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Assessing Group Differences between Hallux Valgus Patients and Healthy Controls using Statistical Parametric Mapping

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Summary

This study characterizes plantar pressure differences between hallux valgus patients and healthy controls using statistical parametric mapping (SPM). The plantar pressure differences are minimal which, combined with previous studies, suggest high variability in the plantar pressures of hallux valgus patients.

Introduction

Hallux valgus is a common and painful foot deformity that researchers have recently attempted to characterize using plantar pressure measurements [1,2,3]. Unfortunately, these studies have shown contradictory results, with plantar pressure differences appearing either only in the toes [1], only in the hallux and metatarsal 5 [2], or only in the central forefoot [3].

Region-based plantar pressure analyses, like those performed in the articles cited above, are known to be sensitive to region boundary definitions [4], and this may explain the differences in previous studies. Statistical parametric mapping (SPM) methods, like pSPM [5] and STAPP [6], do not have this limitation. Therefore, in this study, we use SPM methods to characterize group differences between hallux valgus patients and controls in an attempt to clarify earlier results.

Methods

Thirty hallux valgus patients and 50 healthy controls participated in this study and gave their informed consent. Each individual had their plantar pressures measured 15 times, at their preferred walking speed, using a 1.5m footscan® plate (rs scan, Paal, BE, 7.62mm x 5.08mm, 200 Hz). The 15 measurements were normalized for walking speed, then spatio-temporally aligned and averaged as described in [6].

SPM was performed on peak pressure images using pSPM [5] and on the full plantar pressure measurement using STAPP [6]. Group differences between hallux valgus patients and healthy controls were statistically tested using a linear univariate model:

$$p_i(x,y) = u(x,y)G_i + v(x,y)S_i + e_i(x,y),$$

where $p_i(x,y)$ is the plantar pressure for subject i at pixel (x,y) [or in the case of STAPP, (x,y,t)], G_i is a binary group indicator, S_i are subject factors (age, gender, height, weight, shoe size), $u()$ and $v()$ are unknown functions, and the residuals $e_i()$ are assumed to be independent and normally distributed. The resulting t-statistics from $u()$ were then thresholded for significance using random field theory [5,6].

Results and Discussion

Figure 1 shows the pSPM peak pressure group differences as well as time points in the stance phase where notable plantar pressure group differences were found with STAPP.
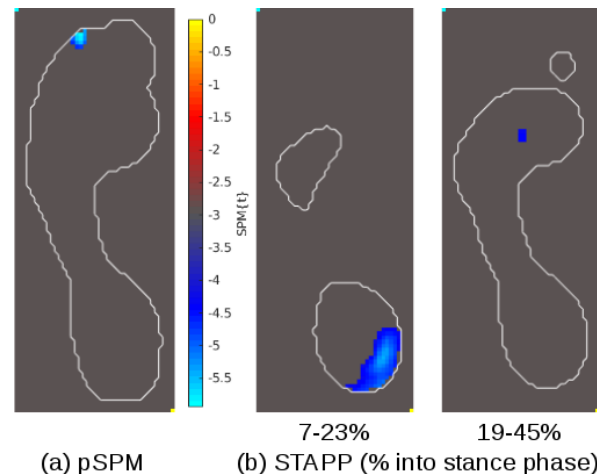

Figure 1: Significant t-statistics from pSPM and STAPP.

pSPM showed decreased pressure in the small toes as a result of hallux valgus (t-statistic = -4.81, p-value = 2e-5), while STAPP showed decreased pressure in the heel during heel loading (duration: 26% of stance phase, t = -3.57, p = 3e-4) and in the forefoot during midstance (duration: 16.3%, t = -3.31, p = 6e-4). However, pressure differences are minimal.

Conclusion

These results, along with those in [1,2,3], suggest that the plantar pressures of hallux valgus patients are highly variable and it may be more productive to evaluate their plantar pressures at the individual level than at the group level.

Acknowledgments

References

[1] Galica AM et al. (2013). *J. Foot & Ankle Res*, **6**:42.
[2] Koller U et al. (2014) *J. Ortho. Res.*, **32**: 1688-1693.
[3] Hida et al. (2017). *J. Ortho. Sci.*, **22**: 1054-1059.
[4] Pataky TC et al. (2008) *J. Biomech.*, **41**: 2772-2775.
[5] Pataky TC and Goulermas JY. (2008) *J. Biomech.*, **41**: 2136-2143.
[6] Booth BG et al. (2018) *Gait & Posture*, **63**: 268-275.