Motor Learning and Adaptation in People with Knee Osteoarthritis and Chronic Pain

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Introduction

Osteoarthritis (OA) affects an estimated 50 million people in the US, and approximately 43% have limitations in daily function due to arthritis pain.[3] Individuals with knee osteoarthritis (OA) have:

- ❑ Heightened sensitization to pain[2,5] as well as reduced strength and diminished function and quality of life[1]
- ❑ Nervous system adaptations to chronic pain include:
  - o Altered sensory perception
  - o Redistribution in muscle activity and changes in mechanical behavior[4]
    - Provides short term benefit of protection from further injury
    - May be detrimental in the long term

Individuals with chronic pain benefit from rehabilitation with the goal to learn to move without pain

- ❑ Motor learning relies on accurate sensory perception to detect movement errors and to plan new motor patterns
- ❑ The extent to which chronic pain affects motor learning in people with chronic pain is largely unknown

The "broken escalator phenomenon" refers to the sensation of imbalance when walking onto an escalator or moving platform that is broken (stationary)[6]

- ❑ The nervous system "expects" to step on a moving platform
- ❑ Adaptation of motor patterns is necessary to adjust to the unexpected environmental condition

Purpose: We use the "broken escalator phenomenon" to study motor adaptation and learning in people with chronic pain from knee OA

We hypothesize that people with chronic pain will have greater first trials responses and require more trials to adapt to new environmental conditions during a stepping task.

Methods

- Motor adaptation and learning
  - ○ 3D Movement analysis (Qualysis 3D Motion Capture System)
    - Trunk, Hip, knee ankle kinematics
    - Translation of Center of Mass
  - ○ Muscle Activity (Noraxon)
    - EMG of gastrocnemius and soleus
  - ○ Broken Escalator Paradigm:
    - The subject stepped from a platform (Fig 1) onto either a stationary or moving treadmill belt
      - 30 null trials (stationary belt)
        - ▪ To establish baseline movement pattern
      - 30 moving trials (moving belt)
        - ▪ Nervous system adapts to the the moving condition
      - 30 after-effect "AE" trials (stationary belt)
        - Nervous system de-adapts from the moving condtion
  - o The step activity was divided into intervals based on foot positions (Fig 2)
    - ▪ AE1 elicits a "first trial response" – associated with the first experience of the return of the stationary belt condition. (Fig 3)
    - ▪ AE2 and beyond, de-adaptation takes place
- Analysis
  - ○ The primary goal of the nervous system during this activity is to maintain upright stance. Thus, we visually analyzed translation of the center of mass (COM); forward trunk flexion and EMG activity of the plantar flexor muscles to assess motor adaptation.
  - ○ Variables were computed during Intervals 2 and 3 where the after effect was most prominent.
    - ▪ Peak forward trunk flexion during interval 3 (Fig 3)
    - ▪ Peak forward translation of the COM during interval 3
    - ▪ Average medial gastrocnemius EMG during Interval 2

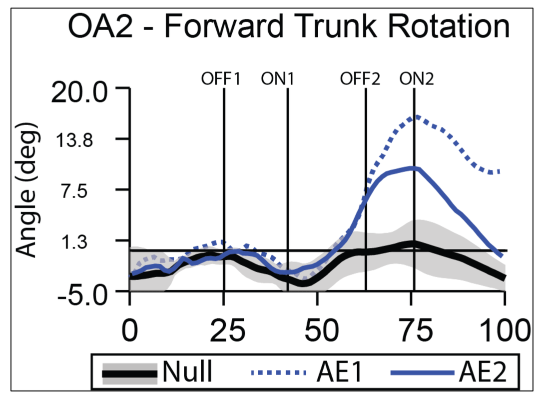


Figure 3. Trunk Flexion during the Null trials (black line represents the mean +/- 1 standard Deviation of 20 trials), the first aftereffect Trial (AE1, dashed blue line) and the second after effect trial (AE2, solid blue line) where significant de-adaptation is observed.

- o Data from each Null trial and each AE trial were plotted as shown in Figure 4.
- o In all variables, de-adaptation occurred within 10-12 AE trials after which the magnitudes leveled off.
- o However, not all AE variables returned to the mean value found in the null trials.
- o Magnitude of de-adaptation was assessed for each subject using paired t-tests to analyse differences between the Null baseline and Null AE conditions (Fig 4).
- o Due to the small number of subjects presented no further statistical analyses were possible.

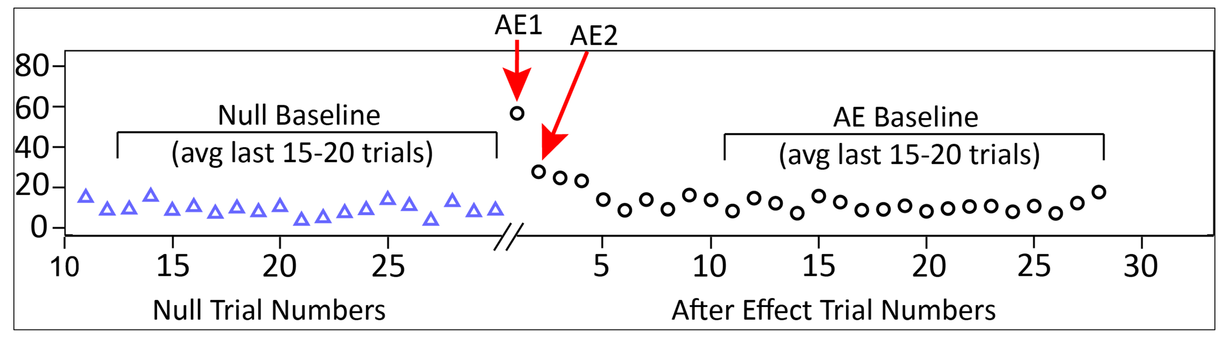


Figure 4. Average Medial Gastrocnemius EMG during Interval 2 in each Null trial (blue triangles) and each AE trial (black circles). Data from the moving trials are not shown.

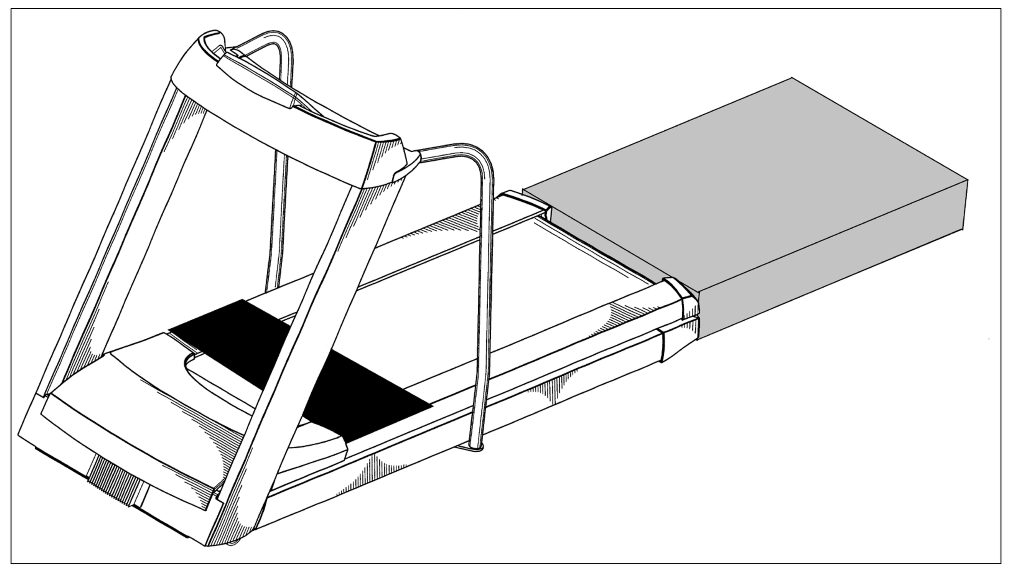


Figure 1. Treadmill with starting platform (black) and landing platform (gray). Subjects stood on the starting platform facing the rear of the treadmill and stepped onto the treadmill belt. During the moving condition, the belt transported them to the end of the belt and they stepped onto the landing platform.

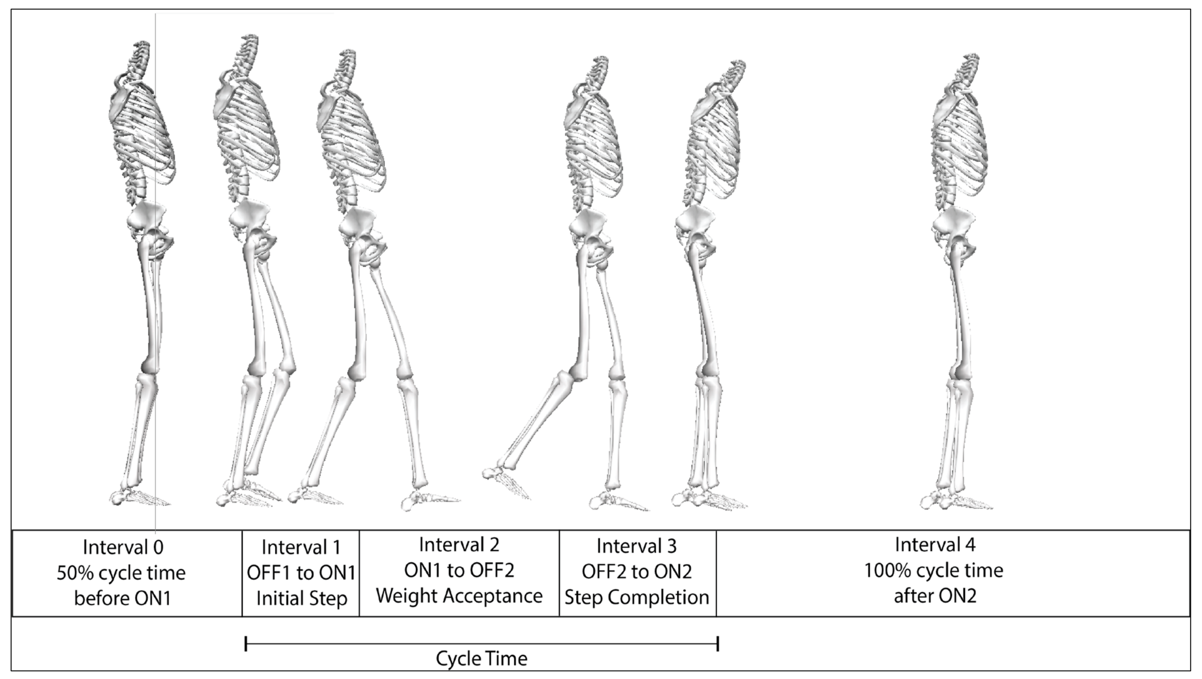
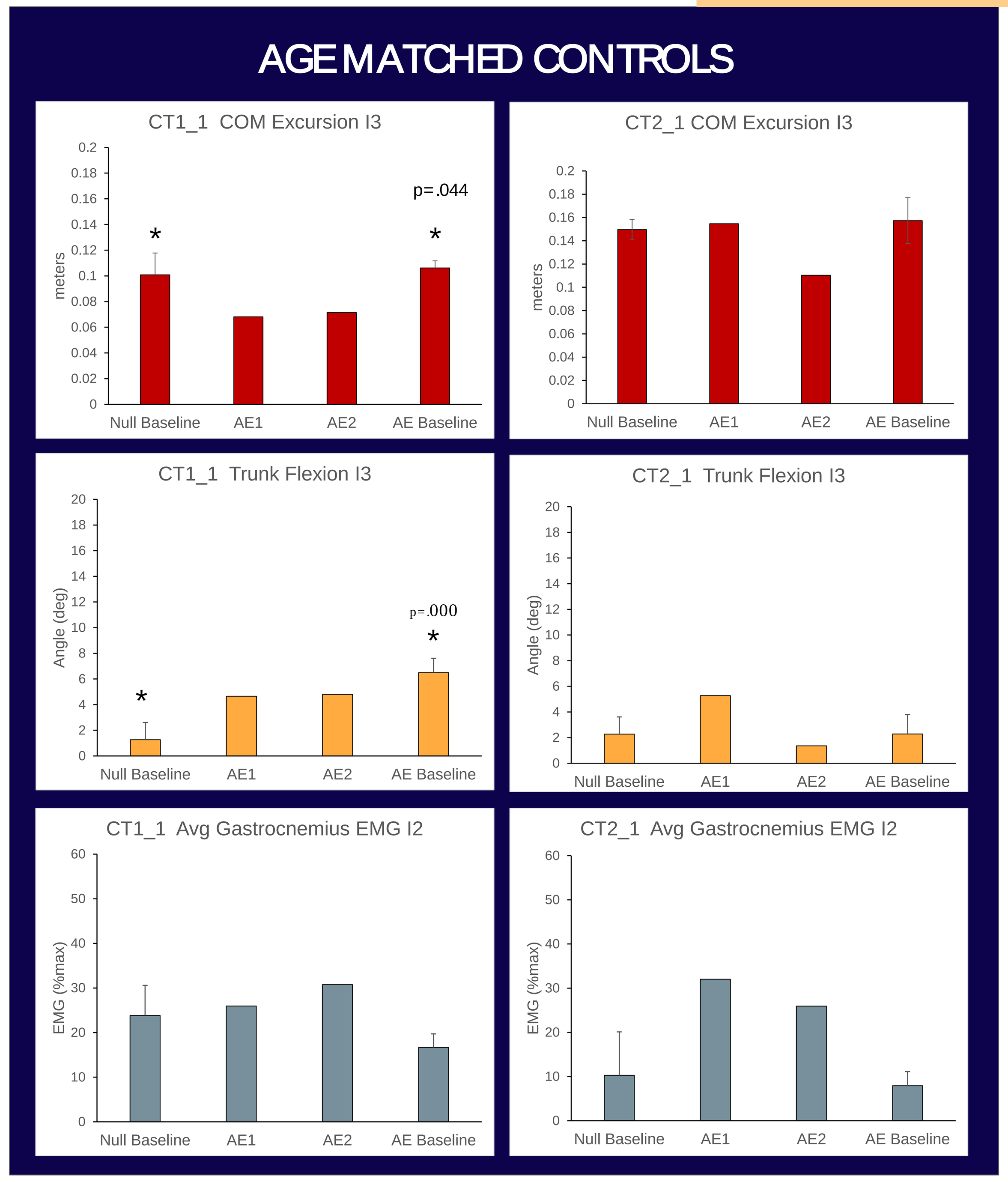
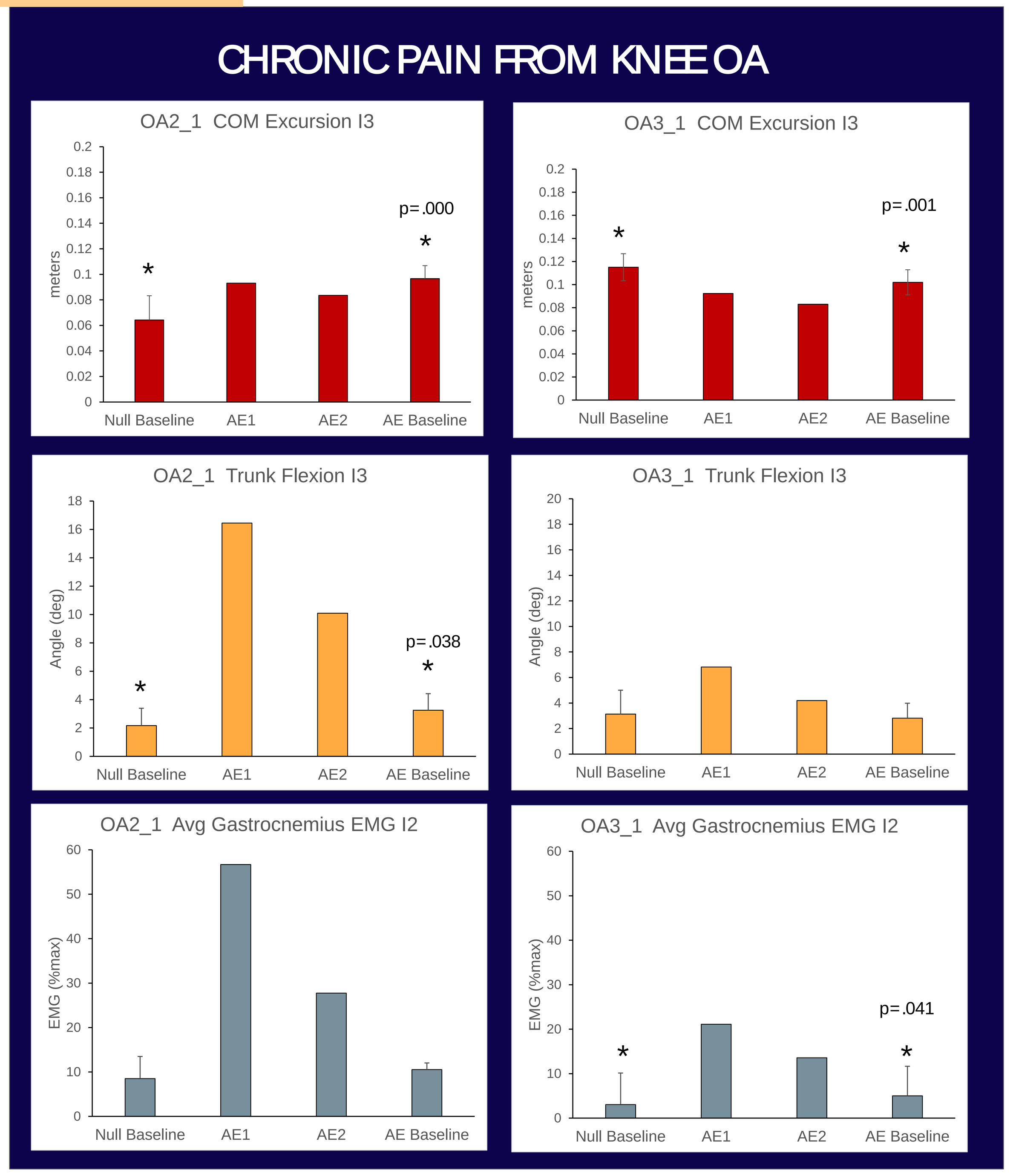


Figure 2. Events of the step cycle and intervals used in the analysis.

Results





Discussion

- Conclusions are limited due to the small sample size, but subjects in both OA subjects had large first trial responses and did not de-adapt to the level of the Null trials, whereas only one control subject showed similar findings
- The 1st trial response was most visible in the forward trunk flexion and magnitude of EMG; whereas COM showed less consistent responses. This is likely because the perturbation of upright stance by the change in belt condition from moving back to stationary was substantial enough to warrant a hip strategy accompanied by flexion of the trunk.
- After adjusting to the return to the belt stationary condition, both OA subjects did not show complete adaptation, as opposed to one Control subject. More subjects are needed to determine if this finding is noteworthy.
- It is notable that neither of the two OA subjects were significantly impaired based on self-report functional questionnaires. Thus, they may not yet have neurologic changes due to chronic pain that influenced motor adaptation and learning.

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