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KNEE MUSCLE ACTIVATION STRATEGIES OF YOUNGER, OLDER AND OSTEOARTHRITIC POPULATIONS DURING STANDING FORCE CONTROL TASKS

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SUMMARY
Age-related changes in muscle function may be a contributing factor to the development and progression of osteoarthritis (OA). This study evaluated knee muscle activation patterns of healthy younger (YC) and healthy older (OC) control groups as well as individuals with OA during a weight bearing isometric force control task. Muscle activation patterns were delineated as stabilization strategies. In most muscles, both OC and OA had greater activation magnitudes than younger adults, indicative of greater co-contraction. The OA group however, demonstrated greater activation of the rectus femoris and reduced specificity of the medial hamstrings, signifying different stabilization strategies compared to OC.

INTRODUCTION
Osteoarthritis (OA) is the most common chronic condition among older adults. The development and progression of OA is thought to be mechanically driven by altering the stabilising integrity of the joint [1]. In many cases of OA, history of a traumatic knee joint injury is not a causal factor [2]. Rather, muscle function, the only dynamic regulator of joint stability, is believed to change with age resulting in reduced strength and force control. Thus, discrepancies between OA and OC groups may provide insight into neuromuscular contributions to the development of OA. The purpose of this study was to investigate the muscle activation patterns of young healthy adults (YC), older healthy adults (OC), and adults with OA during a standing isometric force control task.

METHODS
A force matching protocol [3] was used to evaluate muscle activation patterns of 41 YC (23.1±1.9 years of age) 16 OC (60.3±4.64 years), and 19 OA (63.5±8.1 years). Subjects stood with their dominant foot fixed to a force platform and isometrically modulated ground reaction forces along the horizontal plane. With equal body weight on each leg, subjects generated 30% of their maximal force in 12 different directions, corresponding to various combinations of medial-lateral-anterior-posterior loads.

Surface electromyography (EMG) of 8 muscles that cross the knee joint, kinetics and kinematics were recorded. Processed EMG was normalized to previously recorded maximum voluntary isometric contraction (MVIC) and ensemble averaged into group means for each loading direction. EMG polar plots displayed muscle activation patterns, which were quantified with symmetry analyses, mean activation levels (X_{EMG}), directions (Φ), and specificity indices (SI) [3]. Group differences were tested with independent T-tests at the $p<0.05$ level.

RESULTS AND DISCUSSION

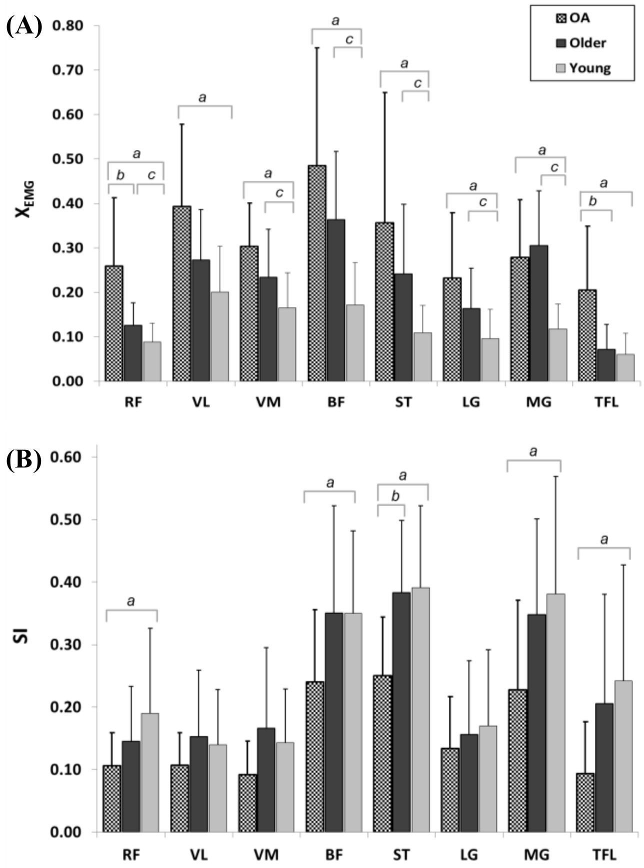

Figure 1: (A) Mean magnitudes of muscle activation (X_{EMG}) and **(B)** Mean specificity indices (SI) of YC, OC, and OA groups. EMG values are normalized so they range from 0 to 1 with 1 being the maximal recorded EMG value for that muscle. Error bars indicate standard deviation. Letters (*a*,*b*,*c*) indicate significant between group difference ($p<0.05$). *a* –OA and YC; *b*-OA and OC; *c*-OC and YC.

Similar muscle activation patterns were observed in all groups (i.e. symmetry and Φ) (Figure 2). However, in 7 muscles, the X_{EMG} was significantly greater in both the OA and OC groups compared to YC (Figure 1A). The OA group also demonstrated significantly greater X_{EMG} in the rectus femoris and tensor fascia lata as well as lower SI in semitendinosus hamstrings (Figure 1B) compared to OC.

Our results indicate that regardless of loading direction, both OC and OA groups have greater levels of muscle co-contraction than YC. This is suggested to be an adaptive response to age-related changes in muscle strength and force control [4]. Considering that individuals with OA have reduced muscle strength and force control compared to age-matched controls [4], it is suggested that the greater levels of quadriceps activation and decreased specificity observed in the medial hamstrings is this "stiffening" response adapted by the OA group but to an extent that may expose the joint to detrimental loading conditions.

CONCLUSIONS

We observed greater activation levels in individuals with OA compared to healthy older adults. It is suggested that individuals with OA under-go age-related changes in muscle function that reduces their muscle strength and force control more so than age-matched controls. As such, neuromuscular adaptations result which may expose the joint to adverse loads contributing to the progression of OA [5]. Further investigation regarding age-related neuromuscular changes and their influence on the development of OA is warranted.

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REFERENCES

1. Herzog W & Federico S, *Biomechan Model Mechanobiol.* **5**: 64–81, 2006.
2. Slemenda C, et al., *Ann of Intern Med.* **127**: 97-104, 1997.
3. Flaxman TE, et al., *J Biomech*. **45**:2570-6, 2012.
4. Rudolph KS, et al., *Phys Ther.* **87**:1422-32, 2007
5. Herzog W & Longino D, *J Biomech*. **40**:S54-63, 2007.

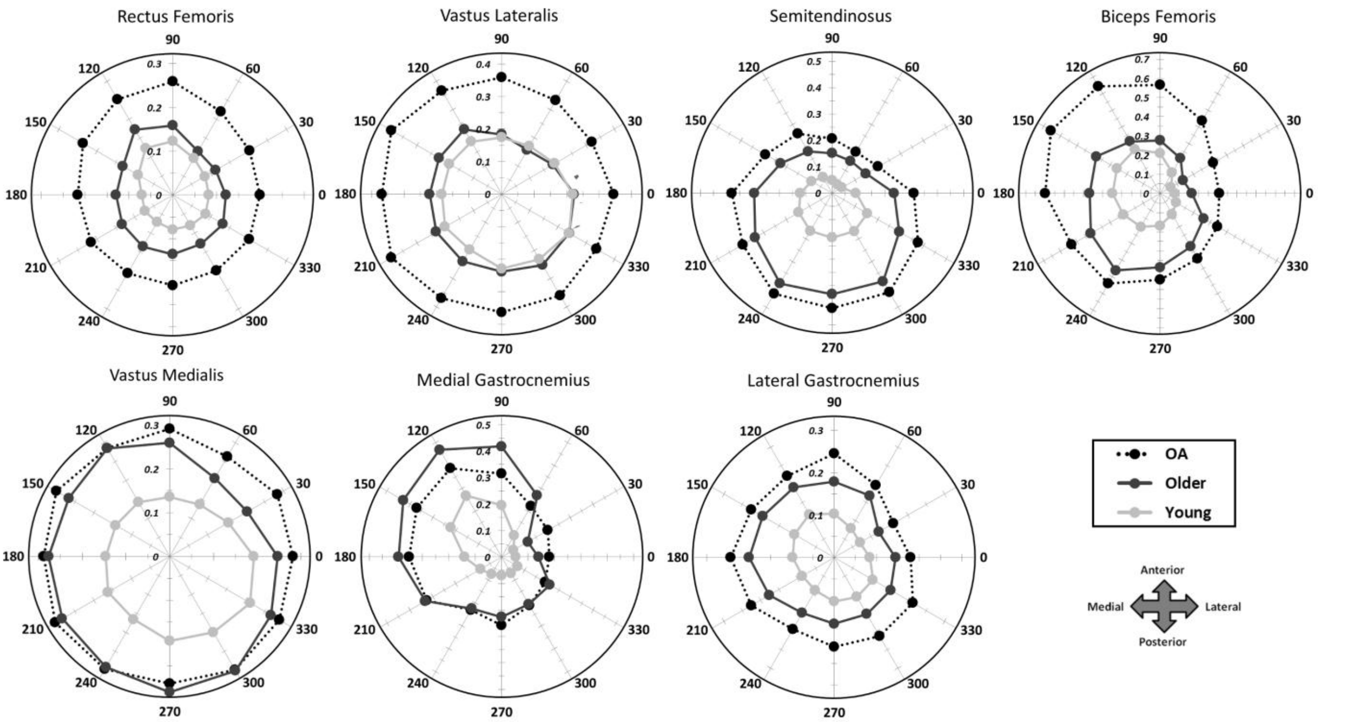

Figure 2: Mean EMG polar plots of YC, OC, and OA groups. Numbers along the circular trajectory represent the force direction angle in degrees. Where the pattern on the force direction's radius intersects represents the mean normalized EMG recorded for that direction. EMG magnitudes indicated by numbers along the vertical radius.