The Role of Movement Errors for Modifying Spatiotemporal Gait Asymmetry

Kyle Rascoe, SPT
Jeff Feasel, MS
Michael Lewek, PT, PhD

Division of Physical Therapy
University of North Carolina at Chapel Hill

Gait Impairments in Chronic Stroke

- Typical gait patterns of individuals post stroke (Olney, 1994; Ada, 2003)
  - Decreased walking speed
  - Decreased efficiency
  - Decreased spatiotemporal symmetry
    - Decreased stance time on the paretic limb
    - Increased stance time on the non-paretic limb
- Spatiotemporal (e.g., stance time / step length) asymmetries are thought to influence gait speed and efficiency. (Olney, 1994; Reisman, 2010)
- Traditional gait training yields…
  - Increased gait speed by increasing cadence and absolute step length (Patterson, 2008; Ada, 2003)
  - No effect on inter-limb symmetry. (Patterson, 2008; Hornby, 2008)

Error Augmentation vs. Minimization

- Motor adaptation shows promise (Patton, 2006; Reisman, 2010)
  - Patients with chronic stroke demonstrate the ability to adapt their gait pattern to a novel situation (Reisman, 2007)

- Augmenting error during treadmill training can lead to after-effects. (Reisman, 2007; Reisman 2009; Reisman 2010)
  - Decreased step length asymmetry
  - Decreased double-limb support asymmetry
  - No effect on stance time asymmetry

- Minimizing error during training results in (Reisman, 2007; Domingo, 2010)
  - Improvements during training
  - A return to baseline values after training

Purpose

- To compare the effects of Error Augmentation, Error Minimization, and a Control condition on imposed spatiotemporal gait asymmetry in unimpaired control subjects during and immediately following treadmill walking.

Subjects

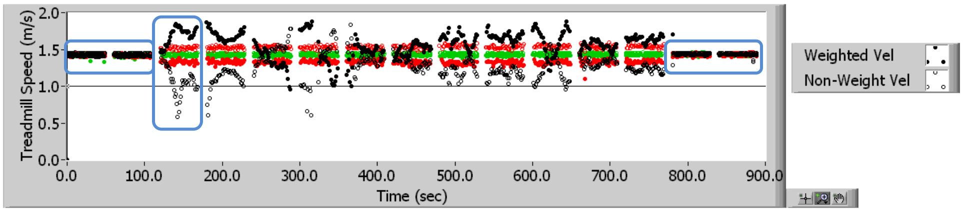
Demographic	
Gender	9 females/5 males
Age	22.36 +/- 2.31 years
Weight (lbs)	145.71 +/- 19.77
Height (in)	67.29 +/- 3.83
Weighted side	6 Right; 8 Left
Overground Asymmetry	1.12 +/- 0.05

- 14 healthy, college-aged individuals
  - Inclusion criteria
    - Induced stance time asymmetry ratio $\geq$ 1.05(Patterson, 2010) using unilaterally applied ankle weight.
  - Exclusion criteria
    - Any musculoskeletal injury in the lower extremities that limits performance.

Setup

- Participants walked over ground across a 14-foot GAITRite mat (CIR Systems, Havertown, PA)
  - Without weight: to determine comfortable gait speed
  - With weight: to determine baseline stance time asymmetry
- Adjustable ankle weight (10% BW) strapped to mid shank of one limb to induce stance time asymmetry

Training Sessions



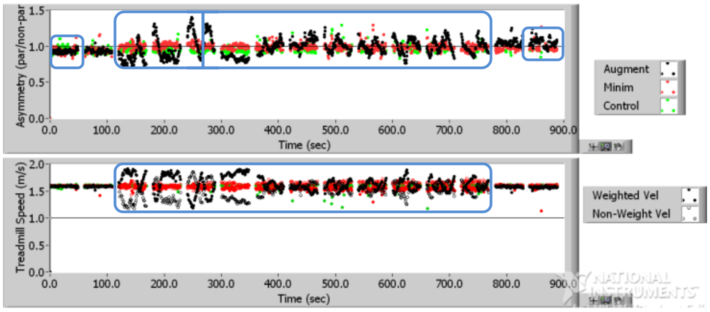
- Participants walked on a split-belt treadmill (Bertec Corp, Columbus, OH) for 15 minutes at 115% of their typical walking speed.
  - Baseline – first 2 minutes
  - Adaptation Training – middle 11 minutes
    - Error Augmentation
    - Error Minimization
    - Control
  - Post-adaptation – final 2 minutes

- Treadmill belts remained the same speed during the Baseline and Post-adaptation minutes.

Data Collection

- Foot trajectories
  - Retro-reflective markers captured at 120 Hz with 8 camera Vicon system (MX40+; Vicon/Peak, Los Angeles, CA)
- Ground Reaction Force
  - Captured at 600 Hz
  - Stance duration: when the vertical force reached $\geq$ 20 N

Outcome Measures



- Baseline
  - Stance-time asymmetry
- Training period – minutes 3-13
  - Treadmill speeds between limbs
  - Average stance-time asymmetry
  - Percent of symmetric steps
  - Standard deviation of stance-time asymmetry

One-way (condition) ANOVA

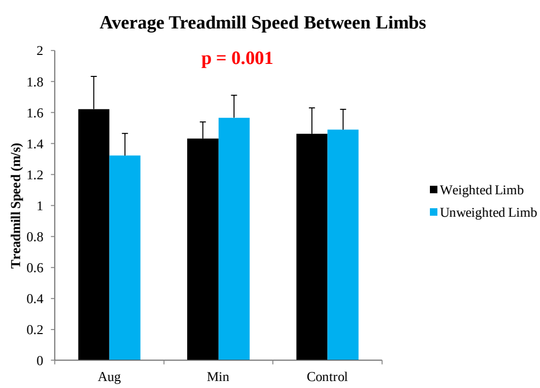
- Change from Baseline (min 1) to Post-Adaptation (min 15)
  - Average stance time asymmetry
  - Percent of symmetric steps

Two-way (condition x time) repeated measures ANOVA

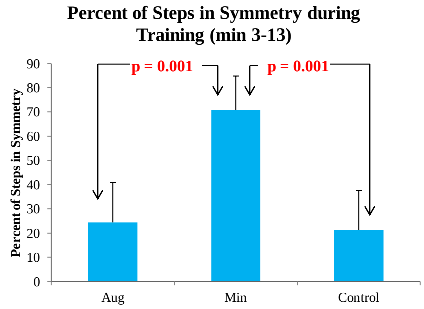
Baseline Values

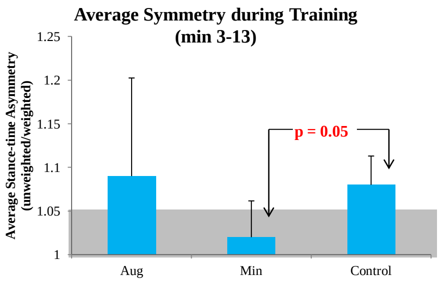
- Average baseline asymmetry (min 1) for all subjects
  - Augmentation = 1.07±0.03
  - Minimization = 1.06 ±0.03
  - Control = 1.07 ±0.03

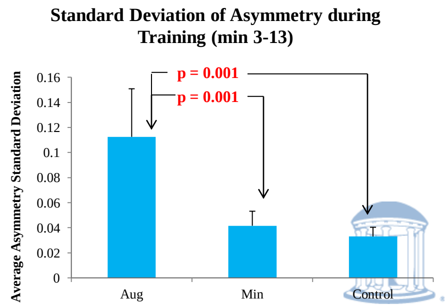
p=0.37



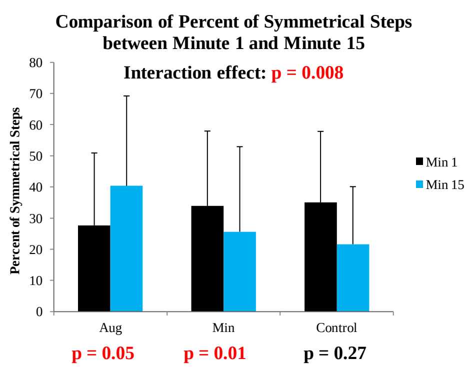
Results during Training (min 3-13)

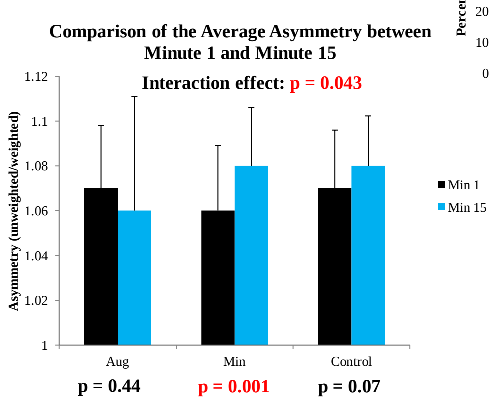




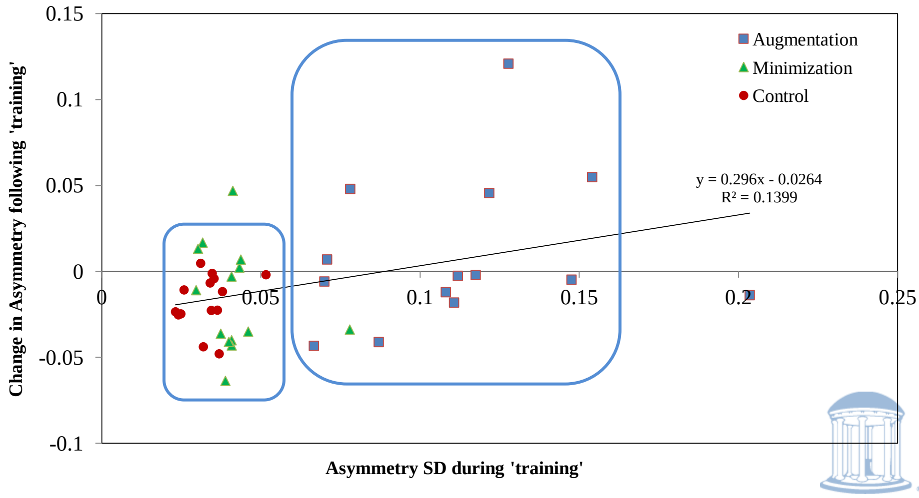


Baseline and Post-adaptation Comparisons





Relationship between Symmetry Variability and Change in Symmetry



Limitations

- Small number of participants (N=14)
  - Healthy, college-aged
- Ankle weight
  - Required to stop during some sessions to adjust
- Time between sessions not standardized
- Practice effect?

Clinical relevance

- Minimizing errors during training
  - Improved performance during training
  - Worsened performance after training
- Augmenting errors to provide feedback during training
  - Increased movement variability during training
  - May improve performance after training

Acknowledgements

- UNC Undergraduates: Nicole Davis
- This project was supported by Award Number UL1RR025747 from the National Center for Research Resources