Behavior of the Foot Regions at Bipedal Quiet Stance

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Summary

This study investigates regional plantar pressures and anteroposterior moment arms' dynamics during quiet stance on ten healthy male participants via pressure pad and force plate data (eyes open, soles intact). Significant differences in weight distribution were found across feet and foot regions, with higher percentages in the right foot and highest in the hindfoot, lowest in the midfoot. No significant differences were observed in Root Mean Square **(**RMS) of regional moment arms or their corresponding velocities (VRMS). These findings may be pointing to a possible deformation of the soft tissue beneath the foot while maintaining a stable upright posture during quiet stance.

Introduction

The human foot is a complex structure (hindfoot, midfoot, forefoot, phalanges) providing weight-bearing support and balance. Plantar soft tissue is a complex structure that plays a crucial role in providing cushioning and support. It consists of specialized adipose tissue organized into compartments, which cushion bones, muscles, and nerves. These compartments can deform under pressure, allowing the enclosed fat tissue to absorb shock and distribute weight effectively [1]. This research explores how different foot regions contribute to weight bearing and balance, aiming to better understand the link between foot mechanics and postural control.

Methods

This study analyzed weight distribution across the front (F), mid (M), and hind (H) regions of the right (R) and left (L) feet during postural sway. Ten healthy, right-handed and footed adult males (29.2 ± 3.88 years, 736.92 ± 82.50 N, 178.7 ± 4.96 cm, 25.56 ± 1.21 cm right foot length) participated. Participants stood on a force platform with a pressure pad overlay, shoulder-width stance, relaxed arms, wearing socks, eyes open, for three 90-second trials. Force and moment data (100 Hz, Bertec®) and pressure distribution (50 Hz, Tekscan®) were collected to estimate regional and overall anteroposterior center-of-pressure (CoPx).

Results and Discussion

We found the highest weight percentage and pressure at the hindfoot, highlighting its role in force absorption and distribution [2], while the lowest was at midfoot reflecting midfoot's role as a bridge-like structure for energy storage, dissipation, and load transfer [3] (Table 1).

Table 1: Mean and Standard Error for regional pressure and percent weight

		Regional Pressure (kPa)	Weight (%)
Foot	Left	44.687±1.482	0.157±0.002
	Right	51.193±3.069	0.176±0.002
p value		0.017*	0.005*
Regions	Fore	37.659±2.673	0.200±0.10
	Mid	27.004±3.919	0.055±0.008
	Hind	79.158±2.999	0.246±0.012
p value		0.001*	0.001*

On the other hand, overall CoPx RMS (0.32 ± 0.069 cm) was nearly seven times larger than regional moment arms, while overall VRMS (0.54 ± 0.220 cm/s) was five times larger for left, seven times larger for right foot regional moment arms' velocities. Similar variations in regional moment arms, scaled almost seven times by overall CoPx, suggests a sliding action of the stable foot structure above the plantar soft tissue [4], as an additional degree of freedom in modeling postural sway [5]. The dominant foot carries a greater percentage of body weight during stance, while the non-dominant foot shows higher velocity in surface exploration [6].

Conclusion

This study demonstrates foot regions' contributions to weight-bearing and postural control. The fine architecture of the plantar soft tissue having sensory capabilities is worth to note for adaptive nature of the foot in maintaining balance.

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