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# Can the supination resistance test help determine the effects of foot orthoses on the foot and ankle biomechanics during walking?

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## 1. Introduction

Foot orthoses (FOs) are devices commonly used in research and clinical contexts to reduce pain and improve function in patients with musculoskeletal disorders (Naderi et al., 2022). Even though their biomechanical effects on lower limbs have been well documented, their effects on the foot need to be further investigated to provide a more comprehensive view of their mechanism of action (Moisan, Mainville, et al., 2022). Considering the heterogeneous biomechanical responses to FOs therapy, it is also crucial to better identify those who will positively respond to wearing FOs.

The supination resistance test (SRT) is a low-cost, easy to use clinical test to determine the required force to supinate the foot and ankle. The quantitative version of this test is highly reliable (Moisan, McBride, et al., 2022) and its outcome is correlated with foot and ankle

biomechanics during gait (McBride et al., 2019). This test could help determine how one will biomechanically respond to wearing FOs by quantifying the force needed to supinate the foot and ankle.

Thus, the objectives of this study were to investigate the effects of FOs on foot and ankle biomechanics during gait, and to correlate these effects with the results of the supination resistance test. The main hypothesis was that FOs would decrease foot and ankle pronation, arch flattening, ankle inversion moments compared to shod, and that lower supination resistance would be associated with greater FOs biomechanical effects.

## 2. Methods

### 2.1 Participants

In this within-subject, randomized cross-over design, a group of 23 flatfooted individuals comprising 16 females and 7 males (age:  $24.9 \pm 5.1$  yr; mass:  $72.7 \pm 21.0$  kg; height:  $166.8 \pm 9.4$  cm; Body mass index:  $25.9 \pm 6.1$  kg.m<sup>-2</sup>, Foot Posture Index:  $8.0 \pm 1.9$ ) were recruited.

### 2.2. Tools

A pair of FOs with forefoot-rearfoot posts and a 5° medial wedge were fabricated with a 3.2 mm polypropylene shell. An OptiTrack motion capture system (Natural Point, Corvallis, OR, USA) with 12 cameras (200 Hz) was used to quantify the spatial position of the kinematic markers placed on pelvis, thigh, leg, and foot segments during walking using the modified Oxford foot model. A floor embedded AMTI force plate (1000 Hz) (Watertown, MA, USA), located in the middle of the calibrated space, was used to quantify the ground reaction forces. Midfoot, ankle angles and moments were calculated and statistically compared between shod and FOs with statistical parametric mapping (SPM). The biomechanical effects of FOs on the foot and ankle were also correlated with the supination resistance test using the SPM regression function.

## 3. Results and discussion

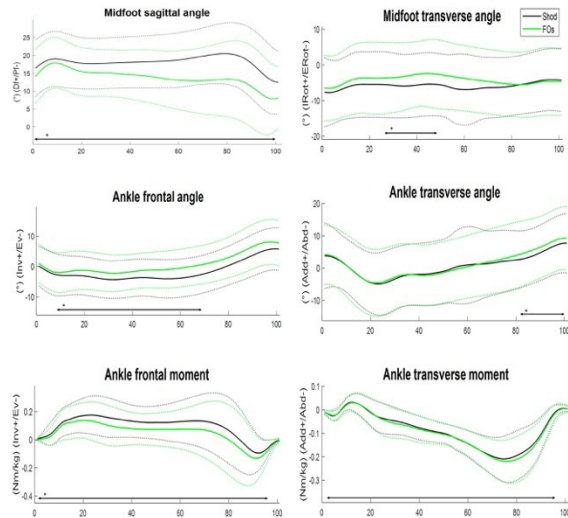
### 3.1. Descriptive data

The mean supination resistance of the dominant leg was  $11.9 \pm 2.1\%$  of the bodyweight. The mean walking speed was  $1.39 \pm 0.14$  m.s<sup>-1</sup> for the shod condition and  $1.39 \pm 0.16$  m.s<sup>-1</sup> for FOs. There was no difference in walking speed across conditions ( $p=0.571$ ).

### 3.2. Comparisons between FOs and shod

During wearing FOs, there was a decrease in midfoot dorsiflexion (0 to 4% of the stance phase (%SP), Maximal Difference (MD)= $1.91^\circ$ ;  $p=0.016$ , and 11-100%SP, MD= $7.16^\circ$ ,  $p=0.001$ ) midfoot abduction (28-45%SP; MD=  $2.82^\circ$ ;  $p=0.035$ ), ankle eversion (11-65%SP; MD= $3.19^\circ$ ;  $p=0.001$ ) ankle abduction (81-89%SP; MD= $1.17^\circ$ ;  $p=0.026$ ) angles compared to shod. While wearing FOs, midfoot plantarflexion

moment (0-58%SP; MD=0.08 Nm/kg,  $p=0.001$ ), ankle adduction moment (0-10%SP; MD=0.04 Nm/kg;  $P=0.003$ , and 11-100%SP; MD=0.07 Nm/kg;  $P=0.001$ ) and ankle inversion moment (0 -10%SP; MD=0.01 Nm/kg;  $p=0.003$ , and 11-98%SP; MD=0.05 Nm/kg;  $p=0.001$ ) were smaller compared to shod walking condition.



**Figure 1.** Kinematic and kinetic differences during the stance phase while shod (black) and wearing FOs (green). \* = significant differences between shod and FOs. Df = dorsiflexion, Pf = plantarflexion, Inv = Inversion, Ev = eversion, Abd = abduction, Add = adduction.

### 3.3. Correlations between SRT and FOs effects.

Greater supination resistance was associated with more pronounced effects on foot and ankle biomechanics, implying a positive relationship between the supination resistance and biomechanical effects of FOs. The most significant findings were the moderate positive correlations between supination resistance and ankle eversion ( $r=0.56$ ) and abduction ( $r=0.62-0.70$ ) angles, and ankle abduction ( $r=0.64$ ) moment, as well as a negative correlation with ankle inversion ( $r=-0.68$ ) moment. There was also a moderate correlation between SRT and FOs effects on midfoot abduction ( $r=-0.63$ ).

## 4. Conclusions

FOs provided diverse effects on the ankle and the foot. They controlled the pronatory forces and movements in the foot and the ankle joints.

We hypothesized that lower supination resistance would be associated with greater FOs biomechanical effects. Contrary to our hypothesis, greater supination resistance was associated with more pronounced effects on foot and ankle biomechanics, implying a positive relationship between the supination resistance and biomechanical effects of FOs. We found moderate correlations between supination resistance and the effects of FOs on ankle inversion and abduction angles and moments. This will enable us to better understand

which participant with flat feet will benefit the most from wearing FOs.

These findings have the potential to improve orthotic prescription strategies, potentially benefiting individuals with musculoskeletal disorders.

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## Conflict of Interest Statement

None to disclose.

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