DETERMINANTS OF GAIT: APPLIED TO CHILDREN WITH CEREBEL PALSEY

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INTRODUCTION

Saunders, et al. defined pelvic rotation, pelvic obliquity, and single support knee flexion as the three major determinants of gait that serve to minimize and smooth the vertical displacement of the center of mass (CoM). Recent research has modified our understanding of the relative contributions of these determinants on CoM vertical motion. Della Croce, et al. defined 5 new determinants: ipsi-, contra-lateral knee flexion, and heel rise at CoM minimum and leg inclination, and heel rise at CoM maximum, to more completely explain the deviation (both increasing and decreasing) of vertical excursion from compass gait values.

In the present study we quantified the isolated contributions of the above 8 determinants of gait on the vertical CoM displacement of both normal and spastic children. The role of the above 8 determinants of vertical excursion have never been examined for children or children with cerebral palsy (CP). We hypothesized that the relative contributions of the determinants to vertical CoM excursion of children with CP would be the same as the age-matched controls because the children with CP are employing the same movement strategy as the controls, but are unable to execute it with the same effectiveness.

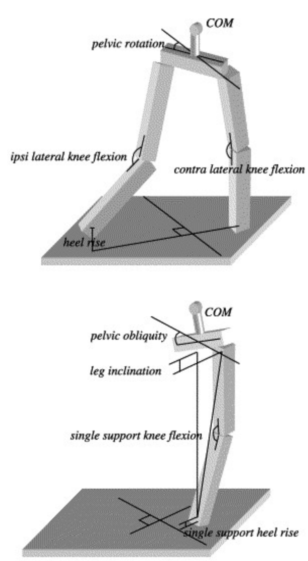

Figure 1. Model 1(above)
Model 2(below)

METHODS

The kinematic data of 23 children was collected and analyzed. This group consisted of two populations; age-matched controls without known musculoskeletal, neurological, cardiac, or pulmonary pathology. The second group consisted of children diagnosed with spastic diplegic CP. These subjects were community ambulators that did not use walking aids. Subjects walked at their self-selected comfortable walking speed while 3-D kinematic data was collected.

The effect of each determinant of gait was computed using the method described by Della Croce. This method employed two models; 1) a modified compass gait model (Model 1, Figure 1) applied at the instant of time of minimum CoM height, and 2) a simpler model (Model 2, Figure 1) was used to evaluate the decrease of the maximum CoM height. For each trial the model geometry was defined using the 3-D position of each joint center determined from a subject's kinematics at the instant of CoM excursion extrema. The isolated contributions of an individual determinant were computed and normalized by the total vertical excursion.

RESULTS AND DISCUSSION

Typical of previous research, when asked to walk at their self selected comfortable walking speed the control group had a longer step length and greater speed. Despite walking with longer step lengths the controls also experienced less vertical excursion when normalized by the predicted compass gait excursion.

The average determinant positive (beneficial) and negative (detrimental) contributions in reducing the total vertical CoM displacement computed using the two models are recorded in Table 1. At CoM minimum excursion ipsi- and contra-lateral knee flexion both resulted in an exaggerated increased in CoM excursion for the CP group, both pelvic rotation and heel rise resulted in similar (across groups) reduction in total CoM excursion. The maximum CoM height occurred during single support when leg inclination reduced total CoM excursion for the CP population than the control group. Single support heel rise was also had a different effect on the two groups increasing the total CoM excursion more in the CP subjects than for the controls.

SUMMARY/CONCLUSIONS

The similarities in the determinants effect on gait between the Controls and adults reflect that children of this age walk with a mature gait. When applied to subjects with CP the determinant analysis found similar, but slightly exaggerated effects of those of the Controls. All determinants that negatively affect CoM excursion were significantly worse in the children with CP, while those determinants that decreased excursion were just as effective in the children with CP as in the Controls. The main cause for increased vertical excursion of the CoM in the children with CP was the increased knee flexion of both legs during double support. This excessive lowering of the CoM means that extra work is done to raise the CoM over the single support leg. The situation is aggravated by the fact that the CoM was lifted higher than typical because of the heel lifting during single support. The only determinant that had a positive effect and was greater in the children with CP was leg inclination. It is unlikely that this results in a reduction in metabolic cost because the delay in CoM maximum height reduced the effectiveness of energy transfer between kinetic and potential forms, a major energy conserving mechanism in walking (Bennett 2004).

Although these determinants provide some useful information for gait they are limited in their ability to quantify the dynamics and kinetics of gait gait that are important for individuals with walking disabilities.

REFERENCES

Bennett,B. et al (2004), *J Sport Ex Psyc*, **26**, S32-33

Della Croce,U (2001), *Gait & Posture*, **14**.2, 79-84

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Table 1. Determinants of Gait: Normalized paramaters of gait. Step length normalized by leg length, Excursion normalized by predicted compass excursion, determinants normalized by measured excursion.

		CP	Control	P <
		avg ± std	avg ± std	
	Step Length	70.6 ± 7.2	84.1 ± 8.9	0.0023 *
	Excursion	86.08 ± 18.7	52.1 ± 7.9	0.0005 *
M	ipsi lateral knee flexion	-54.9 ± 34.0	-23.6 ± 8.5	0.0269 *
I	contra lateral knee flexion	-45.9 ± 16.7	-17.9 ± 17.1	0.0219 *
N	pelvic rotation	28.8 ± 7.7	41.6 ± 13.5	0.0767
	heel rise	87.4 ± 15.8	83.7 ± 17.7	0.5850
M	single support knee flexion	29.6 ± 24.4	17.8 ± 14.6	0.3335
A	leg inclination	37.0 ± 25.1	16.5 ± 7.2	0.0430 *
X	pelvic obliquity	1.9 ± 4.9	-0.8 ± 4.5	0.3176
	single support heel rise	-28.9 ± 27.6	-4.7 ± 10.0	0.0183 *