# Ankle joint complex power during walking and running: effects of marker location, and shoe- vs. skin-mounted markers

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## Summary

When computing ankle joint complex power using inverse dynamics, should you cut holes in the shoes to allow for skin-mounted motion tracking markers? And how important is consistency in marker location on the foot? We addressed these two important questions in walking and running. Our results suggest that you may want to put away the scissors (i.e., forego cutting holes in your footwear), and instead pick up a Sharpie® pen, based on the fact that we did not observe significant differences in joint power when comparing shoe vs. skin-mounted markers, but we did observe significant differences due to the precise location of markers on the foot.

## Introduction

Mounting evidence indicates that ankle joint complex (AJC) power (between the shank and calcaneus) may provide a better estimate of biological ankle function than power computed between the shank and a conventional rigid-body foot segment [1]. However, when estimating shank-calcaneus power it is not yet known whether markers should be mounted on the skin (and made visible via windows cut in the footwear material), or if placing markers directly onto the shoe will suffice. The use of a skin- vs. shoe-mounted marker set has been explored in terms of effects on kinematic outcomes during running [1,2]; however, there is little data in the literature on kinetics (e.g., joint power) or on non-running activities. As such, we aimed to quantify differences in AJC power between a skin- and shoe-mounted marker set throughout the stance phase of walking and running. As a secondary aim, we assessed the effect of modifying foot marker locations when computing AJC power via a shoe-based marker set.

## Methods

Ten healthy adults (age: 23.8±2.9 years; mass: 66.1±8.9 kg)

walked (0.8, 1.2 and 1.6 m·s$^{-1}$) and ran (2.6, 2.8 and 3.0 m·s$^{-1}$) on a force-instrumented treadmill. Kinematics and ground reaction forces were collected. Participants completed two trials per gait speed; one with foot markers affixed to the skin, visible through small circular windows cut in the footwear material (SKIN marker condition). During the second trial, the windows were covered with fabric and new markers were placed in near-identical locations to the first trial (SHOE condition). Three additional calcaneal markers were also placed on the shoe, in locations slightly lower than the SHOE condition. We used these for the SHOE$_{alt}$ condition. AJC power was computed for each condition, then statistical non-parametric mapping was used to determine if there were differences in power across the gait cycle for the SKIN vs. SHOE, or SHOE vs. SHOE$_{alt}$ conditions.

## Results and Discussion

The AJC powers computed from the SKIN vs. SHOE conditions did not exhibit any statistically significant differences across the gait cycle (Bonferroni adjusted alpha level of 0.0083). However, statistically significant differences in AJC power were observed at various time points in both walking and running when SHOE vs. SHOE$_{alt}$ were compared (when black solid line crosses red dashed line in Fig. 1) [3]. These findings suggest that when computing AJC power for walking and running, it may be more beneficial/important to use a template to help maintain consistent marker placement locations across trials and conditions, than to cut holes in your footwear.

## References

[1] Alcantara R et al. (2018). *Gait Posture.*, **63**:68-72.
[2] Trudeau M et al. (2017). *Foot. Sci.*, **9**:79-85.
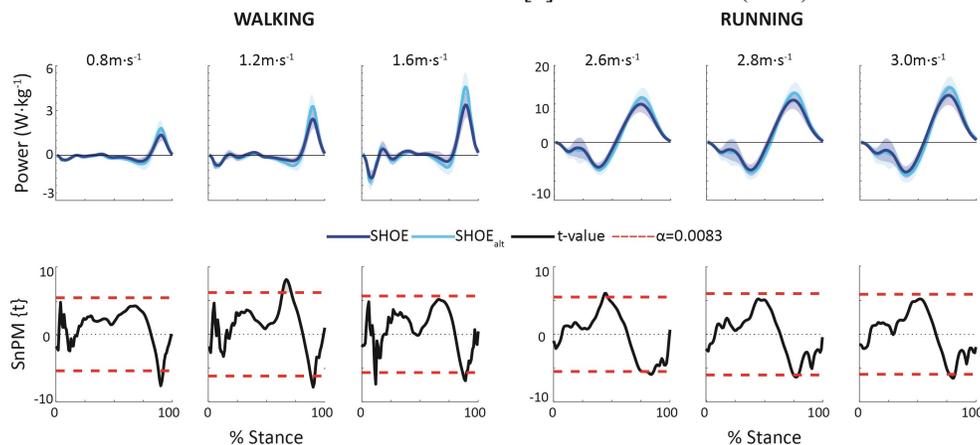[3] McDonald et al. (2019). *In Review.*

**Figure 1** SHOE vs. SHOE$_{alt}$: ankle joint complex power estimates for walking and running using two shoe-applied calcaneal tracking marker set configurations: SHOE (dark blue) and SHOE$_{alt}$ (light blue). Data are presented as mean±s.d. (shaded regions), for stance phase. Statistical non-parametric (SnPM) mapping t-values (black solid line) are displayed in lower plots, with an adjusted alpha level threshold (red dashed line).