Impaired foot-force direction regulation during postural loaded locomotion in people post-stroke

Jing Nong Liang1, 2, David A. Brown1, 2, 3

1Department of Physical Therapy & Human Movement Sciences, 2Interdepartmental Neuroscience Program, Feinberg School of Medicine, Northwestern University, Chicago, IL, 3Department of Physical Therapy, School of Health Related Professions, University of Alabama at Birmingham, Birmingham, AL, USA.

INTRODUCTION

- Appropriate control of foot force direction is important during locomotion.
- Individuals post-stroke have a preference to produce a force with different direction from non-impaired individuals, both when performing a pushing task on a stationary pedal and during pedaling.
- We performed an earlier study and found that resultant force directions were similar between individuals post-stroke and NI, suggesting that in a non-postural related task, misdirection of forces was not a problem post-stroke.
- Massion’s model for integrated control of posture and movement suggested a dual coordinated control system: one for posture and one for movement, and they interact with each other.

RESULTS

- Experimental protocol: Subjects performed a dynamic locomotor-like force generation task with a motor-driven crank moving at a constant speed of 40rpm, and ankles fixed at 90° in custom-made boots, under 2 conditions:
  1. Seated non-postural loaded task: Pedal while generating a Fx target 30% and 50% of maximal effort with body weight supported on a bicycle seat.
  2. Non-seated postural loaded task: Pedaling with the backboard tilted to generate Fx target 30% and 50% of maximal effort to match seated task, actively supporting the body weight.

METHODS

- Subjects: To date, 11 individuals with chronic post-stroke hemiparesis [age = 59.5±7.2 years; time post-stroke = 136.2±76.9 months] and 5 non-impaired (NI) controls [age = 57.6±12.1 years].
- Materials & Methods:
  - Force sensors: Shear (Fx) and Normal (Fx) components of forces exerted on pedal.
  - Surface EMG: soleus (SOL), tibialis anterior (TA), vastus medialis (VM), rectus femoris (RF), biceps femoris (BF).
  - Bike ergometer with:
    - Motor-driven crank, can be decoupled.
    - Sliding backboard: can be locked in place to produce a seated non-postural loaded (S) task or unlocked to slide to produce a non-seated postural loaded (NS) task.
  - Bike ergometer with:
    - Motor-driven crank, can be decoupled.

ACKNOWLEDGEMENTS

- Funded by American Heart Association Predoctoral Award #11PRE5430029.

REFERENCES


DISCUSSION & CONCLUSION

- The results confirmed our hypothesis that post-stroke, inappropriate shear forces were generated during a postural-related task, was exaggerated with increased postural loads and was associated with inappropriate coordination of paretic muscle activity.
- The downstroke phase of NS task has similar dynamic qualities to the stance phase of gait, where the limb is loaded by body weight and extensor moments are required to prevent collapse.
- In pedaling, forward Fx would tend to direct the foot to slip forward off the pedal surface. Therefore, by directing the Fy backwards, neutralizes the forward Fx due to limb weight.
- Increased paretic extensor activity at higher postural loads contributes to forward Fx component.
- Paretic extensor activity did not increase with increased effort. This was similar to our earlier study which found that the paretic limb did not increase amount of support force, which was required at higher effort levels.
- Conclusion: Results supported the theory that there is an interaction between posture and movement, and this interaction is impaired in the post-stroke nervous system.
- Future studies: To investigate influence of postural loads on underlying neural reflex pathway.