Introduction: Large frontal-plane loads at the knee have been identified as a risk factor for the onset and progression of medial knee osteoarthritis (MKOA). These loads, commonly expressed as the external knee adduction moment (KAM), develop during the stance-phase of gait and are often calculated as the frontal-plane ground-reaction-force multiplied by the perpendicular distance from the ground-reaction-force vector to the knee joint center. Recently, hip abductor muscle weakness has been found in patients with MKOA; however it remains unknown as to how or if this muscle weakness contributes to the KAM. It is unlikely that that hip abductor weakness affects loading in the tibiofemoral joint directly, but it is possible that hip abductor weakness could indirectly influence the KAM via a change in the magnitude of the frontal-plane ground-reaction-force components, or a shift in the position of the knee joint during stance consequently altering the length of the ground-reaction-force lever arm. Therefore, the purpose of the present study was to evaluate the relationship between hip abductor strength, the ground-reaction-force lever arm during walking, frontal-plane ground-reaction forces during walking and the KAM to determine if hip abductor weakness should be considered a risk factor for MKOA.

Methods: Eleven healthy volunteers participated in this two-session study (4 female, 7 male, mean±SD age of 25.1±5.1 years, height of 171.5±7.4 cm, and body mass of 70.2±15.8 kg). In session 1, maximal hip abductor strength was assessed using a Biodex System 3 dynamometer. Participants were first asked to stand in the anatomical position, and the frontal-plane hip joint angle was measured using a hand-held goniometer. The joint angle used during testing was 5 degrees less than this measured angle in order to achieve a joint angle that would be similar to what would be experienced at the time of the peak KAM during walking. Participants laid on their left side and provided 5 maximal isometric contractions with their right leg, each 5 seconds in duration with 10 second breaks in between trials. The peak hip moments from each trial were averaged for each subject, and then normalized to body mass. The influence of gravity was taken into account by adding the resting limb-weight moment to the active trial moments. In session 2, participants completed 5 trials walking at a speed of 1.6±0.08 m/s along a 20 meter runway in a gait analysis laboratory while wearing a neutral shoe (adidas Mana). Retroreflective markers were placed at the medial and lateral epicondyles, and 8 Motion Analysis cameras recorded their 3-dimensional trajectories at a frequency of 240 Hz. A Kistler force platform recorded 3-dimensional ground-reaction-forces at a frequency of 2400 Hz during each trial. KAMs were calculated for each trial by taking the cross product between the frontal-plane ground-reaction forces and the mediolateral and vertical distances from the floor to the knee joint center (defined as the mean position between the medial and lateral epicondyle markers) and then normalized to body mass. The peak KAM was used in subsequent analysis. At the time of the peak KAM, the medial and vertical ground-reaction-force components were obtained, and the ground-reaction-force lever arm length was determined by dividing the peak KAM value by the magnitude of the resultant frontal-plane ground-reaction-force. The correlations between maximal hip abductor strength and the ground-reaction-force lever arm, frontal-plane ground-reaction-force components, and the KAM were assessed (α=0.05).

Results: Across participants, the mean±SD maximal hip abductor strength was 1.81±0.35 Nm/kg (range of 1.2 Nm/kg to 2.5 Nm/kg), the mean±SD ground-reaction-force lever arm was 4.5±1.2 cm, the mean±SD medial ground-reaction-force was 0.55±0.15 N/kg, the mean±SD vertical ground-reaction-force was 10.70±0.64 N/kg, and the mean±SD KAM was 0.48±0.11 Nm/kg. The correlations between maximal hip abductor strength and ground-reaction-force lever arm (r=0.09, p=0.785), medial ground-reaction-force (r=-0.54, p=0.087), and vertical ground-reaction-force (r=-0.02, p=0.955) were not significant. Consequently, the correlation between maximal hip abductor strength and the KAM during walking was also not statistically significant (r=0.09, p=0.792). These results are displayed in Figure 1.
Discussion: Despite large differences in maximum hip abductor strength among participants, the ground-reaction-force lever arm, frontal-plane ground-reaction-force components, and the KAM remained roughly similar across participants. This suggests that hip abductor strength (or weakness) does not contribute to KAM magnitude and therefore does not likely play a role in the development or management of MKOA. This notion is supported by the fact that previous studies have found that hip abductor strengthening programs for patients with MKOA have no effect on KAM magnitude. We therefore propose that hip abductor weakness is more likely an outcome of MKOA rather than a predisposing factor to injury.

Significance: Hip abductor muscle weakness may not be a risk factor for development and progression of MKOA.
Acknowledgments: Adidas, Alberta Innovates-Health Solutions, Canadian Institutes of Health Research, The Killam Trusts, Natural Sciences & Engineering Research Council of Canada CREATE program, Vanier Canada Graduate Scholarships.


ORS 2014 Annual Meeting
Poster No: 1706