# Influence of Experimental Knee Pain on Bilateral Loading Patterns during Walking in Healthy Individuals

S. J. Son[1], H. Kim[2], M. K. Seeley[1], J. T. Hopkins[1];
[1]Brigham Young University, USA; [2]West Chester University, USA.

**Purpose**: Knee pain is one of five leading causes of disability among adults, and is a chief symptom of knee pathology. Both acute and chronic knee pain result in altered joint loads in the lower extremity during walking, which potentially can lead to mechanical and biological changes in knee articular cartilage. Due to confounding factors that are present in clinical knee pain (e.g., effusion, muscle weakness, inflammatory response, structural changes, and etc.), it is difficult to examine the independent effect of knee pain on walking mechanics. The purpose of this study is to examine whether unilateral experimentally induced knee pain acutely influences bilateral loading patterns during walking in healthy individuals.

**Methods**: This study was a controlled laboratory, cross-over trial. Each of 30 able-bodied subjects (M = 20, F = 10; 23 ± 2.4 yrs, 71 ± 12.7 kg, 178 ± 8.2 cm) completed three experimental sessions: pain (5.0% NaCl infusion), sham (0.9% NaCl infusion), and control (no infusion) in a counterbalanced order, 2 days apart (a washout period). For the experimental sessions, hypertonic (5% NaCl) or isotonic (0.9% NaCl) saline was continuously infused into the right (involved limb) infrapatellar fat pad using a portable infusion pump, which produced a continuous saline flow of 0.154mL/min (total 2.16 mL) for 14 min for the pain or sham session, respectively. No infusion was administered to the control session. Subjects and investigators were blinded regarding the saline solution which was being infused. During each of three experimental sessions, subjects performed 30-sec gait trials at a self-selected speed at two time points (pre- and post-infusion). Ground reaction force (GRF) data were collected using an AMTI instrumented force-sensing tandem treadmill (1200 Hz). The first 4 successful gait cycles in each limb were used for data analysis. A functional data analysis approach ($\alpha = .05$) was used to detect time (pre- and post-infusion) x limb (involved vs. uninvolved) interactions for the vertical, anterior-posterior, and medial-lateral GRF. This functional statistical approach compared variables as polynomial functions rather than discrete time points (e.g., initial heel-strike or peak vertical GRF). Functions (mean curve) and corresponding 95% confidence intervals (an estimate of effect size) were compared between limbs over times during stance (heel-strike to toe-off). When 95% confidence intervals did not overlap zero, significant time x limb interactions existed ($p < .05$). The gait cycle across stance were defined as follows: 0-17% = loading response, 18-50% = midstance, 51-83% = terminal stance, and 84-100% = pre-swing.

**Results**: Figure 1. Significant time x limb interactions were observed during the pain session (hypertonic saline; 5.0% NaCl; $p < .05$). Experimentally induced knee pain resulted in up to (i) 0.05 N/kg less vertical GRF during 0-32% and 70-98% of stance, and 0.02 N/kg more vertical GRF during 39-53% of stance in the involved limb relative to the uninvolved limb; (ii) 0.01 N/kg less posterior (breaking) GRF during 8-32% of stance in the involved limb relative to the uninvolved limb; and (iii) 0.007 N/kg less lateral GRF during 17-31% of stance and 0.007 N/kg more lateral GRF 63-100% of stance in the involved limb relative to the uninvolved limb. No time x limb interactions were detected during the sham (isotonic saline; 0.9% NaCl) and control (no infusion) sessions ($p > .05$).

**Conclusions**: Relative to the pre-infusion condition, subjects during the knee pain condition tended to walk with less vertical, posterior and lateral GRF in the involved limb (painful limb) across various portions of stance, which simultaneously increased loads in the uninvolved limb (non-painful limb). Our data suggest that compensatory loading patterns occur simultaneously for the involved and uninvolved limbs. The unloading pattern in the involved limb results in a greater loading pattern in the uninvolved limb. This unloading pattern in the involved limb may be due to perception of knee pain, which can make subjects feel fear for damaging or provoking pain more during walking. Moreover, voluntary and/or involuntary quadriceps inhibition (e.g., neuromuscular activation and strength) due to experimentally induced knee pain may play a role in reducing the loads in the involved limb because the quadriceps support the center of body mass eccentrically from initial loading response to midstance to prevent collapse of the lower limbs. These asymmetrical loading patterns due to knee pain and associated with neural inhibition may be a risk factor for knee joint disease progression via changes in mechanical components.

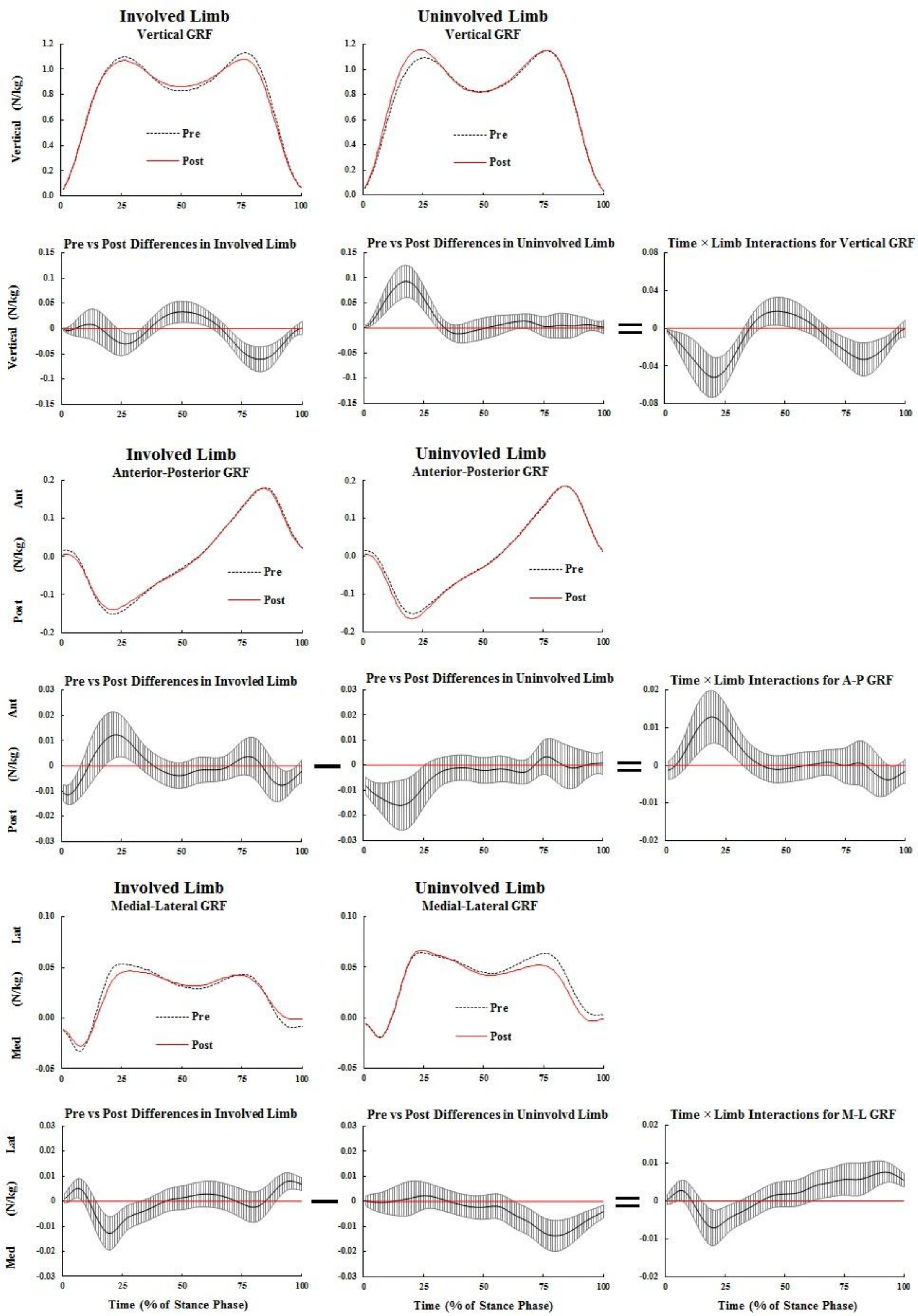


**Figure 1. Grand ensembles for ground reaction forces during the stance phase of walking. A Time x Limb Interaction was defined subtracting "Pre vs Post Differences in Involved Limb" from "Pre vs Post Differences in Uninvolved Limb". When 95% confidence intervals (shaded area) did not overlap the zero (horizontal red line), significant differences existed ($p < .05$). Abbreviations: Ant: anterior, Post: posterior, Lat: lateral, Med: medial, GRF: ground reaction force, A-P: anterior-posterior, M-L: medial-lateral.**