

Symmetry of Planter Pressure During Self-Selected Walking, Fast Walking, Heel Raise and Sit-to-Stand

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INTRODUCTION

- High levels of asymmetry have been associated with musculoskeletal injury in activities such as running. [1]
- Symmetry of plantar pressure has been studied in walking [2] but not in activities of daily living (ADL) such as sit-to-stand. Current studies indicate that plantar loading is strongly influenced by activity. [3]
- Walking, sit-to-stand and heel raise are common weight bearing ADL as well as critical exercises for clinical intervention such as muscle strengthening, coordination and balance training.

The purpose of this study was to determine the degree of symmetry for in-shoe plantar pressure between the left and right feet of healthy subjects during walking, heel-raise, and sit-to-stand in six foot regions.

- An improved understanding of plantar pressure symmetry in ADL may provide useful information in designing footwear, preventing lower extremity injuries, and assessing the effectiveness of training programs.

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. All subjects were free from any musculoskeletal and neurological disorders.

Procedures: Subjects performed the following four activities : self-selected walking (SSWV), fast walking (Fast), heel raise (HR), and sit-to-stand (STS).

Data Collection: An in-shoe device (Pedar-X, Novel Inc.) was used to acquire plantar pressures. Peak pressure (PP, kPa) and pressure-time integral (PTI, kpa.s) were examined for four activities in six foot regions: heel, midfoot, medial forefoot, central forefoot, lateral forefoot, and hallux.

Data Analysis: Absolute symmetry index (ASI, %) of PP and PTI for each activity and region were calculated based on the following formula [4]:

$$ASI = \frac{|X_R - X_L|}{\frac{1}{2}(X_R + X_L)} \times 100\%$$

where X_R indicates PP or PTI on right foot and X_L indicates PP or PTI on left foot.

Statistical Analysis: The effect of activity and foot region on ASI of PP and ASI of PTI were determined by using a two way repeated measures ANOVA. If the interaction effect (activity x region) was significant ($\alpha < 0.05$), simple effects of activity on each foot region were assessed subsequently. Bonferroni adjusted pair-wise comparisons were applied for post-hoc tests.

RESULTS



Figure 1. Plantar pressure (PP, kPa) between left (blue) and right (red) feet in six foot regions during four activities: SSWV (walking at self-selected velocity), Fast (walking at fast velocity), HR (heel raise) and STS (sit-to-stand).

A significant activity-by-foot region interaction was found for absolute symmetry index of plantar pressure (ASI-PP, $P=0.03$). Subsequently, significant simple effects were noted for ASI-PP at the lateral forefoot ($P=0.01$) and hallux ($P=0.005$).

Activity	ASI of PP				ASI of PTI			
	SSWV	Fast	HR	STS	SSWV	Fast	HR	STS
Heel	0.8%	0.9%	9.1%	4.9%	2.4%	3.2%	1.6%	6.8%
Midfoot	5.4%	2.3%	9.8%	1.8%	3.7%	5.7%	12.0%	7.3%
Medial Forefoot	12.5%	10.7%	12.3%	12.0%	5.6%	3.7%	0.4%	41.5%*
Central Forefoot	15.0%	6.4%	8.4%	16.8%	8.1%	5.3%	2.6%	17.5%*
Lateral Forefoot	3.0%	0.1%	5.0%	14.3%*	2.7%	0.6%	11.6%	17.8%*
Hallux	7.6%	15.5%*	10.2%	5.0%	5.2%	10.7%*	1.8%	2.7%

Table 1. Summary of absolute symmetry index (ASI) of PP and ASI of PTI during self-selected (sswv, blue) and fast (fast, red) walking, heel raise (HR, green) and sit-to-stand (STS, purple) activities. Foot regions include heel, midfoot, medial, central, lateral forefoot, and hallux. * indicates significant difference compared to sswv, based on Bonferroni adjusted pair-wise comparisons.

DISCUSSION

- For peak pressure , average absolute symmetry index across the four activities ranged from a maximum of 15% at the forefoot to a minimum of 4% at the heel. Average absolute symmetry index across the different foot regions ranged from 9% during the sit-to-stand to 4% during fast walking.
- For pressure time integral, average absolute symmetry index across the four activities ranged from 7% at the midfoot to 3% at the medial forefoot. Average absolute symmetry index across the different foot regions ranged from 6% during the sit-to-stand to 4% during fast walking.
- Bilateral activities such as heel raises and sit-to-stand may be accompanied by significant asymmetry in plantar loading. Additional studies are indicated to examine patterns of asymmetry in clinical populations.

References.

1. Sadeghi, H., et al. (2000). *Gait Posture*, 12(1): 34-45.
2. VanZant, R.S., et al. (2001). *J Am Podiatr Med Assoc*, 91(7): 337-42.
3. Guldemond, N.A., et al. (2007). *Diabetes Res Clin Pract*, 77(2): 203-9.
4. Zifchock, R.A., et al. (2006). *J Biomech*, 39(15): 2792-7.

Acknowledgements: We would like to acknowledge support from the New York Physical Therapy Association.