# Center of Pressure Displacement and Abductor/Adductor Activation for Variable Landing Heights and Foot Spacings

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## Introduction

Landing techniques are essential for sports where knee injuries are common. To identify the biomechanical risk factors, previous studies have focused on peak vertical ground reaction forces (GRFs), center of pressure (CoP) excursion, and knee flexion angles (1, 2). However, most of this research was conducted using constant landing heights and foot spacings. The purpose of this study is to understand the biomechanical effects of landing from variable heights and foot spacings with a focus on CoP displacement and hip abductor/adductor muscle activation.

## Methods

One recreationally active male (age: 39 years, height: 190.5cm, body mass: 93.9kg) was asked to perform a step-off landing from two heights (30.48cm and 60.96cm) while using three different foot spacings (20cm, 40cm, and 60cm). Three trials were performed for each landing height/foot spacing combination. The subject wore 14 lower-body markers while kinematic data were collected at 100 Hz. Two in-ground force plates recorded kinetic data and two EMG sensors placed on the right hip abductor and adductor muscles collected data at 1000 Hz. The EMG data were rectified prior to analysis using 4$^{th}$ order zero-lag band-pass Butterworth filters with cut-off coefficients of 10 Hz and 400 Hz. Only data from the right leg were analyzed.

## Results and Discussion

An analysis of peak values for each trial showed that as height increased, so did vertical GRFs, although there was no significant effect across foot spacings (Table 1). However, as foot spacings increased, CoP displacement moved medially to laterally (Figure 1). Adductor muscle activation was greatest for the 20cm foot spacing, whereas abductor activations were greater for the 40 and 60cm foot spacings. Knee flexion angle increased with foot spacing for the 30cm landing height but remained constant for the 60cm landing height.

**Table 1**: Peak values for each landing height/foot spacing combination.

| Height (cm) | Spacing (cm) | Peak GRF (N) | Peak Knee Angle (degrees) | Max CoP Lateral Displacement (mm) | Max Abductor EMG (mV) | Max Adductor EMG (mV) |
|---|---|---|---|---|---|---|
| 30 | 20 | 2240.5 | 68 | 13.4 | 0.84 | 1.22 |
| | 40 | 1839.5 | 72 | 19.8 | 0.85 | 0.33 |
| | 60 | 2014.8 | 84 | 27.7 | 0.31 | 0.32 |
| 60 | 20 | 2305.1 | 96 | 22.2 | 0.24 | 1.27 |
| | 40 | 2356.4 | 95 | 22.8 | 1.09 | 0.31 |
| | 60 | 2506.1 | 96 | 36.8 | 1.50 | 0.32 |

## Significance

As foot spacings increased, so did peak knee flexion angle, lateral CoP displacement, and abductor activation, all of which have been associated with decreased risk of knee injury. Interestingly, similar responses were recorded for both landing heights, suggesting that a wider stance may reduce the risk of injury landing from different heights. Future studies should incorporate a more diverse population to test these initial findings.

## References

1. Dural CJ, et al. *J of Sport Rehabilitation* **20**, 406-418, 2011.
2. Wang J, Fu W. *Adv in Mechanical Engineering* **11**, 1-8, 2019.

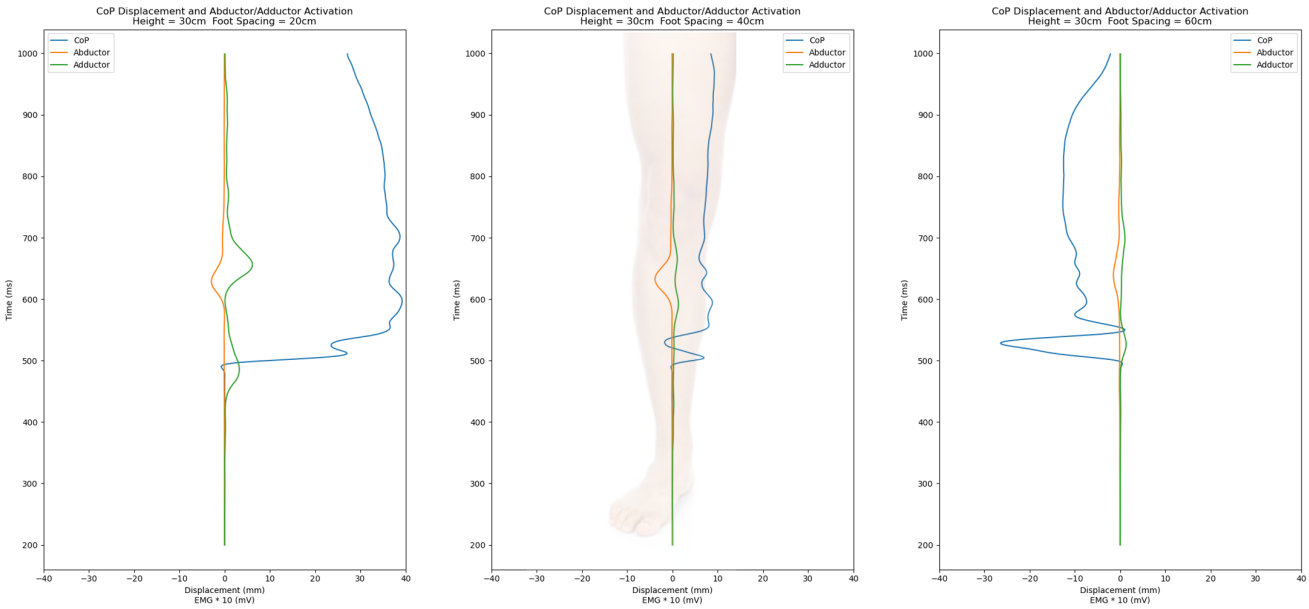


**Figure 1:** CoP Displacement and Abductor/Adductor Activation for 30cm landing height with various foot spacings. The EMG signals were inverted to align anatomically with an anterior view of the right leg and amplified to improve readability.