

# BIOMECHANICAL ANALYSIS OF LOADS ON LUMBAR SPINE, KNEE, AND HIP JOINTS DURING MANUAL LIFTING

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**INTRODUCTION:** Work-related low-back pain is prevalent in both developed and developing countries. Since this injury often results in considerable discomfort for the employee and a large expense for the employee and employer, there have been many studies on manual lifting. As it is a major health-risk factor in China, research into problems related to manual lifting is of the utmost importance. Therefore, the purpose of this study was to examine the effect of loads on lumbar spine, knee, and hip joints during manual lifting, and to provide a biomechanical basis for establishment of a Chinese Recommended Weight Limit for employees and for employers.

**METHODS:** The subjects for this study included eight males with no previous history of low-back pain. They were of medium height and weight as indicated by height of  $173.4 \pm 3$  cm and weight of  $75 \pm 2.3$  kg. Subjects stood on a force plate and lifted boxes that weighed from 100 to 350 Nm. They were required to lift from the floor to two different heights. The first was the mean knuckle height, which was followed by elbow height. Every subject performed 7 trials with a normal and freestyle technique. Four high-speed cameras and a force plate were used to record kinematic and kinetic data. KinTrak, a software package included in Motion Analysis System, was used to analyze data. The lifting was performed in a position which was as symmetrical as possible. Net joint forces and moments at L5/S1 level, hip and knee joints as well as knee angle were calculated. By combining the kinematical and kinetic information with the vertical ground reaction force, biomechanical analysis was performed which revealed a relationship between forces and moments at the L5/S1 level. In order to determine the contribution of the hip and knee joints when lifting, the moments at the hip and knee joints were analyzed at the time of peak L5/S1 moment.

**RESULTS AND DISCUSSION:** Results indicated the loads on the L5/S1 level, hip and knee joints and the moment at the L5/S1 level, hip and knee joints increased with increasing weight and height of lift. This was also the case with the vertical ground reaction force. The data from the study determined that the moment and force at L5/S1 level reached maximum ( $m = 324.7 \pm 53.3$  Nm,  $f = 1115.2 \pm 68$  N, box weight = 350 N) at the beginning of lifting from floor. Therefore, the time that lower back injuries will occur can be identified. It has been established that in order to reduce the incidence of lower back injury, direct lifting from the floor should be avoided. Also, the study found that dynamic factor of body segments plus loads and the location of the trunk made a great influence on the moment at L5/S1 level. To further avoid injury to the lower back, it is necessary to use an appropriate lifting technique with a smooth and well-planned action, keeping the trunk as upright as possible. Data from this study produced smaller values than those reported in the literature. A possible reason for this is the different technique used by the subjects. Obviously, more attention should be placed on the lifting technique.