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A MULTIDISCIPLINARY APPROACH TO A TIME-EFFICIENT LOW BACK EXERCISE INTERVENTION IN A SMALL MANUFACTURING PLANT: A CASE STUDY

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ABSTRACT

Boyce RW, Stallings JA, Wilde CW. A Multidisciplinary Approach to a Time-Efficient Low Back Exercise Intervention in a Small Manufacturing Plant: A Case Study ***JEP****online* 2008;11(4):12-24. Reports suggest low back extensor muscles have a large potential for strength gain with one maximum set of 10 reps/week. The purpose of the present study was to test potential benefits of a back extension exercise program and safe lifting practices reflecting job tasks in a small manufacturing plant. Volunteers (N=18) (42.7±11 yrs) ranged from heavy labor to clerical positions. Pre- and post-testing of static strength included a full-range-of-motion lumbar back extension test on a MedX back machine at 0, 12, 24, 36, 48, 60, and 72 degrees. The program included warm-ups of stretches, lower and upper body resistance exercises and one set of 10 reps/week to fatigue on a Nautilus back machine. Repeated measures ANOVA and paired sample t-tests procedures were used to compare before and after fitness test means. After 12 weeks, participants (n=13) increased in overall back strength (219±69 vs. 275±80 ft-lbs, $p<0.05$). Strength at 12, 24, 36, 48 and 60 degrees were significantly improved ($p<0.05$). The Nautilus 2ST, spine extension flexibility, curl-ups, push-ups and squat test significantly improved ($p<0.05$). Final questionnaire reported improvement in all variables, 100% wanted the program to continue. Back extension exercises, one set/week, with warm-ups reflecting job tasks, improve back strength and comfort in manufacturing settings. Potential benefits include improved perception of safety, safe lifting awareness, increased work quality, productivity, morale and home/recreation.

Key Words: Health Promotion, Back Comfort, Back Strength, Ergonomics, Occupational Safety.

INTRODUCTION

Back pain among workers has an enormous effect on American industry accounting for at least 14 billion dollars in terms of lost workdays (1). The Bureau of Labor Statistics reports that back injury and illness are the most common reason, 21%, for work days lost in industry. The manufacturing industry is in the top three industries with this problem (2).

Over the last 100 years, rehabilitation and exercise physiology literature explored exercise solutions for reducing back pain (3-6). The literature has suggested that training the lumbar spine can reduce lower back pain (7-8). It has also been reported that the lumbar area has a large potential for strength increase (9). Positive results have been reported with training one time per week using one set of 6 to 15 repetitions to volitional fatigue (10). Further work explored the optimal back exercise frequency and recommended a training regimen of once per week, every week (11). Low volume and frequency back exercise protocols have been reported to significantly improve bone density, strength and the muscle cross sectional area (12-13).

Research has stressed the importance of isolating lower back muscles through stabilizing the pelvis and/or the lower extremities (7, 11, 14-18). The development of simple calisthenics-type exercises and improved back exercise machines that utilize pelvic stabilization have aided in back training. A randomized controlled study of Swedish nurses demonstrated potential benefits of basic pelvic stabilization techniques when training the lumbar spine (7). The average number of training sessions was 6 per month for 13 months. Exercises included calisthenics-type back extensions and some pushing and pulling movements using body weight, elastic bands and hand-held weights for resistance. The training group increased back strength and showed significant decreases in back pain complaints, back pain intensity, and work absences.

In a larger controlled study of Montana coal miners, (19) subjects performed back exercises, during working hours, on a lumbar extension machine to muscular fatigue one time per week for 20 weeks. Each exercise session included only 2 minutes of exercise. Low back strength increased at a reported range of 54% to 104%. Previously the mine's average back injury incidence rate was 2.94 per 200,000 working hours. Following training, this rate dropped to .52 for the exercise group and the non-exercise group had a rate of 2.55. The exercise group showed significant increases in strength and significant decreases in workers' compensation liability claims.

Despite this, there is no consensus regarding the effectiveness of exercise regimens in reducing back pain (20). A literature review by Tveito et al. included the following criteria of a controlled trial, work setting and an assessment of at least one of four main outcome measures: (a) sick leave; (b) costs; (c) new episodes of low back pain; and (d) pain. The six exercise interventions reviewed showed limited evidence of effect on sick leave, costs, and new episodes of lower back pain; and no evidence of effect on level of pain. This was mainly due to the low methodological quality of the assessed studies. Also, an active workplace is not an ideal setting for a controlled intervention (21) .

Improper choice of protocol may also affect outcomes in exercise interventions. William's flexion and McKenzie's extension exercises for the spine are commonly prescribed for low back pain. However, they lack the requirements to facilitate optimal strengthening in the de-conditioned tissue (8). Furthermore, callisthenic floor exercises, that don't effectively stabilize the lower extremities, may not isolate the low back muscles sufficiently for optimal results (20).

Little has been reported on the effectiveness of low-volume, low-frequency back training techniques in small manufacturing operations. Furthermore, no work was found regarding using on-the-job physical training time to instill proper lifting methods at high injury risk work stations. Also, no literature was found combining back pain exercise interventions, back strengthening and safe lifting training, into one program.

A small manufacturing company elected to engage an exercise physiology consultant to conduct an initial work-site survey. Based upon the survey results, management directed the consultant to design a trial back extension exercise intervention to improve back strength. The intention was to use a low frequency and volume training program in order to have minimum interference with work schedules.

The objective for this work-site intervention was to demonstrate the potential benefits of the exercise program on low back strength and back comfort while reinforcing safe lifting practices and to document employee perceptions. In an effort to synergistically combine health promotion and safety techniques, exercises were designed to instill proper lifting techniques and safety awareness directly related to job duties. Another goal was to compare findings from the MedX and Nautilus2ST back training machines to determine if results were comparable. We hypothesized that this exercise intervention would result in a significant improvement ($p = 0.05$) in low back strength as measured by the MedX and Nautilus2ST back machines as well as an increase (percent reporting increase = 50%) in back comfort as reported in an end-of-program questionnaire completed by the subjects.

The purpose of this paper is to describe the multidisciplinary health promotion processes of this intervention while demonstrating areas of opportunity for exercise physiologists in industry. Pre and post test findings of this case study will be reported, detailing the benefits of blending health promotion and safety concerns.

METHODS

Subjects

Subjects included 20 volunteers from a plant with 80 employees. Two were eliminated, due to medical conditions and plant schedule, prior to the pre-test. Of the remaining 18 volunteers, 16 (89%), completed the pilot study (14 males, 2 females). The average age of participants was 42.7 ± 10 years. Thirteen volunteers completed the post test MedX back extension evaluation.

Procedures

A small manufacturing company (< 80 employees) in the southeastern United States elected to engage an exercise physiology consultant, with experience in ergonomics. The consultant assessed the work-site by first conducting an initial body discomfort survey of the plant employees. Participants represented eight separate areas of the company including management, three areas of industrial production, maintenance, warehousing, clerical and quality control personnel.

The discomfort questionnaire, an ergonomic assessment form by the Ergonomic Center of North Carolina (22), included self-reported assessments of age, gender, job characteristics, body part discomfort levels on a scale of 0-5 (0 = no discomfort to 5 = very uncomfortable), discomfort history, and any job task concerns. Of the entire sample, 53% reported experiencing back discomfort.

Next the consultant conducted a safety walk-through to target potential problem areas within the plant. Employees at each work area were interviewed. Employees who had sustained a work-related injury also completed a written injury survey and were interviewed in order to identify potential high injury risk work areas. This ergonomic inspection of the work site revealed five work areas with high injury risk related to force and awkward postures that could benefit from muscular strengthening and proper lifting skills. Tasks included: reaching low and handling heavy materials, lifting heavy buckets from a squat position, lifting heavy buckets from floor to chest high, shoveling heavy materials, and pushing or pulling heavy materials.

Based on the data derived from the survey, the walk through and the employee interviews, management elected to assign a high priority to back discomfort and safe lifting as a focus for an intervention. The health promotion process commenced with the formation of a Safety Committee including management, safety personnel and the consultant. The committee elected to use the continuous improvement model guidelines suggested by the National Safety Council for formation and implementation of interventions. Process was in 5 phases: Phase 1- gain commitment, involvement and ownership by management and personnel; Phase 2 - establish base line data; Phase 3 - set goals; Phase 4 - implement strategies; Phase 5 -review outcomes, make necessary adjustments and begin again with Phase 1.

The consultant developed a back strengthening exercise program procedures manual detailing the purpose, goal, scope and specific exercises for this company. Then, from the Safety Committee, the company Safety Director was appointed as Back Exercise Project Coordinator to manage operation of the program and act as company liaison with the exercise physiology consultant. A Medical and Legal Advisory Committee, consisting of the plant manager, the company's lawyer, the safety director and the consultant cleared all legal forms and approved all exercise regimens prior to implementation. The committee followed the United States National Institutes of Health guidelines and the Helsinki Declaration concerning rights of human subjects this committee

A Back Exercise Committee was formed which included representatives from various work areas within the plant, the Safety Director and the consultant. A back exercise room was set up with a Nautilus 2ST back machine (manufactured by Nautilus GSA), incline sit-up board, hand weights, instructional posters and signage. There was a series of posters featuring photographs of actual employees performing the warm-up exercises and explanations that connected the exercise to high risk work stations. The posters were intended to reinforce proper lifting procedures within the plant.

The program sought to enlist twenty volunteers. It was promoted to the employees by the Back Exercise Committee and management to encourage employees to sign up for the trial program. Promotion included letters from management and orientation sessions. Twenty volunteers signed up. They represented different departments of the plant, from heavy physical labor to clerical employees. Each completed a written informed consent prior to participation. Managers assisted in scheduling employees' participation. All participants received a preliminary medical examination, as part of their annual job medical examination, consisting of a medical history questionnaire, a physical examination, and medical approval.

A pre-test was administered consisting of a full-range-of-motion lumbar back extension test on a MedX back machine (manufactured by MedX Corporation, Altamonte Springs, FL) at an outside medical spine center. Static strength (torque) was measured at 0, 12, 24, 36, 48, 60, and 72 degrees. Other data was collected in the company's exercise room including blood pressure, a trunk and neck extension flexibility test (spine extension) (23), push-up, curl-up (24) and squat. The curl-up test was modified to let the subject do the exercise at their own rate. The squat test was modified to mimic work site lifting and stooping. Subject stood with feet shoulder-width apart and squatted until thighs were parallel to the floor, returning to full upright position at a pace of one complete cycle every two seconds. Test was timed with a metronome. The test was terminated when participant could no longer keep the two-second cadence or had met the test’s two-minute time limit.

After two weeks, additional back strength tests were given on the Nautilus 2ST back machine. A ten repetition maximum load test was given followed after five minutes with a one repetition maximum load. The two week delay for this Nautilus 2ST test was to allow participants time to become accustomed to the machine and the exercise for safety purposes.

Each participant was provided an individualized exercise prescription session where they were trained on the proper use of the Nautilus 2ST back machine, the warm-up exercises and conditioning of opposite muscle groups. The importance of stabilizing the legs and using back extension movements instead of hip extension was emphasized. The participant exercise prescription was updated two weeks later following their maximal strength testing using the Nautilus 2ST back machine.

All participants warmed-up with the following stretches: standing reach, lateral trunk flexion, shoulder stretch, groin stretch, calf stretch and chest stretch. They also performed exercises with hand weights (1 set, 10 reps, performed with both hands simultaneously) including shoulder shrugs, squats and upright row. Other exercises included forward squatting lunges (10 reps), abdominal crunches (20 reps) on an incline board and push ups (20 reps of standard style for men and modified for women).

Exercises were chosen to replicate job tasks: Squatting lunge strengthened legs for reaching low or shoveling, shoulder shrugs and upright row replicated pulling tasks and lifting buckets to a high ledge, two hand squat simulated lifting buckets and other heavy objects from the floor, push ups strengthened muscles needed for pushing heavy objects and crunches increased abdominal strength and complemented the back extension exercises. One set of this routine was completed during each exercise session prior to exercise on the back machine. The warm-up routine lasted approximately 10 minutes.

Following the warm-up exercises subjects trained on the back machine. For the first two weeks, subjects trained at approximately 75% of capacity three times per week with one set of 10 repetitions on the Nautilus2XT in order to become accustomed to the back exercises. After the initial two weeks, subjects trained one time per week until volitional muscular fatigue using one set of 10 repetitions. Once participants could perform 12 repetitions until volitional fatigue on two consecutive days, loads were increased to a level where they could still perform at least 6 to 10 repetitions before volitional fatigue.

The exercise coordinator oversaw completion of three forms by each participant during each session: A sign-in form; an exercise log recording load, sets and repetitions, along with any pertinent comments; and a scheduling calendar for subsequent visits. The exercise coordinator was responsible for supervising, assisting and motivating the volunteers. A reward and incentive system was recommended. Duration of the program was 18 weeks.

Post-testing followed the same protocol as pre-testing and was scheduled with management's assistance. However, post testing was given at two intervals. Due to plant schedules, the MedX test given at 12 weeks and the physical fitness test and Nautilus 2ST test given at the end of 18 weeks. The exercise physiologist administered the post testing except for the off-site MedX test.

Participants filled out a final program questionnaire which included rating the exercise facility, program and organization of the program and perceived benefits. Subjects were asked to rate the following: back strength, overall strength, flexibility, ability to lift safely, safety awareness, back comfort, quality of work, productivity, moral, and home/recreation quality in terms of increased (I), decreased (D), or stayed the same (S). They also noted if the program had met their expectations and if they wanted the program to continue. Participants received a certificate of completion with charts showing their individual progress.

Following the statistical analysis of the data, as detailed below, the exercise physiologist consultant compiled the results, presented it to the Back Exercise Committee and together, they reviewed the outcomes. The consultant then presented the full report to management. Working with the consultant, the Back Exercise Committee and management went on to set new goals and strategies, revise procedures as needed and made plans to implement the program for the entire plant. One of the first steps of the new plant-wide program was to present the results of the trial intervention to plant employees at company safety meetings.

Statistical Analysis

A repeated measures ANOVA with compound symmetry correlation structure, using SAS 9.1, was utilized to compare the pre and post training differences of the MedX back test (Table 1). Contrasts using the least squares means were used to compare pre and post training means by angle. The level of test significance is $p = 0.05$. Reported p-values are not corrected for experiment-wise error rates due to the fact that this was a preliminary study. Paired sample t-tests were used to compare pre and post fitness training test results (Table 2) using SPSS version 15.0. The data is presented as mean ± SD. Post-hoc power test were performed for each MedX test angle and fitness test. Results of the end-of-program questionnaire were reported in percentages (Table 3).

Table 1. MedX static back extension strength results pre and post 12 weeks of training.

Back Angles (Degrees)		N	Torque (ft-lbs) Mean ± SD	p-value
0	Pre	13	140±65	0.171
	Post	13	165±62	
	?		25	
12	Pre	13	187±63	0.001***
	Post	13	248±86	
	?		61	
24	Pre	13	221±77	0.002**
	Post	13	278±89	
	?		57	
36	Pre	13	237±89	0.000***
	Post	13	303±93	
	?		66	
48	Pre	12	246±82	0.001***
	Post	12	314±95	
	?		68	
60	Pre	11	254±82	0.019*
	Post	11	301±87	
	?		47	
72	Pre	7	260±101	0.283
	Post	7	286±105	
	?		26	
Overall	Pre	13	230±59	0.004**
	Post	13	274±79	
	?		44	

P-values are based upon repeated measures ANOVA using compound symmetry correlation structure: $*p = 0.05$, $**p = 0.01$, $***p = 0.001$. SD=Standard Deviation

RESULTS

Out of the 80 plant employees, 20 volunteered for the study. Two were eliminated, due to medical conditions and plant schedule, prior to the pre-test. Of the remaining 18 volunteers, 16 (89%), completed the pilot study (14 males, 2 females). The average age of participants was 42.7±10 years. Thirteen volunteers completed the post test MedX back extension evaluation. The post test MedX evaluation was completed at 12 weeks into the study. Plant fitness post tests and end of program evaluation were completed at 18 weeks. These post tests were conducted at different intervals due to plant schedules and work requirements. Participants averaged 9 weeks of exercise, or 75%, during the

Table 2. Fitness test results for the back exercise program pre and post 18 weeks of training.

Test		N	Mean ± SD	p-value
1 Rep. Max (lbs)	Pre	16	182±62	0.000 ***
	Post	16	217±60	
	?		35	
10 Rep. Max (lbs)	Pre	16	147±50	0.000 ***
	Post	16	190±57	
	?		43	
Spine Extension	Pre	16	14±4	0.043 *
	Post	16	15±4	
	?		1	
Push-ups (reps)	Pre	13	26±14	0.000 ***
	Post	13	32±16	
	?		6	
Curl Ups (reps/min)	Pre	15	23±14	0.014 *
	Post	15	28±16	
	?		5	
Squat (reps/2 min)	Pre	15	35±16	0.003 **
	Post	15	45±18	
	?		10	

Paired sample t-tests comparisons between pre and post training scores: *p = 0.05, **p = 0.01, ***p = 0.001. SD=Standard Deviation

first 12 weeks. They averaged 12 weeks of exercise, or 67%, for the 18 weeks. The approximate time required to complete each exercise session was 10 to 15 minutes.

Table 1 provides the MedX static back extension strength results pre and post 12 weeks of training. Strength increased in all seven back angles with significant increases, $p < 0.05$, with the middle angles, 12, 24, 36, 48, 60 degrees. There were no significant differences found in the extreme angles of 0 and 72 degrees. Figure 1 provides a graphic representation of the MedX pre and post static back extension strength results with the MedX normative values that were provided by the MedX manufacturer. As seen in Figure 1, before test values are similar to normative data. Following training, the highest strength increases occurred in the more centralized angles. The post-hoc power calculation for 0, 12, 24.36,36,48, 60, 72 degrees were 0.40, 0.91, 0.84, 0.94, 0.96, 0.78, 0.28 respectively.

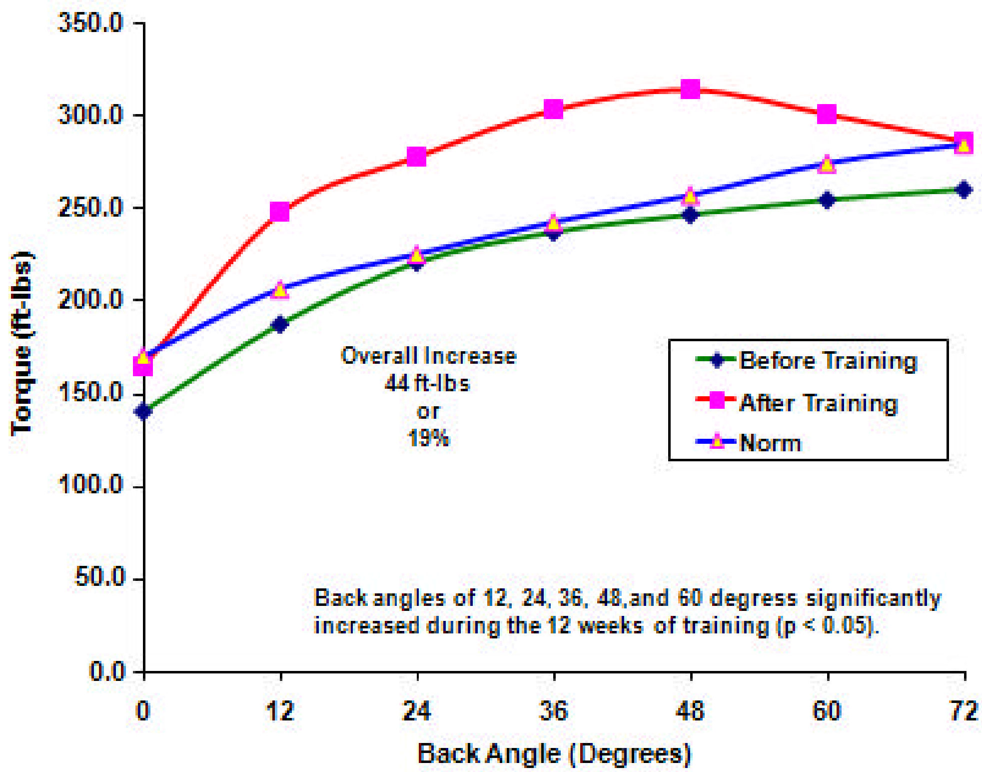
Table 2 compares pre and post training fitness tests of the back exercise program after 18 weeks. Fitness test scores significantly increased for all measurements, $p < 0.05$. Figure 2 illustrates percent change in each of the fitness tests with 18 weeks of training. The percent change was greatest on the 10 repetition max Nautilus 2ST test and least in the spine extension test. The fitness test post-hoc power test calculations for I rep max back test, 10 rep max back test, spine extension, push-ups, curl-ups and squat were 1.0, 1.0, 1.0, 1.0, 0.84, and 0.96, respectively.

Table 3 provides end of program qualitative assessment of the 18 week program. A least 38% of the subjects subjectively reported an increase in back strength, overall strength, flexibility, ability to lift safely, safety awareness, back comfort, quality of work, productivity, morale and home/recreation quality. One participant reported that they had a decrease in back comfort. Ninety-four percent of the participants rated overall value of the program as good to excellent and 100% of the participants rated the exercise prescriptions and training from good to excellent. The lowest rating was the programs administration with 57% rating from good to very good. Their motivation to participate was evenly distributed from fair to excellent. All participants wanted the program to continue, 81% reported program met their expectations and 19% reported program was better than expected.

DISCUSSION

The primary findings of this applied exercise physiology intervention were three fold. First, combining exercise physiology, health promotion and safety techniques was determined to be effective in the design and implementation of a time efficient work-related exercise program. Second, there was a significant increase in back strength, muscular endurance and back flexibility with a minimal time commitment.

Figure 1. Manufacturing plant's back exercise program: Static back extension strength with 12 weeks of training



Finally, participants reported increases in their ability to lift safely, quality of work, productivity, safety awareness, their back comfort, morale and home recreation quality.

A primary strength of this report was that it detailed the implementation of a practical program in a relatively small manufacturing setting. The use of a state of the art MedX back testing machine to verify the Nautilus 2ST back machine's results, as well as the end-of-program qualitative measures, added to the comprehensiveness of this report. Designing work-related warm-up exercises served to increase lifting strength related to work activities as well as

Table 3. Back exercise program participant end-of-program evaluation after 18 weeks of training. (How the program has affected you?)

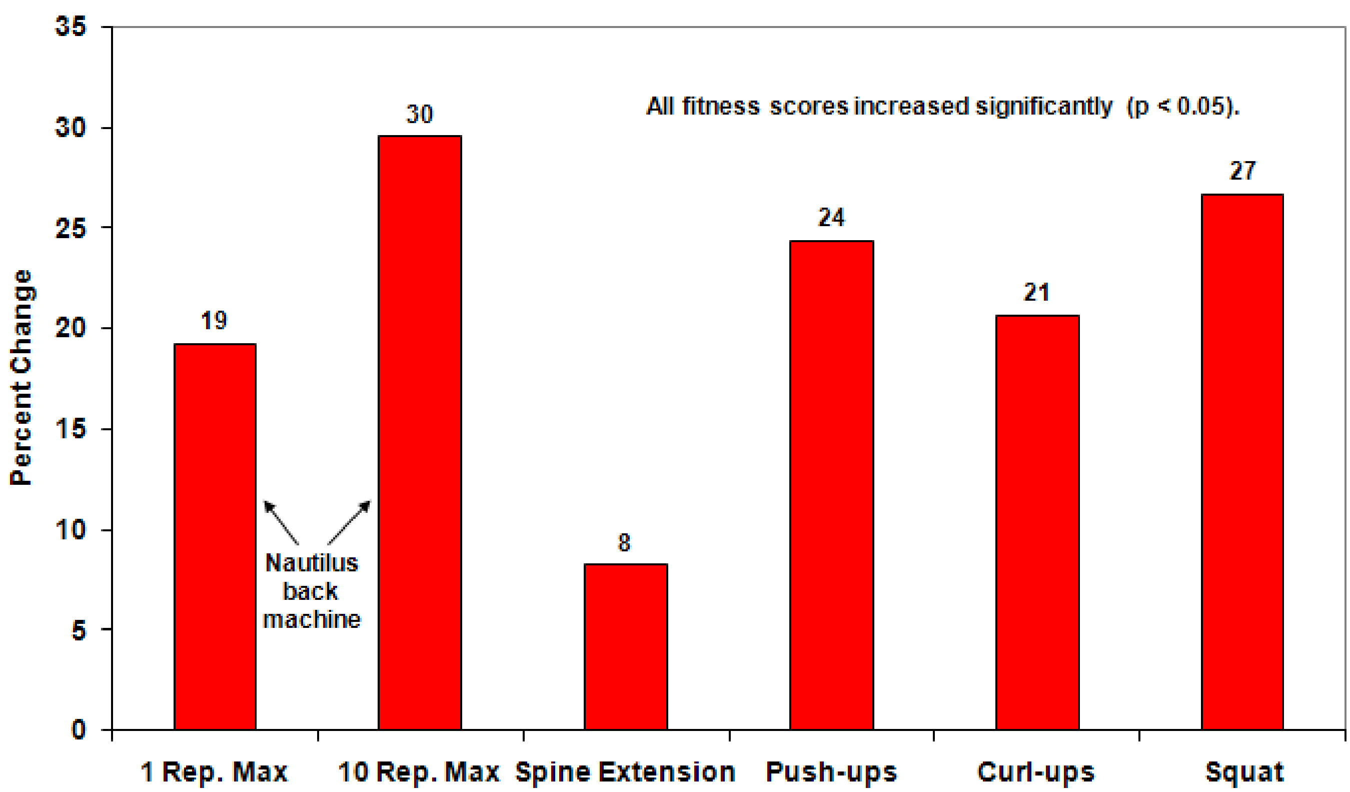
Variable	Increased	Same	Decreased
Back strength	88%	13%	
Overall strength	69%	31%	
Flexibility	75%	25%	
Ability to lift safely	81%	19%	
Safety awareness	75%	25%	
Back comfort	81%	13%	6%
Quality of work	38%	63%	
Productivity	50%	50%	
Morale	50%	50%	
Home/recreation quality	69%	31%	

Number completing the survey n=16

reinforcing proper lifting techniques. Positive strength results generated by using low volume and frequency of low back extension exercises corresponded with the literature (10, 13-14). A program promoting only one set of back exercises one time per week, requiring only a 10 to 15 minute work station break each week, increases feasibility and cost effectiveness of exercise interventions in many work situations.

Both the MedX and the Nautilus 2ST machines confirmed there was an increase in back strength. The MedX a measure of isometric strength and the Nautilus a measure of isotonic strength were similar to the gains reported by others for a variety of muscle groups, 20 to 30% (25). However, the extreme ends of the full range of motion on the MedX did not show significant strength increases. It has been reported that the extreme angles, 0 degree and 72 degrees have the largest improvements, as high as 105% and 42% when trained on a MedX (10). One explanation for the lack of strengthening results at these extreme angles is the decreased ability of the Nautilus 2ST, when compared to the MedX, to stabilize the lower extremities at these ranges (16). In order to receive optimal benefit at all back angles when using the Nautilus 2ST, detailed instruction in technique, concentrating on these extreme angles, may counteract the tendency to use hip extension as opposed to the desired back extension. More work is needed to examine differences in outcomes between these two machines and to identify the best technique for using the Nautilus 2ST or other similar back extension machines.

Figure 2. Manufacturing plant's back exercise fitness program: Percent change with 18 weeks of training



Procedures were subject to plant schedules and output requirements reinforcing the fact that the work place is not an ideal environment to conduct a study (21). As a trial implementation of the program, the number of volunteers was intentionally kept below 20 with no control group. One factor was the added expense of MedX analyses at an outside clinic. Plant schedules impacted scheduling of MedX analyses and they were conducted at a different interval than the fitness testing, which included the Nautilus 2ST back machine test. This impacted the inferences that could be made in strength comparisons of the two back machines as was originally intended.

Furthermore, in Table 1 which details the results of the MedX tests, the N values show some variation due to the fact that some subjects were unable to perform the back exercises at all back angles due to physical limitations. Plant scheduling and production needs also impacted the number of subjects who took the off-site MedX test. The pre and post training fitness test N values in Table 2 were impacted by the fact that some subjects were physically unable to perform certain fitness measures. Finally, the end-of-program questionnaire was subject to common limitations of self-reported instruments.

There was a drop in program participation from 12 to 18 weeks. It can be expected that eventually only a minimum core group would continue to use the exercise facility. Daily monitoring by the safety director of this trial program may have influenced its success. Without the commitment of a primary overseer, one may see a decrease in program participation at a more rapid rate. Therefore, it may be best to view such programs as short-term promotions within the overall safety goals of the plant. Regular modifications of the exercise regimen encourage continued commitment and interest of participants. A continuous improvement model, as described in the first paragraph of the methods section, is recommended.

This study has implications for exercise physiology professionals. First, a professional exercise physiologist can aid company safety personnel in meeting their Occupational Safety and Health Administration (OSHA) requirements. This multidisciplinary approach can be especially effective in occupations with a high risk of musculoskeletal disorders. This further demonstrates the need for communication and cooperation between the plant-sponsored exercise facility and plant safety personnel. This study demonstrated ways to improve the physical fitness of employees with exercises tailored to reinforce safe movements and safety awareness.

Second, a professional exercise physiologist can contribute to greater productivity in the plant. A high quality worksite evaluation integrating safety, health promotion and ergonomics along with a body part discomfort survey and the identification of high physical demand areas can lead to creative exercise interventions and engineering design. This process provides baseline data for design and implementation of exercise interventions addressing the specific needs of the worksite and to measure the program's impact on productivity and insurance costs. In this case, the time-efficiency of a low volume, low frequency training program made it feasible.

Third, such interventions include social benefits, such as addressing the United States Healthy People 2010 goals (26). Plant employees reported increases in their ability to perform recreational sport and home activities as well as increases in morale. Thus, these types of exercise intervention programs provide an opportunity for improved relations between the plant and its employees and the community as a direct result of addressing national health initiatives.

Finally, this study demonstrates opportunities for professional exercise physiologists possessing occupational skills. This intervention required standards of practice that established clear communication, participation, endorsement and mutual support among such diverse groups as safety and health promotion personnel, industrial engineers, ergonomists, and plant managers to address occupational health needs and issues. The National Institute for Occupational Safety and Health (NIOSH) suggests creating a 'synergism of prevention' by simultaneously addressing occupational safety and health as well as worksite health promotion to improve the health of workers through comprehensive risk reduction (27). Integrating these approaches has demonstrated long-term cost savings for businesses (28).

Although this approach was successful in this case, further study is needed to review long-term effects of such a program. Suggested future research and development of systems that combine safety, exercise physiology and physical fitness include: 1) Determining if training regimens strengthen structures and systems, especially when the employee is performing similar tasks at work. A variety of training protocols would need to be evaluated for the purpose of keeping the program stimulating, ensuring maximum and consistent participation. 2) Documenting whether such programs result in a positive return on investment, including productivity and insurance costs. 3) Comparisons of the MedX and other back machines to determine if some of the less costly machines are capable of yielding similar training results to the MedX at all back flexion angles. 4) Evaluating back strengthening procedures that require no machinery to reduce equipment set-up costs and increase ease of conducting program in multiple locations. 5) Development of computer software for ease in auditing and tracking personal fitness entries of participants, participant compliance, profit/loss results, and program administration for a variety of back and workstation specific strengthening programs. This would greatly assist in collecting and evaluating consistent longitudinal data, and 6) Evaluating the minimum exercise needed for maintenance of strength after strength gains in the work setting to maximize the return on investment. Previous work conducted outside the work setting suggests that a minimum for maintenance of lumbar extension strength is once every 4 weeks (16, 29).

CONCLUSION

Job-site analysis and body discomfort questionnaires provide opportunities for professional exercise physiologists to provide innovative safety and physical fitness health promotion programming in a manufacturing workplace. Back extension exercises, with one set of 10 repetitions to muscular fatigue, once per week, supported by targeted warm-up exercises designed to mimic actual job tasks, have the potential to improve back strength and back comfort of employees in manufacturing settings. Potential benefits include improved employee perception of safety, safe lifting awareness, increased work quality, productivity and morale.

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