

CENTER OF PRESSURE MEASURES PREDICT HEMIPARETIC GAIT VELOCITY

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INTRODUCTION

Stroke is the leading cause of disability in the US, leaving two-thirds of survivors with abnormal motor function, including hemiparetic gait. Gait velocity is commonly used to assess locomotor function in this population, though velocity alone provides only a general index of function (1). A more detailed description of hemiparetic gait can be derived from center of pressure (CoP) time series measurements taken at each foot during the gait cycle. These measures may reflect aspects of the underlying motor control for walking and have been used to characterize asymmetries in hemiparetic gait (2). The goal of this study was to identify paretic and nonparetic foot CoP characteristics that may have a predictive relationship with the global functional measure of gait velocity.

METHODS

Thirty-three chronic stroke survivors > than 6 months post-stroke (10 female; 22 with left hemiparesis; mean age 67±10 yrs) were evaluated during walking at a self-selected speed on an instrumented gait mat (GaitRite®, CIR Systems, Clifton, NJ, USA). Patients wore pressure sensitive shoe insoles (Pedar®, Novel, Munich, Germany) and completed 15 steady-state gait cycles (five from each of three trials). Walking velocity and center of pressure parameters were measured during each cycle. Multiple regression analyses were used to model 58 CoP and symmetry parameters as predictor variables of gait velocity in all possible combinations. For the final model, parameters were evaluated using an adjusted regression model with $\alpha \leq 0.05$ and independence defined as a Variance Inflation Factor <10.

RESULTS

Table 1 shows the intercept and 11 parameters used to construct the final model, including bilateral variability of CoP mean location and displacement in anteroposterior (A-P) and mediolateral (M-L) directions, bilateral peak force, variability in stance time symmetry, and variability in CoP path length symmetry index. All parameters in the resulting final model contributed significantly and independently to the prediction

of gait velocity. CoP and symmetry parameters in this model accounted for a large portion of the variance in hemiparetic gait velocity ($R^2_{adj} = .90$), showing strong predictive ability in this group of patients with chronic stroke.

DISCUSSION AND CONCLUSIONS

In the present study, 8 of the 11 variables used to predict hemiparetic gait velocity were derived from CoP time series. In addition, the relationships between the variability of the CoP parameters to gait velocity suggest a connection to motor control deficits at the foot and ankle during hemiparetic stance in both limbs. For example, velocity is positively related to variability of the nonparetic mean M-L CoP location, but is negatively related to the variability of A-P CoP location. Thus increased walking velocity may improve consistency of loading related to nonparetic dorsi-plantar flexor control, but it simultaneously introduces less predictable loading through the range of inversion-eversion. This latter effect is underscored by increasing ranges and variability on M-L loading of the paretic foot. The notion of improved motor control with higher velocities is also supported by the decreased variability in the symmetry ratio of paretic-to-nonparetic stance times, an indication of more consistent interlimb patterning. The significance of these results is that foot CoP measures not only successfully index functional locomotor status, but they may also be useful in determining adaptive mechanisms of recovery associated with specific therapeutic interventions.

REFERENCES

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Table 1: Multiple regression results from combined paretic and nonparetic parameters to predict velocity.

Final Model	Parameter Estimate	Standard Error	t value	Pr > t	Variance Inflation
Intercept	88.34	10.15	8.70	< 0.01	0
Max M-L Paretic CoP displacement	0.86	0.17	5.14	< 0.01	1.73
SD Max M-L Paretic CoP displacement	2.09	0.96	2.18	0.04	1.65
SD Max A-P Paretic CoP displacement	-0.53	0.21	-2.55	0.02	1.90
Mean Peak Force: Paretic Foot	-0.06	0.01	-5.39	< 0.01	5.29
Mean A-P Location: Paretic CoP	-0.19	0.06	-3.25	< 0.01	1.63
Mean Peak Force: Nonparetic Foot	0.07	0.02	4.14	< 0.01	5.58
Mean Nonparetic Stance Time	-44.97	3.88	-11.58	< 0.01	1.45
SD Mean M-L Location: Nonparetic CoP	7.45	1.26	5.92	< 0.01	1.19
SD Mean A-P Location: Nonparetic CoP	-0.92	0.32	-2.85	< 0.01	1.26
SD Symmetry Ratio of Stance Time	-9.60	3.19	-3.01	< 0.01	1.35
SD Symmetry Index of Total CoP Path Length	0.40	0.08	5.01	< 0.01	1.49