Multi-segmental foot modelling during shod activity: study of running shoe integrity

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Introduction

Multi-segmental foot modelling (MSFM) during shod activity has the potential to enhance our understanding of how footwear influences foot motion. Recent work by Bishop *et al*. (2015) and Shultz & Jenkyn (2012) has validated the incision parameters to accommodate surface mounted markers for two alternative MSFMs, requiring 7 and 5 incisions respectively, within the shoe. These MSFMs have been sparsely used in contrast to 3DFoot model (Leardini *et al*. 2007) which would require 10 incisions and has not been used previously to assess in-shoe foot motion.

Purpose of the study

To determine the influence of incisions to accommodate Jenkyn and Nicol (JN) and 3DFoot MSFMs upon the structural integrity of neutral running shoes.

Methods

Two procedures were applied to assess shoe deformation. A) Eight males (30±8yrs, 1.78±0.05m, 84±7kg) completed 2 testing sessions. Participants ran at a self-selected pace ($3±0.5 m.s^{-1}$) in standard ASICS running shoes. Baseline shoe deformation data was collected during the first session. Prior to session 2, 25mm incisions were made to accommodate MSFMs: 3DFoot (left shoe) and JN (right shoe). Kinematic data were recorded using 3D motion analysis (VICON, Oxford, England) at 200Hz. Three retro-reflective markers (Figure 1) were used to measure as shoe distance and shoe angle at initial contact (IC), heel rise (HR) and toe off (TO). Shoe deformation measures were compared using paired t-tests. B) Material strain of the shoe upper was assessed in 1 male participant (26yrs, 1.80m, 80kgs) using ARAMIS optical system. Material strain patterns were compared between intact and cut conditions using Trend symmetry (TS) analysis (Crenshaw & Richards, 2006).

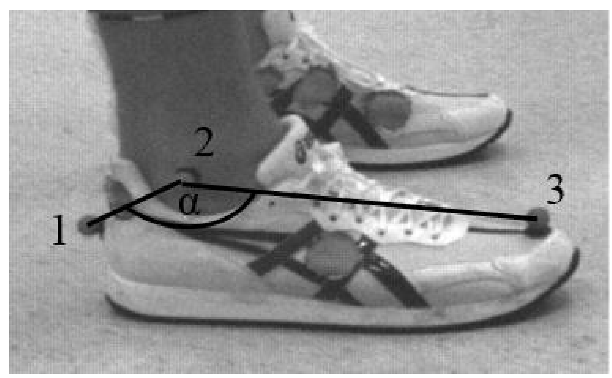

Figure 1. Marker placement for shoe deformation analysis

Results

No significant differences ($p > 0.05$) in shoe distance were recorded between intact and cut conditions but significant differences ($p < 0.05$) were reported in shoe angle at all three events of running gait (Table 1). Material strain assessment showed lower TS scores for the lateral aspect of the shoe (TS = 0.81 ± 0.11) than the medial aspect (TS = 0.89 ± 0.12). Symmetry was greater between the intact and JN shoe (TS= 0.88 ± 0.10) than the intact and 3DFoot shoe (TS = 0.82 ± 0.13).

Table 1. Mean difference (SD) between intact and cut conditions

	Shoe Distance (mm)		Shoe Angle (°)	
	JN	3DFoot	JN	3DFoot
IC	1 (2)	1 (4)	4 (5) *	1 (5)
HR	0 (2)	1 (5)	-1 (3)	-3 (3) *
TO	0 (3)	2 (4)	3 (3) *	1 (3)

* $P < 0.05$

Discussion and Conclusion

Analysis of kinematic shoe deformation measures revealed individual responses to incisions made within the upper of a running shoe to accommodate MSFMs. Significant ($p < 0.05$) changes in shoe angles were noted between the intact and cut conditions at IC and TO for the JN incisions and HR for the 3DFoot incisions. However, while the changes in shoe angle were significant, the mean difference was small (≤ 5°). This value is lower than the minimal important difference proposed by Nester *et al*. (2007) for comparison of gait kinematics. Thus, it may be argued that the differences in shoes angles between intact and cut conditions were negligible and the results support the use of either MSFM to assess shod foot motion.

While the use of kinematic measures to infer the shoes structural integrity have been used previously (Shultz and Jenkyn, 2012), no validation of these measure has been undertaken. The small and non-systematic findings reported in both this study and that of Shultz and Jenkyn (2012), particularly for shoe distance measures; question the sensitivity of kinematic shoe deformation measures to detect changes in structural integrity. Material strain analysis was used to further explore area specific alterations in the running shoes structural integrity from the different incision sets. The material strain analysis supported the use of the JN foot model to assess in-shoe foot kinematics, due to higher symmetry scores and smaller mean differences between the intact and JN shoes. Further exploration of additional means of assessing the influence of incisions to accommodate MSFM upon the shoes structural integrity is warranted.

References

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