INTRODUCTION
Stroke-induced hemiparesis affects patients’ abilities to gauge force production in their limbs. These individuals’ inability to understand their limitations in producing appropriate force levels with their paretic limb affects their mobility and transfers (e.g. standing from a seated position). A mismatch between expected force production and actual force production in these situations can have serious implications on safety. Previous studies that have examined upper limb force production and perception suggests that individuals with hemiparesis use a sense of effort, more than proprioceptive feedback, to gauge force production in their upper limbs (Gandevia and McCloskey 1977, Bertrand et. al. 2004, Mercier et. al. 2004).

We investigated post-stroke individuals force production in their lower limbs during isometric and isotonic movements to determine if stroke subjects primarily rely on sense of effort for gauging force. Results from these experiments will provide insight into whether or not control of force in stroke subjects is the same for static and dynamic movements. We hypothesized that hemiparetic subjects attempting to produce equal forces in their lower limbs would generate equal percentages of their bilateral maximum voluntary strength rather than equal absolute limb forces during both types of movement.

METHODS
Eight subjects with stroke-induced hemiparesis performed isometric lower limb extensions on an exercise machine (Figure 1).

For all trials, we recorded individual limb forces from a dual force plate. We measured subjects’ strength of bilateral, non-paretic limb, and paretic limb maximum voluntary contractions (MVC) for both isometric and isokinetic movements.

In Experiment 1, subjects were asked to exert an isometric force using their non-paretic limb equal to 35% of the paretic limb peak force during bilateral isometric MVC condition. Subjects received visual force feedback of only the target and non-paretic limb force. When subjects reach the target force level, they began applying force with the paretic limb and verbally signaled to the experimenter when they believed they had matched forces in both lower limbs.

In Experiment 2, subjects performed lower limb extensions against a constant (isotonic) resistance equal to 80% of the paretic limb peak force during bilateral isokinetic MVC testing. We instructed subjects to push equally with their feet.

For all trials we calculated the average force applied by each limb during the extension movement. We normalized foot forces to each limbs’ bilateral MVC. We used a repeated measures ANOVA and Tukey-Kramer
RESULTS
During the isometric force matching trials of Experiment 1, subjects consistently produced significantly less absolute force in the paretic limb than the non-paretic limb (ANOVA: P < 0.0001) (Figure 2). Normalizing force to each limbs’ bilateral isometric MVC force showed no significant differences (ANOVA: P = 0.11). There was only an 11.3% difference between normalized limb force as compared to a 34.5% difference between absolute limb force.

In Experiment 2 when subjects were attempting to produce equal forces during isometric lower limb contractions, they produced significantly less absolute force in the paretic limb than the non-paretic limb (ANOVA: P = 0.01) (Figure 3). Normalizing force magnitudes to each limbs’ bilateral isometric MVC force as compared to a 29.3% difference between absolute limb force.

DISCUSSION
The results supported our hypothesis that for isometric and isokinetic conditions hemiparetic subjects relied primarily on sense of effort, rather than proprioceptive feedback, for gauging lower limb force production. Individuals with post-stroke hemiparesis did not produce equal lower limb forces even though the target forces were set to levels below the paretic limbs’ bilateral strength capabilities. The results for Experiments 1 and 2 indicate that bilateral lower limb force production in stroke subjects is similar for isometric and isokinetic contractions. This outcome is important because it extends the findings to force production during dynamic movements that are functionally relevant for activities of daily living. Our findings about the importance of sense of effort in post-stroke individuals suggests that lower limb rehabilitation therapies need to not only train strength in the paretic limb but also to train patients to recalibrate their force scaling abilities.

REFERENCES

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