LOADS ON THE LUMBAR SPINE DURING PUSHING AND PULLING TASKS

INTRODUCTION:
The makeup of industrial work has recently changed, favoring pushing and pulling with material handling devices instead of lifting. Accordingly, pushing and pulling are now extremely prevalent in industry. Unfortunately, very few biomechanical studies have examined pushing and pulling. Those studies that have examined pushing and pulling were unable to explain the mechanism by which injury occurs, reporting spinal load levels below reported tolerance values. Thus, the objective of this research was to develop a more detailed biomechanical model to examine the dynamic loads at each level of the lumbar spine while accounting for each subject’s individual anthropometry, kinematics, and muscle activity. The model was used to examine mobile pushing and pulling across a range of conditions on a system similar to commercial material handling devices seen in industry.

METHODS:
A set of 10 male and 10 female subjects recruited from the local university population with no prior history of low back disorders (LBDs) volunteered to participate in this study. Upon arrival subjects were briefed about the pushing and pulling tasks and asked to read and sign a consent form (approved by the University Institutional Review Board). Bipolar surface electrodes were then placed over the right and left latissimus dorsi, erector spinae, rectus abdominus, external oblique, and internal oblique muscle groups. Electromyographic (EMG) data was normalized relative to values collected during maximum voluntary contractions (MVCs). MVCs were obtained by placing subjects in a reference frame restricting movement while they performed isometric exertions. Subjects were then fitted with the appropriate size Lumbar Motion Monitor, an electromiometer that measures the three-dimensional orientation of the upper torso relative to the pelvis. Subjects were then made familiar with the push-pull setup which consisted of a free horizontal bridge mounted perpendicular to two low friction linear track rails onto which a series of cables and pulleys were attached to provide a relatively constant horizontal force on which to push and pull. A vertical balancer mounted to the free bridge supported handles connected to 6-axis transducers, and a handle tracking system.

The experimental tasks consisted of 36 combinations comprised of two activities (pushing and pulling), three handle heights (50%, 65%, and 80% of subject stature), three handle force levels (20%, 30%, and 40% of subject body weight), and two handle degrees of freedom (with and without horizontal freedom). Each of these combinations was repeated twice for a total of 72 trials for each subject.

During the experiment, subjects were instructed to push and pull at a comfortable speed with no restrictions placed on which foot to step with the hands. In both pushing and pulling the greatest spinal loads occurred at the handle height, which produced the largest moment about the spine due to the comparatively greater activity in the erector spinae muscle groups which are oriented more vertically, adding more to compressive loads of the males peaking at over 1200N.

AP Shear Loads at each Lumbar Level

DISCUSSION:
There was a large difference between the mean AP shear loads between male and female subjects. Male AP shear loads were greater than female loads at each lumbar level in both pushing and pulling since the males weighed more than the females, but the difference was much greater in the pushing trials where the male loads were almost double those of the females pushing at over 1200N.

Handle height influenced spinal loads in pushing and pulling differently. In pushing, the low handle height resulted in significantly higher loads than the other heights. The opposite occurred in pulling, with the high handle height resulting in the highest loads. In both conditions, loads exceeded tolerance limits at the upper lumbar levels.