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What Gait Analysis Tells us About Clinical Examination of Spastic Gait in Children.

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Abstract

Data from computerised gait analysis in the important stance period of spastic and normal walking are compared. This data is interpreted in the context of clinical examination of walking in a child with Cerebral Palsy.

Method: Stance period measurements of unaided walking in 33 children with spastic CP are compared with 20 normal measurements.

Results: Spastic gait is characterised by shorter stride length, excessive knee flexion and increased side to side forces in stance. Though walking speed was significantly slower, time spent on one leg and maximal hip and ankle movements are not significantly different within each walking cycle.

Discussion: Spastic gait affects side-to-side stability and knee extension during stance. These are key clinical observations to be made when a child with spastic CP walks into the consulting room. As the key muscles in this phase are the antigravity hip and knee extensors, this observation can lead to practical interventions as well (e.g. hip and knee extensor strengthening).

Key messages: Spastic gait affects side-ways stability and knee extension during the period of walking cycle when the body is on one leg. Identifying this as the child walks in provides the clinician with specific goals for intervention.

Introduction

Computerised gait analysis is useful in the individual child with Cerebral Palsy (CP) [1-5] and is helpful in planning interventions in spastic gait [3, 4, 6-9], but is expensive and often inaccessible. It is prone to providing the clinician with information overload. But gait analysis provides clinicians with useful patterns [10,11].

This report interprets the results of gait analysis for clinical examination. The clinician can put gait patterns identified by gait analysis to clinical use by looking for these key events in gait while observing a child walking into his consulting rooms. Therefore we present a selection of gait deviation measurements to improve clinical skills of examination of spastic gait.

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Methods

Ambulant 5 to 15 year old children with spastic CP - both diplegia and hemiplegia - who presented to the outpatient clinic of Physical Medicine and Rehabilitation over a period of four years were consecutively selected for this study at the completion of their gait training program after obtaining consent. They were evaluated clinically and gait was then recorded by videographic and instrumented gait analysis methods.

Similarly, 6 to 14 year olds without gait abnormalities who volunteered to undergo gait analysis from a neighbouring community were evaluated.

Equipment used was Selspot's kinematic system, Kistler's 500 mm^2 force plate and Motion Labs' MA100 dynamic EMG system. Selspot measures *kinematic* data (stride length, stride time, percentage of stance and swing, walking speed, degrees of individual joint movements) using 3 infrared video-cameras to record from 8 infrared LEDs placed over bony markers on the leg. The force plate concealed in the walkway measured *ground reaction forces* in vertical, forward and lateral directions from the single foot strike made by the subject on it. Walking *EMG* recordings from 4 muscle pairs were collected by surface electrode preamplifier units but this data is beyond the scope of this brief report.

Statistical analysis was done using the Student t test with unequal variance and the Chi-square test using SPSS and MS Excel software.

Results

34 children with spastic CP, 22 with diplegia and 12 with hemiplegia were selected. Data was collected from 49 limbs. 20 collections were taken from lower limbs of the 20 normal child volunteers. There were 4 dropouts from the CP group: one due to presence of ataxia, one due to poor quality of gait recordings and two due to corruption of stored data.

The age and sex distribution of both groups were not significantly different. The mean height of CP children (132 cm) was significantly higher than the normals (111 cm; p=0.016). Despite this, the normalised stride length and walking speed in CP children was significantly lower than the normal children (0.005 Vs 0.008; p=0.000).

The knee could only reach 15 degrees short of full extension in stance in spastic gait while managing

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(Simulated pictures for demonstration)

significantly more (2 degrees short of full extension; p=0.003) in normal children's group. Analysis of ground reaction forces showed that while there was no difference in vertical and forward forces, there was a significant increase in normalized lateral forces (77% vs. 33%; p=0.000). There was a significant slowing down of walking speed (36 vs. 48metres/minute; p=0.011) which correlated with decreased stride length (65 vs. 84cm; p=0.006) but not affecting the proportion of time spent in stance or single limb support (33% vs. 39%; p=0.039).

TABLE 1: Stance data of spastic and normal gait

	Gait Parameter (Mean; Std deviation)	***CP children***	***Normal children***	***P***
1.	Age (years)	10+ 4	9+2	0.97
2.	Sex(M:F)	23:11	14:6	0.85
3.	Height (cm)	59+ 67	100+46	0.015*
4.	Stride length (m)	0.65+0.25	0.84+0.18	0.006*
5.	Normalized stride length (by height)	0.005+0.002	0.008+0.002	0.000*
6.	Walking speed (m/min)	36+18	48+15	0.011*
7.	Single limb stance % of walking cycle	33+11	39+11	0.039
8.	Stance % of walking cycle	58+11	55+9	0.184
9.	Maximum hip extension in stance (degrees)	4 flexion+14	1.5+ 6	0.09
10.	Maximum knee extension in stance (degrees)	15 flexion+ 17	2 flexion+3	0.003*
11.	Maximum ankle plantarflexion in stance (degrees)	9+12	13+ 9	0.23
12.	Normalised Vertical ground reaction forces (% body weight)	104+37	109+32	0.573
13.	Normalised forward ground reaction forces (% vertical force)	12+6	16+7	0.029
14.	Normalised lateral ground reaction forces (% forward force)	77+46	33+20	0.000*

* Statistically significant differences

Discussion

In the walking cycle, the lower limb is most challenged when it is supporting the body (stance) and especially when it is doing so alone, without the support of the other limb – the single limb support phase of stance (SLS). That is why this report targets this phase of the walking cycle. In spastic gait, an attempt to maintain the time spent in this phase is observed. However this time is maintained at the cost of the way the limb copes during stance i.e. there is a decrease in stride length, knee extension and increased lateral forces (more simply put - a wobbly or side to side force). Interestingly, there is no significant effect on sagittal angles of the spastic hip and ankles in stance.

These findings would direct the clinician's eye away from the side view of the hip to the front or back view of the pelvis to observe sideways instability in single limb stance.

If there is a sideways instability observed in the single limb support phase of stance, as evidenced by excessive swaying or dropping of the pelvis, the clinician would target the glutei muscles for strengthening and the adductor muscles for decreasing spasticity.

Also, the results of this study directs the clinician's eye away from the side view of the ankle towards the side view of the knee, to observe inadequate extension in single limb stance. If discovered, the goal would be to strengthen the knee extensor muscles and decrease spasticity in the knee flexors.

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