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**EXPLORING THE RELATIONSHIP BETWEEN LOCAL AND GLOBAL SPINE STABILITIES DURING REPETITIVE LIFTING TASKS.**

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**Preferred Presentation:** Oral Presentation

**If your abstract is not accepted as an oral do you wish to be considered for a poster?:** Yes

**Clinical Biomechanics Award:** No

**David Winter Young Investigator Awards:** No

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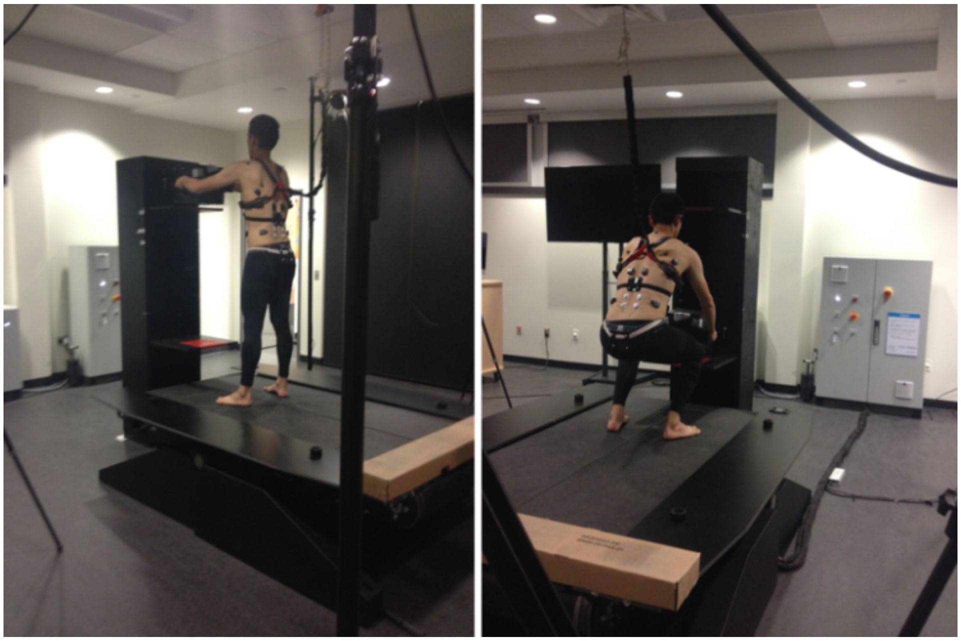
**Promising Scientist Award sponsored by Motion Analysis:** No

**Introduction and Objectives:** Lifting is a major risk factor for low back injury. Lifters experience small continual perturbations, because moving a load provides a disturbance to the lifter's balance and equilibrium [1]. In healthy individuals, these perturbations are offset in order to maintain a stable trunk and spine during movement. However, lifters also experience larger perturbations due to loads shifting in boxes or unstable/slippery floors, which can cause slipping and/or tripping. With enough internal (local) stability the lifter can offset such an external (global) perturbation and return to their desired movement trajectory without injury to the spine stabilizing system [2]. The goal of the present study was to examine the relationship between local and global spine stabilities during global perturbations introduced at the foot-floor interface. It was hypothesized that there would be good agreement between both stability metrics, and that both local and global stabilities would be progressively increased as the lifted load in the hands was increased [3].

**Methods:** 12 healthy males were recruited to participate in this study. Mean age, height, and mass were 23.2 years (SD = 4.0), 178.2 cm (SD = 6.9), and 73.5 kg (SD = 10.7), respectively. Participants completed a freestyle lifting protocol on a perturbation treadmill, while wearing a harness that was secured to the ceiling (V-Gait, Motek Medical, Holland) (Figure 1). Participants lifted a box from knee to shoulder height under three load conditions: 0, 4, and 8kg, in a randomized order, at a rate of 6 cycles per minute to the beat of a metronome. Under each load condition participants performed a total of 40 lifts; the first 20 lifts were without any perturbations. Then, in the following 20 lift cycles (in blocks of 5), participants were randomly given perturbations by the treadmill in each of four direction combinations (forward or backward tilt of 4°, left or right displacement of 5cm). Perturbations were programmed to not occur back to back, and were initiated when the box eclipsed 50% of the participant’s height on the way up. During all trials, 3-D kinematic data were collected from the pelvis and spine at 100Hz (Oqus 400+, Qualisys, Sweden). 6-D state spaces (x,y,z linear and angular velocities of the trunk relative to pelvis) were created using data recorded from the first 20 unperturbed lift cycles (attractor), and local dynamic spine stability was quantified using the local divergence exponent, $\lambda_{max}$ [4,5]. In addition, we analyzed the distance traveled from the unperturbed lifting pattern (B), the time to max distance (Tau) the relaxation distance (A), and the rate of return toward the normal lifting pattern (Beta) following each external perturbation [4,5]. Each global perturbation metric was then averaged across the four perturbations, and both local and global stability values were compared using repeated-measures ANOVAs in SPSS 22 (IBM Corporation, USA).

**Results:** An increase in load lifted lead to significantly increased local spine stability, quantified using $\lambda_{max}$ during the unperturbed lifts ($p = 0.046$) (Table 1). Post-hoc results revealed that the 8kg condition was significantly more stable than the 0kg condition ($p = 0.011$). Higher load also lead to decreased distance (B) traveled away from the unperturbed trajectory ($p = 0.023$). Post-hoc results revealed that both the 4 and 8kg conditions were more stable than the 0kg condition ($p = 0.007$ and 0.018).

**Figure:**



**Caption:** Figure 1. Experimental set-up. Under each load condition participants were required to repetitively lift between the targets placed at shoulder and knee height.

**Conclusion:** Results agree with our previous research that increasing the load lifted significantly improves local spine stability during non-perturbed lifting due to higher muscle activation that translates into greater lumbar spine rotational stiffness [3]. Here we have shown that these changes also translate into a greater ability to resist external global perturbations, which may reduce injury risk and should be explored in the future. The exact relationships between local and global stabilities are currently being analyzed in each individual subject using linear mixed modelling (repeated-measures regressions).

**Table:**

| Stability Values | | 0 kg | 4 kg | 8 kg | Repeated-Measures ANOVA Results |
|---|---|---|---|---|---|
| | | Mean (SD) | Mean (SD) | Mean (SD) | p-value |
| Local | λmax | 1.09 (0.25) | 0.99 (0.17) | 0.96 (0.14) | 0.046 |
| Global | A | 3.14 (0.77) | 3.14 (0.97) | 2.96 (0.54) | 0.652 |
| | B | 38.6 (16.7) | 31.0 (13.2) | 27.7 (10.0) | 0.023 |
| | Tau | 57.4 (21.3) | 58.7 (21.6) | 56.8 (19.3) | 0.966 |
| | Beta | 0.17 (0.09) | 0.24 (0.09) | 0.22 (0.11) | 0.105 |

**Caption:** Table 1. Stability mean (standard deviation) and ANOVA results. Bolded values indicate significance at $p<0.05$.

**References:** [1] Graham et al., Gait Posture, 34: 561-563, 2011.
[2] Panjabi, M., J. Spinal Disord., 5: 383-389, 1992.
[3] Graham et al., J. Biomech., 45: 1593-1600, 2012.
[4] Bruijn et al., J. Exp. Biol., 213: 3945-3952, 2010.
[5] Toebes et al., Gait Posture., 40: 215-219, 2014.

**Disclosure of Interest**: None Declared