DOES A UNILATERAL RESTRICTION IN ANKLE MOBILITYAFFECT TRUNK KINEMATICS AND LOW-BACK LOADING DURING MANUAL LIFTING TASKS?

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INTRODUCTION

Pain or mobility limitation in any area of the body could influence the trunk kinematics of workers. Davis and Seol [1] found that individuals who had previously injured upper or lower extremity joints moved their trunk differently when lifting than did individuals without previous injuries. Interestingly, previously injured segments or joints most distal to the low-back (e.g., hands/wrists and feet/ankles) had a greater influence on trunk kinematics than more proximal joints (e.g., shoulder). Because low-back loading patterns and trunk kinematics are tightly coupled, it is possible that distal joint dysfunction (e.g., injury-induced deficits in joint mobility) could alter the potential for low-back injury associated with occupational task performance. The purpose of this study was to determine if low-back loading during manual lifting tasks could be altered by a unilateral loss of ankle joint mobility.

METHODS

Eight male university students who had a mean age of 25 yrs (SD = 3.9 yrs), a mean stature of 1.84 m (SD = 0.06 m), and a mean mass of 88.5 kg (SD = 9.5 kg) participated in this study.

Together with force platform data, 3D kinematics of the trunk, pelvis, thighs, shanks, and feet were collected from study participants while they performed 18 permutations of a laboratory-based manual lifting task. Participants lifted two masses (light = 3.72 kg; heavy = 12.73 kg) from three different origins to three different destinations (Figure 1) at a self-selected pace. All lifts were performed both with and without the presence of a custom right ankle restraint; three repetitions of each lifting permutation were performed. An off-the-shelf support (T1 brace, Active Ankle Systems Inc., Jefferson, IN, United States) was modified to restrict ankle dorsiflexion in addition to limiting inversion and eversion.

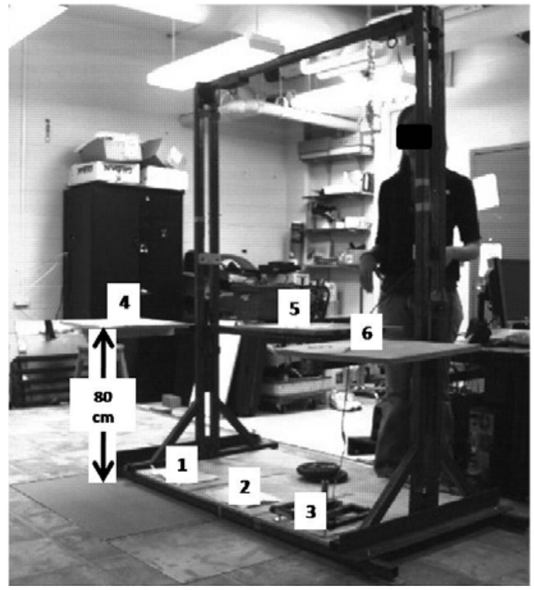

Figure 1. Configuration of experimental set-up. Lift origins (1,2,3) and destinations (4,5,6) are labeled.

Using measured anthropometrics, kinematic, and force platform data as inputs, a 3D inverse dynamics link segment model (LSM) of the lower body and trunk was created for each participant using commercial software (Visual3D, C-Motion, Inc., Germantown, MD, United States). From the LSM, orthogonal components of a net reaction moment about the low-back were calculated and subsequently input into a regression model [2] to yield estimates of L4/L5 joint compressive forces while lifting. No attempt was made to quantify L4/L5 joint shear forces, although anterior/posterior (A/P) and medial/lateral (M/L) shear components of net L4/L5 reaction forces were calculated based on the LSM.

Dependent variables were calculated as the mean of three “peak” values garnered from selected kinetic (L4/L5 load magnitudes) and kinematic (trunk and ankle angles) time-series data associated with each lifting permutation. Within-participant statistical comparisons were made using a general linear model ANOVA ($\alpha = 0.05$).

RESULTS

Significantly less ankle joint motion was permitted during lifting when the ankle restraint device was worn by study participants ($p < 0.0398$). Ankle dorsiflexion was most restricted, as losses of over 20 degrees were documented in some participants.

Qualitatively, various compensatory movement strategies were exhibited when ankle motion was restrained during lifting (Figure 2). Participants typically elected to flex their trunk by about 2 to 5 degrees more when the ankle restraint was present, although differences were not always statistically significant and were often greater when loads were lifted from the affected side. No statistically significant differences in trunk lateral bend or axial twist angles were observed when the ankle restraint was present ($p > 0.05$).

Figure 2. Various compensatory movements were exhibited in response to a unilateral restriction in ankle joint mobility.

Associated with compensatory lifting strategies, the L4/L5 reaction shear forces were altered in the A/P and M/L directions when ankle motion was restrained (Figure 3). As participants adapted their movement patterns in response to decreased ankle mobility, low-back loading patterns differed significantly from those observed when no deficits were imposed in ankle motion during lifting. In many cases, L4/L5 shear loads were of greater magnitude when the ankle was restrained, especially in the A/P direction. However, L4/L5 shear loading responses in the M/L direction were dependent on the external task demands (i.e., lift origins and destinations). L4/L5 joint compressive forces were unaffected by unilateral ankle joint motion restriction regardless of the specific external task constraints (Figure 3).

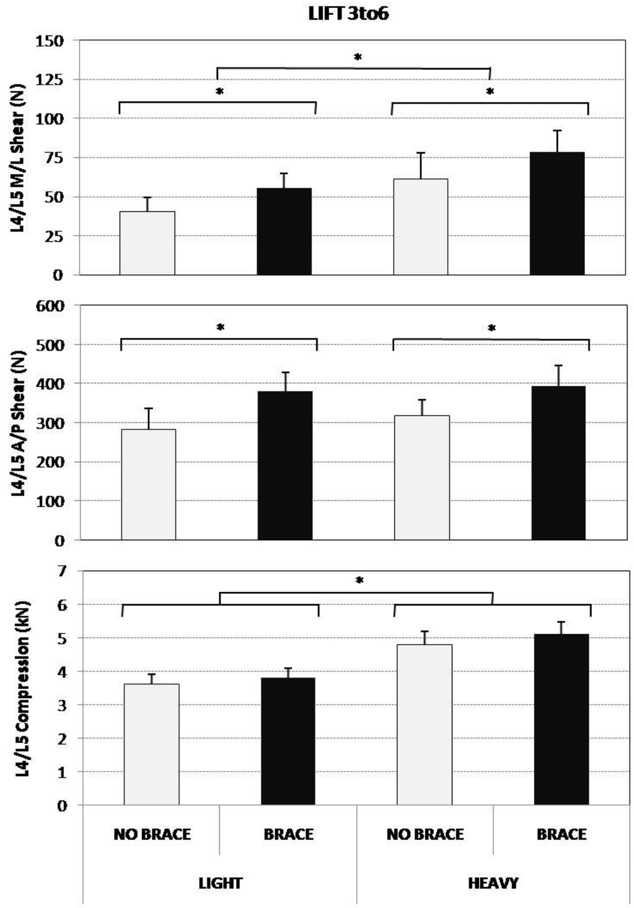

Figure 3. Low-back loading response of participants when they lifted light and heavy loads from positions 3 to 6 with and without restricted ankle mobility.

DISCUSSION AND CONCLUSIONS

Gross limitations in distal joint mobility can alter the way in which individuals move and load their low-backs when lifting. These altered loading patterns may increase the risk for low-back pain reporting [3] and therefore more work is necessary to track low-back pain incidence after peripheral joint injury. Given the complex changes observed in L4/L5 reaction kinetics, future attempts to incorporate trunk muscle activation patterns into the computation of low-back joint loads under similar conditions are warranted.

REFERENCES

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