

# CO-ACTIVATION DIFFERENCES IN LOWER LIMB MUSCLES BETWEEN ASYMPTOMATIC CONTROLS AND THOSE WITH VARYING DEGREES OF KNEE OSTEOARTHRITIS DURING WALKING

Cheryl Hubley-Kozey<sup>1,2</sup>, Nicholas Hill<sup>2</sup>, Derek Rutherford<sup>2</sup> and William Stanish<sup>3</sup>

<sup>1</sup>School of Physiotherapy, Dalhousie University, Halifax, NS, Canada, [clk@dal.ca](mailto:clk@dal.ca)

<sup>2</sup>School of Biomedical Engineering, Dalhousie University, Halifax, NS, Canada

<sup>3</sup>Department of Surgery, Dalhousie University, Halifax, NS, Canada.

## INTRODUCTION

Increased muscle co-activation during gait has been identified as a neuromuscular alteration associated with knee osteoarthritis (OA). Lewek *et al.* 2004 reported higher co-activation indices during initial stance in those with medial compartment OA. A high degree of co-activity among muscle sites, based on principal component analysis (PCA), has also been found in those with severe knee OA (Hubley-Kozey *et al.*, 2008). While differences have been noted between controls and individuals with OA, levels of co-activation among varying degrees of OA has not been established. Muscle activation characteristics could be a valuable adjunct in the diagnostic classification of those with knee OA given the poor association between radiographic scores and symptoms (Creamer *et al.* 2000).

The purpose of this study was to determine if differences in co-activation could be detected among asymptomatic (ASYM) controls, those with moderate OA (MOA) and those with severe OA (SOA) using i) a co-activation index (CCI) during the initial phase of the gait cycle and ii) PCA.

## METHODS AND PROCEDURES

Sixty three ASYM, 59 MOA and 48 SOA participated. The study was approved by the Institutional Ethics Board. Assignment to MOA and SOA was based on both radiographic and functional assessments. After standard skin preparation, surface

electrodes (Meditrace™ Graphics Control) were placed in a bipolar configuration over the vastus lateralis (VL) and medialis (VM), lateral (LH) and medial hamstring (MH) and lateral (LG) and medial (MG) gastrocnemius muscles of the affected leg for OA groups and a randomly selected leg for ASYM. Subjects walked at their self-selected walking velocity along a 6 meter walkway while electromyographic (EMG) signals were amplified (Bortec™) and digitally converted at 1000Hz. The raw signals were bias adjusted, full-wave rectified then low-pass filtered (Butterworth 6Hz recursive). The EMG waveforms were amplitude normalized to MVIC and time normalized to the gait cycle. First CCIs were calculated for the initial stance phase using the method of Lewek *et al.* 2004. Then waveforms from all participants for all muscles formed a matrix (101 by 1190) that was entered into a principal component analysis model (Hubley-Kozey *et al.*, 2008). Differences between the co-activation indices were tested among groups using a Kruskal-Wallis test. A mixed model ANOVA (group, muscle) tested for differences in the principal component score. Post hoc analyses were performed on significant results ( $\alpha=0.05$ ).

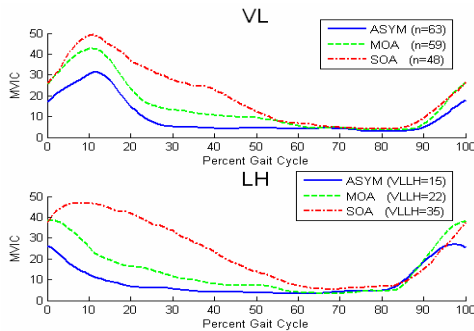
## RESULTS

Demographic data are in Table 1. There was a significant group effect ( $p<0.05$ ) for all four CCIs. ASYM was less than SOA for all CCIs, but only different from MOA for VLLH. MOA was significantly lower than

SOA for all CCIs except VMMH. The waveforms for the VL and LH muscle sites and the CCIs are in Figure 1.

Variable	ASYM	MOA	SOA
Age (years)	49(10)	58(9)	64(8)
BMI	25 (4)	31 (5)	32(5)
Velocity (m/s)	1.37 (.1)	1.27 (0.2)	0.97(0.2)
KL score	--	2.47 (0.8)	3.2 (0.4)

**Table 1.** Subject Demographics. Means (SD).



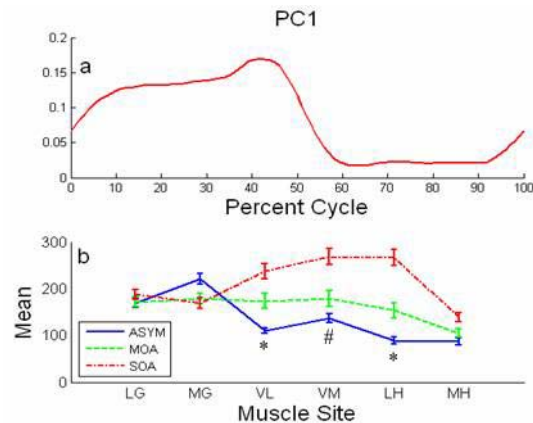
**Figure 1:** Waveforms with median CCI in brackets on lower graph.

Four principal patterns explained over 90% of the variance in the waveforms. PC1 (46% variance) captured the magnitude of the waveforms indicative of the relative level of activity over the stance phase (Figure 2a). ANOVA revealed a significant ( $p < 0.05$ ) group by muscle interaction for PC1 scores (Figure 2b). Post hoc analyses showed that the MG was higher than all other muscle sites for the ASYM whereas no significant muscle differences were found for MOA. Two vasti and LH were higher for the SOA. Significant differences were found between the ASYM and OA groups as well as between the two OA groups (Figure 2b).

## DISCUSSION

CCIs for the ASYM group are similar to those reported in the literature (Lewek *et al.* 2004). There are no CCIs reported for MOA and SOA groups separately and the values in the present study are different from Lewek's findings. The only CCI difference among all three groups was VLLH (Figure 1), resulting

from increased VL and LH activity with increased disease severity. PC1 shape is similar to that reported for severe OA (Hubley-Kozey *et al.*, 2008). The group by muscle interaction captured variation in strategies unique to each group. Key features include the VM working at higher %MVIC for the SOA perhaps to stabilize the medial compartment. The higher LH and VL activity in both OA groups aimed to unload the medial compartment and differential recruitment of MG in ASYM.



**Figure 2:** a) PC1 and b) interaction plot of Mean (SEM) PC1 scores. (\* all groups different, # ASYM=MOA < SOA  $\alpha = 0.05$ )

## SUMMARY

Both CCI and PCA captured differences in co-activity patterns among the three groups and most importantly, between the two OA groups. These findings suggest that measures of muscle co-activity provide valuable information related to severity of knee OA.

## REFERENCES

- Creamer *et al.* (2000) *Rheumatology* 39, 490-496.
- Lewek M.D *et al.* (2004) *Osteoarthritis Cartilage* 12, 745-751.
- Hubley-Kozey *et al.* (2008) *Clin Biomech* 23, 71-80.

## ACKNOWLEDGEMENTS

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