cently been shown, in right-handed individuals, using magnetic resonance imaging, that there is no difference in activation of the left motor cortex between ipsilateral and contralateral upper-limb finger movements.\(^8\)

These findings suggest that the left hemisphere may have a more general role in motor control related to the precise temporal sequencing of complex actions.\(^9\) The apparent poor sequencing of the stance-limb force impulse could therefore be a reflection of left-hemisphere damage. Further, the documented deficit in weight transfer to the ipsilesional side may be a reflection of the left hemisphere’s more general contribution to the control of complex actions. I would be interested in seeing these results replicated in a group of individuals with right cerebral hemisphere damage. There are simple clinical screening tests that could be used to rule out the presence of spatial-perceptual deficits in these subjects.\(^10\) Such a demonstration would provide more support for the generalizability of these results.

This commentary raises several issues of concern; however, the contribution of this work to the clinical literature should not be underestimated. Clinical researchers need models of systematic inquiry that serve to inform clinical decision making and challenge untested assumptions. Pai and colleagues have provided such a model and should be congratulated for their significant contribution.

Carolee J Winstein, PhD, PT
Assistant Professor
Department of Biokinesiology and Physical Therapy
University of Southern California
Los Angeles, CA 90033

References

Author Response

We thank Dr Winstein for her thoughtful comments. Our response is directed to the two key issues raised in the commentary.

Do the Measures Used Provide Insight Into the Motor Control Deficit?

Over the past several years, emerging experimental findings have provided a basis for proposing neuromechanical mechanisms to account for the generation of weight transfer in the frontal plane in conjunction with goal-directed movements.\(^1\)\(^2\) More generally, we have focused our attention on the study of movements of the body as a whole that involve three interrelated phases: initiation, dynamic weight transfer, and termination.\(^3\)

The approach taken has utilized an impulse-momentum model. The model stipulates that dynamic transitions from stationary bipedal stance to single-limb support require an initial actively generated propulsive impulse to increase momentum of the body’s center of mass (CM). Subsequently, a braking impulse to reduce momentum must occur if stationary single-limb stance is to be achieved. In this case, the peak velocity, or more directly its product with body mass, is equivalent to the magnitude of the propulsive and braking impulses underlying the initiation and termination phases of the weight transfer. Therefore, the measurements of peak force beneath each limb and the initial rate of change of CM displacement (velocity) suggested by Dr Winstein are also important for understanding the mechanisms underlying the three phases of weight transfer.

We have quantified the CM location with respect to the base of support, as a first level of analysis of problems with weight-transfer function for adults with hemiparesis. This approach allowed us to assess the outcome and classify the bipedal to single-limb transfer component based on the biomechanical principle underlying the maintenance of upright stance.

Although the present focus has been on examining the termination phase of the task, the static characteristic of the measurements taken may be more apparent than real. The termination phase is inextricably linked to the phases of initiation and dynamic

Physical Therapy / Volume 74, Number 7 / July 1994 658 / 55
weight transfer. Therefore, a successful outcome, as defined by the present criteria, is dependent on the successful negotiation of each of the component phases. It should also be emphasized that the measurement of peak displacement of the CM near the completion of the dynamic weight-transfer phase is very different from measurements that have routinely used center-of-pressure recordings to quantify quasi-static stance. Thus, in attempting to gain insight into the motor control deficits that may underlie alterations in weight-transfer capabilities, one is also faced with the need to use a valid method for evaluating and classifying the outcome of performance.

As alluded to in our report, an inter-limb coupling of hip abductor-adductor muscle activations has been proposed to underlie the generation of CM lateral momentum during single-leg movements. One might postulate that deficits in propelling, braking, or maintaining the weight transfer among individuals with hemiparesis might be attributable to alterations in the normal spatial or temporal characteristics of hip muscle activation patterns. This idea is currently under investigation.

Dr Winstein suggests that individuals with hemiparesis may have problems appropriately scaling force amplitude for the leg flexion task. Perhaps, but we do not think the present data can support this hypothesis. In contrast with the study by Velicki et al., the goal for each of the leg flexion trials was the same, and thus the ability to parameterize the motor program for the leg flexion task was not directly tested. Rather, we contend that amplitude reductions of the force contributed from under the paretic flexing limb are consistent with the reduction in force-generation capability in hemiparetic limb musculature. If, as was found in leg flexion trials that were performed "as fast as possible," there is an associated increase in the force acting under the nonparetic stance limb, this suggests the adoption of an adaptive strategy to accommodate the mechanical requirement of overcoming the inertial force of the body mass during dynamic transitions from bipedal to single-limb stance.

### Are the Findings Generalizable to Individuals With a Right Cerebrovascular Accident of Equal Severity?

Dr Winstein’s second concern is the generalizability of the present findings to individuals with a right cerebrovascular accident of equal severity. Dr Winstein provides several noteworthy references suggesting a role by the left hemisphere in temporal sequencing of complex actions. Interestingly, a previous report has identified alterations in the temporal sequencing of CM movement and limb movement onset for paretic leg flexion versus nonparetic leg flexion in individuals with lesions of the left hemisphere. We are in agreement that a sample of individuals with right cerebral hemisphere damage would improve the generalizability of the findings of our study. We have collected data on such a sample and are currently analyzing these data. Results related to hemispheric differences on the performance of this task, if any, will be forthcoming.

Mark W Rogers, PhD, PT
Yi-Chung Pai, PhD
Lois Deming Hedman, PT
Timothy A Hanke, PT

### References

Author Response
Mark W Rogers, Yi-Chung Pai, Lois Deming Hedman and Timothy A Hanke