Plantar soft tissue deformation during walking gait at different speeds

Adam Rowlatt[1], Kristiaan D'Août[1,]
[1]Department of Musculoskeletal and Ageing Science, Faculty of Health and Life Sciences, University of Liverpool, Liverpool, UK.
Email : a.rowlatt@liverpool.ac.uk

Summary

The present study aimed to investigate the soft tissue deformations of the foot through investigating the heel pad and forefoot deformation during walking gait. This study demonstrated no differences between speeds within plantar soft tissue deformation.

Introduction

During human locomotion, the body is subjected to variable forces throughout the gait cycle with initial ground reaction forces interacting with the body through the point of ground contact [1]. It is important to understand how the foot behaves when subjected to these forces of gait. Previously it has been demonstrated how plantar tissue of the heel pad and bone kinematics within the foot behave [2]. This study aims to provide a biomechanical assessment through motion capture of the plantar tissue within both the heel pad and forefoot during walking human gait at slow medium and high walking speeds.

Methods

Twenty participants were recruited (26.8 years ± 4.11, mean ± SD: 8 males, 12 females). A force plate was positioned centrally within 12 motion capture cameras set to 200Hz with timing gates positioned to measure walking speeds. 15 reflective markers were used to measure plantar tissue behavior within participants. Froude number (Fr) is a dimensionless parameter used to normalize walking speeds to size. The 3 walking speeds that were used within this study were low (0.1Fr), medium (0.2Fr) and high (0.3Fr) which were calculated for each participant [3]. The following variables were analysed across all three walking speeds: normalised ground reaction force, heel area (HA), metatarsal width (MW), forefoot plantar tissue width (FPTW) and total forefoot width (FW). Variables are provided as absolute values, total change and relative change. Geometric models were implemented using custom MATLAB code using the 3D marker coordinates of the foot to calculate heel area, metatarsal width, forefoot plantar tissue width and total forefoot width. The static trials were used alongside the absolute values to calculate total change and relative change.

Table 1: Data Presented as Mean ± Standard Deviation

	HA	MW	FPTW	FW
Absolute value	3456.41 ± 132.83 mm^2	80.87 ± 3.07 mm	19.12 ± 1.83 mm	93.89 ± 4.2 mm
Total Change	313.08 ± 132.36 mm^2	6.76 ± 3.05 mm	7.08 ± 1.83 mm	8.34 ± 4.17 mm
Relative Change (dimensionless)	0.1 ± 0.04	0.09 ±0.04	0.67 ±0.17	0.1 ± 0.05

Results and Discussion

There were no significant differences between walking speeds. Relative change within heel area (0.1±0.04) and foot width (0.1±0.05) where similar across stance equating to a total change of 313.08 ±132.36 mm^2 and 8.34.08 ±4.17 mm respectively. Relative change within metatarsal width (0.09±0.04) and forefoot plantar tissue width (0.67±0.17) equated to a total change of 6.76 ± 3.05 mm and 7.08 ±1.83 mm respectively (Table 1). The compression of the heel pad occurs rapidly within 150ms, displaying exponential growth in strain with increased loading forces [4]. Heel pad area was maximal after initial heel strike (Figure 1).

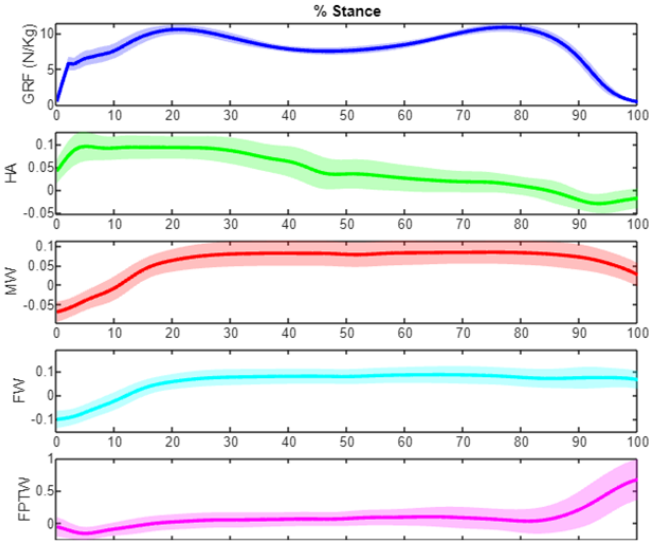

Figure 1: Normalised Ground Reaction Force and Relative Changes in HA, MW, FPFW and FW across Stance

Conclusions

No differences are present when walking at a variety of speeds with maximal plateaus in deformation of the heel area (3456.41 mm^2 ± 132.83), metatarsal width (80.87 mm± 3.07), foot width (93.89 mm ± 4.2), and forefoot plantar fat width (19.12 mm ± 1.83) due to deformations occurring at low loads.

References

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