ERGONOMICS IN CONSTRUCTION: AN INTERVENTION WITH CONCRETE LABORERS

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INTRODUCTION

Construction workers run a significant risk of musculoskeletal injury. Twenty-two percent of lost-time injuries among laborers are due to overexertion, and laborers have the highest risk occupation for work related back pain (Ringen 1995, Guo 1995). The pouring of concrete is a job that poses substantial risks of musculoskeletal injury to laborers due to the weight of the material, awkward postures assumed by workers, schedule pressures driven by the time-sensitive nature of the material, and sometimes harsh environmental conditions.

There have been a number of studies demonstrating the association between occupational factors and low-back disorders (LBD) (Troup 1987, Battié 1990, Marras 1995). Yet there are few rigorous field studies among construction laborers that evaluate the dynamics of the low back or quantify the effect of ergonomic modifications on exposure risk for low-back disorders. Existing studies have been observational evaluations of posture, surveys of worker perception or lab studies in a simulated environment (Buchholz 1996, Spielholz 1998, Chaffin 1999). As new biomechanical assessment tools evolve it has become possible to apply quantitative measures to the evaluation of high-risk tasks among construction laborers, during actual field activities. These tools provide new insight into dynamic aspects of low-back biomechanics and the complex nature of back injury. The goals of this study were: 1) to evaluate the effectiveness of an ergonomic tool called a skid plate, for decreasing exposure to activities that lead to low back injury among concrete laborers and 2) to explore instruments that would quantify dynamic aspects of the low back in relation to injury risk.

METHODS

This study was conducted among concrete laborers during the construction of a $40 million four-story office and classroom building on a university campus. At this site the job task of most concern to the contractor was the horizontal manipulation of the hose that delivers concrete from the pumper to the placement site, in the case where pouring from above was not possible due to overhead obstructions. The concrete-filled hose lays upon iron rebar matting and must be pulled and repositioned as work progresses. Each section of hose was 13’ long and 3” in diameter. Hose sections were joined together by a quick release latch that was difficult to pull over rebar matting, causing workers to use excessive bending and force to move the hose. At the beginning of a concrete pour there could be as many as eight sections of hose attached to the slick line, depending upon the distance to the pumper truck. As the concrete pour progressed the laborer at the head of the hose verbally signaled workers to move the hose. Laborers worked as a team to pull the hose away from the newly poured concrete. They moved the hose by pulling on a 3’-4’ long piece of rope attached to the hose at the couplings and at points half way between these joints.

Researchers introduced skid plates, 2’ diameter metal disks (Conforms, www.conforms.com, part # LH-54) that are placed under the couplings between sections of hose. We hypothesized that skid plates would reduce stress to the low back by preventing the hose couplings from catching on rebar matting and by decreasing the overall friction of pulling the hose. This would reduce the need for repetitive bending and use of excessive force to dislodge and move the hose. All laborers were invited to participate and in accordance with university requirements for research involving human subjects, participation was not compulsory and those who participated provided written informed consent.

To measure low-back activity a Lumbar Motion Monitor (LMM), a portable tri-axial electrogoniometer developed at Ohio State University (Marras, 1993) was used. The LMM glides between a set of harnesses, one fitted around the pelvis and one between the scapulae, and allows collection of data during work activities. It collects instantaneous position, velocity and acceleration of the lumbar region, in three planes, at 60Hz via an analog-to-digital converter. Data are transmitted via digital telemetry to a laptop computer. The mass of the concrete filled hose was measured using a Chatillon 300-strength dynamometer (Ametek, Largo, FL) by lifting it vertically one-foot off the ground. Trials were video taped using a digital camcorder. Hose pulling frequency was estimated over eleven trials by timing workers in 10-minute increments and averaging the results.

Four laborers agreed to evaluation using the LMM. All were right-handed, healthy males with no current low back complaints. Data were collected during three different concrete pour times: 1) baseline, before introducing the skid plates while laborers pulled and moved hoses in the usual manner, 2) using unmodified skid plates under hose couplings, and 3) after worker modifications to secure the hose to the skid plates. All data were collected at the same time and day of the week over several weeks. Approximately twenty trials were recorded for each worker at each time interval as they pulled and moved the hose. Each trial was between 1 and 10 seconds in length with an average trial time of 4.2 seconds, although actual pulls were of shorter duration. Workers were initially instructed by the project supervisor to use the skid plates as they came from the manufacturer. Four to five skid plates were used at the positions closest to the pour end of the hose where most pulling activity took place. After using the skid plates during a 6-hour pour, laborers decided they would be...
more effective if the hose was secured to the skid plates with wire prior to the next pour. This study used a quasi-experimental pretest-posttest design in which subjects served as their own controls. Statistical analysis was performed using a linear regression. Trials were removed from analysis if they did not meet the following criteria: 1) data collection was initiated after the subject began pulling the hose or 2) subjects did any activity other than pulling the hose, such as lifting the hose when a section joint latch caught on rebar or when transporting the hose on the shoulder or 3) trials shorter than 1 second in duration. Ten to fifteen trials per subject were analyzed at each of the three test intervals.

Ballet™ software provided with the LMM outputted position, angular velocity (\(\omega\)) and angular acceleration (\(\alpha\)) data. Due to the rapid pace and restricted working conditions it was not possible to measure pulling force during actual hose pulls, therefore changes in the maximum external moment occurring about the lumbar spine with and without skid plate use were calculated using the relationship between linear and angular acceleration and the equation: \(a = \sqrt{r \omega^2 + \alpha^2}\), where \(a\) = linear acceleration, \(r\) = the perpendicular distance between the force pulled and the low back, measured from L5/S1 to a place just above the elbow. In this way the magnitude of tangential linear acceleration was estimated for each trial. Force was then calculated using Newton’s second law, \(F = ma\) and moments in each of the three planes were estimated. This model makes three assumptions: 1) the body is a rigid link segment model, 2) the arms are stiff so that the moment arm does not change during the pull and 3) estimates of tangential linear acceleration are a reasonable reflection of measured angular acceleration.

The predictor variable was +/- skid plate use on the three different pour dates. Response variables consisted of the LMM trunk kinematic variables: position, velocity and acceleration in the lower back for anterior-posterior (sagittal), mediolateral (frontal) and twisting motions (axial), pulling frequency, and maximum external moment about the lumbar spine. RESULTS

Four of seven laborers on the crew were measured with the LMM (Table 1). The average age of laborers evaluated was 34.8 years compared to the crew average of 39.9 years. The average time in the trade was 13.4 years for the crew whereas the four volunteers averaged only 6.5 years working as laborers. The concrete hose was pulled/moved on average 1.81 times per minute (108.6 times per hour), with a range of 1.2-2.9 times per minute although concrete pouring is sporadic. When activity was steady this average rate was accurate. Yet in any given hour there may have been 10-15 minutes of down time, for example while waiting for another pumper truck or while unclipping the hose. During those times laborers may have removed sections of the hose, carried them out of the work area, performed other tasks as needed, or they may have taken a short break. The average duration of floor pours on this site was 5-6 hours. The mass of the concrete-filled hose measured with the dynamometer was 36.20 kg for a force of 355 N.

Even though 18 kinematic variables were calculated, for the activities evaluated in these workers some variables were considered more fundamental. Since injury risk was evaluated using the LBD risk model, the two kinematic variables used in this model, maximum lateral velocity and average twisting velocity, were assessed. The motion laborers used to move concrete hose across was most commonly a combination of trunk extension from a flexed position, right bending, and right twisting. Awkward and asymmetric work postures have been associated with the risk of low-back injury, especially when coupled with acceleration. Given these relationships measures of right-sided bending and twisting, plus flexion and extension were evaluated. High forces have also been associated with low-back injury (NIOSH 1997). In this study acceleration was used to estimate low back force in three planes during hose pulling. Therefore, in total nine measures encompassing position, motion and force were assessed for the task of pulling concrete hose by laborers. Means and standard deviations for these 9 variables were calculated. Standard deviations were somewhat large but are consistent with values recorded by Marras et al. (1993) in manual material handlers. Mean flexion increased from 6.67° to 13.88° with initial skid plate use but decreased to 4.76° when the hose was secured. Right sided bending and twisting decreased with unsecured and secured skid plate use (Figure 1).

**Table 1**: Crew descriptive information

<table>
<thead>
<tr>
<th>Subject</th>
<th>Height (ins)</th>
<th>Weight (pds)</th>
<th>Age</th>
<th>Years in Trade</th>
</tr>
</thead>
<tbody>
<tr>
<td>S01SB</td>
<td>73</td>
<td>185</td>
<td>24</td>
<td>7</td>
</tr>
<tr>
<td>S02JM</td>
<td>69</td>
<td>170</td>
<td>40</td>
<td>7</td>
</tr>
<tr>
<td>S03KW</td>
<td>69</td>
<td>190</td>
<td>47</td>
<td>6</td>
</tr>
<tr>
<td>S04MT</td>
<td>69</td>
<td>195</td>
<td>28</td>
<td>6</td>
</tr>
<tr>
<td>Crew</td>
<td>71.1</td>
<td>194.3</td>
<td>39.9</td>
<td>13.4</td>
</tr>
</tbody>
</table>

**Figure 1**: Mean Lumbar position with skid plate use

Mean velocity during maximum side bending and average twisting decreased when workers used unsecured and secured skid plates (Figure 2). Similarly, acceleration decreased in all three planes with use of unsecured and secured skid plates (Figure 3). The mean maximum moment in all three planes with use of unsecured and secured skid plates decreased when securing the hose (Figure 4). The greatest change was in twisting movements where the average moment decreased from 35.22 Nm without skid plates to 27.23 Nm using secured skid plates. The peak maximum moment re-
Kinematic and force data were regressed to assess the relative impact of skid plates on the low back, for both unsecured and secured skid plate use (Tables 2 and 3). Two dummy variables represent use of skid plates with no tie down and use of skid plates with tie downs, while pulling the hose without skid plates is represented in the base of the model. To control for individual differences, three person dummy variables are included in the model so that individuals served are their own controls.

Kinematic and force data were regressed to assess the relative impact of skid plates on the low back, for both unsecured and secured skid plate use (Tables 2 and 3). Two dummy variables represent use of skid plates with no tie down and use of skid plates with tie downs, while pulling the hose without skid plates is represented in the base of the model. To control for individual differences, three person dummy variables are included in the model so that individuals served are their own controls.

Forceful movements are factors associated with low back injury risk, especially when considered in relation to asymmetric lifts or rapid speeds (Fathallah 1998). Linear regression showed that lumbar region torque decreased significantly in all three-movement planes when workers used secured skid plates compared to not using skid plates (p<.001). For two laborers individual differences were significant.

For position variables, the degree of maximum flexion was not significantly different when using secured skid plates compared to no skid plates. However, there was significantly greater flexion among laborers pulling the hose using unsecured skid plates (p<.001). Extension, as would be expected with greater amounts of flexion, was significantly decreased when workers used unsecured skid plates. Also, when workers tied the hose to the skid plates there was a significant decrease in the amount of maximum right sided bending (p<.01), although no difference was found in maximum right twisting. In terms of velocity, maximum lateral velocity and average twisting velocity decreased significantly when workers used secured skid plates compared to not using skid plates (p<.001). Acceleration for AP, lateral and twisting movements also decreased significantly using secured skid plates compared to not using skid plates (p<.01). When comparing workers one, two, and three to worker four there were significant individual differences between workers (p<.10 to p<.001).

Using the Ballet™ software, kinematic and kinetic data, in addition to trunk position and lifting frequency were used to estimate low back disorder risk for these concrete laborers. In this model the interaction of five variables, lifting rate, average twisting velocity, maximum moment, maximum sagittal flexion and maximum lateral velocity were found to be the best predictors of low-back injury risk (Marras 1993). Marras et al (2000) ranked LBD risk as high (≥ 70%), medium risk (30-70%) or low (≤ 30%).

Table 2: Estimated Lumbar Moments (unstandardized coefficients)

<table>
<thead>
<tr>
<th></th>
<th>Max AP moment (Nm)</th>
<th>Max LAT moment (Nm)</th>
<th>Max TWT moment (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>15.57 b</td>
<td>21.81 b</td>
<td>29.10 b</td>
</tr>
<tr>
<td></td>
<td>(2.21)</td>
<td>(2.80)</td>
<td>(3.43)</td>
</tr>
<tr>
<td>Skid</td>
<td>-1.33</td>
<td>-1.75</td>
<td>-4.88</td>
</tr>
<tr>
<td></td>
<td>(2.57)</td>
<td>(3.26)</td>
<td>(3.99)</td>
</tr>
<tr>
<td>Tied skid</td>
<td>-7.08 a</td>
<td>-5.92 a</td>
<td>-8.47 a</td>
</tr>
<tr>
<td></td>
<td>(2.22)</td>
<td>(2.82)</td>
<td>(3.45)</td>
</tr>
<tr>
<td>F statistic</td>
<td>15.46 b</td>
<td>18.49 b</td>
<td>7.36 b</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>.27</td>
<td>.31</td>
<td>.14</td>
</tr>
<tr>
<td>N</td>
<td>193</td>
<td>193</td>
<td>193</td>
</tr>
</tbody>
</table>

a p<.05, b p<.001

Figures 5 and 6 compare average crew risk for low back injury without skid plates and then when using secured skid plates. The overall LBD risk decreased from 67 percent prior to skid plate use to 46 percent when using secured skid plates. Lifting frequency did not change with skid plate use and remained constant at 1.81 lifts per minute. Average twisting velocity,
Table 3: Linear regression results for skid plate use (unstandardized coefficients with standard errors in parentheses)

<table>
<thead>
<tr>
<th></th>
<th>Max Flex</th>
<th>Max Extend</th>
<th>Max Right Bend</th>
<th>Max Right Twist</th>
<th>Max LAT Velocity</th>
<th>Ave Twist Velocity</th>
<th>Max AP Accel</th>
<th>Max LAT Accel</th>
<th>Max Twist Accel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.28</td>
<td>-8.02b</td>
<td>7.52b</td>
<td>4.73b</td>
<td>16.37b</td>
<td>6.10b</td>
<td>165.131b</td>
<td>113.944b</td>
<td>217.977b</td>
</tr>
<tr>
<td>Skid</td>
<td>7.73b</td>
<td>3.03b</td>
<td>0.78</td>
<td>-0.37</td>
<td>0.50</td>
<td>-1.19</td>
<td>-4.311</td>
<td>1.70</td>
<td>-26.65</td>
</tr>
<tr>
<td>Tied Skid</td>
<td>2.20</td>
<td>-0.94</td>
<td>-2.03b</td>
<td>-1.94</td>
<td>-8.15b</td>
<td>-2.66b</td>
<td>-54.213b</td>
<td>-53.33b</td>
<td>-69.55b</td>
</tr>
<tr>
<td>F statistic</td>
<td>12.80b</td>
<td>2.95c</td>
<td>11.79b</td>
<td>4.82b</td>
<td>12.08b</td>
<td>6.76b</td>
<td>8.495b</td>
<td>11.11b</td>
<td>5.73b</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.24</td>
<td>0.05</td>
<td>0.22</td>
<td>0.09</td>
<td>0.22</td>
<td>0.13</td>
<td>0.163</td>
<td>0.21</td>
<td>0.11</td>
</tr>
<tr>
<td>N</td>
<td>193</td>
<td>193</td>
<td>193</td>
<td>193</td>
<td>193</td>
<td>193</td>
<td>193</td>
<td>193</td>
<td>193</td>
</tr>
</tbody>
</table>

*p<.01  b p<.001,  c p<.05

maximum lateral velocity, and maximum sagittal flexion all decreased the percent risk for LBD. When using secured skid plates maximum lateral velocity decreased from 68 percent risk to 44 percent risk, maximum sagittal flexion also decreased 24 percent, while average twisting velocity demonstrated the least change, decreasing only 18 percent when using secured skid plates. The greatest reduction was in the sagittal lumbar moment, which decreased from 74 percent to 38 percent with secured skid plates.

![Figure 5: LBD risk prior to skid plate use](image5)

![Figure 6: LBD risk with secured skid plate use](image6)

**DISCUSSION**

As results from biomechanical studies become available, it is evident that in addition to handling heavy loads and repetitive activities, asymmetry and motion effects such as trunk velocity and acceleration and more importantly, the interactions among these factors, are integral to understanding injury risk (McGill 1990, Mirka 1990, Marras 1993, Fathallah 1998). The present study evaluated the interactions among these factors. Use of secured skid plates diminished asymmetric motion in right-sided bending and right-sided twisting an average of 2° in each plane. The average maximum velocity decreased by 4.81° during AP movements, 7.96° with lateral movements, and 8.37° with twisting movements. Even though these are statistically significant decreases, if taken individually the magnitudes may not be substantive. However, Marras et al (1989, 1990) and Mirka et al (1990) demonstrated the importance of interactions among these variables. For example, as trunk asymmetry in the transverse plane increases trunk strength decreases and the external load shifts from the erector spinae muscles to less capable and smaller oblique muscles (Marras 1992). Trunk strength also decreases as velocity increases. Additionally, the degree of flexion interacts with velocity and asymmetry. Trunk strength is greatest when flexed at 22.5° and decreases with more or less flexion. The upshot is that more muscle activity is required to maintain the same level of force production, resulting in additional loading of the spine.

Asymmetric motions have been shown to create significant compressive and shear forces to the lumbar joints (McGill and Hoodless 1990). Fathallah et al (1998) demonstrated substantial levels of compressive and anterior and lateral shear loads at the L5/S1 joint caused by the interaction of velocity and asymmetry during lifting. The interaction of these factors may result in damage to facets and the intervertebral disc (Shirazi 1989, 1991). In the current study, pulling the hose consisted of varying degrees of asymmetry in conjunction with large amounts of force prior to skid plate use. These laborers employ movement patterns with sufficient asymmetry, velocity and force to result in large compressive and shear forces in the low back. Skid plate use decreased worker’s asymmetry and velocity, and calculations from acceleration data suggest that low back torque was also reduced, potentially decreasing L5/S1 loading.
The low back is also affected by the interaction between asymmetry and acceleration. Marras et al (1990) demonstrated that as acceleration and asymmetry increase, so does muscle activity in low back agonists and antagonists. Even with a torque of only 3 ft-lbs, in some conditions muscles are activated up to 50 percent of their maximum to produce angular accelerations. It seems likely that large amounts of muscle activation, and in particular coactivation, may reflect significant increases in spinal loading during larger trunk torque generation. In the present study, without skid plates the average maximum acceleration was 185.82 °/s² in lateral motions, 224.73 °/s² in AP motions and 273.55 °/s² in twisting motions. These amounts decreased by 51.77 °/s² for lateral movements, 51.19 °/s² for AP motions, and 68.64 °/s² for twisting motions with use of secured skid plates. Considering the level of muscle activation that occurs in conjunction with rapid accelerations during asymmetric movements, decreasing these factors is an important aspect of decreasing LBD risk, if for no other reason than to decrease muscle fatigue and the accompanying risk of overexertion injury.

Skid plates did not affect pulling frequency. Yet, these findings are contradictory to those by Fulmer (2002) when evaluating skid plate use at a large Boston highway construction project. He found that laborers using secured skid plates increased their 'no lift time' by 15 percent. They also decreased the number of lifts higher than one foot but increased the number of small lifts less than one foot from the ground. He attributed these findings to the hose being easier to move thereby allowing laborers to make additional small corrections in hose placement while overall lifting the hose less. These contradictions may be accounted for by differences in methodology. Fulmer used PATH, an observational sampling method that sampled the entire job performed by the concrete laborers. This technique may have provided a more comprehensive assessment of hose movement, whereas our study was limited to evaluation of one task, pulling hoses.

Interestingly, sagittal flexion did not change significantly with secured skid plate use although the risk associated with maximum sagittal flexion, based on the LBD model, decreased by 24 percent. This reflects the dynamics of variable interaction as opposed to strictly evaluating the magnitude of individual factors.

Taken individually, the decreases in asymmetry, velocity, and acceleration measured using secured skid plates, while statistically significant, may not be meaningful. The interactions between asymmetric postures, velocity, acceleration and force increase the risk to the low back because of the large trunk moments created in association with decreased available strength. During dynamic activities a substantial portion of back strength goes to support and move the trunk, resulting in less strength capacity for lifting, pulling or otherwise moving an object. The net result is an increased risk for injury. So, when considering the interactions of these motion variables, along with worker characteristics such as lumbar moment, the changes observed using skid plates translate into the potential for decreased injury risk.

Low back injury rates among concrete laborers still need to be linked to skid plate use. Because laborers perform many different duties and come and go from a work site, collecting injury incidence data over an extended period that is specific to a particular activity or group of workers is impossible. Therefore, we are forced to draw conclusions from data gathered from other types of workers. Marras et al (2000) correlated decreases in injury risk, using the LDB risk model, with decreases in injury incidents following ergonomic interventions in over 36 MMH jobs in 16 different companies. They found that for jobs in the medium LBD risk category, a decrease in risk from 67.2 percent to 50.7 percent corresponded to a decrease in injury incidence rate from 11.0 to 4.3 per 100 full time employees. The present study found a similar LBD risk in laborers pulling concrete hoses that decreased from 67 percent to 46 percent. While it is impossible to conclude that this drop in risk would result in a significant reduction in injury incidence, especially considering the wide variety of activities laborers routinely perform, it is reasonable to assume that use of secured skid plates by laborers, when pulling concrete hose, is one component of decreasing their overall risk of low back injury.

Concrete laborers repetitively (1.8 times/hour) pull hoses that weigh 80 pounds across rebar matting for up to six hours a day. It is reasonable to ask if this activity is similar enough to the repetitive movement activities evaluated in manual material handlers, to apply the LBD risk model. Few studies have evaluated the biomechanics of pulling, and three-dimensional dynamic models are needed to fully understand the constraints imposed upon the spine during pulling activities. When developing the LBD risk model Marras et al (1993) evaluated over 450 jobs from 61 different industries, from such diverse jobs as automobile assembly, machined products manufacturing, handling clothing, glass production, electronic equipment manufacturing and food processing. They demonstrated the predictive ability of the LBD model for a wide variety of dynamic MMH activities (Marras 2000). The task of moving hoses by concrete laborers, like those of MMHs, is dynamic in nature consisting of rapid movements, repetitive bending, combined with substantial force production in the L5/S1 region during movement of a mass. It therefore seems reasonable to use the LBD model for assessing pulling activities among concrete laborers.

Construction work by its nature makes field evaluation difficult. Worksites are often noisy, dirty, and chaotic, and they may be dark, cold or wet as well. Worker turnover is often rapid. It is not surprising that most existing studies have been conducted in laboratory or simulated settings or have employed observational techniques and survey data. These studies have been useful for identifying postures and practices that place workers at risk of musculoskeletal injury, yet they are limited, particularly concerning the dynamic aspects of real-time work activities. For these concrete laborers the LMM was an effective field tool for evaluating work activities beyond static postures and worker perceptions. The LMM telemetry worked flawlessly, enabling researchers to observe workers at a distance while gathering accurate and specific position, velocity, and acceleration data for the low back. The LMM could be strapped onto workers and removed in 2-3 minutes, minimizing disruption of work activities. Laborers were able to move about without restriction and did not find the LMM cumbersome.
Limitations in the data collection technique may account for error in our findings. For example, the average perpendicular distance measured from the workers' arms to the back was subject to some variability during any given trial. However, several hours of observing each laborer suggested that workers tended to fix their arms in a position fairly close to their trunk and pull with their entire body. Also, for each worker the length of the moment arm was measured several times at different data collection times, and the results were averaged, so distance measurements are probably realistic. Another source of error may have been due to placement of the LMM during the three collection times. Every effort was made to place the LMM in the same location each time, but it was often applied hurriedly and over jeans and belts. Some variability in the results might have been introduced by slight differences in placement.

Marras et al (2000) calculated moments in the lumbar spine using a 2-dimensional linear model by multiplying the mass of lifted objects by the maximum horizontal distance of the object in the worker's hands from the lumbosacral spine. Since this was not possible at this site, calculations of low back torque were made using acceleration data. The assumption made was that calculation of linear of acceleration from angular acceleration yielded realistic moment values. These values are meant to provide a measure of the changes in moment over the different test times, more than a reflection of absolute moment values.

The question remains as to whether the levels of velocity, acceleration and torque found here are sufficient to cause injury among concrete laborers. Correlation of these results with injury data would be helpful for better understanding this relationship. However, since workers come and go from a site with regularity, and a job may last from a few days to months, gathering this type of data in construction has thus far eluded researchers.

Finally, an important finding of this study was the positive effect of crew involvement. When skid plates were used 'out of the box' flexion increased significantly, whereas other parameters did not change significantly. When workers were invited to evaluate the skid plates and their recommendations incorporated, kinetic and kinematic variables all demonstrated additional, and in many cases, significant decreases compared to use of unsecured skid plates. The challenge of making changes in construction practice makes it particularly important to address the applicability of a research intervention to the "real world" of construction and to solicit both supervisory support and crew involvement to maximize outcome effectiveness.

SUMMARY

In this study an ergonomic tool to decrease the risk of low-back disorders among concrete laborers was introduced and evaluated using a quantitative tool, the LMM, which captures the dynamic aspect of job tasks. When skid plates were initially used flexion, velocity, and acceleration increased, but when they were secured to concrete filled holes the probability of risk of a low-back disorder decreased significantly. The variables most influenced by skid plate use were low-back moments, lateral velocity, and sagittal flexion. The LMM proved to be an effective field tool for quantifying dynamic aspects of work tasks among construction laborers. Future studies are needed to better understand the dynamics of pulling activities and to establish a relationship between changes in risk factors to actual incidence of low back injury.

REFERENCES


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