Effect of co-contraction and muscle strength on muscle-tendon dynamics

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I. Introduction

Muscular co-contraction may be necessary for maintaining stability on uneven surfaces [1]. However, co-contraction analyses are limited due to a sole reliance on electromyography (EMG) measurements, infrequent analysis on uneven terrain, and a focus on muscles stabilizing the hip, knee, and ankle joints—overlooking the 33 joints of the foot and ankle [2]. One such joint is the subtalar joint, crucial for stability in the medial and lateral directions. Recent evidence indicates that co-contraction may influence muscle-tendon dynamics [3]. Yet, the impact of co-contraction on muscle-tendon dynamics, particularly in stabilizing the subtalar joint under mediolateral perturbations, remains unclear.

The purpose of this research was to study how muscles crossing the subtalar joint contribute to foot stabilization and how co-contraction strategies affect muscle-tendon dynamics in young healthy adults.

II. Methods

20 young participants walked on a force-instrumented treadmill at a slow (0.8 m/s), preferred, and fast (1.6 m/s) walking speed, wearing five different 3D printed footwear conditions (Fig. 1). 30 reflective markers were placed over body landmarks and tracked using a 12 – camera motion capture system. EMG activity of the tibialis anterior (TA), peroneus longus (PL), and peroneus tertius (PT) was measured using surface electrodes. The TA and peroneus brevis were imaged with two B-mode ultrasound probes.

Co-contraction was assessed for the TA/PL and TA/PT muscle pairs through **two metrics**: **1)** the ratio of total antagonist to agonist muscle activity [4] and **2)** the ratio of total antagonist to agonist muscle moments.

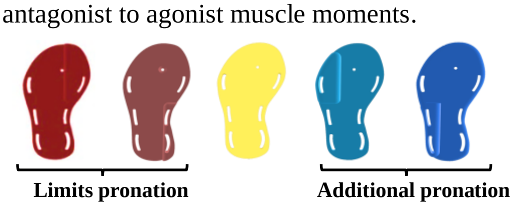

Fig. 1 3D – printed footwear conditions

III. Results and expected results

Using **metric 1**, no significant differences ($p > 0.05$) were found in co-contraction of the TA/PL and TA/PT muscle pairs across all footwear conditions.

Regarding peak-to-peak TA fascicle lengths during stance, no significant interaction effect between footwear condition and speed were found ($p > 0.05$). However, there was a significant difference ($p = 0.009$) in peak-to-peak TA fascicle lengths across the three speeds, where peak-to-peak lengths were greater in the 1.6 m/s vs 0.8 m/s walking speed.

For the second method of co-contraction analysis, using **metric 2,** we anticipate increased co-contraction in the footwear conditions and at higher walking speeds. Co-contraction with the second metric is expected to cause muscle-tendon units to operate more optimally, either by operating at their optimal length or by having the muscle fibers contract more isometrically. It is expected that this co-contraction measure will be more sensitive to detecting changes in simultaneous activation of muscles across the speeds and surface conditions. Future lines of research will assess whether co-contraction will differ depending on a person's overall muscle strength such that an individual with weaker muscles may have increased levels of co-contraction.

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References

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