HOW MUCH CAN TRAINING OF LIFTING TECHNIQUES REDUCE THE THREE DIMENSIONAL MOMENTS ON THE SPINE?

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INTRODUCTION

Training is one of the most relied on approaches to preventing back injuries in industry. This is particularly true in environments where ergonomic changes are not feasible. Most organizations typically use either a back school or a video presentation to demonstrate what constitutes good lifting techniques. The motor skill literature has shown that the conceptual learning that may be achieved with these presentation formats does not reliably lead to adaptations in behavior. In large part, this is because with a lecture or video there is no feedback as to whether the newly trained movements are being done correctly, nor is there feedback regarding the new behavior's impact on the spinal loading. Moreover, there is no individualized information available to guide a trainee towards appropriate behaviors. For many employees engaged in repetitive lifting tasks time pressures arising either through engineered work standards or incentive systems tend to push individuals away from "proper" lifting techniques. The aim of this study was to test the hypothesis that a "biofeedback" approach to training on lifting techniques, where the biofeedback signal is based on the magnitude of the spine moment vector, can effectively be used to reduce the spine moments in a standardized lifting task while not increasing the amount of time used to handle each box.

METHODS

Approach: One hundred thirty two experienced employees (3 months to 15 years), who work in warehousing jobs that require continuous lifting throughout the workday, were recruited to participate in a half-hour one-on-one training sessions using the *LiftTrainer™*. As part of the protocol subjects are instrumented with sensors from a magnetic based motion measurement system (Innovative Sports Training). Subjects lifted boxes from one scale to another, hence the hand loads could be determined. The *LiftTrainer* uses the kinematic and kinetic data in a dynamic linked segment model to compute the three-dimensional moments at L5/S1 in real-time. The magnitude of the instantaneous moment vector is used to adjust the pitch of a "biofeedback" tone that is used, along with some charting functions, to guide participants toward lifting techniques with lower peak moment values.

Procedure: Seven sensors, placed on the head, each lower and upper arm segment, at T1, and at S1, were used. Hand loads were determined by dividing the weight of the lifted boxes in half. While the box weights varied slightly between industrial sites, ranging between 11 and 14 kg they were consistent for each individual trained. A top-down dynamic 3-D linked segment model was used to compute the three-dimensional spine moments in real-time (100 Hz). Each participant was first asked to demonstrate their "normal" lifting technique for transferring a stack of 4 boxes from one side to the other. This task was designed to simulate the simplest palletizing task observed in warehouses. The two scales were positioned to simulate the placement of pallets for this type of work. The spacing between the scales was typically about .8 meters, however, employees were allowed to adjust the spacing if they would typically use a wider or narrower inter-pallet distance. Thus, the lifting task could be performed using a variety of different methods ranging from the commonly seen side-to-side box shuffle to the full squat with a two-step turn. Following the initial set (baseline) the biofeedback tone was turned on and explained to the participant. The pitch of the tone was controlled by the magnitude of the moment vector. Following each set of four lifts the peak three-dimensional moment components (forward bending, twisting, and side bending) were displayed on a charts so that progress could be assessed. An additional chart displayed the duration of each lift. The coach used the biofeedback signal and charting to recommend adjustments to the lifting technique. Hence the training was individualized in that the tips and pointers given to one employee may have been quite different from those given to another employee. Prior to the last set of lifts in the session (evaluation set) the biofeedback tone was turned off. The analysis presented here compared the average moments during this final evaluation set with the averaged moments measured during the baseline set. A repeated measures ANOVA was used to evaluate the moment changes in each direction.

RESULTS AND DISCUSSION

Figure 1 shows the average moments before and after training. The mean forward bending moment decreased by 12Nm or approximately 5 percent ($p<.001$). The twisting moment and side bending moments significantly decreased ($p<.001$) by 11 Nm and 19 Nm, respectively. These changes corresponded to a 16 percent decrease in the twisting moment and a 23 percent change in the side bending moment. The training did, however, increase the lift duration by an average of .34 seconds. This small but significant increment in handling time could be expected to increase total lifting time by approximately 1 minute per hour (~200 lifts/hour) or 8 minutes per day. Most employees agreed that this increment was not much of an issue as they usually finish their allotted work 60 to 90 minutes ahead of time. It is anticipated that this incremental time change may decrease with practice.

The employees in this study, for the most part were well seasoned. Some, if not most, have had previous training on lifting techniques. Typically, their prior training has emphasized the importance of bending the knees and keeping the back straight. Very few of the employees used this technique when asked to show how they would normally performed the defined task. Most believed it was too time consuming and was especially taxing on the legs. Thus, the training approach used in the current study, specifically did not focus on lower extremity use, unless an individual was observed during the baseline session to be using a lower extremity intensive technique. This may account for the relatively small change in forward bending moments. Instead, the training focussed on keeping the box close to the body throughout the lift, how the body is positioned relative to the box, modifying the box trajectory, using the feet to turn or pivot the body, and the smoothness of the lifting motion.

In the motor skill literature three qualities are considered extremely important in the development of new behaviors. First, the learner must have information regarding the performance of the activity. For example, does the golf swing look right? Second, the learner needs information regarding the effectiveness of their activity. Using the golf example, how far did the ball go and did it go straight? Third, the learner needs to know what can be done do address deficiencies in technique (transitional cues). Most training programs for back injury prevention have not addressed these three points. In large part because the results of the activity, spinal loads, are typically unknown. Therefore, any transitional cues are based only on performance, which may lead to incorrect modifications in behavior. Thereby suggesting at least one reason why training programs for back injury prevention have been largely ineffective with regard to controlling back injuries.

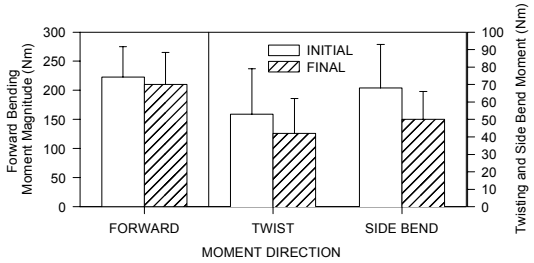

Figure 1. The mean initial and final moments averaged across the 4 lifts in the inital and final sets. All changes were statistically significant ($p<.001$).

CONCLUSION

This study has shown that by providing a training process which incorporates many of the aspects considered to be important in the development of motor skills can lead to significant decrements in spine moments. Ultimately, time will tell whether these employees experience fewer back injuries than their untrained counter-parts within the same organizations.