Altered Hip Biomechanics and Muscle Activation in Response to Walking Surface Perturbations in Asymptomatic Adults and Individuals with Osteoarthritis

Derek, J Rutherford[1], Nathan Urquhart[2], William, D Stanish[2]
[1]Schools of Physiotherapy and Biomedical Engineering, Dalhousie University, Halifax, Canada
[2]Faculty of Medicine, Dept. Orthopeadics, Dalhousie University, Halifax, Canada
Email: djr@dal.ca

Summary

The current study aimed to better understand how individuals with lower extremity osteoarthritis responded to unexpected perturbations while walking compared to asymptomatic controls. Immediately following the perturbation, all groups responded with less hip range of motion and greater muscle activation with no influence from knee or hip osteoarthritis. Results show that osteoarthritis did not specifically affect walking responses, which may support the development of walking perturbation training in these groups.

Introduction

Osteoarthritis (OA) is a multi-factorial joint disease that impacts mobility, particularly in those with hip (HOA) or knee (KOA) involvement [1]. Joint function can be impaired to the point where, while walking, people are not stable and lose confidence. It is currently unclear whether the addition of gait perturbations to individuals with OA results in altered hip mechanics and muscle activation patterns as they strive to maintain walking. The study objective was to determine the impact of unexpected walkway surface perturbations on hip motion and muscle activation patterns in asymptomatic older adults and those HOA or KOA.

Methods

40 asymptomatic (ASYM) older adults, 26 participants with KOA, and 16 participants with HOA, of moderate severity, defined using functional and radiographic criteria were recruited and provided informed consent.

Skin surface electrodes were placed over rectus femoris (RF) and gluteus medius (GM) while retro-reflective markers were affixed to standard boney landmarks and rigid segments as per standard procedures [2]. Participants walked barefoot on a dual-belt instrumented treadmill, at a self-selected walking speed. After a six-minute warmup, participants experienced three randomized blocks of eight unexpected medial and lateral walkway surface translations of 1 and 3cm magnitudes (rate=0.1m/s) [3]. Medial 3cm perturbations were analyzed.

Marker trajectories (Fs=100Hz) and electromyograms (Fs=2000Hz) were processed using a standardized method that has previously shown excellent reliability [2]. Three strides before each walkway translation were averaged (T0), and the first stride (T1) following the walkway translation was obtained for the symptomatic limb and random limb in ASYM. Ranges of motion were determined from hip motion waveforms. Principal component analysis was used to identify features of variability in the RF and GM maximal voluntary isometric contraction amplitude normalized waveforms. *PP-scores* were calculated. Analysis of Variance models tested main effects and interactions (sig. = 0.05).

Results and Discussion

At T1, sagittal (diff =2º) and frontal (diff=1º) plane hip motion was less compared to T0 ($p<0.05$) (Figure 1). No differences were found between groups for frontal plane motion ($p>0.05$), however the HOA group walked with less sagittal plane hip motion than ASYM and KOA groups (diff=5º). No other main effects or interactions were found ($p>0.05$).

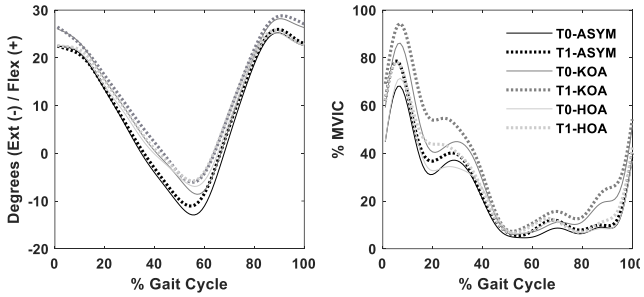

Figure 1: Left Panel – Sagittal Plane Hip motion; Right Panel – GM Muscle activation, time normalized to Gait Cycle for group assignment and Condition (T0 – Pre-Pert. and T1 – Post-Pert).

For GM, no group or interaction effects were found ($p>0.05$) whereas for RF, *PP1-scores* were different among groups (KOA>ASYM>HOA; $p<0.05$) indicating greater overall amplitudes were found in the KOA group. No other group or interaction effects were found for RF. For GM and RF, condition effects were found among *PP1-*, *PP2-* and *PP3-scores*, suggesting greater overall, and prolonged mid-stance amplitudes at T1 compared to T0 in all groups (Figure 1).

Conclusions

Hip motion and muscle activation alterations suggest a strategy to increase control of hip function (less range of motion and more muscle activation) in response to walkway perturbations. This response was found in all groups, suggesting knee or hip OA did not significantly alter hip function after experiencing perturbations.

Acknowledgments

Funded, in part, by the Nova Scotia Health Research Foundation (MED-DI-2014-9558)

References

[1] King LK et al (2018). *Arth Care Res*, **70**: 71-79.
[2] Rutherford DJ et al. (2020). *J Electr Kin*, **51**: 102401.
[3] Baker MD et al (2019). *Hum Mov Sci*, **68**: 102542