

Comparison of In-shoe Plantar Loading During Walking, Heel Raise and Sit-to-Stand

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INTRODUCTION

- Foot pain affects one in five community-dwelling adults, and has a substantial negative impact on quality of life¹.
- The development of foot pain has been related to abnormal plantar loading².
- Plantar loading is influenced by type of weight-bearing activity and foot region³⁻⁵. While the effect of walking speed on plantar loading has been previously reported, limited objective data are available elucidating plantar loading during other activities of daily living (ADL) such as heel raises and sit-to-stand.
- Heel raise and sit-to-stand are common ADL, that are also used as exercises in physical therapy rehabilitation.
- **The purpose of this study is to assess regional peak plantar pressure and pressure-time integral during walking at self-selected and fast speeds, heel raise and sit-to-stand activities.**
- The findings of this study may help quantify plantar loading during common unilateral and bilateral ADL, and help identify activities that may contribute to foot pain and symptoms.

METHODS

Subjects: 11 asymptomatic subjects (7 males: 30.3 yrs, BMI: 26.4kg/m²; 4 females: 29.5 yrs, BMI: 21.2kg/m²) participated in this study.

Procedures: Subjects performed four activities: self-selected walking, fast walking, heel raise, and sit-to-stand. Subjects were encouraged to walk at self-selected and fast speeds along a 10 m walkway. For heel raise, subjects were instructed to “go up on their toes and come back down”. For sit-to-stand, subjects were instructed to “stand up from a seated position”.

Instrumentation: An in-shoe device (Pedar-X, Novel Inc.) was used to acquire plantar pressures. Peak pressure (PP, kPa), contact time (CT, ms) and pressure-time integral (PTI, kPa.s) were examined for four activities in six foot regions (Figure 1).

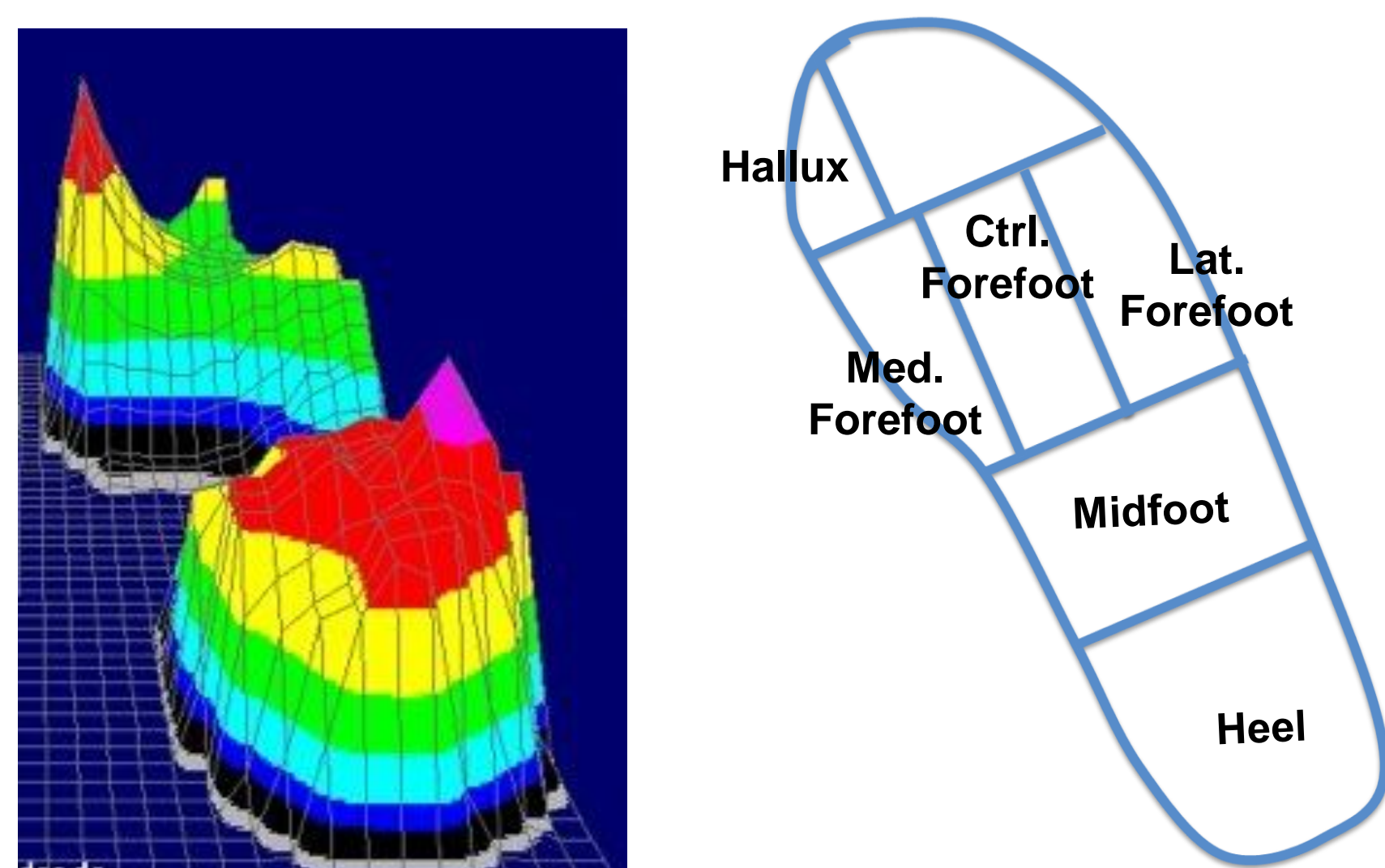


Figure 1. Peak pressure (Left) and foot regions (Right) used to assess dependent variables.

Statistical Analysis: A two-way repeated measures ANOVA was used to examine the effect of Activity and Foot Region (Within-subjects effects) on three dependent variables (PP, CT and PTI). In presence of a significant interaction effect, one-way ANOVA simple effects of activity on each foot region were then assessed subsequently. Bonferroni adjusted pair-wise comparisons were applied for post-hoc tests.

RESULTS

Peak Pressure

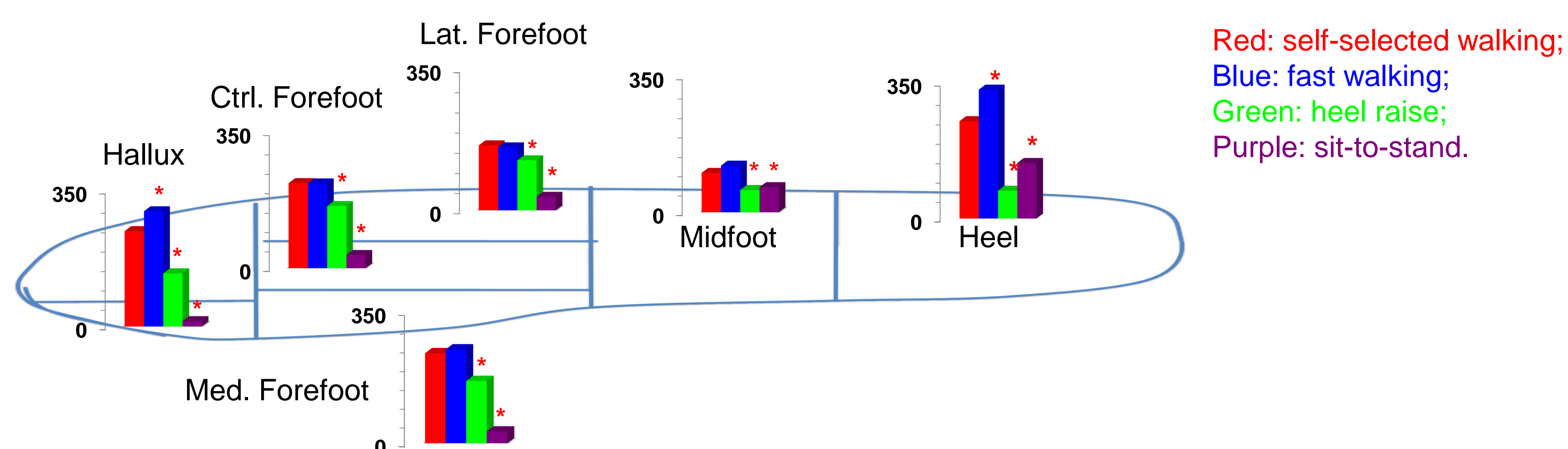


Figure 2. A significant activity x foot-region interaction was found for Peak Pressure (PP, kPa) ($P < .01$). Subsequently, significant simple effects of activity on PP at each foot area were noted at heel, midfoot, medial, central, lateral forefoot, and hallux (all $P < .01$). Pair-wise comparisons of activity on PP at each foot region are summarized in Figure 2. * indicates statistically significant differences, compared to self-selected walking ($P < .05$).

Pressure-Time Integral & Contact Time

	Walking at Self-selected Speed		Walking at Fast Speed		Heel Raise		Sit-to-Stand	
Heel	55.23	9.88	54.85	8.74	19.58	10.25 *	59.83	35.58
Midfoot	29.35	7.08	24.97	7.87 *	19.47	7.01 *	23.57	12.58
Med. Forefoot	55.20	25.94	45.52	21.68 *	145.46	52.80 *	6.36	6.64 *
Ctrl. Forefoot	55.15	18.92	44.43	17.59 *	143.24	55.99 *	8.81	6.12 *
Forefoot Lat.	47.45	10.55	37.38	8.85 *	109.25	27.85 *	9.02	6.01 *
Forefoot Hallux	48.64	11.66	46.53	9.67	115.48	33.47 *	2.57	4.83 *

Table 1 (Left). A significant activity x foot-region interaction was found for Pressure-Time Integral (PTI, kPa.s). Subsequently, significant simple effects of activity on PTI at each foot area were noted at all foot regions (all $P < .01$). Pair-wise comparisons of activity on PTI at each foot region are summarized here in Table 1. * indicates statistically significant differences, compared to self-selected walking ($P < .05$).

Table 2 (Right). A significant activity x foot-region interaction was found for Contact Time (CT, ms). Subsequently, significant simple effects of activity on CT at each foot area were noted at all foot regions (all $P < .01$). Pair-wise comparisons of activity on CT at each foot region are summarized here in Table 2. * indicates statistically significant differences, compared to self-selected walking ($P < .05$).

	Walking at Self-selected Speed		Walking at Fast Speed		Heel Raise		Sit-to-Stand	
Heel	524.09	95.87	447.95	113.85*	1364.63	304.42*	606.36	360.01
Midfoot	534.55	55.47	464.32	65.88*	1377.60	244.09*	526.36	349.15
Med. Forefoot	510.45	102.45	420.00	78.95*	1383.65	250.13*	200.91	193.31*
Ctrl. Forefoot	557.50	50.30	462.95	67.38*	1395.17	253.03*	341.82	203.56
Forefoot Lat.	582.27	43.80	486.14	55.79*	1396.17	251.98*	346.36	194.08*
Forefoot Hallux	474.77	122.19	390.00	103.02*	1326.58	262.46*	110.91	160.84*

DISCUSSION

- Consistent with previous reports, our findings indicate that peak pressure increases with increasing walking speed. Greatest increases were noted at the heel (30% change) and hallux (20% change). Bilateral activities such as heel raise and sit-to-stand, resulted in substantially lower levels of peak regional plantar loading. For the heel raise activity, reduction in peak pressure was accompanied by increased contact time. For the sit to stand activity, reductions were noted in both, peak pressure and contact time.
- This study examined asymptomatic subjects for establishing a baseline understanding of the loading during daily weight bearing activities among different foot regions. Further study will extend to individuals with foot pain.

References

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Acknowledgements

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