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# The Effect of Workplace Based Strengthening on Low Back Injury Rates: A Case Study in the Strip Mining Industry

**Vert Mooney,[1,3] Marvin Kron,[2] Patrick Rummerfield,[2] Bryon Holmes[1]**

*The purpose of this study was to demonstrate the effect of a once a week exercise program focused specially at lumbar extensor strengthening. This is a comparative study where workers volunteered to exercise were compared to workers who did not exercise. Low back claims for one year were noted to document efficacy of the training program. Change in strength was also noted. There was a 54% to 104% increase in strength during a 20 week program. The incidence of back injuries in the exercise group was .52 injuries per 200,000 employee hours versus the industry average of 1.09 back injuries per 200,000 employee hours. The average incidence of injury for the previous nine years at the company participating in the program was 2.94 injuries per 200,000 employee hours. The injury incidence in the workers not exercising was 2.55 injuries for 200,000 employee hours. The average workers' compensation liability dropped from $14, 430.00 per month to $380.00 per month for the study year. The significant increase in strength associated with the exercise program correlated with the greatly reduced incidence of back claims.*

**KEY WORDS:** industrial back injury; workplace exercises; exercise compliance.

## INTRODUCTION

The relationship between back injuries and back strength still has not been well defined. Although it now seems well established that diminished trunk function correlates with low back pain (1–3) back strength and back injury in the workplace seem poorly correlated. The confusion in this picture may be related to how we measure back strength, and the physical demands of the workplace. It seems intuitively reasonable that a back weaker than normal should be predisposed to a greater incidence of injuries. The literature does not give much support for this concept.

[1]University of California, San Diego, Department of Orthopaedics, OrthoMed Center.
[2]Western Energy Company, Colstrip, Montana.
[3]Correspondence should be directed to Vert Mooney, Professor of Orthopaedics, UCSD OrthoMed, 150 Regents Park Row #300, La Jolla, California 90237.



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Chaffin and Keyserling did show that prospective employees when tested using isometric whole body lifting strength showed that weaker workers were at greater risk for workplace back injury (4,5). The isometric testing used in these studies was uncontrolled for posture and tested entire body lifting strength, not isolated lumbar extensor strength. Also, the particular industry for which workers were being tested, at that time, was tire manufacturing. This was extremely strenuous manual labor. Few industries today are comparable in the physical demands placed upon their employees. This point is reinforced by the work of Battie and Bigos *et al.*, who used essentially the same test system of isometric testing of total body lift capacity without postural control for pre-employment evaluation (6). They evaluated prospective employees for the aircraft manufacturing industry. None of the jobs in that particular industry were as demanding as in the earlier studies of Chaffin *et al.* Their study could not demonstrate any predictability of lifting strength correlation to back injury. The discrepancy in results may be due to inaccurate testing or grossly different job demands.

It has been established that pre employment worker fitness evaluation can be utilized to reduce workplace injury claims. The recent study by Reimer *et al.*, documented that pre-placement testing with isokinetic lift strength evaluation could identify those workers apparently at risk for injury (7). In this particular study, 33 experienced workers without back injury were tested and defined as the minimum standard. The job applicants who did not meet these standards (number not recorded), were reassigned. There was a significant reduction in back injury claims which the authors related to pre-placement testing. It should be noted that the strength requirements of specific class of employee—in this case, warehouse workers, in a grocery business—was achieved. This allows the pre-placement testing to be in compliance with the Americans with Disabilities Act. Most industries have not classified the physical demands of the job and indeed do not make an attempt to establish the physical capacities before the individual is hired. No on the job prophylactic strengthening was attempted. It is not clear whether surveillance alone may not have been the critical feature associated with reduced claims.

In spite of lack of consensus as to how pre-employment lumbar strength is related to workplace injury, there is the classic firefighter study which reveals that poor back muscle endurance and low general fitness increase the risk of occupational low back injury (8). General aerobic fitness alone, however, seems to have no relationship to workplace injuries as shown in the Boeing Study (9).

Thus, it seems reasonable to expect that strengthening exercises might be a benefit. There is the question, of course, as to how to weave a training program into the fabric of the workplace. One approach has been to introduce a lecture series urging wellness and specific exercise program. A prospective study undertaken by Leino *et al.*, for Scandinavian lumberjacks attempted such a program (10). In this study, 1-week courses were designed to activate exercising during leisure time. They incorporated various fitness and strength tests into the lecture program. This was a prospective controlled comparative study. The baseline and study end-points were largely questionnaires and thus, poor functional data were available. Fitness training was urged to be done on leisure time. Compliance was not defined. Not surprisingly, no major change in the incidence of workplace injuries was reported.

A much more specific approach was undertaken by Gundewall *et al.* (11). This was also a prospective comparative study which was randomized so that 28 participants were in a exercise group and 32 participates were in a control group. Nursing personnel made up the 60 participants. Specific strength testing was undertaken in this study, and 20% increase in strength was noted following a specific exercise program which focused significantly on extensor strengthening. The control group did not improve their strength. The test maneuver was isometric back strength in extension while standing. The position was not precisely controlled. Significant resistive exercises under the supervision of two physiotherapists were provided to the treatment group averaging five 20-minute sessions per month. At the end of 13 months, there was a significant difference in workplace sick listing. Only one individual in the treatment group while 12 individuals in the control group were sick listed. The study compared well with a Kellet study which did not use as an intense exercise program, but carried out exercise during working hours (12). In this study, the sick listing was reduced by 51%. Neither of these studies, however, documented compliance or the total amount of exercise carried out during the work week. Nonetheless, the studies did document that strengthening exercises to the torso correlated with a reduced incidence of workplace back injuries. The studies did not specifically indicate, however, to what degree this intervention changed the incidence of workplace injury compared to that particular industry or compared to experience in previous years at that facility.

Whether due to the physical demands of the job or other factors, the incidence of back injuries between industries and between various workplaces in the same industry is quite variable. In the strip mining business, the incidence of torso injuries was 63% and strains to the low back were 59% of these injuries, thus, amounting to about 25% of all injuries. The incidence of injury at the Western Energy Rosebud Mine in Coalstrip, Montana, easily exceeded industry levels. Over the previous 9 years there was an average of 1.5 lost time injuries per month at the strip mine (13,14).

Lecture training programs had been initiated in the previous years at that company, but no change had occurred in the incidence of workplace injury. Because of increasing insurance rates, the safety manager was prepared to initiate a more specific training program utilizing dedicated equipment. A new safety coordinator was hired by Western Energy (PR) in 1992. He had a background in fitness training, but no medical treatment experience. After presenting his proposal to carry out specific strength training to the management, they agreed to fund the project and purchase the test and exercise tool. He received training in the use of the MedX lumbar extension machine and a program using the equipment was initiated in August of 1993. The purpose of this case report is to document the effect of this training program in a prospective comparative study.

## METHODS

This study was carried out at the Western Energy Company Rosebud Mine Coal Strip Montana. All of the mine workforce were men. With management and union permission, the workforce was approached by the Safety Director with a pro-

posal for a once-a-week strength training program using a newly purchased piece of exercise equipment. This was a voluntary program. Only those who agreed to participate would be tested and trained. This was on company time. However, there were no incentives to participate in this program. Continuation with the strength training program was purely voluntary and volunteers could drop out at any time.

The program started on August 2, 1993 with approximately 30 participants. Employees continued to volunteer so that there were ultimately 197 workers carrying out the treatment program.

Of those who volunteered, 90% stated that they had had previous back problems. None had current claims against the company for back injuries. In that this was a completely volunteer program, those who did not volunteer were not surveyed and there is no information as to their incidence of previous back problems. Those who volunteered all agreed to participate in the program for at least 20 weeks.

## EXERCISE PROTOCOL

The test and training program was carried out by a single technician (PR). Employees were scheduled on a once-a-week basis at times which fit best into their work pattern. Each employee was initially tested for baseline strength using the MedX unit according to the standardized protocol (15).

This equipment was chosen in that it is both a test and training tool. Using this system of isolation of the lumbar extensors in the sitting posture and testing strength in an isometric manner at equal points of the full range offers highly reproducible testing data (Fig. 1). Data on reliability for normals by sex and age group have been published (16). Also, protocols for the exercise routine have been established which are based on previous experience using this equipment so that all participants in the training program are able to use the same protocol (17). As documented in various studies, due to the high level isolation achieved by design of the equipment, an exercise program can be accomplished which is so specific that strengthening exercises at a once-a-week incidence are as effective as 2 or 3 times a week (18).

Thus, all participants were placed into the same exercise protocol. Once baseline maximum isometric strength had been defined, an exercise program was initiated which starts with a beginning resistance at 50% of the maximum torque produced. The participants exercise in the equipment using extended resistance isotonic mode of strengthening wherein the lumbar extensors are challenged in both the concentric and eccentric phase (Fig. 2). Once 20 repetitions have been performed through range at a specific resistance level, the resistance is increased approximately 5% on the next exercise occasion. When 20 repetitions once again have been achieved, the resistance again is increased by 5%. The exercises are accomplished at a very slow rate with each flexion/extension repetition lasting 6 to 8 seconds. Thus, the entire exercise program would normally include 2 minutes of actual exercise.

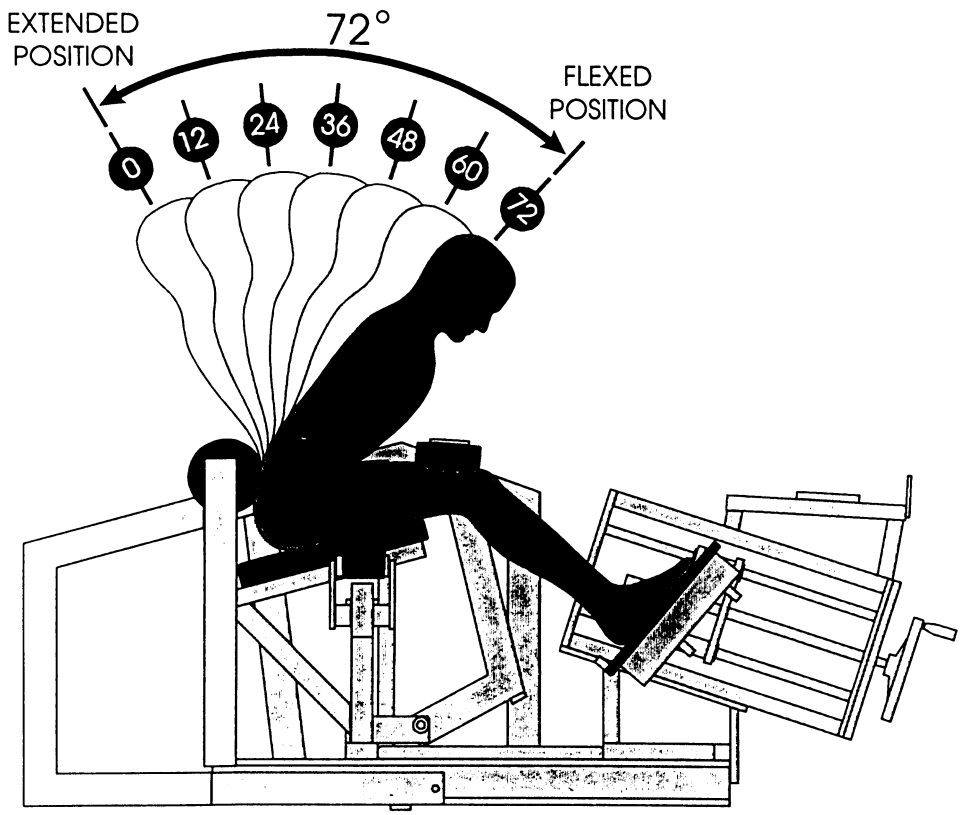


**Fig. 1.** This illustrates the mechanism by which isometric strength is measured for lumbar extensors through full range. The pelvis is isolated from the lumbar spine due to the adjustable nature of the equipment. A pattern of strength is thus created at the points along the range. This can be graphically displayed.

## RESULTS

### Accident Rates

The U.S. Department of Interior Bureau of Mines reported 1279 back injuries for 234, 416, 978 hours worked at strip coal mines for the year 1991 through 1993 (MK). This calculates to be an incidence of 1.09 back injuries per 200,000 employee hours. The incidence of injury at the Western Energy Rose Bud Mine in Coal Strip Montana prior to the initiation of the program was 2.94 injuries per 200,000 employee hours worked. This was an average over the previous 9 years. During the 1-year period of this study, the incidence of back injuries for the non-exercise group was five, which computed to 2.55 injuries per 200,000 hours. The incidence of back injuries for the exercise group was .52 injuries per 200,000 hours. Thus, the incidence for the entire mine was 1.55 injuries per 200,000 hours.

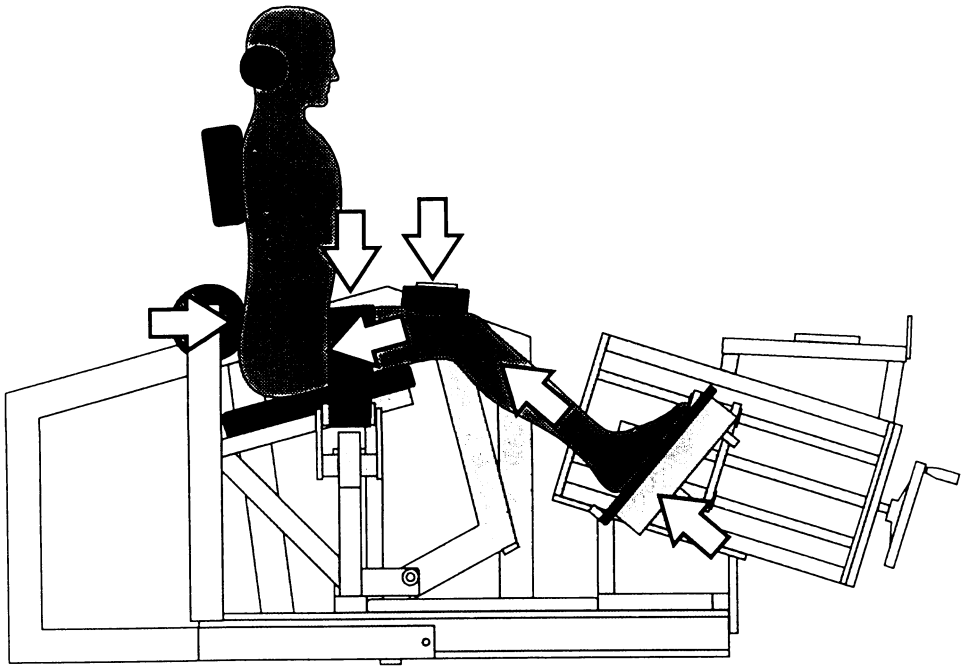

**Fig. 2.** This represents the pressure points needed to fully isolate the lumbar spine. By so doing, only lumbar extensor strength is exercised through full range in both concentric and eccentric modes.

## Workers' Compensation Cost

The average workers' compensation liability for the 40 months prior to initiating program was $14,430.00 per month. The average cost following implementation of the program was $380.00 per month. The one injury in the exercise group was an individual who missed 1 day of work and thus had an estimated liability of $76.46. This was a work related injury, but did not occur while exercising.

## Trunk Strength

The overall lumbar extension strength improved from 54% in the flexed position to 104% in the extended position. The average initial exercise resistance was 108 foot pounds and this improved to 242 foot pounds (Table I). This improvement is graphically displayed on Fig. 3. In spite of the significant improvement, the workers at the 20-week test had not all reached the norm for their age group. The data was visually inspected and not statistically analyzed due to lack of access to statistical data in normals (15).

All participants were encouraged to remain with the program for at least 20 weeks. There was an initial drop out rate of 5% with all but one of this group

Table I. Average Isometric Torque in Foot Pounds at Points in Isolated Lumbar Range of 197 Workers Compared to Normal (15)[a]

| | Foot pounds lumbar extensor torque | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Ext. | | | | | | Flex | |
| Lumbar range | 0° | 12° | 24° | 36° | 48° | 60° | 72° | Average |
| Initial | 74 | 114 | 142 | 166 | 189 | 193 | 183 | 108 |
| 20 weeks | 151 | 200 | 228 | 242 | 264 | 289 | 293 | 242 |
| Normal | 141 | 204 | 235 | 258 | 279 | 303 | 327 | 274 |

leaving the program within the first week. After the 20-week exercise period, additional participants left the program so that at the end 1 year, 112 were still participating. Thus, at 20 weeks there was a compliance rate of 95%, and at 52 weeks it was 57%.

## DISCUSSION

This case study has several limitations. It basically was not initiated as a scientific study—merely an attempt by the management of one strip mining company to reduce its costs. The individuals being trained and tested were not patients, but volunteer workers. Participants who were volunteers, of course, is the only feasible

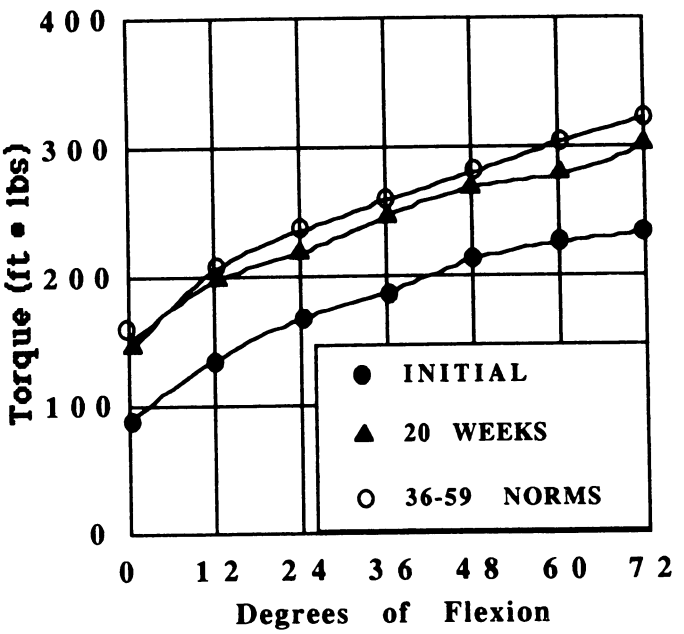


Fig. 3. The pattern of strength is displayed in foot pounds through full lumbar range. The average 20 week strength is displayed after 20 specific exercise sessions. Slight deficit (not statistically different) from expected normal is noted.

manner by which this unfunded study could have subjects recruited for a strength training program. Therefore, it is by no means randomized. In fact, it is apparent that those who volunteered for the study probably had a self interest in participation in that over 90% reported having had back problems before they participated in the study. None of these workers, however, had worker's compensation claims for back problems. Those 203 workers who did not volunteer (controls) had a reasonable lack of interest in an exercise program in that statistically this group should have had less back problems at the time of invitation to participate. No incentives for participation were provided. One might infer, therefore, that those who participated in the training program were more at risk for repeat back injury than the nonvolunteers. A recent study by Gundewall emphasizes that history of previous back problems predisposes to a recurrence, but the specific medical diagnosis is irrelevant in predicting who will have a back injury or how long it will persist (19). As to this particular case study, the particular anatomic diagnosis possible from medical evaluation would have been irrelevant in those workers who had history of back pain, but were not currently seeking attention for it. No data were available as to the previous history of incidence or the type of past treatment for these individuals, either volunteers or controls. This was not a medically based study.

Compliance with any volunteer program is a significant concern. Those participating in the training program did so during working hours. The duration of time away from work was minimal requiring only a once-a-week training event. The entire episode would last 10 to 15 minutes with the actual specific exercises lasting about 2 minutes, in that the participants carried out 20 repetitions of the lumbar extension exercise routine. Feedback of performance, however, was visible by a video monitor, and at each training event a comparison with previous achievement was available. On each occasion of testing, the level of improvement could be defined and indeed the deviation from the expected normal could also be presented. Perhaps this amount of reinforcement offered sufficient feedback to encourage return and continued compliance.

The compliance rate of 95% for 4 months is higher than would have generally been expected in an exercise program. No comparable industrial study exists for comparison. A back exercise study by Manniche utilized an intensive dynamic back strengthening program for chronic low back pain patients (20). This study used a very vigorous lumbar extensor training, 2 to 3 times a week, lasting about 1 1/2 hours. This study on low back pain patients had about an 85% compliance rate of those randomized to the extensive exercise program. Theoretically, the pain patients had motivation to continue the entire 3 months of the study. This prospective randomized study did document that the intensive strengthening exercises were much more beneficial for chronic low back pain patients than less vigorous exercises. In this study also, direct measurement of lumbar strength using simple equipment did document significant measurable training benefit.

There are other limitations to the interpretation of the current study. During the period of this study, there were internal events at the work site which were changing. The company in 1992 transferred the worker's compensation management to the mine site itself rather than using company-wide supervision. Thus, the employees were encouraged to dedicate their efforts to establish an accident-free work-

place. This may indeed explain why the incidence of back injuries to the control group was also reduced compared to previous history. Nonetheless, even under the influence of management encouragement to reduce the accident rate, there was a significantly lower rate of injury for those participating in the exercise program compared to those who had no specific training in lumbar extensor strength, and for apparently fewer episodes of previous problems.

There is concern that the low baseline testing of those who volunteered for the training program represented a specific abnormality of this group. Were they weaker because of previous back problems or were they merely representative of the industry as a whole. It may be that industrial workers, even those with no pain complaints, have lower than expected levels of lumbar strength. In a recent study by Mayer *et al.*, 160 apparently healthy male railroad workers were tested for lumbar flexion extension strength using isokinetic technology. This group who had no back pain complaints or history of back pain, demonstrated about 15% deficit in lumbar strength compared to normals using the same measurement technology. Of course, comparisons of the Mayer study to our study are difficult, in that, the technology used in our study requires isometric testing over range whereas the Mayer study (21) used dynamic isokinetic testing in a less well stabilized system. Nonetheless, it is apparent that in our study the workers who volunteered for the study, had even a greater deficit than expected.

Participation in a specific strengthening program using the protocol identified in this study will increase strength significantly. A prospective randomized study of back pain patients using a similar training protocol were compared to those who were not participating in a training program (22). Those patients participating in the treatment program increased their strength by about 32% while those not participating but being tested before and after the same period of time did not change their strength.

In spite of all the confounding factors noted in the discussion above, it is clear that those workers who participated in the training program, had a lesser incidence of back injury claims than the typical for workers in this same industry. They were also lower than those who did not participate in the training program. Those who participated in the strengthening program also reported an improvement in function when not at work. Statement of improvement of function, when not working provides only anecdotal evidence of their subjective improvement. This is unmeasureable and thus incomparable. This case study, however, illustrates the utility of objective measurement of some characteristic of function. Only standardized equipment and protocols can do this. With data developed on a standardized testing tool, comparative studies become available.

There has been some concern as to the validity of test protocols and treatment protocols using computerized equipment. A recent article by Newton and Waddell reviewed the scientific literature and challenged the use of "iso-machines" for routine clinical assessment. They suggested that there were no standardized test and treatment protocols available in the literature. They also noted that there was a lack of information in the literature demonstrating how protocols could be used. In addition, they stated that the protocols were usually not adhered to particularly in patients with low back pain (23). Unfortunately, as was reported in a subsequent

article, they failed to comment on isometric testing at equal points in range with this equipment which specifically isolates the lumbar extensors (24). As was pointed out in the Controversies article, the Newton and Waddell article indeed included in their bibliography references to the MedX equipment in this study above, but did not refer to them in the text.

Our study does document the efficacies of the protocols in terms of testing for deviation from normal and to establish baseline training. In our study a specific standardized test for baseline and definition of progress was used. Also, a standardized protocol for the progressive isotonic exercises was used by a single instructor throughout the study. This study documents that it is possible to use standardized protocols for all participants. This study does relate improved strength in the back to a reduced incidence of back injuries.

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