

# Effects of Biomechanical Model Based Feedback on the Joint Torques of Warehouse Employees During Lifting

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## ABSTRACT

Work environments with lower compressive forces on the spine have fewer incidents of low back injuries than work situations with higher compressive forces. These forces are caused by the large muscle moments needed for spinal support during lifting. Moments that the spinal muscles produce depend on trunk and limb acceleration, the amount of load lifted and the body posture utilized. The purpose was to examine the effects of using an audible feedback signal proportional to the magnitude of stress on the spine during lifting. Twenty warehouse workers were recruited: 10 were in the control group and 10 were in the experimental group (received auditory feedback). Testing consisted of using an electromagnetic tracking system interfaced with scales to measure the dynamic joint moments at L5/S1 at 100 Hz over a 40 second work bout. Pre-test and post-test data consisted of lifting trials realistic to the workers job tasks. Two training sessions with audible feedback were performed two weeks apart. Post-tests were conducted 6 weeks later. The experimental group received two training sessions with audible feedback during the 2nd and 4th week. Training with auditory feedback was effective in reducing the flexor and rotary joint torques of the experimental group compared to the control group ( $p < 0.05$ ).

## INTRODUCTION

Approximately 85% of all people in the western world have experienced lower back pain at some time in their lives. Industrial back injury has become a major health concern, as incidence of low-back pain is highest during the most productive years, resulting in more lost work time (Bigos, et al., 1986). Exposure to physical stress has been related to low back pain and injury (Norman et al., 1998). Brophy et al. (2001) reported that the reduction of low back injuries reduces financial costs associated with low back injury and lost workdays. Auditory feedback during performance has been used effectively to reduce the peak ground reaction forces during landing from a jump and with stress on the spine during lifting (McNair et al. 2000, Lavender & Andersson, 2000). Perhaps coaching and performance based auditory feedback can reduce the peak spinal moments during lifting/lowering of warehouse workers. The purpose of this study was to address this question.

## METHODS

### Subjects

A six-week study was completed at a local distribution center. Twenty male workers that performed a variety of warehouse tasks participated. Ten of these workers were placed into an experimental group (receiving technical and performance based auditory feedback) and ten served as a control group. Each group was divided equally based on anthropometric data.

### Instrumentation

Baseline data on the side-bending, flexor, and rotary moments at L5/S1 of each participant was collected with the Motion Monitor Electromagnetic Tracking Device (Figure 1) (IST, Inc., Chicago, IL) during lifting scenarios for six lifting/lowering tasks. This system uses analog scale data and X, Y, Z coordinate data of the participant to calculate the spinal moments at L5/S1 (Lavender & Andersson, 2000).

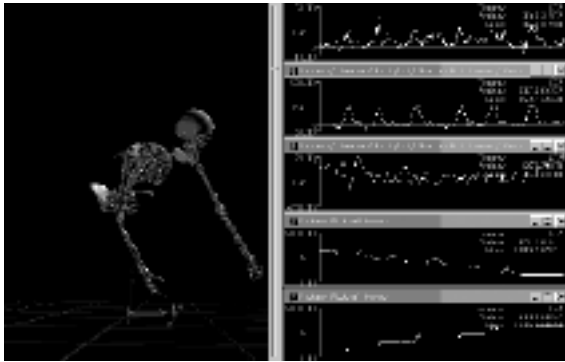


Figure 1. Example of computerized software used for data analysis

### Procedure

Week one was devoted to evenly dividing experimental and control groups based on anthropometric data. Baseline testing was also performed during this time. On week two, the experimental group received technique coaching and auditory feedback through speakers based on the magnitude of the moments during lifting/lowering (Figure 2) (Lift Trainer Software, IST, Inc., Chicago, IL). On week four, the experimental group received the same coaching and auditory feedback. On week six, all participants were tested under the same conditions as during the baseline testing.

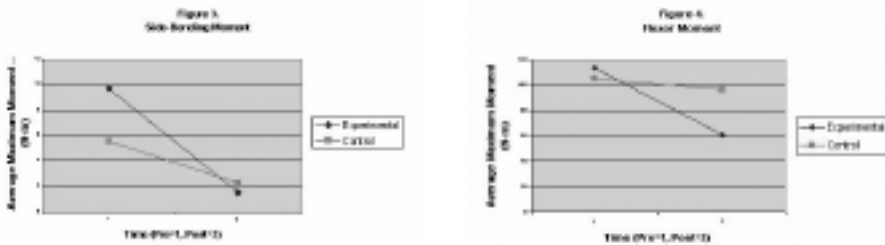


Figure 2. Subject being tested using the Motion Monitor Electromagnetic Tracking Device

## RESULTS AND DISCUSSION

A series of repeated measured analysis of variance were performed on the average peak moments from six lifting/lowering cycles in all three directions: side-bending, flexor and rotary. For the side-bending and rotary moment, the absolute values were used in the calculations since the data is biphasic. There was a significant group by time interaction for the side-bending moment ( $p < 0.05$ ) and the flexor moment ( $p < 0.05$ ), but not the rotary moment ( $p > 0.05$ ).

The experimental groups decreased average peak moments in two of the three directions. It appears that the auditory feedback they received based on the computer model of their performance was effective in reducing spinal stress. The rotary moments did not significantly change between the experimental and control groups. Perhaps auditory training is more effective in reducing side-bending and flexor moments (Figures 3 and 4).



**Figures 3-4.** Figures 3 and 4 depict the flexor and side-bending peak moments during lifting activities. Note the experimental group's decrease in maximum moment relative to the control group.

## SUMMARY

Coaching combined with auditory feedback during lifting/lowering may be effective in reducing the average peak side-bending and flexor moments of warehouse workers over the short term (six weeks). This can be an effective training regimen for all workers involved in heavy lifting. Upon study of epidemiological data, incidence of low-back pain in warehouse workers shows little discriminatory difference in the type of task performed or type of person performing the task (Bigos, et al., 1986). The same result was observed in this study amongst task type. The test groups performed three different tasks; each task showed similar spinal moments during lifting.

The numerous mechanical factors associated with back injuries in the industrial settings are important. Our limited data collection leaves room for future research. Although some questions still remain unanswered, continued study may lead to new solutions for the prevention of low-back problems. One such opportunity for further research includes the idea of various coaching techniques that involve pivoting differently with the load. This could potentially be effective in reducing rotary torque moments. Results of one study showed that pivoting the feet while moving a load required larger extension moments with less rotation moments. Our test subjects struggled with reducing rotation moments; techniques such as this may help. The biomechanics with this combination could lead to a safer overall trunk posture with lifting (Gagnon, et al., 1993).

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