Research Paper Review

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Unilateral Ankle Immobilization alters the Kinematics & Kinetics of Lifting

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ABSTRACT

BACKGROUND: *Theoretical and empirical data support the notion that distal lower extremity joint dysfunction could influence the low-back injury potential of workers, but the impact of unilateral ankle immobilization on low-back loading during lifting has yet to be examined.*

OBJECTIVE: *To examine the influence of unilateral ankle immobilization on the kinematics and kinetics of lifting.*

METHODS: *With and without their right ankle immobilized, 10 men performed laboratory-simulated occupational lifting tasks. Together with force platform data, three-dimensional kinematics of the lumbar spine, pelvis, and lower extremities were collected, and a dynamic biomechanical model was used to calculate peak compressive and shear loads imposed on the L4/L5 intervertebral joint.*

RESULTS: *In comparison to the unaffected conditions, ankle immobilization generally resulted in less knee ($0.001 \leq p \leq 0.07$) and greater lumbar spine ($0.001 \leq p \leq 0.35$) sagittal motion when lifting. Associated with this compensatory movement strategy were greater L4/L5 anterior/posterior reaction shear forces ($0.001 \leq p \leq 0.25$). However, there were cases when individual compensatory movement strategies differed from the "group" response (i.e., subjects increased their sagittal knee motion on the affected side about 8% of the time); this resulted in increased peak L4/L5 joint compression forces without changing the peak L4/L5 anterior-posterior shear forces.*

CONCLUSIONS: *Ankle dysfunction can alter the way in which individuals move and load their low-backs when lifting. The different ways in which individuals compensate for personal movement constraints could alter the potential site and mechanism of occupational low-back injury.*

BACKGROUND INFORMATION

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The human body can be thought of as a 'kinetic chain', implying that motion and dynamics of the human movement system are intimately coupled. If we accept this construct, we could then logically infer that local movement constraints (such as immobilization) can alter the kinetics and kinematics of (potentially) all bodily segments, particularly during closed kinetic chain activities such as lifting.

Injury to a joint, with subsequent immobilization, has the potential to create long-lasting functional deficits. For instance, an ankle fracture with subsequent casting can result in loss of ankle joint range of motion that can persist long after acute treatment (1-3). This can force the affected individual to compensate by adapting their whole-body movements.

It is possible that distal lower extremity joint hypomobility can increase the potential for injury to the low back while lifting. The goal of this study was to understand the effect unilateral immobilization of the ankle joint has on low back loading while lifting. The authors hypothesized that peak low-back loading during lifting would be influenced by unilateral ankle immobilization, as subjects would be obliged to adapt their movement strategies to compensate for the loss of ankle joint motion.

PERTINENT RESULTS

The impact of ankle immobility was equivocal under both the 3.7 and 12.7 kg lifting tasks. Compensatory movement strategies were varied based on the lift origin and destination. This being said, a number of common kinematics responses were observed when comparing the no-brace vs. brace conditions:

- Braced subjects used less ankle and knee motion, and greater hip and lumbar spine sagittal plane motion when lifting (defined as strategy 1).
- Differences in sagittal plane motion were generally greater in magnitude and more consistently observed on the braced side of the body when lifting from positions 2 and 3. *Specifically, when lifting from floor level directly in-front or from their right side (positions 2 and 3, respectively), the peak A-P L4-L5 shear forces were an average of 23% greater when wearing the ankle brace.*
- Similar responses were found when lifting from position 1 to position 4, but not from position 1 to 5, or from position 1 to 6.
- No differences were found in L4-L5 compressive or medial-lateral shear forces between braced and non-braced conditions.

The authors also discussed a recurrent scenario whereby some individuals responded uniquely to the braced condition. In 14/180 cases, lifting from floor level and to the right (position 3), whilst in the braced condition, resulted in greater right knee sagittal plane motion (strategy 2). When this occurred, more right 'heel lift' was observed. The heel-lift strategy resulted in greater L4-5 compression and less L4-L5 A-P shear. L4-L5 medial-lateral shear was equivocal between the 2 strategies.

CLINICAL APPLICATION & CONCLUSIONS

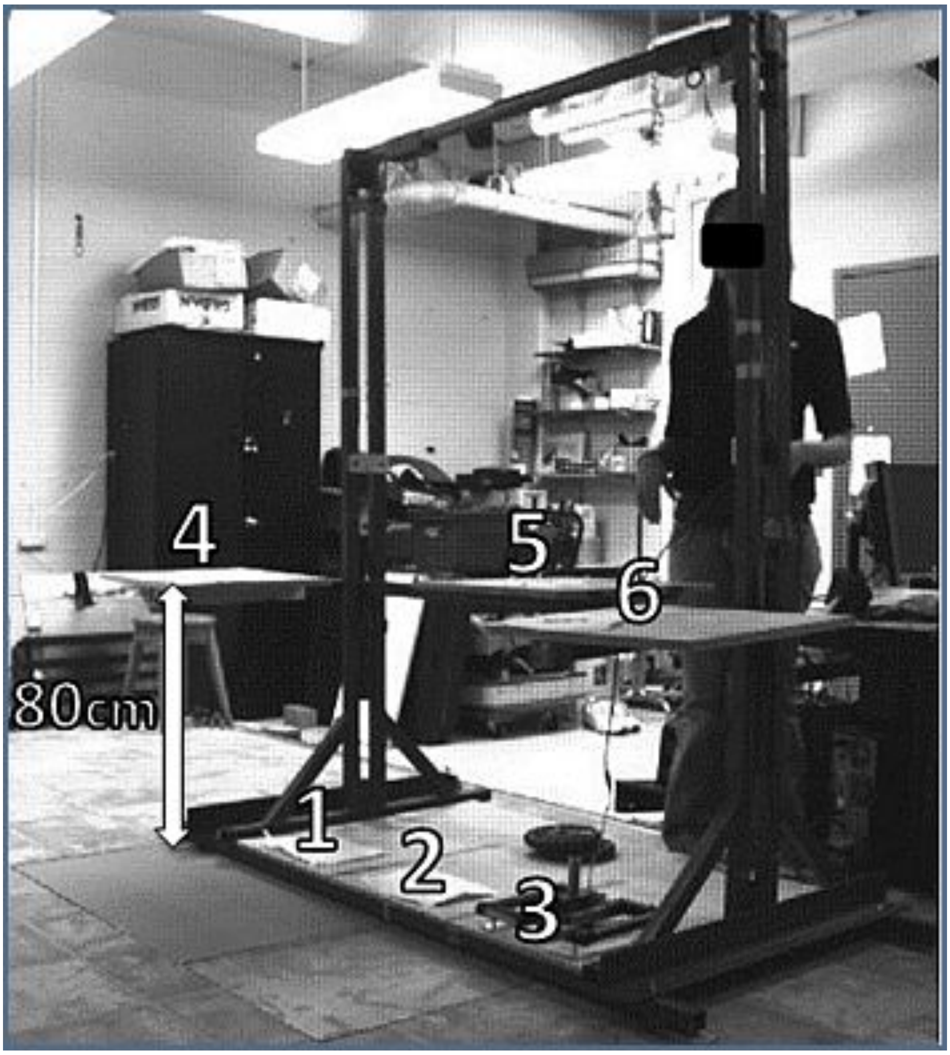
In this study, an increase in peak L4-L5 anterior-posterior (A-P) reaction shear (especially in Strategy 1: lumbopelvic compensation) and bone-on-bone compression (especially in Strategy 2: heel lift compensation) were shown when the right ankle was immobilized. This is meaningful if applied repeatedly (4) and/or if the lumbar spine is deviated from its neutral lordotic position (5-7). This supports the notion that workplace injury prevention strategies could be enhanced if the kinetic chain concept is considered.

It was demonstrated that lower extremity joint dysfunction, in this case, unilateral ankle immobilization, could alter low back injury potential while lifting at work. Therefore, it is appropriate, and most certainly important, to interpret the body as a unified kinetic chain. This consideration might yield important information that might not be apparent during more targeted investigations. This is also important in cases where modification of work tasks is not possible or practical (i.e. firefighting).

STUDY METHODS

Ten healthy male volunteers participated in this study. Their average score on the Lower Extremity Functional Scale (LEFS) was 79.2/80, indicating no significant functional limitation.

All subjects completed occupational lifting tasks from three different origins to 3 different destinations (for a total of 18 permutations), both with and without their right ankle immobilized. A 3.7 and 12.7kg mass were lifted a standardized distance of 0.8m. Three repetitions of each permutation were performed, totalling 108 lifts (54 lifts with immobilization, 54 without). Order of task performance was randomized.



Right ankle immobilization was achieved through the use of a custom brace, fitted into each subject's athletic shoe. It was designed to restrict sagittal, frontal and transverse motion during lifting, in a closed kinetic chain.

Optotrak Smart Markers were attached to the feet, shanks, thighs, pelvis and trunk. Marker positions were collected using a six-sensor Optotrak motion capture system while the subjects performed lifting tasks. 3D kinematic measurements of the lower extremities, pelvis and trunk were collected from 2 AMTI force platforms during lifting tasks. Six degrees of freedom (all planes of motion) were calculated for each measured body segment. Using a bottom-up inverse dynamics approach, instantaneous reaction forces and joint moments about the origin of the pelvis were computed. L4-L5 joint compressive, A-P shear (anterior/posterior translation), M-L shear (medial/lateral translation) forces while lifting were also calculated.

Statistically, within-subject comparisons were performed to examine the effects of the no-brace/brace and light-load/heavy-load conditions, and the interaction of condition and load on lifting kinematics and kinetics.

STUDY STRENGTHS / WEAKNESSES

Weaknesses:

1. The subjects were healthy, university aged males. As such, the results of the study are poorly generalized to the rest of the population.

Strengths:

1. This was a very innovative study, discussing the importance, and regional interdependence, of the human body as a kinetic chain.
2. They aligned their findings with already well known, published data (i.e. certain postures can increase shear and compressive loads), and infer how force changes through the kinetic chain can impose loads to create pathology.

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