Hip Fracture Subject Demonstrated: • Dissociation between perception and force output

• A nervous system tuned to level of effort rather than level of force (VAS)

• Greater weight bearing on the fractured side. Possibly due to: time between hip fracture and data collection, type of rehab, and/or other unidentified motor control variables.

• An altered pattern of signal recognition post-hip fracture (self-selected load matching task). Generated greater force through the right (fractured) LE. This key finding demonstrates the strong impact of orthopedic injuries on the nervous system.

There were several limitations that will need to be addressed in future research, such as: $\mathcal{L}_{\mathcal{A}}$ is a subject size of subjects of subjects of subjects of subjects of subjects of subjects

• Inability to define a standardized interval of vGRF values to sample in the sit to stand synergy • It would be valuable to incorporate the Brière model of using 0.5 sec before and 0.5 seconds after seat off, which would require the use of a switch or other seat-based sensors that were not available at time of t

• Decreased variability in selecting strategies to complete a task. A deepened attractor state; subject is limited in their ability to accomplish synergistic movements with variable patterns of muscle activation, limb loading, and COM trajectory.

• Significant error in knee extension trials, indicating a misperception. Finding serves as evidence that orthopedic issues impact entire nervous system, adaptations emerge and influence sense of

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- perception.

Follow-up projects may focus on: • Center of mass trajectory in synergistic movements/tasks

• Possible role of physical therapy interventions in addressing perceptual deficits in hip fracture

patients

- \mathcal{P}_c as \mathcal{P}_c values with a symmetry will exist \mathcal{P}_c values with a symmetry will exist \mathcal{P}_c
- Hip fracture subjects will be unaware of the asymmetry.
- Asymmetry will be tuned to perceived level of effort (VAS/Matching), rather than actual level of force (vGRF) ("Principle of Bilateral Effort" – Bertrand 2004; Brière 2013)

Methods

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Background

• Two community-dwelling older adults were included who fulfilled the inclusion criteria:

- Participants were recruited from the community via flyers. Once the participants were contacted, each were screened over the telephone - those who were accepted were given informed consent upon arrival of the test day.
- Data was collected using a 10 camera Qualisys IR Camera system at 100 Hz. The two AMTI force platforms are collected at 1000 Hz. Visual 3D (C-Motion) software was used to create the biomechanical model from the marker data, interpolate any gaps in marker trajectory, filter the marker data and force data, and create kinematics (angles and COM).
- $\mathcal{S}_\mathcal{S} = \{ \mathcal{S}_\mathcal{S} \mid \mathcal{S}_\mathcal{S} \}$ is the symmetry for feet; $\mathcal{S}_\mathcal{S} = \{ \mathcal{S}_\mathcal{S} \mid \mathcal{S}_\mathcal{S} \}$ excursion to $L^2(\mathbb{R}^d)$ to $L^2(\mathbb{R}^d)$ to $L^2(\mathbb{R}^d)$ to $L^2(\mathbb{R}^d)$ to $L^2(\mathbb{R}^d)$
- Load Matching (Self-selected submaximal vGRF L/R matching, seated then standing
- Knee Extension (MVIC; Cued 50% of MVIC with VAS rating; Self-selected submaximal with VAS rating)

References

Figure 1: Right Hip Fracture Subject Self-Selected STS

Sit-to-Stand Symmetry in Individuals with Hip Pathology

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Figure 2: Right Hip Fracture Subject $L_{\rm eff}$

- scale)
- depicted below.
- the corresponding left vector. In the corresponding left vector is a corresponding left vector. In the corresponding lef

Declarative Statements

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1Bernardi, M., Rosponi, A., Castellano, V., Rodio, A., Traballesi, M., Delussu, A., & Marchetti, M. (2004). Determinants of sit-to-stand capability in the motor impaired elderly. *Journal of Electromyography and Kinesiology, 14*(3), 401- 2Brière, A., Lauzière, S., Gravel, D., & Nadeau, S. (2010). Perception of Weight-Bearing Distribution During Sit-to-Stand Tasks in Hemiparetic and Healthy Individuals. *Stroke, 41*(8), 1704-1708. 3Brière, A., Nadeau, S., Lauzière, S., Gravel, D., & Dehail, P. (2013). Knee efforts and weight-bearing asymmetry during sit-to-stand tasks in individuals with hemiparesis and healthy controls. *Journal of Electromyography and* 4Brière, A., Nadeau, S., Lauzière, S., & Gravel, D. (2013). Perception Of Weight-Bearing And Effort Distribution During Sit-to-Stand in Individuals Post-Stroke. *Perceptual & Motor Skills, 117*(1), 166-181. 5Bertrand, A., Mercier, C., Lam Wai Shun, P., Bourbonnais, D., & Desrosiers, J. (2004). Effects of Weakness on Symmetrical Bilateral Grip Force Exertion in Subjects With Hemiparesis. *Journal of Neurophysiology, 91*(4), 1579- 6Houck, J., Kneiss, J., Bukata, S., & Puzas, J. (2011). Analysis of vertical ground reaction force variables during a Sit to Stand task in participants recovering from a hip fracture. *Clinical Biomechanics, 26*(5), 470-476.

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- $\mathcal{L}_{\mathcal{D}}$. So that the $\mathcal{L}_{\mathcal{D}}$ is the $\mathcal{L}_{\mathcal{D}}$ is the $\mathcal{L}_{\mathcal{D}}$ of $\mathcal{L}_{\mathcal{D}}$
	- Subjects asked to generate best estimate of 50% of their MVIC.
	- respectively.
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	- Overall error 13.23% (L), 0.74% (R) Non-Hip Fracture Subject

1585.

 $\mathcal{P}_\text{max}(\mathcal{P}_\text{max})$ is defined as a percentage of left/right symmetry and load (as a percentage of maximum maxim effort) suggests that the nervous system is tuned to level of effort rather than level of force after

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105-111.

11Yamada, T., Demura, S., & Takahashi, K. (2013). Center of gravity transfer velocity during sit-to-stand is closely related to physical functions regarding fall experience of the elderly living in community dwelling. *Health*, *5*(12), 2097-

2103.

Our results revealed more significant errors of weight bearing perception in hip fracture participants compared with healthy individuals during the sit-to-stand task and self-selected load matching in standing. Furthermore, errors were also seen when rating sense of effort with isolated movements, such as activation of knee extensors.

Results Discussion

- Hip fractures occur approximately in 300K individuals aged 65+ annually post-fall \sim 53.3% will sustain another fall; \sim 33.3% will sustain another fall; \sim 25% will sustain another fall; \sim
- The sit-to-stand (STS) task is impacted by hip fractures.
- $\mathcal{L}_{\mathcal{A}}$ as $\mathcal{L}_{\mathcal{A}}$ as $\mathcal{L}_{\mathcal{A}}$ by $\mathcal{L}_{\mathcal{A}}$ post-hip fracture (Houck et al.), and $\mathcal{L}_{\mathcal{A}}$ as $\mathcal{L}_{\mathcal{A}}$ • Hip fracture side < non-fractured side
- Asymmetry not fully explained by LE strength in hip fracture nor CVA

Hypotheses

Sit to Stand Trial Results:

• Dissociation found in hip fracture subject between level of effort and level of force with STS synergy (VAS

• When hip fracture subject attempted to maximally load the left LE throughout the STS, there a significant perceptual error (rated 100% left LE WB). Hip fracture subject feels that the effort is maximal due to an inability to generate high forces bilaterally, simultaneously (central drive issue precludes nervous system from recruiting & rate coding adequately). Nervous system adopted obligatory strategy (amount of variability available decreased). The lack of "good" variability constrains the subject into the movement pattern that is

• An obvious asymmetry in vGRF between right and left LEs. Larger vector indicates greater right vGRF than

Load Matching Trial Results:

- Hip fracture subject consistently generated more force (weight) through the right LE when attempting to match exactly what the left, non-fractured LE had generated. • True in sitting and standing
- standing trials, compared to the non-fracture subject's average error of 0.85% of body weight.

• In standing, the hip fracture subject was unable to accurately match the amount of loading between lower extremities. There was significantly more error in load matching, averaging 13.32% of body weight over the

Knee Extension Trial Results:

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• Hip fracture subject rated effort given with greater error, displaying error between perception of effort (VAS) and actual knee extension force (% of MVIC), with 30.91% and 32.49% error left and right, respectively. The non-hip fracture subject had 3.89% and 0.10% error left and right, respectively.

• Hip fracture subject generated 20.31% and 12.59% of the MVIC, left and right lower extremities, respectively. The non-hip fracture subject generated 36.77% and 49.26% of the MVIC, left and right,

• Overall error: 29.69% (L), 37.41% (R; Fracture side) – Hip Fracture Subject

• In order for an individual with a previous hip fracture to perceive symmetry in weight bearing, they must bear a greater amount of weight through the fractured side.

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- hip fracture.
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• Following a hip fracture, individuals develop a deepened attractor state that obligates them to complete synergistic movements with diminished variability.

Conclusion