THE IMPACT OF A PRE-SHUTDOWN WORK CONDITIONING PROGRAM AT A PETROCHEMICAL REFINERY: EFFICACY AS A PROACTIVE APPROACH FOR DECREASING INJURY POTENTIAL AND IMPROVING WORKER FUNCTIONAL PERFORMANCE

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ABSTRACT

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The Impact of a Pre-Shutdown Work Conditioning Program at a Petrochemical Refinery: Efficacy as a Proactive Approach for Decreasing Injury Potential and Improving Worker Functional Performance.
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Research supports the use of workplace exercise to improve worker performance and decrease potential for injuries. A review of the literature revealed no published studies addressing the unique physical challenges faced by refinery operators during a process-unit shutdown period. Since operators transition from several months of sedentary work to physically demanding work at shutdown time, there is considerable risk for musculoskeletal injury. The purpose of this research was to investigate the effects of exercise on operator job performance and injury prevention during a refinery shutdown period. The goals of the study were to assess the effects of exercise on operators' perceived abilities in functional mobility, job-task performance, and to determine which exercises may have contributed to recognized improvements. Seventeen operators performed the exercises for thirty minutes each shift for one month prior to the shutdown. Upon completion of the six-week shutdown period, data from all 17 operators were collected. Descriptive statistics, *T*-Tests, and a Spearman correlation procedure indicated that the exercises positively influenced operators’ perceived flexibility ($p<0.05$) and their perceived abilities to perform shutdown tasks ($p<0.05$). The operators reported no injuries during the shutdown period. The most important contributing exercise components were identified as stretching and ball exercises.

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CHAPTER I: INTRODUCTION

Petroleum processing operations of a large oil refinery involve the daily conversion of crude oil into millions of gallons of petroleum products such as asphalt, gasoline, jet propulsion fuel, propane and butane. The workers responsible for maintaining the high production capacity of the facility are engineers, chemists, plant operators, pumpers, pipefitters, lab technicians, and maintenance workers. Typically, it is the plant operators' duty to maintain and control the continuous operations involved in petroleum refining and processing that results in the production of saleable products. Plant operators must demonstrate operational knowledge of refinery systems and equipment such as pumps, motors, heat exchangers, valves, and boilers. Operators will routinely monitor and control refinery processes and system flow configurations locally in the field and remotely within a control room. They must continuously interpret and analyze readings from various measuring instrumentation so that process determinations and adjustments accurately facilitate the production of petroleum products in accordance with established specifications.

The routine refinery operator job functions at XYZ Oil Refinery are performed by either sitting within a control room or by walking outdoors to make independent visual surveillance rounds within the facility. Surveillance rounds are important for the investigation of refining process conditions such as leaks, temperatures, pressures, and flow rates. Besides the usual light preventative maintenance activities, most operator tasks require relatively low worker physical effort. In order to meet consumer demand for petrochemical products, the plant operator position requires daily 12-hour rotating shifts from 6:00am to 6:00pm. The typical operator at XYZ Oil Refinery will work 36 to 48 hours per week.

Approximately twice per year, operators at XYZ Oil Refinery are called upon to participate in scheduled corrective maintenance activities called “unit shutdown periods,” wherein an entire petrochemical process unit is shutdown. Scheduled shutdown periods involve process unit emptying, cleaning, modification, replacement, and overhaul. These periods can last several weeks in which operator work-related physical-functional demands are significantly increased. During shutdown, operators are called upon to perform physical work-tasks that require considerable increases in the use of the upper extremities, lower extremities, and proximal (trunk) stability for activities such as climbing, lifting, pushing/pulling, and reaching while handling tools, equipment, and materials. Shutdown periods also demand increased time working outdoors in all weather conditions, around elevated noise levels, and in the presence of typical petrochemical industry materials. Since plant operators are expected to rapidly transition from several months of sedentary work to non-routine physically demanding work at shutdown time, there is a high potential for varying degrees of work-related musculoskeletal strain and sprain type injuries to occur.

Purpose of the Study

The purpose of the study was to investigate the efficacy of a daily therapeutic exercise program as a proactive approach to improved worker physical performance and injury prevention during a refinery unit shutdown period, by physically conditioning the plant operators to perform the shutdown one month prior to its commencement.

Goals of the Study

The goals of the research presented were to address the following questions:

1. Will the pre-shutdown conditioning program influence participants' ability to perform job-related physical work tasks during the shutdown period?
2. How will the pre-shutdown conditioning program affect basic functional mobility and range of motion, which are both necessary for successful job-task performance?
3. What components of the pre-shutdown conditioning program (stretching, cardiovascular training, resistive exercises, and trunk strengthening & stabilization) may contribute to any changes in functional abilities recognized by the participants?

Background and Significance

It is well known that the physical demands of certain industrial operations are responsible for the high musculoskeletal injury rates reported in industry (Genaidy , Delgado, Garcia, & Al-Herzalla, 1994). US National public health objectives have targeted worksites as important settings for opportunities to involve workers in physical activity interventions, since most adults spend half of their waking hours at the worksite (Dishman, Oldenburg, O'Neal, & Shephard, 1998). The recognized benefits of workplace stretching programs have been widely investigated and are pervasive in the literature; however, no such data is yet available addressing the unique physical challenges experienced by petrochemical refinery workers. Implementation of a workplace stretching program alone may not sufficiently prepare refinery operators for refinery shutdown periods in which dramatic increases in other physical performance areas such as endurance, strength, and power are also required. Less than optimal refinery operator physical performance during unit shutdown periods adversely affects XYZ Refinery's productivity and competitiveness with others in the same industry. Delayed onset muscle soreness, ready fatigue, and varying grades of strain and sprain type injuries have been reported by refinery operators during past shutdown periods. Historically, XYZ Refinery management has not generally viewed these employee reported conditions in terms of their resultant potential for losses to refinery production efficiency. Undoubtedly, the more immediate observable losses such as workers compensation-related costs have always been recognized by XYZ Refinery management — lending support for this pilot program. The information gained from this study may help to justify refinery management support for starting and continuing a pre-work conditioning program for involved refinery employees prior to each process unit shutdown period.

Assumptions of the Study

1. It is assumed that the typical refinery operator did not participate in additional exercise outside of the work environment.
2. The second assumption is made that the seventeen refinery operators surveyed gave truthful and complete answers on the questionnaire forms that were distributed and collected by the refinery staff. It was also assumed that the 6-week refinery shutdown period under investigation was typical of other shutdown periods.

Definition of Terms

Bicep tendonitis: inflammation of the bicep tendon.

Cardiovascular training: pertaining to physical conditioning of the heart and blood vessels (Mosby, 1998).

Cervical: referring to the neck.

Delayed onset muscle soreness: typical muscle soreness that generally results several hours after overworking the particular muscle group.

Function: task-related observable behavior or series of processes that serve a purpose (Mosby, 1998).

Functional: pertaining to performance of a task (Mosby, 1998).

Hawthorne effect: a beneficial effect from treatment based on ones knowledge of the treatment or expectations (Mosby, 1998).

Hypertension: high blood pressure.

Lateral epichodylitis: inflammation at the elbow joint which is also known as tennis elbow (Mosby, 1998).

Lumbosacral: region that includes the low back and pelvis.

Mobility: movement and range of motion of the limbs and body (Mosby, 1998).

Morbidity: pertains to disease (Mosby, 1998).

Mortality: pertains to death (Mosby, 1998).

Musculoskeletal: pertaining to all joints, muscles, tendons, bones and connective tissues of the body (Mosby, 1998).

Physical demands: the observable and measurable job-related stressors such as lifting, pushing, walking, and climbing.

Physical fitness: the ability to carry out daily tasks without experiencing ready fatigue (Mosby, 1998).

Proximal: usually refers to the trunk of the body (Mosby, 1998).

Range of motion: the maximum extent of movement for any joint of the body (Mosby, 1998).

Resistive exercise: method used for strengthening using resistance, weight or force (Mosby, 1998).

Rotator cuff: tendons around the shoulder joint.

Sprain: a traumatic injury to the ligaments (connective tissue) of the body usually occurring around a joint (Mosby, 1998).

Stabilization exercises: exercises to develop proximal (trunk) control and strength (Mosby, 1998).

Strain: Injury usually involving muscle that results from excessive physical effort (Mosby, 1998).

Thoracic: the upper-back area.

Work capacity: the amount of workload that can safely be tolerated by an employee.

Work conditioning: simulated work activities and therapeutic exercise programs based on the analyses of a target job's physical demands and significant worksite measurements (Robert, Blide, McWhorter, & Coursey, 1995).

Workload: the amount of work that must be completed during a specified period of time (Mosby, 1998).

CHAPTER II: LITERATURE REVIEW

The purpose of the study was to investigate the efficacy of a daily workplace exercise program as a proactive approach to improving XYZ Oil Refinery operator physical performance and injury prevention during a refinery unit shutdown period. Information within this chapter will focus on the methods and results of previously published research that has provided substantial evidence regarding the value of exercise interventions in the workplace.

Rationale

There is considerable empirical evidence in the athletic community that supports the use of physical conditioning of the musculoskeletal system to enhance performance and prevent injuries through strengthening of involved tissues (Stone, 1990). The recognized benefits of athletic fitness training principles have been investigated and in some cases adopted in the workplace. Many organizations have implemented worksite exercise interventions in an attempt to increase productivity and decrease workplace injury-related healthcare costs (Dishman, Oldenburg, O'Neal, & Shephard, 1998). Several different approaches have been undertaken by organizations to achieve these goals. Health promotion programs for firefighters, factory workers, warehouse workers, meatpacking, and other industries where the incidence of workplace musculoskeletal injuries are high, have integrated tailored exercise programs in an attempt to address the identified needs of the particular industry. Objectives of these projects have included the evaluation of strength and flexibility improvements, improved cardiovascular endurance, injury reductions, employee-perceived health benefits, and reduction in workers compensation costs. These studies and related projects are briefly reviewed below.

Exercise Interventions

One relevant area of research includes performance improvement and injury prevention programs for emergency response personnel such as firefighters. Much like the physical requirements of refinery operators, firefighters must be capable of making periodic transitions from low activity levels to high workloads. The effects of exercise on strain and sprain type-injuries incurred by firefighters have been investigated by Hilyer, Brown, Sirles, & Peoples (1990). In a pretest-posttest control group design, Hilyer et al. subjected an experimental group of 251 firefighters to a 30-minute exercise session each shift across a six-month time frame. According to Hilyer et al., the exercises consisted of stretches involving the hamstrings, low back, trunk, and shoulders. Hilyer et al. reported that the results of an analysis of covariance (ANCOVA) statistical procedure of pretest-posttest injury data and flexibility measures indicated that exercise training reduced the severity of joint injury and, consequently, employer cost from absenteeism among firefighters. These results lend support to the widespread use of worksite stretching seen in industry today.

Besides stretching, other approaches that have included the addition of strengthening and cardiovascular components to workplace physical conditioning programs have also shown to yield positive results. The effects of fitness counseling along with cardiovascular and strength training prescriptions given to approximately 1800 firefighters, as part of a Los Angeles County Occupational Health Service program, was assessed by Cady, Thomas, & Karawasky (1985). According to Cady et al., the goals of the 14-year program were to increase muscular strength and endurance, and reduce insurance claims for musculoskeletal injuries. Cady et al. reported that the outcome of the study indicated a 25% decrease in workers compensation claims per $100 of payroll, and a 16% increase in firefighter physical work capacity with respect to endurance. Cady et al. did not assess which components of the 14-year program were most effective in giving the greatest contribution to the decrease in workers compensation costs observed in this study. Combined program elements such as counseling, strengthening, and cardiovascular training should take into consideration an assessment of the fitness and health needs that are particular to occupations like firefighting.

Fitness and Health Promotional Needs

An even broader “health and wellness” approach has been taken by many organizations with programs that promote areas such as smoking cessation, diet, mental health, hypertension, alcohol abuse, and other causal factors that are known contributors to increased worker morbidity and mortality rates. It is widely known that morbidity data are routinely collected from industries through the use of surveillance systems (Tsi, Dowd, Cowles, & Ross, 1991). From January 1, 1981 through December 31, 1988, Tsi et al. analyzed health surveillance morbidity data for 14,170 Shell refinery employees and found that five disease categories accounted for 72% of all male refinery worker illnesses and absences. In descending order, Tsi et al. identified these disease categories as injuries (25%), respiratory illnesses (17%), musculoskeletal disorders (14%), digestive illnesses (9%), and heart disease (7%). While there was little indication as to how this information was ultimately used from a worker health standpoint, it would appear that the identification of morbidity-related statistical data could be used to help guide the focus and direction of refinery health promotion efforts.

Many organizations with health and wellness programs list health promotion components as incentives along with employee benefits. Peterson & Dunnagan (1998) suggested that job satisfaction is higher among those who exercise regularly than those who do not, regardless of whether the physical activity is organizationally sponsored. Two-thirds of all businesses in the USA with over 50 employees offer at least one type of health promotional program for employees (Talvi, Jarvisco, Knuts, & Kaitaniemi, 1998). The viability and effectiveness of these programs are questionable, particularly during times of rising healthcare costs, downsizing, and economic hardship for US industry (Wilson, Holman, & Hammock, 1996). Due to financial constraints, elimination of workplace sponsored health and fitness programs may lead to a rise in workers compensation costs for some industries.

Workplace musculoskeletal disorders continue to be a major source of worker suffering, lost time, and high employer workers compensation costs, particularly in industries where workers are subjected to ergonomic risk factors such as high forces, sustained postures, and high repetitions (Silverstein, 1988). Dunnagan, Haynes, and Noland (1999) explored the relationship between employee exercise status and employer healthcare costs at the University of Kentucky. Dunnagan et al. reported that employees who routinely exercised had a statistically significant ($p = 0.048$) lower 3-year healthcare cost claim average of $207 in comparison to $266 for those that did not participate in routine fitness activities. While these figures are encouraging, Wilson et al. conversely reported that an employer's heath promotion policy does not necessarily lead to an environment that is conducive to healthy employees, unless it is supported by the organization's structure, including supervisors and top management. It should be noted that a poor economic climate can adversely affect non-revenue generating programs within companies and consequently lead to higher production demands across fewer employees. In reality, however, top management commitment for the implementation and maintenance of employee fitness programs may be based on business necessity if an organization's primary financial losses are related to workplace musculoskeletal injuries.

Some health promotion programs for refinery workers include physical fitness activities. The XYZ Oil Refinery under investigation supports a program that subsidizes a portion of the cost for employee membership at an offsite local fitness club. Refinery operators have reported that they do not have time to participate in a fitness club incentive program, given that the operator position requires 12-hour work-shifts. A study was designed by Bungum, Katherine, Orsak, and Chng (1997) in an effort to explain why an estimated 80% of employees did not participate in company sponsored physical fitness activities that were offered as wellness program components. According to Bungum et al., statistical analyses of 431 correctly completed questionnaire forms that were obtained from a nationally recognized company in Texas indicated that blue collar status was shown to be associated with higher non-participatory and dropout rates than white collar status. Bungum et al. concluded that blue-collar workers in this study had less flexibility with their work schedules and found that inconvenience served as a barrier to involvement with fitness opportunities. This gives strong indication that the workplace may be a more ideal place to intervene with physical fitness activities for employees that find it otherwise inconvenient to join a local fitness club. In the past, workers at XYZ Oil Refinery have requested an onsite fitness facility, but a lack of management support has prevented its construction.

Exercise Interventions for Refinery Workers

A review of the literature revealed that few studies are published regarding the use of onsite exercise interventions for refinery workers. Of the studies found, fitness activities have been included as a small part of more comprehensive health promotion program efforts. In a recent attempt to evaluate the effectiveness of a health promotion program, two oil refineries (group A and B) located in southern Finland completed employee needs assessments (Talvi, Jarvisco, & Knuts, 1999). From 1988 to 1994, refinery employee health promotion needs were assessed by Talvi et al. in relation to nine areas: physical activity, musculoskeletal problems, diet, obesity, blood pressure, serum lipids, smoking, quality of sleep, and mental wellness. Baseline and follow up information was obtained by Talvi et al. from laboratory tests and questionnaire forms that were distributed to refinery workers. According to Talvi et al., group A received special counseling and active exercise programs, whereas participants in group B were made aware of their needs and received only written literature. After a 3 year follow up, Talvi et al. reported that the results of the study showed statistically significant improvements in the key health indicator variables of group A, while group B participants showed a tendency toward further deterioration. The three key health parameters assessed by Talvi et al. were serum cholesterol level, maximum oxygen uptake, and body mass index. Talvi et al. concluded that the most extensive changes occurred in the area of decreased workplace musculoskeletal symptoms with group A. In concurrence with Kroll, Goodwin, Nelson, Ranelli, and Roos (2001), workplace exercise has been shown to reduce the duration and onset of muscle soreness. These findings suggest that refinery employees may benefit from physical activity based health promotional program components. Reductions in physical discomfort may also lead to improvements in worker performance, positively affecting employee productivity and retention.

Relationships between Physical Fitness and Worker Productivity

Given the previously discussed work by Talvi et al. (1999), there are known relationships between worker physical fitness levels and the extent of musculoskeletal problems. The effects of progressive resistive and trunk flexibility exercises on reducing overexertion-type musculoskeletal injuries brought about by workers performing manual material handling operations have also been investigated (Genaidy, Delgado, Garcia, & Al-Herzalla, 1994). Genaidy et al. proposed that physical training could be used to improve manual material handling (MMH) capabilities of employees, and reduce risk for musculoskeletal injuries. As part of this research initiative by Genaidy et al., 22 healthy employees from each of three different manufacturing plants were divided up into experimental (training) groups and control groups that did not receive the training program intervention. According to the procedure outlined by Genaidy et al., employees placed in the experimental group participated in 20-minute exercise training sessions, four times per week, over a six-week period. Genaidy et al. used weeks one and six for physical evaluation of the workers in the training group and the controls for strength, endurance in terms of MMH capability time (total number of lifting cycles across time), and trunk flexibility, for statistical comparison. Genaidy et al. found (a) almost no changes in the fitness variables for the controls; (b) changes in arm strength, shoulder strength, trunk flexibility, and MMH for the training groups ($p<0.05$); and (c) differences in subjective ratings of perceived exertion with the training group at only one of the three manufacturing plants investigated. Genaidy et al. speculated that improvements in strength and job-related worker productivity should not affect load or physical exertion perception, since this perception remains constant as load bearing capabilities of the human body increase. In conclusion, it appears that even a short-term fitness program can show improvements in job-related physical performance.

Stretching, Flexibility, and Self-perception

More recently, Moore (1998) studied the impact of an even shorter duration two-month, 36 session, workplace stretching program on employee flexibility and physical self-perception at Merck Medical Corporation. The pretest-posttest design developed by Moore involved anatomical and self-perception measurements that were taken at the beginning and end of a 2-month period. According to Moore, 62 of the 92 initial volunteer participants completed the stretching program that consisted of trunk rotation, sit reach, and shoulder rotation measures. The self-perception area of this study was measured by Moore using five scales pertaining to sports competence, strength, attractiveness, physical condition, and self-worth. At the end of the two month stretching program, Moore reported that data analyzed with paired *t* tests showed statistically significant differences in all flexibility areas tested, and that improvements were observed in self-perceptual areas of physical condition, attractiveness, and self-worth. In addition, Moore maintained that there were no reports of workplace musculoskeletal injuries by participants during the program’s two months. Moore reported that changes in sports competence and physical strength perception ratings did not reach statistical significance. These findings suggest that stretching exercise by itself may not influence physical strength perception. Perhaps a multifaceted program that included aerobic and strengthening components could have served to demonstrate recognized improvements in sport and strength perceptual rating areas as well.

Clinical Interventions

In the clinical setting, work-conditioning programs are commonly employed to recondition workers that have experienced several months of restricted duty or physical inactivity while recovering from work-related injuries. Basically, work conditioning involves simulated work activities and the development of tailored therapeutic exercise programs based on the analyses of a target job's critical physical demands and significant worksite measurements (Robert, Blide, McWhorter, & Coursey, 1995). A six-week work-conditioning program, designed by Robert et al., on cardiovascular fitness and muscular strength, involved 30 subjects from Rehability Center in Lubbock, Texas. According to Robert et al., subjects with varying diagnoses and degrees of work-related deconditioning were involved with weight training, cardiovascular conditioning, stretching, and work simulation activities five days per week for six weeks. Paired *t* tests were used by Robert et al. to assess changes upon completion of the six-week work condition program and the results of such analysis indicated marked statistically significant improvements at the $p < 0.001$ level for cardiovascular fitness, and static lifting, pushing, and pulling strength. The results of this study are significant in that it is likely work-conditioning programs may help to further reduce an employer's existing injury-related losses by ensuring that the injured employee is physically capable of safely tolerating the target job before placement in that job. Workplace productivity-related losses due to employee injury may also be reduced, as work conditioning may facilitate a graded employee transition back to full work capacity.

Many organizations use fitness for duty exams and pre-placement screening processes to ensure that workers are physically qualified and are an appropriate match for the given job's physical demands. Pre-placement assessment (PPA) programs can assist employers with making employee job placement-related decisions that can prevent losses by identifying job candidates that are vulnerable to injury (Nachreiner, McGovern, Kochevar, Lohman, Cato, & Ayers, 1999). The study designed by Nachreiner et al. longitudinally investigated workplace musculoskeletal injury outcome data of 331 workers after completion of PPA screening and subsequent job placement within various industrial settings. Over a three-year period, Nachreiner et al. compared a group of 67 workers that were given PPA resultant work restrictions, to 264 controls that successfully completed the PPA without recommendations for work restrictions. An analysis of variance (ANOVA) statistical procedure used by Nachreiner et al. to assess the interactions of employment duration, experimental and control group status, and injury incidence indicated no statistically significant relationships (p>0.05) between these variables. Nachreiner et al. concluded that PPA testing was effective for workers that were placed according to work restriction recommendations. Just as PPA testing has been used to screen for safe placement by physically matching workers to demanding jobs, work conditioning programs have been successful in preparing less physically qualified workers for the safe transition into those physically demanding jobs as well.

Summary

From a risk control point of view, it is likely that there are no differences between the following conditions: (a) placing a new hire into a physically demanding job; (b) transferring an employee within the organization from a sedentary job to one of high physical demands; and (c) transitioning refinery operators from several month of inactivity to highly athletic, physically-demanding, semi-annual unit shutdown periods. Each of these conditions offer considerable employer and employee exposure to potential losses associated with workplace musculoskeletal injuries. It has been established that a physical fitness element is needed as an important part of an overall health promotional program for refinery operators. Based on a review of the literature, no previously published studies were found regarding the unique physical challenges that refinery operators face during unit shutdown periods. Perhaps firefighters and other emergency response personnel can best identify with refinery operators since they too are called upon to make rapid episodic transitions to significantly higher workloads without a preconditioning or warm up period. Existing studies have not addressed the needs that are exclusive to refinery operators; however, evidence has been presented that demonstrates short-term (6-week to 2-month) exercise and conditioning programs can be effective when tailored for targeted worker populations. The goals of work conditioning programs include defining and implementing an exercise program which is tailored to the physical demands of a specific job like that of the refinery operator.

CHAPTER III: METHODOLOGY

The purpose of the study was to investigate the effectiveness of a pre-work conditioning program as a proactive approach to improve worker performance and injury prevention during a XYZ Refinery shutdown period. This study involved secondary analysis of existing questionnaire form data that was collected from refinery operators upon completion of the six-week shutdown period. The following research questions and null hypotheses were addressed:

1. Will pre-work conditioning influence refinery operators' ability to perform job-related tasks during the shutdown period?

   H_0: Pre-work conditioning will not influence refinery operator perception of ability to perform job-related tasks.

2. How will pre-work conditioning affect basic functional mobility and range of motion, which are both necessary for successful job-task performance?

   H_0: Pre-work conditioning will not have an effect on refinery operator perception of functional mobility and range of motion.

3. What components of the pre-work conditioning program (stretching, cardiovascular training, resistive exercises, and trunk strengthening & stabilization) will contribute to any refinery operator recognized changes in abilities?

   H_0: None of the components of the pre-work conditioning program will be perceived as being more beneficial than the others.

Subjects

The group of XYZ Refinery operators consisted of 17 males with ages ranging from 24 to 56 years old. All 17 operators participated in pre-work conditioning exercises for one half-hour prior to beginning each 12-hour shift. The program's duration lasted for one month, ending upon commencement of the unit shutdown period. Daily exercise program supervision was provided by safety department representatives who were trained in carrying out the program according to proper exercise technique.

Development and Description of the Conditioning Program (Treatment)

Functional (task-related) job information was obtained by direct observation of XYZ Refinery operators in the field. Operator physical demands (i.e., lifting, carrying, pushing/pulling, climbing, and postural conditions) were measured along with other worksite factors such as environmental conditions, work duration, tool use, and productivity requirements. This information was documented and sent back to the operators for review of correctness and content validation. See Appendix A for a copy of the functional job analysis.

XYZ Refinery operator injury data were assessed for common musculoskeletal injuries that have occurred during previous refinery shutdown periods. Frequent diagnoses have included conditions such as lateral epichodylitis, bicep tendonitis, rotator cuff strains and tears, cervical and upper thoracic strains, and lumbosacral strains and sprains. The job-related information and historical injury data were used in the development of the pre-work conditioning exercises. In part, the program's aim was to treat those common musculoskeletal injuries before refinery operators were given the opportunity to acquire them. Only those exercises that were identified as crucial for injury prevention and maximizing refinery operator abilities to safely tolerate the identified physical demands were used. In addition to specific stretches, the program included strengthening of target muscle groups that were found to be frequently involved in injury, cardiovascular conditioning using an aerobic step, and physio-ball exercises to improve trunk stability. See Appendix B for a copy of the exercise program components. The following four training components were included in the pre-shutdown conditioning program:

1. Stretching: wrists, forearms, shoulders, chest, upper-back, neck, hamstrings, and lower back.
2. Strengthening: wrists extensors, forearms, biceps, shoulders (rotator-cuff), upper-back, neck, thighs, and hip extensors.
3. Low Back and Trunk Stabilization: back extensors, abdominals, and hip flexors.
4. Aerobic Conditioning: a four-inch aerobic step for five minutes at a rate of 96 steps per minute.

Inexpensive equipment used during the stretching/strengthening activities included 65cm and 75cm physio-balls, an adjustable step, and thera-band resistive rubber bands.

Development of the Follow-up Questionnaire

XYZ Refinery operator job analysis provided useful information for the development of the pre-work conditioning questionnaire. Questions on the form ask the operators to rate perceived changes in ability to perform job-related tasks, and range of motion activities such as reaching overhead. Based on any operator perceived improvements in these areas, operators were then asked to rated which of the components of the pre-work conditioning program were viewed as most beneficial in preparing for the shutdown. The questionnaire form will provide operator response information needed to evaluate the effectiveness of the pre-work conditioning program. See Appendix C for a copy of the questionnaire form.

Analysis

Upon completion of the six-week shutdown period, the XYZ Refinery operators were given the conditioning program questionnaires. The operators were informed of the confidentiality and anonymity of their responses to questions on the form. Response data from the 17 operators regarding changes in strength, endurance, flexibility, work performance, and self-perceived functional abilities, were obtained from rating scales on the anonymous questionnaire. Respondent information was further explored and summarized using Microsoft Excel 4.0 descriptive statistics and SPSS 11.0.

Limitations

1. The small sample size, absence of a pretest survey, and the absence of a parallel control group, limits the generalizability and statistical power of the results. A non-randomized case study was an acceptable alternative to an experimental design, given the lack of XYZ Refinery resource allocation to this project.
2. Because the refinery operators knew the purpose of the preconditioning program, the Hawthorn effect may provide an explanation for a favorable outcome with any of areas investigated by this study. There may also be influence from the expectations of management and health & safety department staff on participant perceptions and subsequent ratings on the questionnaire.

CHAPTER IV: RESULTS

The purpose of this study was to investigate the effectiveness of a daily exercise program as a proactive approach to improving worker job-related physical performance and injury prevention during a XYZ Refinery shutdown period. The goals of the study were to assess the effects of the pre-work conditioning program on refinery operators' perceived abilities in functional mobility (flexibility), job-task performance, and to determine which program components may have contributed to any recognized improvements. In order to determine the pre-work conditioning program elements, a previous job analysis was conducted for determination of refinery operator physical demands. Based on the identified physical demands, an exercise program was developed and performed by a group of 17 operators for approximately 30 minutes at the beginning of each work shift for a period of 1 month prior to the shutdown period. Exercises were then discontinued at the start of the shutdown period. Upon completion of the six-week shutdown, information from the 17 operator participants regarding recognized improvements in strength, flexibility, work performance, and self-perceived functional abilities were obtained from rating scales provided on anonymous survey forms. The following paragraphs review the results of those survey forms.

Improvement in Ability to Perform Work

Data was entered into an Excel spreadsheet, as shown in Table 1, in order to summarize operators' perceived improvement in ability to perform common refinery work during a typical shutdown period. The task-related information presented here was obtained from a thorough operator job analysis in the field. The tasks identified in Table 1 are believed to be critical since they were considered by the operators to be physically demanding and performed more frequently during routine shutdown periods. Upon completion of the shutdown period, the 17 operators rated the tasks such as ladder climbing, turning valves, and using hand tools, according to self-perceived changes in ability to perform the tasks. As demonstrated in Table 1, each operator rated their ability to perform these duties according to (a) no change, (b) minimal change, (c) moderate change, and (d) significant change, given participation in the pre-work conditioning program.

Table 1

Number of Workers Reporting Improvement in Ability to Work

Ability to Work	No Improvement	Minimal Improvement	Moderate Improvement	Significant Improvement
Climbing Ladders	4	5	8	0
Using Hand Tools	5	7	5	0
Driving	9	6	1	1
Turning Valves	4	5	3	1
Performing Maintenance	5	7	5	1
Use of Pull Chains	4	5	4	1

Information from Table 1 was further described using graphics to visually demonstrate responses regarding *improved ability to work* in each of the performance areas shown in Figure 1. According to the data, the greatest impact of the pre-work conditioning program was reported in the area of climbing ladders. Eight operators reported moderate improvement in ability to climb vertical ladders, and five operators recognized moderate improvement in ability to use hand tools and perform maintenance. Operator ratings for tool use and performance of maintenance activities are somewhat inconsistent, since five operators also reported no improvement in both of these areas. The performance area affected least by pre-work conditioning was vehicle driving, where nine operators reported no recognized improvement in ability to perform this task. It is interesting to note that one operator rating of significant improvement can be

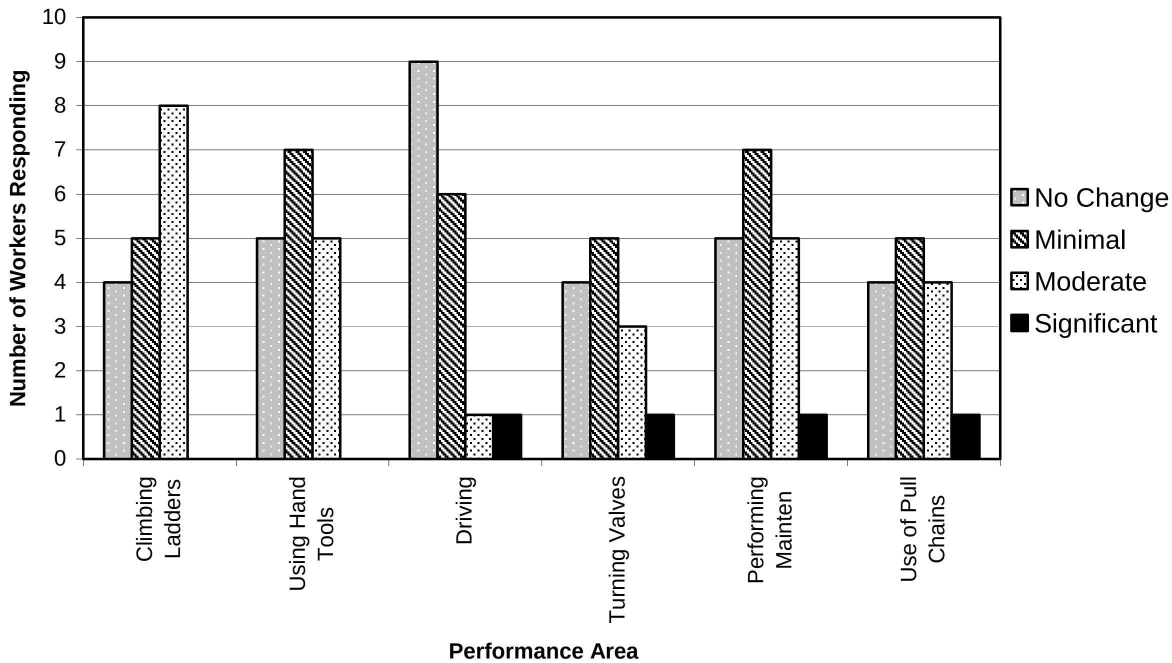

Figure 1. Number of workers reporting changes in ability to perform work in respective task performance areas.

observed in the categories of vehicle driving, turning valves, performing maintenance, and using pull chains. According to the questionnaire data collected, a single operator, as an outlier, reported significant improvement in these areas.

Operator improvement in work performance across all workers in terms of percentages is given in the pie chart below (Figure 2). In total, 68% of the 17 operators reported that they recognized improvement in ability to perform the identified critical tasks as a result of participation in the pre-work conditioning program. While reported changes in perceived abilities varied for each critical task as shown in Figure 1, the pie

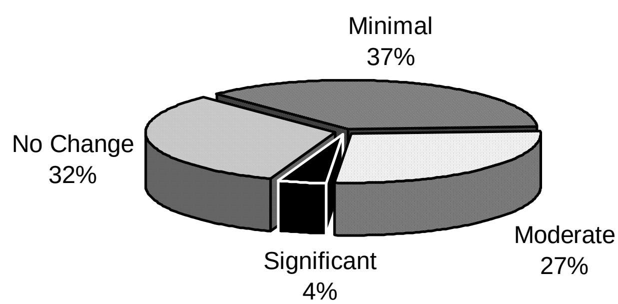

Figure 2. Overall changes in work-related performance abilities reported by all refinery operators surveyed.

chart (Figure 2) summarizes the operators' ratings as though all of the critical tasks combined makeup the refinery shutdown period as a job in itself. It is important then to observe that 27% of the refinery operators reported that the pre-work conditioning program moderately improved their abilities to perform the refinery shutdown job.

According to the first null hypothesis, the pre-work conditioning program will not influence refinery operator perception of ability to perform job-related tasks. In order to test this hypothesis, operator task rating data were subjected to a single sample *t*-test using SPSS. The results of the one sample *t*-test indicated statistical significance at the $p < 0.01$ level for more than no perceived improvement in job-task performance across all tasks identified (see Table 2). In other words, there was less than a 1% probability that operator *perceived improvement in job performance* as observed was due to chance. The pre-work conditioning intervention was therefore the likely explanation for operator reported improvements.

Table 2

One-Sample T-Tests of More than No Perceived Improvement in Job Performance

Critical Tasks	t	df	Sig.	Mean Difference	95% Confidence Interval Lower	95% Confidence Interval Upper
Climbing ladders	6.126	16	.000	1.24	.81	1.66
Using hand tools	5.215	16	.000	1.00	.59	1.41
Driving	3.096	16	.007	0.65	.20	1.09
Turning valves	4.070	12	.002	1.08	.50	1.65
Performing maintenance	5.236	17	.000	1.11	.66	1.56
Using pull chains	4.505	13	.001	1.14	.59	1.69

Improvement in functional mobility

XYZ Refinery operators were then asked to rate perceived changes in functional mobility (flexibility) as a result of participation in the pre-work conditioning program. Data regarding improvements in functional mobility were inserted into Table 3 below. The data represents the number of workers reporting perceived improvement in their ability to perform basic functional mobility skills such as bending at the waist, squatting, and reaching above shoulder height. Similar to Table 1, the mobility rating scale used with Table 3 is based on degree of operator self-perceived improvement in terms of (a) no change, (b) minimal change, (c) moderate change, and (d) significant change. As

Table 3

Number of Workers Reporting Improvements in Functional Mobility

Functional Mobility	No Improvement	Minimal Improvement	Moderate Improvement	Significant Improvement
Turning the head	3	5	7	2
Bending at the waist	3	3	9	2
Rotating the body	3	4	7	3
Squatting	3	6	8	0
Reaching below shoulder	3	7	7	0
Reaching above shoulder	4	5	8	0

displayed in Table 3, all of the operators reported considerable changes in functional mobility. The most noteworthy changes reported were moderate to significant improvements in proximal mobility of both the cervical spine (turning the head), and the lumbosacral spine with trunk flexion/extension (bending at the waist) and trunk rotation (rotating the body). The 17 operators were consistent with their ratings of each mobility area such that moderate improvements were most frequently rated, and no improvements were least frequently rated. Information from Table 3 was further described using Figure 3 to visually demonstrate operator responses regarding improved mobility in each of the performance areas. The most frequently reported areas were moderate perceived improvements in squatting, reaching above the shoulders, and bending at the waist.

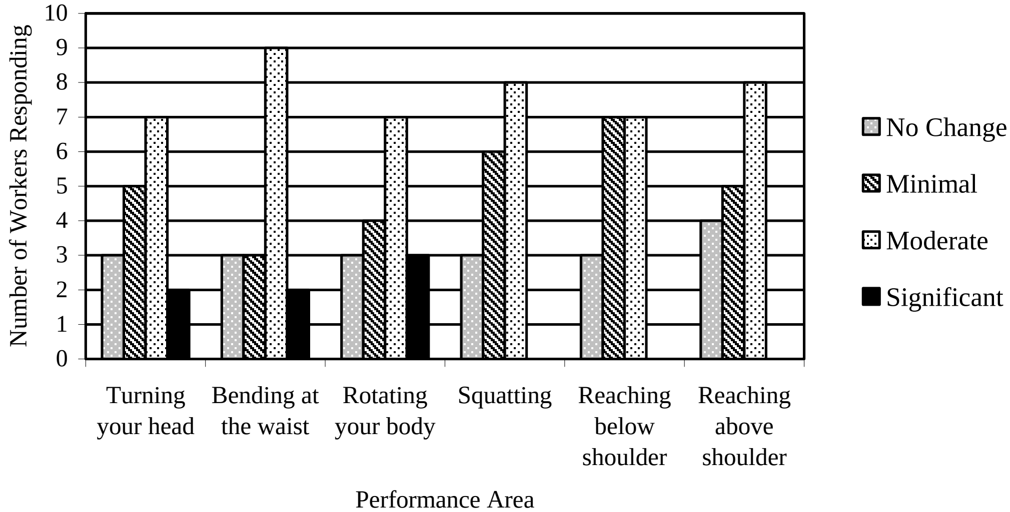

Figure 3. Number of workers reporting changes in functional mobility skills in respective performance areas.

The overall improvement in functional mobility across all workers in terms of percentages is given in the pie chart below (Figure 4). Most important here is that 45% of the operators reported that they recognized moderate improvements in functional mobility as a result of participation in the pre-work conditioning program. In total, 81% of the operators indicated a degree of mobility improvement in all of the areas on the questionnaire. Conversely, only 19% operators reported no improvement in the functional mobility areas. It would be expected that successful completion of numerous identified refinery tasks require operators to have adequate functional mobility for assuming a multitude of awkward body positions outside of anatomical neutral.

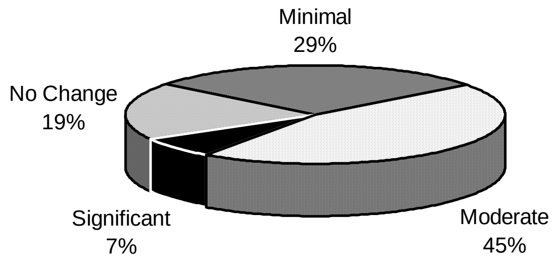

Figure 4. Overall improvement in basic functional mobility skills reported by all refinery operators surveyed.

According to the second null hypothesis, the pre-work conditioning program will not have an effect on refinery operator perception of functional mobility and range of motion. In order to test this hypothesis, operator functional mobility data were subjected to a single sample *t*-test using SPSS. The results of the one sample *t*-test indicated statistical significance at the $p < 0.01$ level for more than no perceived improvement in functional mobility across all areas identified (see Table 4).

Table 4

One-Sample T-Test of More than No Perceived Improvement in Functional Mobility

					95% Confidence Interval	
Functional Mobility	*t*	*df*	*Sig.*	*Mean Difference*	*Lower*	*Upper*
Turning the head	6.428	16	.000	1.47	.99	1.96
Bending at the waist	6.971	16	.000	1.59	1.11	2.07
Rotating the body	6.525	16	.000	1.59	1.07	2.10
Squatting	6.914	16	.000	1.29	.90	1.69
Reaching below shoulder	6.769	16	.000	1.24	.85	1.62
Reaching above shoulder	6.126	16	.000	1.24	.81	1.66

In order to take a more strict approach to testing the operator functional mobility ratings, the data were again subjected to a single sample *t*-test to look for statistical significance with *more than minimal perceived improvement in functional mobility* (see Table 5). As shown in Table 5, *rotating the body* and *bending at the waist* reached statistical significance at the $p < 0.05$ level after changing the comparison value to test against minimal perceived improvement in functional mobility.

Table 5

One-Sample T-Test of More than Minimal Perceived Improvement in Functional Mobility

					95% Confidence Interval	
Functional Mobility	*t*	*df*	*Sig.*	*Mean Difference*	*Lower*	*Upper*
Turning the head	2.057	16	.056	.47	-.01	.96
Bending at the waist	2.582	16	**.020**	.59	.11	1.07
Rotating the body	2.416	16	**.028**	.59	.07	1.10
Squatting	1.571	16	.136	.29	-.10	.69
Reaching below shoulder	1.289	16	.216	.24	-.15	.62
Reaching above shoulder	1.167	16	.260	.24	-.19	.66

Beneficial Program Components

Following the self-perceived ratings of improvement in ability to perform work and basic functional mobility skills, the XYZ Refinery operators were asked to rate five exercise components of the pre-work conditioning program. These five components were presented on the questionnaire as stretching, strengthening, resistive band exercises, ball exercises, and use of the aerobic step. Based on a scale from one to ten, with one being least beneficial and ten most beneficial, the operators were asked to rate which of these program components gave the greatest contribution to any self-perceived changes in ability to perform work and basic functional mobility skills. Table 6 represents the raw data counts collected from each operator surveyed. It is interesting to note that use of the aerobic step received a rating of zero by seven of the operators, and that no other program components received zeros. Stretching, physio-ball exercises (trunk/lumbar stabilization), and resistive band exercises were the only program elements to receive ratings of 10 by just a few operators.

Table 6

Raw data scores from operators rating exercise benefit

Survey#	Stretching	Strengthening	Resistive Band	Ball Exercise	Aerobic Step
1	6	2	7	8	4
2	8	8	5	5	
4	8	5	2	10	8
6	10	2	4	10	
7	8	4	5	8	5
8	10	1	2	9	
9	10	2	1	3	
10	6	6	7	5	1
11	8	8	8	6	8
13	8	7	10	5	
14	10	1	1	1	
15	8	8	8	8	8
16	5	2	5	7	7
17	8	8	5	9	

From Table 6 above, descriptive statistics were used to compute the means and standard deviations of respondent ratings in an attempt to determine which exercise program components were perceived as most beneficial in preparing the operators for the shutdown period. As shown in Table 7 below, stretching exercises (mean of 8.07) were perceived as being the most beneficial in preparing workers for the shutdown period. The standard deviation of 1.53 for stretching shows good agreement among the operators as well. Lumbar & trunk strengthening and stabilization exercises, using the physio-ball, were perceived as the second most beneficial exercises.

Table 7

Responses on Exercise Benefit on a 0 to 10 Scale

Summary statistic	Stretching	Strengthening	Resistive band	Ball exercise	Aerobic step
Mean	8.07	4.57	5.00	6.71	5.86
Standard Deviation	1.53	2.77	2.70	2.58	2.47

In order to identify where the data points fall in the scheme of variance from the mean, Figure 5 was created to demonstrate the adjusted means after adding and subtracting one standard deviation (SD).

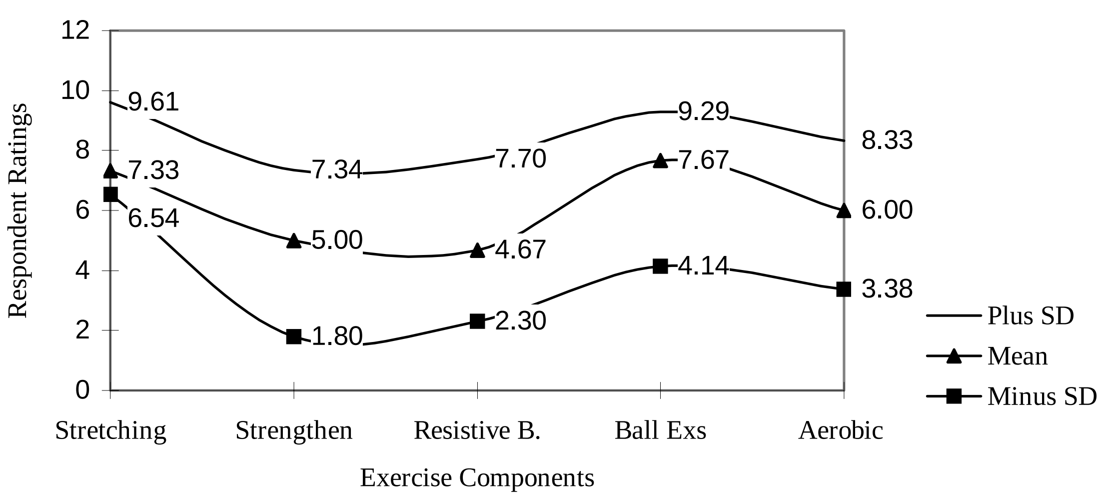

Figure 5. The adjusted operator ratings of pre-work conditioning components after adding and subtracting one standard deviation from the mean.

With the mean adjusted according to the variance in the data (+/- 1 SD), the ball exercises for low back and trunk stability take the lead for being considered most beneficial by the operators as shown in Figure 5. In descending order, operators rated physio-ball exercises (mean = 7.67) as most important in preparation for the shutdown period, followed by stretching (7.33), aerobic step (6.00), strengthening (5.00), and resistive band use (4.67). Without adjusting for the variance in operator ratings, in descending order, stretching exercises (8.07) were rated as most important followed by physio-ball exercises (6.71), aerobic step (5.86), resistive band (5.00), and strengthening (4.57). Given these findings, it appears that stretching, and physio-ball exercise components were regarded as the most important pre-work conditioning program components by the operators. Concerning operator rating consistency, there was much better agreement with the importance of stretching (SD = 1.53) than with physio-ball use (SD = 2.58). According to the third null hypothesis, none of the components of the pre-work conditioning program will be perceived as being more beneficial than the others. Given the above results, the third null hypothesis was rejected.

In order to check the soundness of operator ratings, the nonparametric exercise rating data were subjected to a Spearman correlation procedure using SPSS (see Table 8). Of the variables tested, stretching ($p < 0.05$) and strengthening ($p < 0.01$) ratings were shown to have statistically significant correlations with resistive band exercises. Strengthening exercises were directly correlated ($r_s = 0.664$) with resistive band use. In contrast, stretching exercises were inversely correlated ($r_s = -0.623$) with resistive band use, which is consistent in theory since resistive exercises have traditionally been used for strengthening. These results suggest that operators gave consistent and truthful ratings according to what would generally be expected in exercise theory and practice.

Table 8

Spearman Correlations of Exercise Components

	Strengthening	Resistive band	Ball exercise	Aerobic step
Stretching	-.362	-.623*	.005	.620
Strengthening		.664**	.006	.491
Resistive band			-.053	.114
Ball exercise				.385

* Correlation is significant at the .05 level (2-tailed).
** Correlation is significant at the .01 level (2-tailed).

Discussion

The results of this investigation suggest that a one-month pre-work conditioning program was perceived as beneficial by the majority of refinery operators. Short duration workplace exercise interventions have been shown to yield positive results. A two-month workplace stretching program conducted by Moore (1998) produced measurable improvements in employee flexibility and physical self-perception. In an even shorter duration six-week strengthening and trunk flexibility program, Genaidy, Delgado, Garcia, and Al-Herzalla (1994) found statistically significant changes in employee arm strength, trunk flexibility, and in job-related physical performance as well.

Trunk stability and stretching exercise interventions are important considerations for refinery operators that must assume a variety of unpredictable awkward bodily positions and postures. With respect to the physical demands during refinery shutdown, successful job-task performance requires workers to have adequate strength, stability, and mobility of the body. According to operator ratings, stretching and trunk stability exercises were regarded as most important in contributing to recognized improvements in ability to perform the identified critical job tasks. Ultimately, through increasing operator flexibility and subsequent body mobility, pre-work conditioning appears to have positively influenced operator productivity as well as injury potential during the refinery shutdown period. Remarkably, none of the 17 operators that participated in this investigation reported work-related musculoskeletal injuries over the six-week refinery shutdown period. In concurrence, Moore (1998) maintained that 67 employees involved in a workplace stretching intervention also reported no musculoskeletal injuries over the program's two-months. According to Robert, Blide, McWhorter, and Coursey (1995), work conditioning has been shown to help reduce employer injury-related costs by physically preparing employees to safely tolerate the physical demands of a job before placement in the job. It appears that the XYZ Refinery pre-work conditioning program was successful in physically preparing operators to perform the refinery shutdown job. The results of this pilot study support the contentions held by Dishman, Oldenburg, O'Neal, and Shephard (1998) that workplace exercise may positively affect productivity and decrease employer injury-related healthcare costs.

CHAPTER V: CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to investigate the effectiveness of a daily exercise program as a proactive approach to improving worker physical performance and injury prevention during a XYZ Refinery shutdown period. The goals of the study were to assess the effects of the pre-work conditioning program on refinery operators' perceived abilities in functional mobility, job-task performance, and to determine which program components may have contributed to any recognized improvements. A previous job analysis was conducted for determination of refinery operator physical demands. An exercise program was developed and performed by a group of 17 operators for approximately 30 minutes at the beginning of each work shift for a period of one month prior to the refinery shutdown. Upon completion of the six-week shutdown period, information from the 17 operator participants regarding perceived improvements job-task performance and flexibility were obtained from rating scales provided on anonymous survey forms. Data gathered were entered into Microsoft Excel and SPSS 11.0 in order to summarize operators' perceived changes in ability to perform common refinery work during a typical shutdown period.

Conclusion

The results of the data collected indicate that the pre-work conditioning program has positively influenced operators' perceived abilities to perform critical refinery tasks such as ladder climbing, using hand tools, performing maintenance, and using pull chains. These tasks are major activities that must be frequently performed by operators for the successful completion of a routine refinery shutdown period. As a result of the pre-work conditioning program, increases in flexibility and functional mobility were consistently reported by the operators in the areas of reaching above shoulder height, squatting, bending and rotating at the waist, and rotating the head. Perhaps improvements in operator flexibility and functional mobility played a role in easing the performance of the identified critical tasks. In addition to these recognized improvements in ability to perform work, functional mobility, and flexibility, there were no operator injuries reported during the six-week shutdown period. The most important contributing pre-work conditioning program elements identified by the operators were stretching exercises for flexibility, and ball exercises for proximal (trunk) strength and stability. Other program components such as resistive band strengthening and step aerobic conditioning were rated as less important contributors to improving operator job-task performance.

Recommendations

A four part pre-work conditioning program has been specifically developed to meet the needs of XYZ Refinery operators. Based on job analysis, only those exercises that were crucial for maximizing an employee's ability to safely tolerate refinery physical demands were included in the program. The implementation of such a pre-work conditioning program for refinery operators should, in addition to specific stretches, include strengthening of target muscle groups that are most frequently involved in injury. Another important program consideration involves the use of physio-ball exercises to build low back & trunk stability for improved load bearing capability. The reason that focused ball exercises on the trunk/lumbar area is so important is that it is an area of the body rarely exercised, thus relatively weak and unprepared for the stresses placed on it during refinery shutdown.

The ability of XYZ Refinery operators to perform physically may have direct bearing on the productivity and competitiveness of the refinery, much like the success of an athlete's team. Evidence in the athletic community supports the use of exercise to enhance athletic performance and prevent injuries as well (Stone, 1990). Similar to athletes developing strength and flexibility for competitive events through exercise training, refinery operators must undergo training to acquire those physical adaptations necessary for successful performance and tolerances of increased workloads without injury. Given the results of this study, it is apparent that this work conditioning adaptation or training effect may occur over a short duration (four-week) timeframe. Besides preventing workplace injuries, the benefits of appropriate types of fitness programming are likely to include enhancement of corporate image, an increase in worker satisfaction and productivity, a decrease in worker turnover, and improved employee retention (Wanzel, 1994). Given the positive outcome of this study and the overwhelming supporting literature, it is recommended that XYZ Refinery integrate this pre-work conditioning program for operators as a required part of refinery shutdown preparation. Facilitation of exercise programming onsite at XYZ Refinery will ensure the full-participation of operators that work 12-hour rotating shifts, since they may otherwise find exercising away from the workplace inconvenient.

Areas of Further Research

In the future, data (subjective and objective) should be collected before workers begin a pre-shutdown conditioning program, and upon completion of the conditioning program, in order to investigate statistically significant differences between the pre and post shutdown period. A larger sample size along with the presence of a parallel control group would also strengthen internal validity and add significant credibility to the results obtained in this pilot study. Information presented here will hopeful prompt further investigation into the effectiveness of pre-work conditioning for refinery operators, and help to recruit support from top management for the implementation of this program in order to prevent XYZ Refinery workplace injuries and increase productivity.

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APPENDIXES

APPENDIX A: THE QUESTIONNAIRE FORM

1. As a result of the pre-work conditioning program, did you notice any changes in your ability to perform work-related tasks?

	No Change	Minimal	Moderate	Significant
Climbing Ladders	☐	☐	☐	☐
Using Hand Tools	☐	☐	☐	☐
Driving	☐	☐	☐	☐
Turning Valves	☐	☐	☐	☐
Performing Maintenance	☐	☐	☐	☐
Use of Pull Chains	☐	☐	☐	☐

2. As a result of the pre-work conditioning program, did you notice any changes in your functional (task-related) mobility?

	No Change	Minimal	Moderate	Significant
Turning Your Head	☐	☐	☐	☐
Bending at the Waist	☐	☐	☐	☐
Rotating Your Body	☐	☐	☐	☐
Squatting	☐	☐	☐	☐
Reaching Below Shoulder	☐	☐	☐	☐
Reaching Above Shoulder	☐	☐	☐	☐

3. Circle the following on a scale from 1 to 10, with number 1 being the least beneficial and number 10 being the most beneficial in preparing you for the refinery shutdown period.

Stretching	1	2	3	4	5	6	7	8	9	10
Strengthening	1	2	3	4	5	6	7	8	9	10
Resistive Band	1	2	3	4	5	6	7	8	9	10
Ball Exercises	1	2	3	4	5	6	7	8	9	10
Aerobic	1	2	3	4	5	6	7	8	9	10

APPENDIX B: THE OPERATOR JOB ANALYSIS

Job Task Analysis (JTA)
Category: Operations
Position/s: All Operators
Analyst: David Rodriguez

Overview of job characteristics: The position has 12-hour rotating shifts from 6:00am to 6:00pm, 24 hours per day, 7 days per week. The typical employee works 36 to 48 hours plus, per week. Job functions vary considerably. The status of refinery process flow/production will determine the level of operator cognitive and physical demand. Overtime is optional or on an as needed basis.

Job Objective: Maintain, direct, and control the continuous operations involved in petroleum refining and processing that results in the production of saleable petroleum products.

Essential Job Functions: (Any one position may not perform all of the duties listed, nor do the listed examples comprise all of the duties which may be performed in positions allocated to the operations category)

1) Sets up, starts, controls, monitors, adjusts, and stops refinery process operations and system flow configurations locally and remotely
2) Demonstrates operational knowledge of refinery system pumps, compressors, blowers, turbines, motors, exchangers, coolers, and cooling towers, valves, traps, furnaces, boilers
3) Applies procedures for gauging, storage tank inventory, and transfer of crude and refined materials
4) Determines and maintains normal process operating limits
5) Makes instrument and process determinations and adjustments in order to accurately produce required petroleum products
6) Troubleshoots and takes corrective action during abnormal process conditions
7) Performs emergency operations and emergency shut down procedures
8) Makes independent visual surveillance rounds for conditions such as leaks, vibrations, temperatures, levels, noises, pressures, flow rates, electrical parameters, etc…
9) Interprets and analyzes readings from various measuring instrumentation such as gauges, meters, sampling equipment, level indicators, digital and analog measures
10) Interprets blue print and physical plant schematic diagrams
11) Possesses computer literacy and perform data entry
12) Documents plant parameters, and related administrative procedures in writing
13) Obtains, handles, and transports samples from refinery processes
14) Manually operates valves, levers, and controls in awkward positions
15) Uses assistive moving devises such as chain falls, dollies, carts, and portable man lifts
16) Effectively uses common and special hand tools (hammer, screwdriver, spanner wrench, vice, impact wrench, ratchet, pipe wrench, allen wrench, etc…) for preventive maintenance activities

17) Negotiates on varied, slippery, and uneven surfaces
18) Ascends/descends stairs, ladders, and ramps
19) Tolerates working at significant heights
20) Tolerates small enclosed or confined spaces
21) Possesses sound safety judgment and demonstrates ongoing compliance with physical plant safety, environmental, and health standards
22) Operates and interprets industrial gas analyzers, identifies material/chemical properties and hazards, and use safety systems such as showers and eyewash stations
23) Uses hand-held communication devices for coordinating operations with control room and other operators
24) Applies knowledge of and uses fire prevention/fire protection equipment
25) Possesses a general learning ability, reading ability (related technical information), writing ability, numerical, arithmetic, and mechanical aptitude
26) Applies reasoning and common sense understanding to carry out instructions furnished in written, oral, or diagram form.
27) Speaks and understands spoken words during high dB background noise levels
28) Visual perception during low light levels and safe navigation with a flash light
29) Color discrimination for interpreting labels, instruments, lights, controls, and valves
30) Works effectively outdoors in varying weather conditions ranging from 150^0 to -30^0 Fahrenheit.
31) Effectively dons/uses refinery-wide and special PPE: fall protection, SCBA, fire retardant clothing, respirator, without obstruction.

Tools and Equipment: (Any one position may not use all of the tools and equipment listed, nor do the listed examples comprise all of the tools and equipment which may be used in positions allocated to this job category). Computers & printers, manuals, fresh air equipment, masks, harnesses, lock/tagout, work orders, etc… Equipment list (but not all inclusive) common and special hand tools, valves, chain-falls, tape measures, tape, flashlight, funnels, face shield, bottles, stools, ladders, 2 wheelers, hoses, cans, bottles, tongs, extension cords, rags, fire extinguishers, radio, batteries/battery chargers, gloves, PPE, microscope, labeling system, oxygen tank, spectrophotometer, beakers, flasks, buret, vials, cylinders, centrifuge, sampling pump, pH probes, thermometer, pipettes, filter paper, drums, drill stems, cutting bits, jackhammers, overhead crane, filters, elevators. Refinery equipment varies according to unit.

Work Environment: The work environment characteristics described here are representative of those an employee encounters while performing the essential functions of this job category. Work is performed in and around high noise levels, high and low temperatures, vibrating machinery, moving mechanical parts, and high electrical currents. Work may be performed in high places and confined spaces, in conditions such as high humidity, in the presence of gases, fumes, vapors, dusts, mists, and exposure to petrochemical industry airborne toxicants. Typically, ~50% of the work may be performed outdoors on varied terrain in all weather conditions.

Clothing Used: Refinery PPE Standards including: Hard hats, steel-toed footwear, Nomex, safety glasses, ear plugs/muffs, Bulwark flame/water retardant suites, gloves, rain & winter clothing.

Significant Worksite Measurements: The significant worksite measurements are summarized in the "Activity Description" section of the physical demands table below.

Physical Demands: The physical demands described here are representative of those that must be met by an employee to successfully perform the essential functions of this job. Reasonable accommodations may be made to enable individuals with disabilities to perform the essential functions.

Survey definitions:

- Never/Rare: 0-5% of the time.
- Occasional: 6-33% of the time.
- Frequent: 34-66% of the time.
- Continuous: 67-100% of the time.

In an eight-hour workday, the job category requires employees to:

Task Factor	Never/Rare (0-5%)	Occasional (6-33%)	Frequent (34-66%)	Continuous (67-100%)	Activity Description
Sitting			**4-8 hrs**		Completing paperwork, operating computer, riding in motor vehicles, fire/safety watch, decoking
Standing		**2-3 hrs**			Observing, inspecting, reading levels, fire/safety watch, turning valves
Walking			**2-8 hrs**		Making rounds, inspections, gathering samples, variable outdoor terrain and conditions

The job category requires employees to:

Lifting and Carrying	Never/Rare (0-5%)	Occasional (6-33%)	Frequent (34-66%)	Continuous (67-100%)	Activity Description
1-15 lbs		**XXX**			Floor to overhead use of tools and sample testing equipment, 26" wrench =15 lbs, spanners = 2 lbs to 7.5 lbs, air socket wrench =10.5 lbs, 1 gal oil bottle = 7.5 lbs
16-30 lbs		**XXX**			Floor to shoulder height to overhead use of tools. Air wrench = 20.5 lbs, sample bottle rack 26 lbs, bump test tank 22.5 lbs
31-50 lbs		**XXX**			Carrying is minimal. Floor, shelves to overhead lifting. Bag of oil dry = 50 lbs, impact gun = 32 lbs, largest 4" open-end wrench = 35 lbs, 5-gallon pail of anti-foam = 40 lbs, fire extinguisher 34.5 lbs, fresh air respirator = 35 lbs, steam/water hose = 50 lbs dry

51-75 lbs	**XXX**				Carrying is minimal. Floor to shelf lifting/carrying. 60" pipe wrench = 53 lbs, ice cooler with composite sampler jug from polishing pond = 60 lbs, equipment parts
76-100+ lbs	**XXX**				

PUSHING/PULLING

- Pushing/pulling wrenches – Largest wrenches available include 4 ¼" open-end wrenches, 60" pipe wrench, etc…
- Push/pulling many hand tools for operation/use – large to small wrenches, socket wrenches, putty knife/scrapers.
- Pulling/pushing 2 wheeled dollie to transport 55 gallon drums & deliveries dropped off at Bullpen, etc…
- Push/pulling on doors to fin fans with vacuum suctions/drafts.
- Using chain-falls & overhead cranes.
- Pulling/lowering of pails tied-off with rope to pull tools/equipment to elevated work places accessed only by ladder climbing.
- Pulling self up during vertical ladder climbing.
- Using cleaning equipment such as shovels, brooms, etc…
- Pulling of wheeled carts to transport mechanical equipment to/from shop, pallet jack use.
- Push/pulling on spanner wrenches to turn valves.
- Push/pulling on valves to open/close process flow. Some valves in extremely difficult/awkward places (i.e., climbing on rungs/frame to reach valve with center at 91" from deck in Unit 23).

Sample pulling forces on spanner wrenches & valves in refinery:

- Average of 20.6 lbs. of force to pull down on chain valve (21E11).
- Average of 8.7 lbs. of force to open Vent valves at top of C Drum with spanner wrench.
- Average of 12.7 lbs. of force to close Vent valves at top of C Drum with spanner wrench.
- Average of 172 lbs. of force to open 15C1 1st stage suction valve without using a spanner wrench.
- Average of 33 lbs. of force to close 15C1 1st stage suction valve with using a spanner wrench.

The job category requires employees to:

Task Factor	**Never/Rare (0-5%)**	**Occasional (6-33%)**	**Frequent (34-66%)**	**Continuous (67-100%)**	**Activity Description**
Neck Flexion			**XXX**		Inspecting, using tools, observing work, walking over varied ground surfaces, taking product samples, paperwork, writing, lab work, reading, cutting coke drum
Neck Extension			**XXX**		Inspecting, communicating with co-workers, looking into heaters, turning valves, following steam/electrical tracings, safety observations
Neck Rotating			**XXX**		Inspecting, observing, close listening to equipment
Neck Side Bending			**XXX**		Inspecting, taking product samples, taking fine

					measurements, close listening
Trunk Flexion			**XXX**		Inspecting and examining equipment, preparing equipment before work orders, tuning valves at low levels, crawling in pipe racks, retrieving tools and equipment, sitting
Trunk Rotation			**XXX**		Inspecting and examining equipment, preparing equipment before work orders, pushing and pulling on carts/2-wheelers/valves, moving in tight areas, retrieving tools and equip.
Kneel or Crouch			**XXX**		Low level work with using tools, taking samples, inspecting
Squatting		**XXX**			Low level work, retrieving
Pivot		**XXX**			Working around tight spaces
Climbing		**XXX**			Stairs, ladders, step stools, fin fan 42 steps, cooling tower 51 steps, blower 144 steps, crude structure 125 steps
Reaching to Shoulder Height				**XXX**	Working at extended distances, inspecting, placing/removing parts, using air/manual tools, in crowded spaces, reaching for turning valves/caps/plugs, climbing ladders
Reaching Above Shoulders			**XXX**		Turning valves, pulling chains, chain falls, climbing, moving overhead cranes
Wrist Turning		**XXX**			Tool use, operating equipment, taking samples, turning valves
Grasping				**XXX**	Tool use, rope & chain pulling, levers/handles/tongs/clamps, operating equipment, valves
Finger Manipulation			**XXX**		Fastening devises, securing tags/seals, operating equipment controls, writing, pH testing, writing
Foot Controls	**XXX**				Driving vehicles

Near Vision				**XXX**	Ascending & descending steps, sampling, inspecting, tools use, gauges & instruments, paperwork, reading charts & diagrams
Far Vision				**XXX**	Observing work area, safety, co-workers, obstacles, making rounds, following electrical/steam tracings
Diminished Vision			**XXX**		Low light levels, working with obstructed view, steam, glare
Color Perception				**XXX**	Wire and label color-codes, test equipment, monitors, lights, control panels, pH test
Depth Perception				**XXX**	Climbing/descending, inspection, raise/ lower equipment and supplies, using chain falls, walking on uneven surfaces
Hearing Sensitivity				**XXX**	Audible status of mechanical equipment & tools, communications, ear protection
High Temperature			**XXX**		Fin fans can reach 146^{0}F, heaters can reach 1800^{0}F, steam hose 300^{0}F, asphalt 350^{0}F, coker drums 800^{0}F, tar 900^{0}F, steam at bleed valves 325^{0}F
Moving Objects				**XXX**	Cranes, tools, equipment, machines
Uneven Surfaces				**XXX**	Uneven ground and climbing surfaces, soft sand, gravel/rocks, ramps, railroad tracks, over pipes
Wet/Slippery Surfaces			**XXX**		Outdoor elements (snow, rain, ice, mud), unclean working and walking surfaces, oily surfaces, grating, concrete
Vibration Jerking Compression			**XXX**		Pulling/pushing on wrenches and mechanical equipment, pneumatic tools, valves, powered tools, hammer, machines, steam hoses
High Elevations			**XXX**		Climbing stairs & vertical ladders, crude tower 220 ft
Crowded Spaces		**XXX**			Valve pits, vessel skirts, around piping systems, tight work spaces

Inhalation			**XXX**		Petrochemical gases, fumes, vapors, mists, dusts
Chemical Contact		**XXX**			Petrochemical products, cleaning & degreasing agents

APPENDIX C: THE PRE-SHUTDOWN CONDITIONING PROGRAM

Pre-Shutdown Work Conditioning Program: Stretching

Stretching increases flexibility for assuming awkward positions in turning valves, squatting and positioning around pipes.

Hamstring Stretch
(Prevents back injury by reducing the pelvic muscle imbalances that promote a forward flexed lumbar spine)
Place foot onto the edge of a chair or stool, gently reach for the toes by bending forward at the hips while keeping the your back straight until a stretch is felt at the back of the thigh, then return to the starting position.

Hold stretch for 10 seconds.
Repeat 5 times.
Do 2 sessions per day.

Standing Back Bends
(Reduces spinal disk bulging caused by forward flexed postures by forcing the disc material to the front of the spine---away from the nerve roots)
Place the hands in the small of the low back as shown, slowly extend the upper-body to bend backwards at the low back, then return to upright standing.

Hold stretch for 5 seconds.

Repeat 5 times.

Do 2 sessions per day.

Doorway Pectoral Stretch
(Reduces forward rounded shoulder posturing that can mechanically contribute to shoulder rotator cuff impingement conditions)
Place the arms across an open doorway with the palms against the wall, gently lean forward while relaxing the chest until a stretch is felt across the chest, then return to normal standing.

Hold stretch for 5 seconds.
Repeat 5 times.
Do 2 sessions per day.

Posterior Shoulder Stretch
(Improves shoulder joint articular mobility by reducing restrictions of the posterior rotator cuff)
Gently pull on the elbow with the other hand until a stretch is felt at the back of the shoulder, then release.

Hold stretch for 5 seconds.

Repeat 5 times.

Do 2 sessions per day.

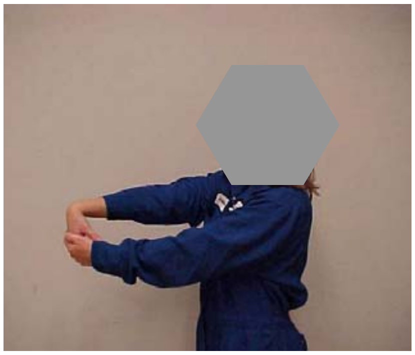
Inferior Shoulder Stretch
(Improves shoulder joint articular mobility by reducing restrictions of the inferior rotator cuff)
Gently pull on the elbow until a stretch is felt below the shoulder, then release.

Hold stretch for 5 seconds.

Repeat 5 times.

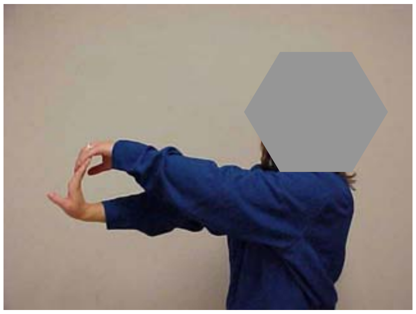
Do 2 sessions per day.

Wrist Extensor Stretch
(Improves forearm/wrist flexibility and soft-tissues extensibility for improved tolerance of workloads without strain)
Keeping the elbow straight, grasp the involved hand and slowly bend the wrist down until a stretch is felt, then relax.



Hold stretch for 5 seconds.
Repeat 5 times.
Do 2 sessions per day.

Wrist Extensor Stretch
(Improves forearm/wrist flexibility and soft-tissues extensibility for improved tolerance of workloads without strain)
Keeping the elbow straight, grasp the involved hand and slowly bend the wrist down until a stretch is felt, then relax.



Hold stretch for 5 seconds.
Repeat 5 times.
Do 2 sessions per day.

Neck Stretches

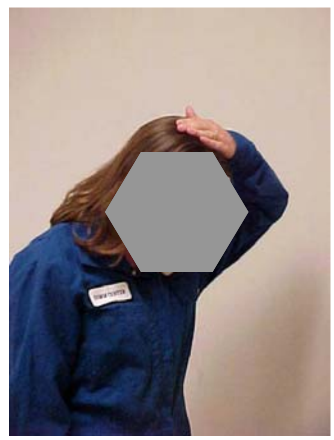
(Reduces potential for neck strain by increasing flexibility and soft-tissues extensibility for improved tolerance of workloads without strain)

Slowly move the head into each position indicated until end range is felt. Gently push/pull into stretch range using your hand, then return to a neutral position.

Hold stretch for 5 seconds.

Repeat 3 times.

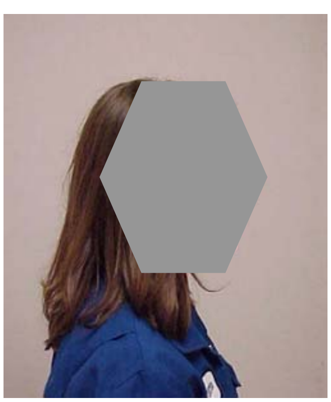
Do 2 sessions per day.

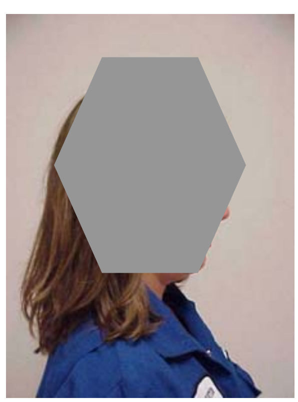


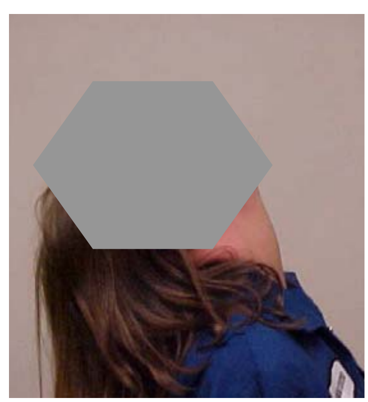
Chin Tucks with Neck Extension

(Chin tucks can decrease neck muscle activity by reducing forward head type posturing. When combined with neck extension, spinal disk bulging can be reduced by forcing the disc material to the front of the spine---away from the nerve roots)

Starting with your head in a neutral position, gently tuck your chin and hold for 3 seconds, then look up and return to neutral. Repeat 5 times, 2 sessions per day.







Pre-Shutdown Work Conditioning Program: Strengthening

Increases strength of the body's tissues and increases tolerance of forces in heavy tool use such as impact wrenches, spanner and pipe wrenches, valve turning, pushing pulling and lifting.

Bicep Curls

(Strengthening of the biceps and forearms)

Stand holding elastic band with palms facing forward, bend the elbows as shown, then return.

Hold for 5 seconds.
Repeat 10 times.
Do 2 sessions per day.

Reverse Bicep Curls

(Strengthening of the lateral forearms)

Stand holding elastic band with the palms facing backward, bend the elbows as shown, then return.

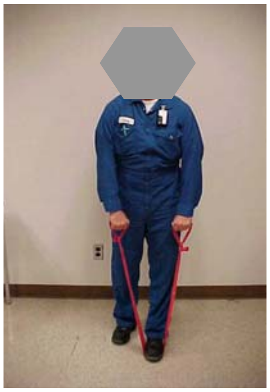
Hold for 5 seconds.
Repeat 10 times.
Do 2 sessions per day.

Upright Rowing

(Strengthening shoulders, upper-back & neck)

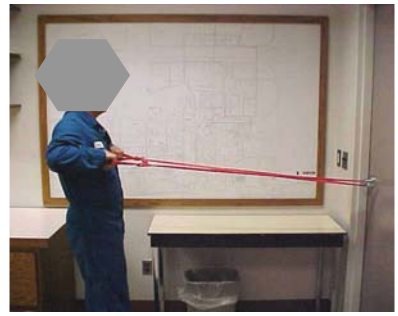
Stand holding elastic band as shown, lift the band towards your breast bone keeping your elbows above your wrists at all times, then return.

Hold for 5 seconds.
Repeat 10 times.
Do 2 sessions per day.



Rowing
(Strengthening of the mid-back & posterior shoulders)
Grip the band with the arms extended, pull the elbows back and squeeze the shoulder blades together, then return.

Hold for 5 seconds.
Repeat 10 times.
Do 2 sessions per day.



Shoulder Inward Rotation
(Strengthening of the shoulder-rotator cuff inward rotators)
Grip the band with the elbow bent along side the body, then rotate the forearm inward until the hand touches the stomach.

Hold for 5 seconds.
Repeat 10 times.
Do 2 sessions per day.

Shoulder Outward Rotation
(strengthening of the shoulder-rotator cuff outward rotators)
Grip the band with the elbow bent along side the body with the hand touching the stomach, then rotate the forearm outward.

Hold for 5 seconds.
Repeat 10 times.
Do 2 sessions per day.

Pre-Shutdown Work Conditioning Program: Trunk Stability

Tightening and strengthening of low back muscles to increase load bearing tolerances for heavy pushing, pulling, and lifting activities.

Kick Out

(Strengthening of the hip flexors can help to increase the normal lumbar curvature of the spine, placing the disks in an optimal position for load bearing. Tightening of the abdominals occurs for stability and balance)

Slowly extend the knee until straight with the thigh parallel to the floor (do not compensate by forward bending the trunk), then return foot to floor.

Hold for 5 seconds
Repeat 10 times
Do 2 sessions per day

Partial Sit-Ups

(strengthening of the abdominals without forward flexing the spine reduces the potential for lumbar disk bulging, while improving stability of the trunk)

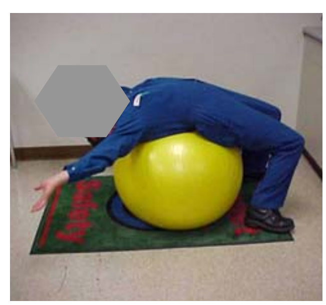
Roll back on the ball until tension is felt at the abdominal muscles (do not compensate by forward rounding the back), then return.

Hold for 5 seconds
Repeat 10 times
Do 2 sessions per day

Supine Back Extension

(Stretching the spine in the reverse direction can promote forward movement of spinal disk material to the front of the spine---away from spinal nerve roots. Once this is achieved, strengthening and tightening of the back extensors must follow in order to maintain the disks in their optimal mechanical positions)

With the assistance of a partner (safety), from sitting---walk your way down to a laying position on the ball, relax while extending backward around the ball, then return to sitting. Hold for 10 seconds, repeat 4 times, do 2 sessions per day.



Ball Press Ups

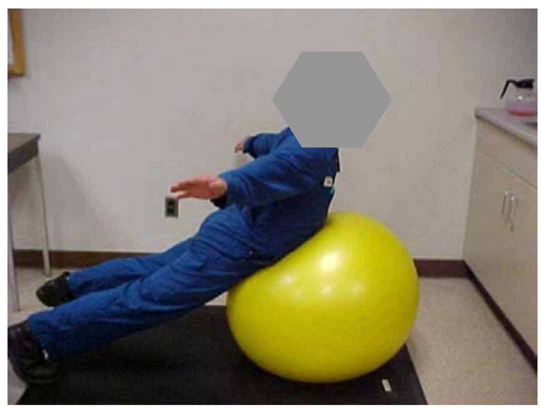
(Following the back extension exercise above, strengthening and tightening of the muscles that extend the spine will help to permanently maintain optimal spinal disk positions)

Assume a laying position on the ball as shown, press up on the ball while extending the back as far as comfortable, then return to starting position. Hold for 5 seconds, repeat 10 times, do 2 sessions per day.

Prone Back Extension

(Advanced back extensor strengthening will ensure maintenance of optimum spinal disk positions, and significantly improve low back strength for resistance to common muscle, tendon, and ligamentous soft-tissue strains and sprains that can result from heavy lifting, pushing, pulling, and forward bending)

Assume a laying position on the ball as shown, extend the back while bringing the arms back and squeezing the shoulder blades together, then return. Hold for 5 seconds, repeat 10 times, do 2 sessions per day.



Wall Squats
(Strengthening of the glutes and thighs for lifting, pushing, and pulling must occur as an alternative for relying on using back strength in forward bending)

With the feet shoulder width apart, assume a comfortable squatting position.

Hold for 20 seconds
Repeat 8 times
Do 2 sessions per day

Pre-Shutdown Work Conditioning Program: Aerobic Conditioning

Increases employee tolerance to working longer shifts through increased endurance. This will also prepare the employee for physically demanding tasks such as climbing.

Aerobic Step-Ups

(Step-ups are great for cardiovascular and pulmonary conditioning while, at the same time, strengthening thighs and hip-extensor muscles for improved ladder and stair climbing ability)

Beginning with the right foot, step up onto the adjustable height step. Then step back down to the floor beginning with right foot first, until both feet are back on the floor.

Step Rate: 100 steps per minute with the metronome

Stepping Duration: 5 minutes leading with the right foot, then left foot (optional)

Target Heart Rate: Not to exceed 85% of max= .85(220-age)

Recommendations:

1. Start with the lower step initially, increasing the height of the step as a way to advance in the program.
2. If dizziness, shortness of breath, or any discomfort occurs, discontinue stepping. Report any symptoms to the onsite Nurse. You may need to schedule an appointment with your physician for a routine physical exam before continued participation in this Pilot Program.