LOWER-BACK COMPRESSIVE FORCES DURING DROP LANDINGS

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INTRODUCTION

Lower back injuries account for 10 to 15% of all injuries in athletes (Tall and Devault, 1993). A study of 31 Olympic athletes with lower back pain suggested that the most frequently affected area was the joint between the 5th lumbar and 1st sacral vertebrae (L5S1) (Ong et al., 2003).

Athletes suffering from L5S1 pain are often involved in sports that require repetitive landing from various heights. This type of repetitive loading may lead to L5S1 joint degeneration, and subsequent joint pain, if compensatory strategies are not undertaken to reduce the loading environment.

Research focusing on L5S1 joint loading during landing activities is sparse. The purpose of this study was to determine L5S1 compressive forces during landings from three heights. We hypothesized that L5S1 compressive forces would increase with landing height.

METHODS

Five females (age 21.2 ± 0.5 yrs, height 1.6 ± 0.1 m, mass 59.1 ± 8.5 kg) and four males were recruited for this study (age 27.5 ± 3.9 yrs, height 1.8 ± 0.1 m, mass 82.4 ± 2.1 kg). Motion-capture (160 Hz) and force platform data (1600 Hz) were collected while subjects landed from three separate heights (26, 39, 52 cm) in a balanced order. Ten trials were collected at each height.

Kinematics of the trunk, pelvis and right lower-extremities were calculated in a flex/ext, abd/add, int/ext sequence. Assuming symmetry of both legs, a bottom-up inverse dynamics approach was used to obtain reaction forces and the flex/ext moment at the L5S1 joint. Anthropometrics of the lower extremity and pelvis were obtained from Vaughn et al. (1992) and Zatsiorky (2002), respectively. The reaction forces and moment were calculated in the global reference frame and then rotated into a local L5S1 reference frame. The local L5S1 reference frame was estimated from a -45° rotation of the pelvic reference frame about the medial-lateral axis.

Kinematic data were imported into a scaled SIMM 4.0 model to obtain lower back flex/ext moment arms. Using these moment arms, compressive L5S1 contact forces were calculated as follows:

\[ F_c = RF_{axial} + \frac{M}{r} \]

where \( F_c \) is the L5S1 compressive contact force, \( RF_{axial} \) is the axially oriented reaction force, \( M \) is the flex/ext moment, and \( r \) is the corresponding flex/ext moment arm (depending on the direction of the moment).

Peak compressive forces during the first 200 ms of landing were determined for each trial. Mean peak compressive forces were calculated at each height. Differences in peak compressive forces were examined using a repeated measures ANOVA (\( \alpha = 0.05 \)) with Bonferroni adjustment for pairwise comparisons (\( \alpha = 0.017 \)).
RESULTS

Group ensemble curves for L5S1 compressive forces are displayed in Figure 1. The assumption of sphericity was not met (Huynh-Feldt $\varepsilon = 0.68$) for the univariate repeated measures ANOVA. Therefore, multivariate tests were used and a significant Pillai’s Trace statistic was observed ($F = 5.65, p = 0.035$). Pairwise comparisons revealed that the 39 and 52 cm drop heights had larger L5S1 compressive forces than the 26 cm drop height. No differences in L5S1 compressive forces were found between the 39 and 52 cm drop heights (Figure 2).

**Figure 1.** Group ensemble L5S1 compressive forces.

![Image](image1.png)

**Figure 2.** Mean peak L5S1 compressive forces (* significantly different from 26 cm).

DISCUSSION

Our hypothesis was only partially supported by the results of this study. L5S1 compressive forces increased from 26 to 39 cm, and no change was observed from 39 to 52 cm. Caster and Bates (1995) suggested that subjects may choose from one of two strategies during landings: 1) a mechanical strategy in which forces increase in accordance with Newton’s 2nd law, and 2) a neuromuscular strategy in which compensatory strategies are undertaken to reduce loads. Further review of within subject differences suggested that only 1 subject adopted a neuromuscular strategy from 26 to 39 cm, but 4 subjects adopted a neuromuscular strategy from 39 to 52 cm. This discrepancy in landing strategies may have led to the larger variance in L5S1 compressive loads during the highest drop, preventing significant differences between the 39 and 52 cm conditions.

SUMMARY

L5S1 compressive forces increase from a 26 to 39 cm drop height, but not from a 39 to 52 cm drop height as some subjects may adopt a landing strategy that prevents further increases in loads. Athletes able to adopt compensatory landing strategies at higher drop heights may be at a lower risk for L5S1 joint pain.

REFERENCES


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