to determine each pass and foot contact/off events at the end of each repetition

were identified using previously established methods [3]. The overall time of the attempt was calculated for each repetition, and the Split time (travel time between end lines) and Lag time (transition times at the end lines) were also calculated based on the lead foot. Leg movement was assessed by calculating the peak acceleration (peak G), integral of the vector magnitude of acceleration signal in the frontal/mediolateral planes (VMag Int) and stride frequency (Stride Freq). Side to side differences were analyzed by separating the accelerometry data based on whether the movement was driven by the affected and unaffected sides and an average of the measures (time/accelerometry measures) was taken. Signed rank test were performed comparing the affected (Aff) to the unaffected side (unAff). Spearman rank correlations were performed between isokinetic ankle strength of the affected and unAff sides and the time/accelerometry measures. Alpha was set to 0.05.

RESULTS

17 non-operatively treated unilateral clubfoot patients were tested. The affected side had significantly weaker dorsi- and plantarflexion strength when compared to the unAff side ($p < 0.001$). There was no significant difference in Split, Lag time, Peak G or Stride Freq between sides ($p > 0.05$). VMag Int was significantly higher on the affected side (Aff 168.7 vs. 156.9, $p = 0.04$). unAff feet with greater plantarflexion had a quicker overall time on the test ($\rho = -0.669$, $p < 0.01$), quicker Split time ($\rho = -0.655$, $p < 0.01$), higher Peak G ($\rho = 0.532$, $p = 0.03$) and higher VMag Int ($\rho = 0.581$, $p = 0.01$). Greater affected side plantarflexion strength correlated with a quicker Lag time ($\rho = -0.620$, $p < 0.01$) indicating less time was needed to change directions at the end-lines of each pass.

DISCUSSION

Children with unilateral clubfoot who remained nonoperative by skeletal maturity did not appear to show a significant amount of sided differences in time/accelerometer measures when performing a sport specific dynamic agility test, though sided differences in ankle strength were observed. Interestingly, the affected limb adopted a strategy where velocity (VMag Int) was sustained, while traveling between end lines to maintain a similar split time, as compared to the unaffected limb.

Correlations to ankle strength were mainly observed in the unaffected feet as greater strength in those feet resulted in better performance on the agility test and greater movement quality. Integration of accelerometry measures during agility testing further enhances the functional assessment of children treated for clubfoot and allows a more in-depth movement profile that could help describe functional deficits and the relationship to ankle strength. Movement quality can now be quantified outside of the typical lab environment as accelerometry measures provide information on leg movement that have an association to the preservation of ankle strength. Further work is necessary to utilize accelerometry data to describe the movement profile of children with clubfoot across the treatment outcome spectrum (poor/good outcomes; nonoperative/surgical feet).

	unAff PF		Aff PF	
	ρ	p-value	ρ	p-value
Overall time	-0.669	<0.01	-0.439	0.08
Split time	-0.655	<0.01	-0.216	0.41
Lag time	-0.437	0.08	-0.620	<0.01
Peak G	0.532	0.03	0.338	0.18
VMag Int.	0.581	0.01	0.422	0.09
Stride Freq.	0.108	0.68	-0.123	0.64

Table 1. Spearman rank correlations between plantarflexion strength (PF) and time/accelerometer measures for unilaterally affected clubfoot patients evaluating their unaffected (unAff) and affected (Aff) sides.