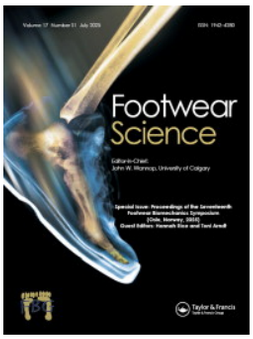

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ABSTRACT

Behaviour of foot regions at bipedal quiet stance

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KEYWORDS Postural control; quiet stance; foot regions; foot structure; foot function

Introduction

The human foot is a complex structure with four segments: hindfoot, midfoot, forefoot, and phalanges (Abboud, 2002). It functions as a weight-bearing support and plays a crucial role in balance. The combined truss and beam function of the foot is essential for its support mechanism. To achieve this, the foot employs several biomechanical mechanisms, including arch support and bony structure, muscle activation, and load transfer. Plantar soft tissue is a complex structure that plays a crucial role in providing cushioning and support. It consists of specialised adipose tissue organised 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 (Kelikian & Sarrafian, 2011).

Purpose of the study

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 analysed 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).

The Human Subjects Ethics Committee of the Middle East Technical University approved the experimental protocol for this study under protocol number 0423- ODTU IAEK-2022. All participants provided informed consent before participating.

Results

In this study, significant weight percentage and pressure differences were found between feet and regions, with higher percentages on the right foot and highest in the hindfoot, lowest in the midfoot (Table 1).

On the other hand, RMS values of regional CoPx (cm) were: 0.051 ± 0.021 (FL), 0.043 ± 0.016 (ML), 0.046 ± 0.019 (HL), 0.064 ± 0.023 (FR), 0.043 ± 0.029 (MR), and 0.039 ± 0.014 (HR). Overall CoPx RMS (0.32 ± 0.069 cm) was nearly seven times larger than regional CoPx. VRMS values (cm/s) were: 0.12 ± 0.074 (FL), 0.12 ± 0.076 (ML), 0.09 ± 0.048 (HL), 0.13 ± 0.067 (FR), 0.07 ± 0.033 (MR), and 0.06 ± 0.027 (HR). Overall VRMS (0.54 ± 0.220 cm/s) was five times larger for left, seven times larger for right foot.

Discussion and conclusion

Consistent with prior works (Cavanagh et al., 1987), we found the highest percent weight and pressure in the hindfoot, highlighting its role in force absorption and distribution. Similarly, the lowest midfoot pressure and percent weight are aligned with studies that reflects the midfoot's role as a bridge-like structure for energy storage, dissipation, and load transfer (Kim & Voloshin, 1995).

Foot intrinsic muscles stabilise the medial longitudinal arch by adjusting stiffness to an external load, possibly via isometric contractions during stance (Kelly et al., 2014). Similar variations in regional moment arms, scaled almost seven times by overall CoPx, suggests a sliding action of

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*

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the stable foot structure, which may be modelled as an additional degree of freedom during postural sway (Bojsen-Moller & Flagstad, 1976; Gürses, 2002).

The dominant foot carries a greater percentage of body weight during stance, while the non-dominant foot shows higher velocity in surface exploration (Pourreza et al., 2024).

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.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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