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Evaluation of a Workplace Exercise Program for Control of Shoulder Disorders in Overhead Assembly Work

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Abstract

Objective—The aim of this study was to assess effects of exercise on shoulder musculoskeletal symptoms among employees with overhead assembly work exposures.

Methods—A voluntary workplace shoulder exercise program was offered to employees in two automotive assembly departments, while two similar departments served as controls. N=76 total workers participated. Shoulder Rating Questionnaire (SRQ) and Discomfort of the Arm Shoulder and Hand (DASH) symptoms were queried monthly for seven baseline months, followed by six months that included exercise.

Results—SRQ scores were higher for exercisers than among controls in the six exercising months, but not in the baseline months. While the group × month interaction was significant ($p < 0.05$), the temporal trend was inconsistent.

Conclusions—Exercise may have temporarily lessened decline in SRQ. It is not clear whether shorter term differences were clinically meaningful or predictive of longer term disability prevention.

Keywords

Exercise; Workplace; Shoulder; Musculoskeletal Pain

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Conflicts of Interest: None declared.

Introduction

Musculoskeletal disorders (MSDs) continue to represent a major proportion of injury/ illness incidence and cost in the U.S. Manufacturing (MNF) sector. In 2015, 34% of non-fatal injuries and illnesses involving lost time (LT) in the MNF sector involved MSDs and the MNF sector had one of the highest rates of MSD LT cases (1). Specific shoulder disorders and shoulder pain are prevalent in the general population and in the workplace, and have been estimated to represent approximately 20% of all disability payments for MSDs (2). In 2015 shoulder injuries accounted for 72,270 cases with lost work days (1). Approximately 15% (10,840) of these were in the Manufacturing sector and 9% of Manufacturing sector injuries with LT were shoulder injuries.

Despite of many engineering controls and workplace tools and equipment to reduce MSD risk factors, automotive manufacturing is characterized by repetitive manual work with short cycle times and sustained musculoskeletal loading. The prevalence of MSDs in this industry continues to be a concern. The motor vehicle manufacturing sub-sector (NAICS 3361) has been among the highest of MNF sub sectors, with MSD LT rates that were on average 96% higher than the general manufacturing MSD LT rates from 2003-2007. Assembly processes in this industry involve overhead conveyance of the vehicle chassis and overhead use of tools with elevated arm postures and musculoskeletal disorders of the shoulder are of particular concern. Shoulder MSDs account for upwards of 50% of all injuries in some automotive manufacturing departments. At the manufacturing facility where this study took place, shoulder disorders accounted for 17% of all injury cases. At this facility, shoulder injuries had been the highest cost class of injury for six consecutive years, and for eight of the prior nine years.

Prolonged overhead working postures are believed to be associated with symptoms of upper limb discomfort, fatigue, and impingement syndromes (3) and may contribute to shoulder disorders independent of high forces or load exerted with the hands. Fatigue of the shoulder muscles may result in changes in scapulo-thoracic and glenohumeral kinematics that affect risk for shoulder impingement syndromes (4,5). A number of studies and subsequent reviews suggest that there is limited evidence for exercise having benefit on preventing complaints of the arm, neck, shoulder (6,7,8)

A proactive individualized strategy to improve shoulder function of employees led to development and pilot testing of a shoulder conditioning program at this manufacturing facility, and anecdotal benefits had been reported by pilot participants. In a small group of pilot participants the reported percentage of discomfort free days increased over four weeks of exercise program participation. The program was developed by a physical therapist to condition the musculature of the shoulder complex to increase resistance to fatigue and improve musculoskeletal responses to, and tolerance of, overhead work. The general strategies include: (i) strengthening of serratus anterior and the rotator cuff musculature; (ii) enhancing normal patterns of scapulo-humeral motion that reduce activation of upper trapezius; and (iii) stretching to reduce “tightness” in pectoralis minor and the posterior capsule of the shoulder. The exercise routine is similar to a number of shoulder conditioning protocols that have been designed to improve motion and muscle activation and are believed to be beneficial to those whose occupation requires significant exposure to humeral elevation and overhead work (9,10,11). In a previous review of workplace exercise programs for the neck/shoulder few evaluative studies were found in Manufacturing industries that included a non-exercise control group and that followed outcomes for more than 12 weeks (8). Studies have specifically addressed construction work (10, 11), however, previous prospective studies do not appear to have specifically addressed Manufacturing industry employees with significant exposure to overhead work.

The objective of the present study was to prospectively evaluate the longer term effect of a workplace shoulder exercise program on shoulder and upper limb symptoms among Manufacturing industry workers with jobs involving significant overhead work. All of these individuals performed overhead automotive assembly work. Although the exercise program was ultimately followed for six months, the duration of the prospective study period was defined to be at least four months.

Methods

Study Design

The study design was a prospective trial with randomization at the work group level. Four assembly groups (departments) were identified in physically separate areas of the plant. First and second shift employees were recruited from two departments with the second shift employees randomly chosen (by coin flip) to receive the opportunity to participate in the voluntary shoulder exercise program. The study design originally included an ergonomic tooling intervention to be assigned to one of the two departments (across both shifts). However, during this study period the tooling intervention was successfully implemented in less than 20% of its originally planned use. Thus, for this analysis the first shift groups (in both departments) have been combined in the comparison (control) group.

A time series design (12) was employed with seven monthly symptom queries in a baseline period including the months of May – November 2013. The six month intervention period from December 2013 – May 2014, during which time exercise session participation was encouraged for that treatment group, also included monthly symptom queries.

Participants

Participation in the study was voluntary and the protocol and all procedures were approved by the Institutional Review Board (protocol #12-DART-04XP). The recruitment activity included delivery of an information session presented to approximately 80-90 eligible workers in the four work groups during lunchtime breaks. These eligible participants worked in automotive assembly processes using torque tools and involving manual insertion of fasteners, grommets, gaskets, retaining clips and other parts on the vehicle chassis while conveyed overhead. The processes had a cycle time of approximately 54 seconds. Work with the elbows above shoulder height was common to these processes. The participants were aware of their work group's assignment to the Exercise or Control (non-exercise) treatment group at the time of enrollment. The information sessions were different for the work groups assigned to the Exercise and Control conditions. The Exercise group received an explanation of the design of the exercise program and how participation would be incentivized. Both groups received an explanation of the monthly musculoskeletal symptom questionnaires and how completion of the surveys would be incentivized.

Shoulder Exercise Program

The exercise program had been designed previously by a physical therapist with the goal of improving function of the shoulder by decreasing susceptibility to muscular fatigue and improving tolerance to the demands of the specific overhead work. The program was also designed to be time-efficient, requiring a relatively short period of compensated employee time. The program had been pilot tested previously in a similar manufacturing facility. The exercise program included resistance band (Therabands™) strengthening movements and stretching/lengthening of the pectoralis and trapezius muscles (See Appendix A for specific movements). Muscle groups targeted were similar to program designs reported in other studies (9,10,11) and the set/repetition design for resistance-based movements was typical. The protocol was specifically designed for stretches to be less than 30 sec duration (13).

The exercise sessions were offered during the 15-minute period prior to the work shift in both departments. Because equipment needs were minimal the sessions took place at the group's work area next to the assembly line. Sessions were led by a member of a team of National Athletic Trainers' Association (NATA) certified athletic trainers who assured quality of the movements. These athletic trainers documented session attendance and participant's resistance band progression (dates at which the participant transitioned to progressively higher resistance band levels). Exercise participation was not mandatory and was incentivized by reimbursing participation time at the employee's regular hourly wage. Participants were encouraged to attend as many sessions per week as possible.

Work hours and Physical Exposure

Work hours and work-related physical exposure at the individual level were collected. Exposure time on individual work processes was determined by tabulating hours worked on each process as documented by the line supervisor. Work related physical exposure to musculoskeletal risk factors was determined from prior job analyses of the work processes in combination with time on work process during months 9-12. The job analyses were based on a proprietary assessment method to quantify shoulder physical risk factor exposure. This shoulder risk factor exposure score calculation accounts for three components: loads generated by the posture of the arm; weight of any objects held; and loads generated by other forces such as pushing and pulling. The calculation also accounts for process cycle time and the percentage of work cycle with loading. Employee exposure to shoulder risk factors was determined by an individually-calculated time weighted exposure score.

Outcome Measures

Each month during the study period employees completed three standardized questionnaires of musculoskeletal discomfort symptoms: Shoulder Rating Questionnaire, SRQ (14), Discomfort of the Arm, Shoulder, and Hand, DASH (15,16), and the Standardized Nordic Questionnaire for Analysis of Musculoskeletal symptoms, NORDICQ (17). Questionnaire completion took approximately 0.3 hours and, because these were not completed during normal paid hours, the employee received 0.3 hours additional pay for submitting a questionnaire. Questionnaire responses were confidential and participants were assigned a random number which was used to code identity on the survey questionnaires. Only the lead investigator held a key to individual participant identity. Company management was notified of which employees completed the questionnaire each month (for the authorization of additional pay), but were not given information on individual responses. Completed questionnaires were securely submitted to the principal investigator. The SRQ was scored per the published approach (14) with a higher score, up to 100, indicative of improved shoulder function. For the DASH a lower score (100 – 0) is indicative of fewer upper limb symptoms. NORDICQ is reported as the percentage responding affirmatively to a query by specific body region, e.g. "have you had trouble (ache, pain, discomfort) at any time during the last 7 days".

Statistical Analysis

Linear mixed models tested the fixed effects of treatment group (Exercise vs. Control), age, and month, as well as interaction terms. The models included a term for the baseline symptom score, defined as the average of the monthly scores over the seven months preceding the exercise program (May – November, 2013). The model included random effects for worker and time. The Kenward-Roger method was used for computing denominator degrees of freedom for F-tests. Additional linear mixed models tested for the effects of physical exposure, exercise dose, and exercise resistance band progression. In the models testing the effects of exercise dose and exercise resistance band progression treatment group was eliminated because these factors are only applicable to the Exercise participants. The modeling was carried out using PROC MIXED in SAS (v. 9.3).

Results

Adherence to Protocol

Seventy-six (n=76) employees consented to participate and the initial monthly query resulted in an 87% questionnaire return rate. Over the subsequent 12 months the questionnaire return rate decreased steadily. Overall questionnaire return rates were similar between the groups. One third of the employees originally enrolled completed 50% (or more) of symptom questionnaires and half of the participants completed fewer than 25% of the monthly questionnaires. Only one control and two Exercise group employees completed all 13 monthly symptom queries. Figure 1 summarizes study enrollment and adherence to the protocol.

Baseline Assessment

Averaged over the seven month period prior to the exercise program the SRQ scores for exercise and control groups were similar, as were the DASH scores (see Table 1). Exercise group participants were slightly younger, on average.

Exercise Program Compliance and Progressivity

Among Exercise group participants, exercise "dose" was assessed summing the number of sessions attended. Participants were not excluded on the basis of attaining a minimal level of compliance (18,19). From December 2013 – May 2014 participants attended 1,550 of 4,419 total exercise session opportunities. This corresponds to 35.1% of sessions attended (1.8 sessions/week), overall, for the exercise group participants.

Exercise dose (as proxied by session attendance) varied widely. Approximately equal percentages of participants in the Exercise group (~46%) attended one or fewer session per week (on average) as attended an average of two or more sessions per week. Fifteen of the employees enrolled in the Exercise group attended zero exercise sessions in the six month time period. However, that count includes individuals who left employment in these departments during, or prior to, the months of the Exercise program. Six employees who attended zero exercise sessions did complete symptom questionnaires and these individuals were re-assigned to the Control group in the, “as treated” analysis. The distribution of percentage of exercise sessions attended among the Exercise group (mean exercise sessions attended/week) is shown in Figure 1. The most frequent exerciser attended 104 of 117 possible sessions - equivalent to attending 4.4 sessions/week.

Resistance band progressions were documented for 20 of the exercise program participants as shown in Figure 2. Six individuals attended exercise sessions but had no documented resistance levels and are not shown in the graph. No relationship is observed between individual participant's exercise session attendance and their level of resistance progression over the course of the program. However, the *minimum* number of sessions to progress in resistance was monotonically increasing as 32, 35, 44, and 50 sessions for 1, 2, 3, and 4 levels of resistance increase, respectively. Conversely, three individuals attended over 80 sessions without ever increasing their exercising resistance.

Effect of Exercise on Symptoms

A box plot of SRQ scores over the 13-month study period is shown in Figure 3. The model of SRQ outcomes showed significant effects for month ($p = 0.036$), exercise group × month interaction ($p = 0.015$), and age × month × exercise interaction ($p = 0.014$). The variable for age × month nearly met the 0.05 statistical significance criterion ($p = 0.067$). The significant exercise group × month interaction, indicating a differential response over time between the Exercise and Control groups, appears to be due to a decline in SRQ among the control group, particularly in the second (January 2014) and third (February 2014) months of the Exercise program. The lower SRQ, relative to the baseline month levels, among controls was more substantial than any increase in SRQ (improvement in function) among the exercisers. This trend was not apparent over the latter three months of the Exercise program and confidence intervals around SRQ scores increased in the latter months (see Figure 4).

DASH scores (plotted by month in Figure 5) were modelled similarly to SRQ. Neither main effects for treatment group ($p = 0.280$), month ($p=0.468$), or age ($p = 0.315$) were significant. The group by month interaction was also non-significant ($p=0.344$).

A second series of models, restricted to SRQ and DASH outcomes for the exercise group added the variables for exercise dose (number of sessions attended) and progression in exercise intensity (band resistance level progressive increases). Neither of these were significant factors in improving SRQ or DASH outcomes.

NORDICQ percentages are shown as an average over months prior to (months 1-7), and during (months 8-13), the exercise program (Figure 6). These percentages reflect the percentage of returned questionnaires rather than percentage of participants. Average positive response percentages to *trouble in last 7 days* were lower in months 8-12 compared to months 1-7, regardless of Exercise/Control group membership. This is evident for all body regions. The percentage reporting shoulder trouble declined by 44% among the exercise group compared to 15% for controls between months 1-7 and months 8-13. Noticeable reductions in the percentage reporting *trouble in the last 7 days* appeared in the upper and low back regions.

Discussion

Interpretation of the differences in SRQ between the Exercise (Exercise) and Control groups over the months of the exercise program should consider multiple factors including: a possible regressing to baseline levels beginning three months after the exercise program began, and the absence of any relationship between exercise dose and SRQ score among exercisers. A slight improvement in the SRQ was observed in the Exercise group in the first five months after the exercise program began. However, more of the difference between groups in the exercise months was due to a decline in SRQ score in the control group; the decline was most marked in the month after the exercise program began. The early differences between the groups observed during the exercise period may reflect some preventive effect of exercise in reducing a decline in SRQ. The absence of any relationship between exercise dose (sessions attended) and SRQ among the exercise group suggests minimal improvement in SRQ score among the exercise group. Three months after the exercise program commenced SRQ scores in the control group improved steadily, regressing towards the baseline level. The reason for this is not clear, but the inconsistency of any trends calls into question the long term effectiveness of exercise on controlling shoulder symptoms.

The Nordic Questionnaire confirmed that the shoulder was the body region exhibiting the highest percentage of employees reporting problems and that this was the case in the seven months preceding, and six months during, the exercise program. A general decreasing trend in the percentage of responses reporting "*trouble at any time during the last 7 days*" is apparent in both Exercise group and the Controls for many body regions, including the shoulders. This finding is inconsistent with that of the SRQ score, which suggests a worsening of symptoms in the controls, and minimal improvement in symptoms among exercisers, during months 8-11.

Adherence to the questionnaire administration protocol declined over the course of the study period, resulting in lower questionnaire response rates and smaller sample sizes in the later months. The adherence to questionnaire completion was unrelated to exercise session participation. Exercise participation (compliance) was fairly consistent across months - between 28%-43% of sessions attended.

The differences in mean SRQ scores observed between Exercise and Control groups during the December '13 to May '14 period was similar to the 12 unit change in SRQ in a symptomatic group over an 8-12 week exercise program reported by Ludewig and Bordstad (11), however, in that study the SRQ improved among symptomatic workers who exercised, while in the present study the difference was observed as a decrease in SRQ among the Control group participants. SRQ scores, prior to, and following, the 6 month exercise program were lower in the present study than those reported in asymptomatic shoulders of construction workers (11). Ludewig and Borstad (11) reported a mean SRQ of 93.9 in an asymptomatic population of Construction trade journeymen, which is 10-12 points greater than the average pre-Exercise scores in the present study. Construction journeymen presenting with positive shoulder impingement tests and pain reproduction symptoms in specific clinical tests (classified as symptomatic) reported an SRQ in the range of 65.9-72.5. In the present study, the three months of lowest SRQ for the control group dropped to that level, but this appeared to be an inconsistent trend. The assembly line employees in the present study could be considered moderately symptomatic, with SRQ in the 70 – 90 range, at baseline and generally remained so throughout the exercise program.

A potential study limitation is the group randomization that resulted in the exercise program being assigned to only second shift employees. This confounding of the exercise treatment with work shift was due to a study design strategy that was anticipating an ergonomic tooling intervention that was ultimately not successfully integrated during the study period. A consequence of this study design was that employees to whom the exercise condition was assigned were slightly younger, by four years on average, on the second shift. Otherwise, the study groups were homogenous in terms of workplace exposures to risk factors and similar work environment factors at the same manufacturing facility. Another study limitation is that the duration of the pre-intervention and intervention periods resulted in missing follow-through observations (“drop out”) due to factors such as employee transfer out of the specific work groups or merely declining compliance with monthly symptom questionnaire completion. Issues of employee turnover and continuation through the study period are a challenge to any prospective workplace intervention evaluation study, and compliance with a voluntary exercise program added another layer of challenge in this study. It is not surprising that most studies of workplace exercise reporting positive effects on shoulder symptoms have been of less than 16 weeks duration (8).

In a review of 38 studies of workplace exercise for control of neck/shoulder disorders conducted between 1997-2014 half of the study populations were employees in office environments with computer work exposures (8). This may be due to the ubiquity of office work and office/computer workstation exposures making this environment efficient for recruiting larger homogenous samples. Or, office work may afford greater schedule flexibility relative to other industries for exercise session participation during the workday. Regardless, that review identified only five studies since 1997 that evaluated exercise benefits specific to shoulder musculoskeletal symptoms of manufacturing industry employees (20-24). Two of these four studies were cohort designs: a 12-week pre-test/post-test study in beverage and tin mill industries reporting a positive effect of a daily stretching session (20), and an 8-week study of assembly line workers reporting a positive effect of two weekly sessions of strengthening and stretching (21). A third study, describing a group of industrial workers including those assembling printed circuit boards, found no difference between a strength and an endurance training program on pain and perceived exertion (22).

Two of the five studies included a non-exercising control group. Maher et al. (23) evaluated a 6-month resistance band strengthening program among n=4 exercisers compared to n=5 controls at a diesel engine assembly facility. That study reported no significant difference between exercisers and controls in 15 of the 16 disability index items queried and only one of the four exercise participants completed exercise logs to track compliance. Sundstrup et al (24) evaluated effects on a 7-item Workability Index outcome resulting from a 10-week resistance training program administered to slaughterhouse facility workers. Workability Index declined in a non-exercising control group relative to the exercisers. Compliance with the supervised exercise program averaged 2.4 (of 3 recommended) sessions per week attended. Compliance in the present study was weaker, with an average of 1.8 sessions per week attended. Other than Maher et al (23) we are not aware of other studies of workplace exercise longer than 10 weeks in duration that addressed shoulder disorders among manufacturing employees and that contrasted the exercise group to comparable non-exercising controls. In only one of the Manufacturing industry studies (24) was exercise compliance reported sufficiently for the determination and comparison of exercise dose.

A strength of the present study was the supervision and monitoring of the exercise and the reliable measure of exercise compliance and intensity progression by the participants. Many occupational studies in which the exercise was done without direct supervision at the workplace have less reliable measures of actual exercise compliance of participants. For example, Ludewig and Bordstad (11) used self-reported compliance through daily exercise logs and 39% of participants did not return the logs and among the 61% who did only 9 of 34 participants reported 75% or greater compliance with the program. Compliance among the present study participants is comparable to that figure - confirming 10 of 39 individuals participating in three quarters of the sessions. Other studies have reported program compliance based on meeting a low threshold for participation, e.g. attending as few as one exercise session per week, so that a high percentage of participants achieve the minimum compliance, when in fact, participants experienced a low exercise dose. Conversely, an “acceptable” exercise compliance is difficult to establish as no consensus exists regarding minimum effective dose for exercise. A more important indicator than simply attendance of sessions might be the degree of progression in increasing the training stimulus. Of 26 participants who participated in any exercise sessions 15 were documented with progression through one or more increases in band resistance during the program. The progression to higher resistance bands indicates that training stimulus was increased for these individuals, and this is suggestive of increased performance and sincerity of training effort. However, band resistance progression was not predictive of reported musculoskeletal symptoms among the exercisers over time.

The present study evaluated a voluntary workplace exercise program, in the automotive manufacturing industry, that can be implemented as a countermeasure to control the burden of shoulder disorders. When employees were incentivized some participated regularly by attending two or three sessions per week, which was believed to be a minimum target. Several individual comments were in praise of the program. One employee commented that he “…felt better able to perform at the beginning of shift.” Another reported feeling “…’loose’ at the beginning of the shift.” An employee with one of the highest levels of participation reported that he “…felt as though it did prevent him from getting hurt.”

Conversely, a negative response to the program was that "…they (employees) work hard enough on-line and more exercise would tire them out too much."

Automotive assembly employees in this study spent approximately 388 hours (1,550 exercise sessions attended) participating in exercise with 39 employees having the opportunity to participate in daily pre-shift sessions. We based cost estimates of the exercise program on representative U.S. national wage averages and the participation time observed in the present study. The U.S. Bureau of Labor Statistics (BLS) average hourly wage for Team Assemblers (OES code 51-2092) in Motor Vehicle Manufacturing is $23.34 (25). We assumed an hourly wage estimate for NATA certified trainers (exercise session leaders) of $23.77 in the Industrial/Occupational/Corporate setting (26). These result in a cost estimate for this exercise program over the six months as $10,209 ($23.34 × 388 for employee exercise time plus the exercise group leader time of $23.77 × 48.5 hours). Equipment costs associated with this program included only elastic resistance bands which are available in economical bulk rolls. These costs were trivial and thus disregarded. We estimated the average cost of a compensable shoulder injury claim to be $31,000 in the automotive manufacturing industry, based on an unpublished analysis of 106 compensable claims for shoulder injuries in that industry (NAICS 3361) in the state of Ohio. Since additional indirect costs would be incurred to train a replacement employee, true cost avoidance (benefit) would exceed a direct injury cost of $31,000. Thus, through simplified cost-benefit considerations, the program break-even point could be considered to be less than one-third of a single compensable injury avoidance.

Conclusion

The workplace administered shoulder exercise program may have lessened a decline in SRQ score, an instrument specific to shoulder symptoms, for a few months. The program had no effect on DASH score, which more broadly queries all upper limb symptoms. Observed trends in the SRQ scores among exercisers and controls in the first three months after the Exercise intervention did not appear to stabilize and cast doubt on whether shorter term effects can be predictive of longer term outcomes. The findings are also difficult to interpret in the face of low employee participation, which may be common to voluntary workplace exercise programs. Only 19 of the 41 employees who enrolled in the exercise condition attended an average of two or more exercise sessions per week over the study period. The present study represents one of few prospective studies of workplace administered exercise program interventions with employees in a manufacturing industry. It may be the only such study to include an occupational group with significant workplace exposure to overhead work.

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APPENDIX A: Exercise Program Description

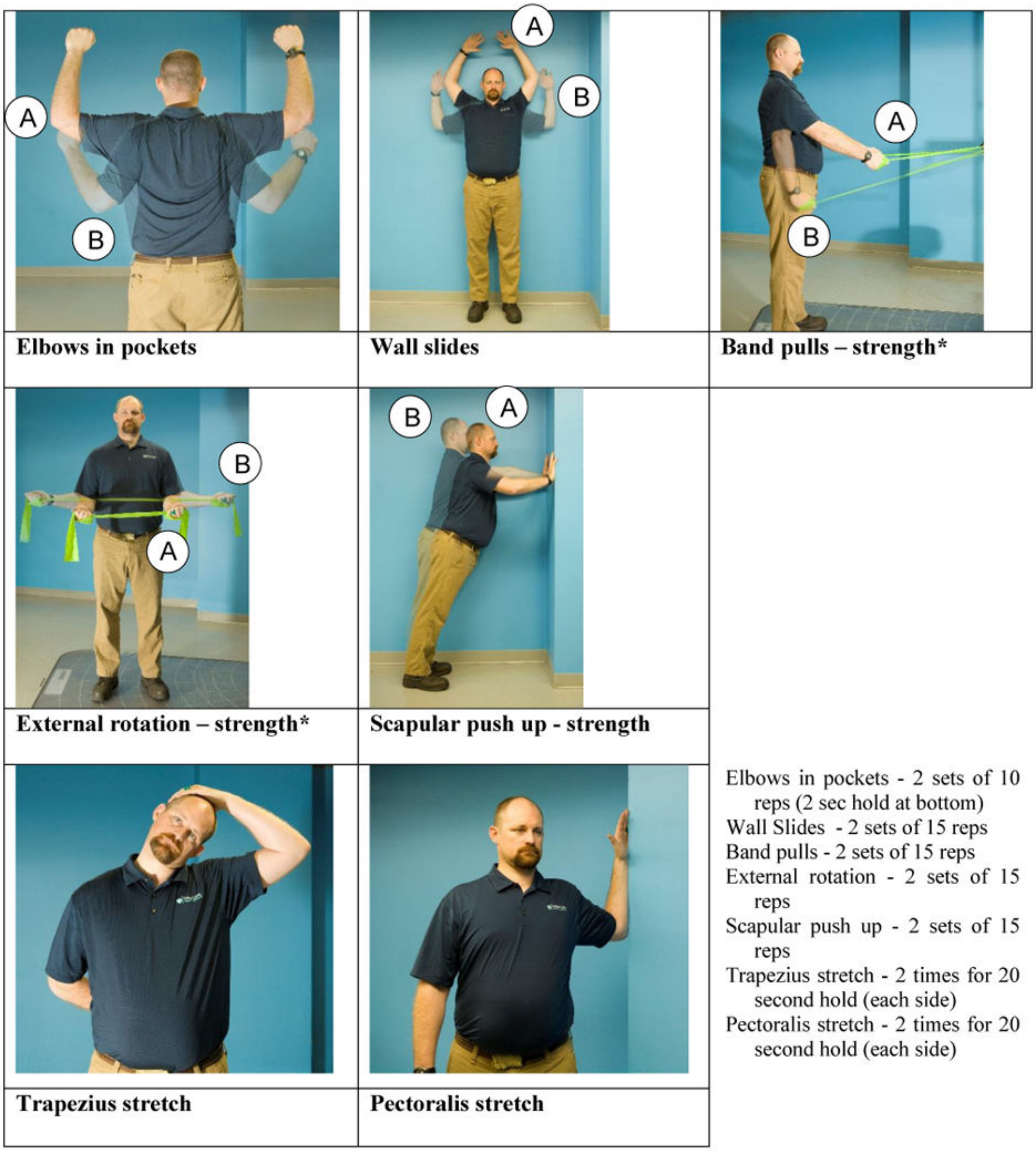

Figure A1. Exercise illustrations

*progressive by increasing band resistance level

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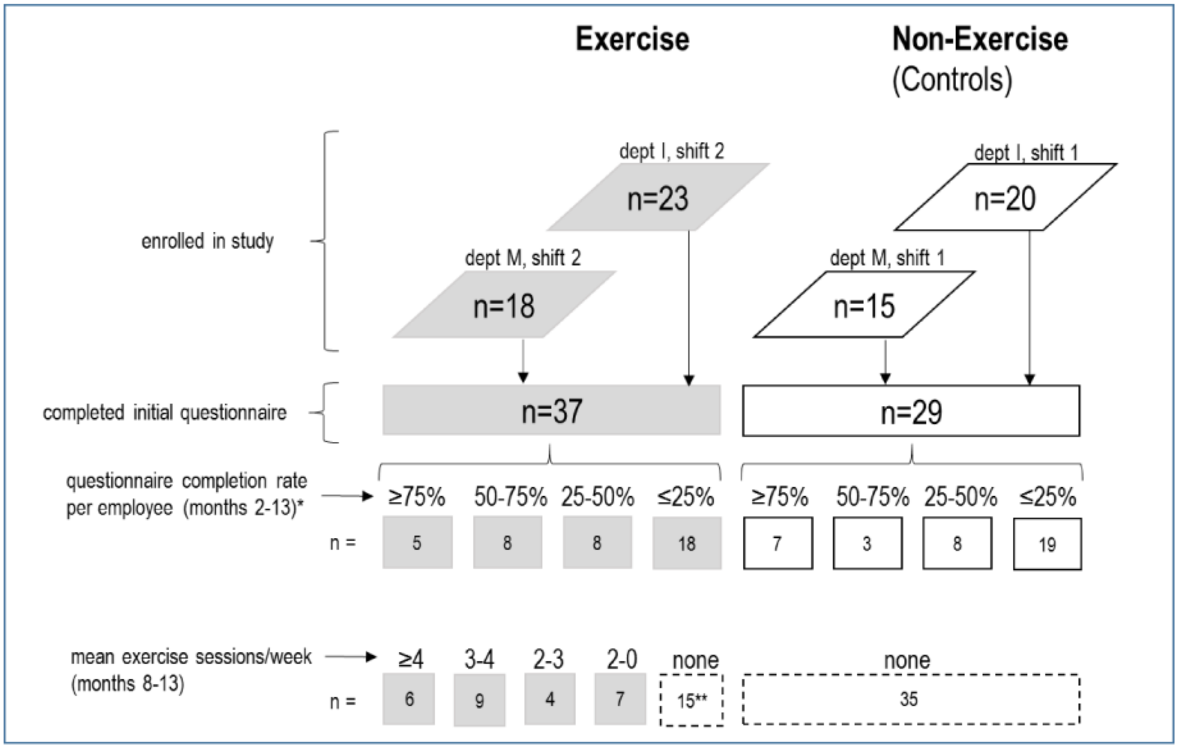

Figure 1.

Overview of study design and participant adherence to study protocol.

*Two employees changed shifts after enrollment in the study. Shifted from Exercise to Control condition.

**Includes employees transferred from department or separated from employment. Employees who had responded to symptom questionnaires were grouped as controls (as treated).

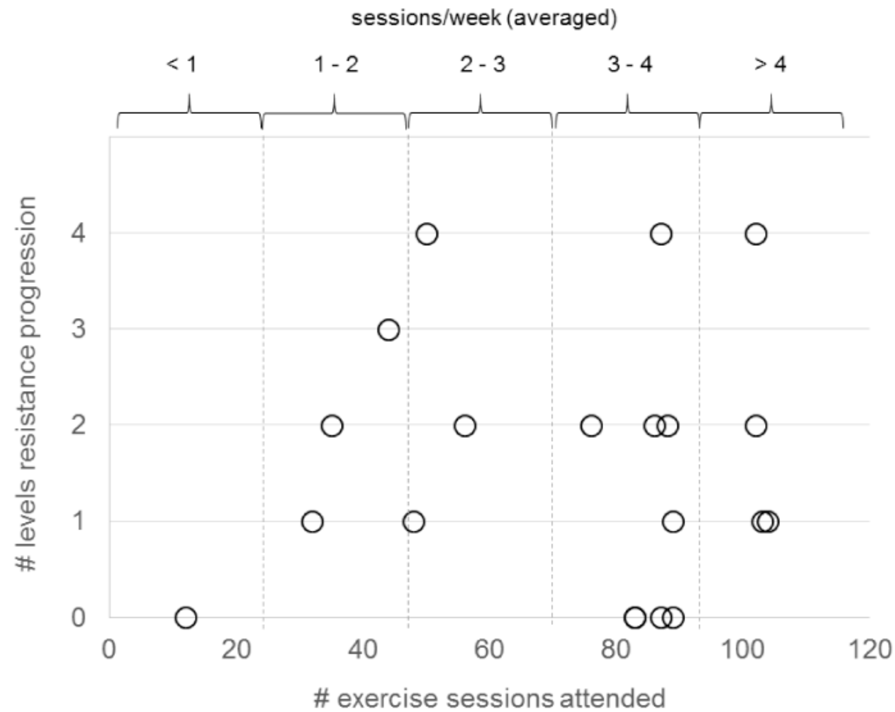

Figure 2.

Resistance progression in strengthening exercises versus exercise session participation. (Note: sessions/week at the top is an equivalent average based on the total possible sessions and duration of study.)

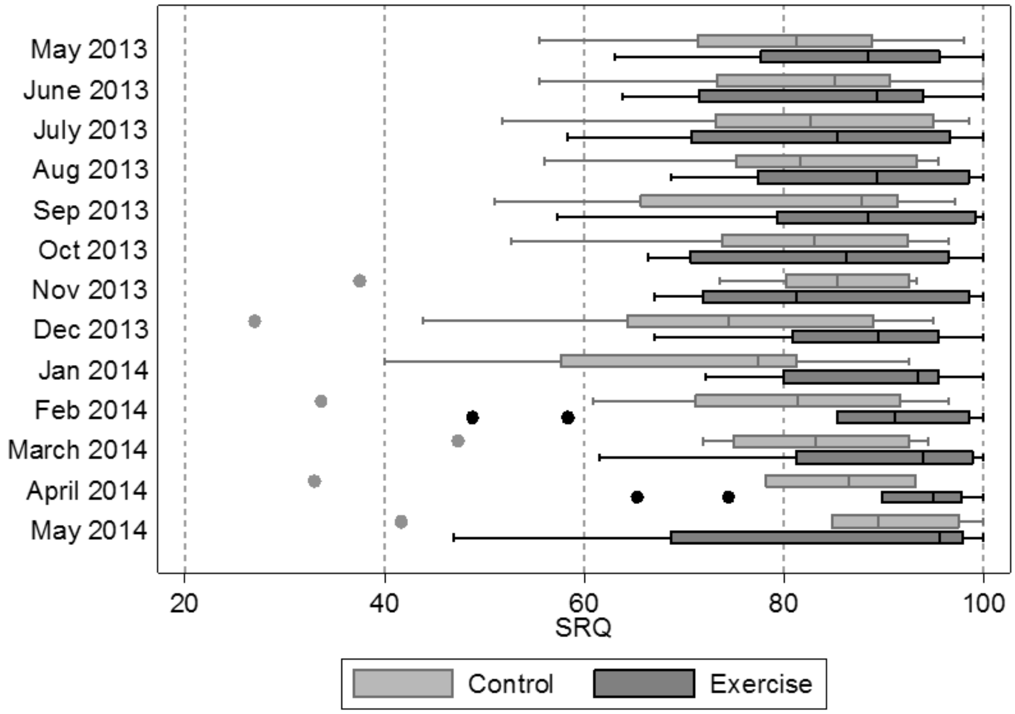

Figure 3.

Box plot for SRQ scores by month. Higher SRQ score indicates improved function.

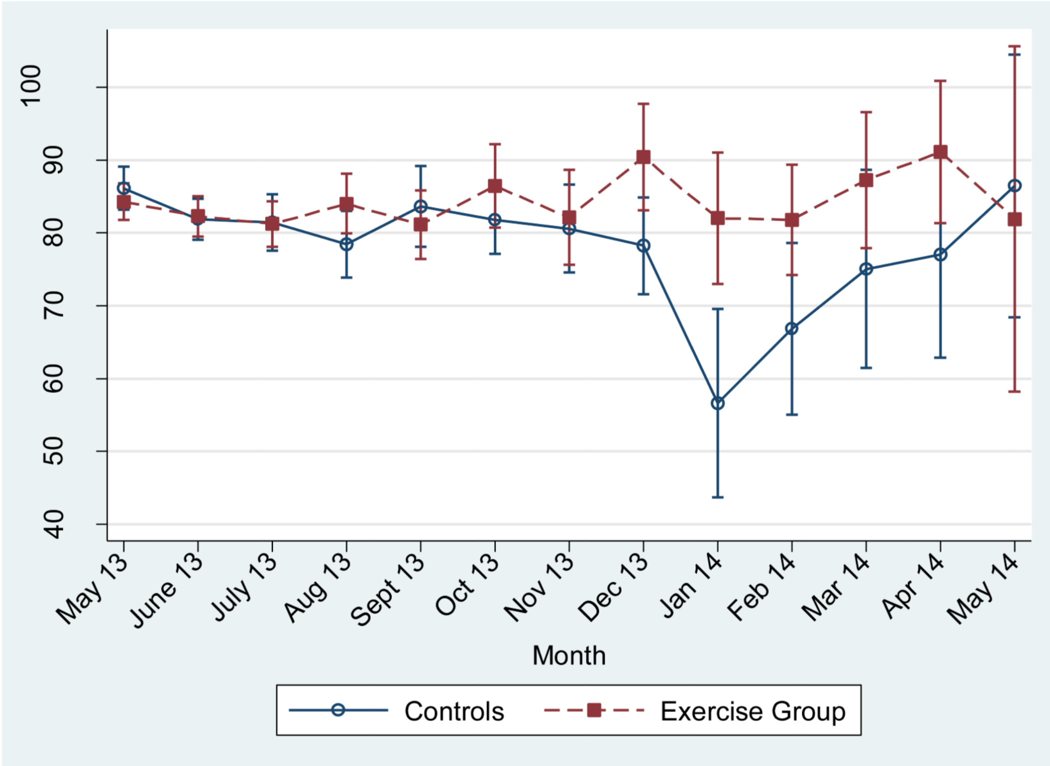

Figure 4.
SRQ scores (least squares means) by month shown for 13 month study period. Exercise was offered to the exercise group in the months spanning December '13 - May '14.

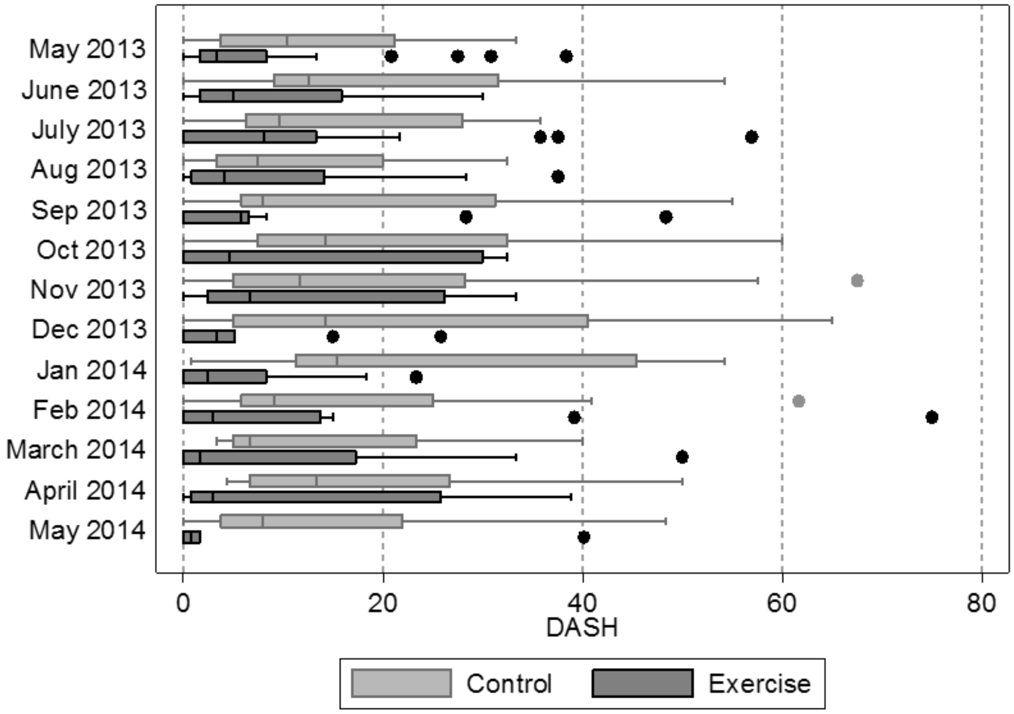

Figure 5.

Box plot for DASH scores by month. Lower DASH score indicates improved function.

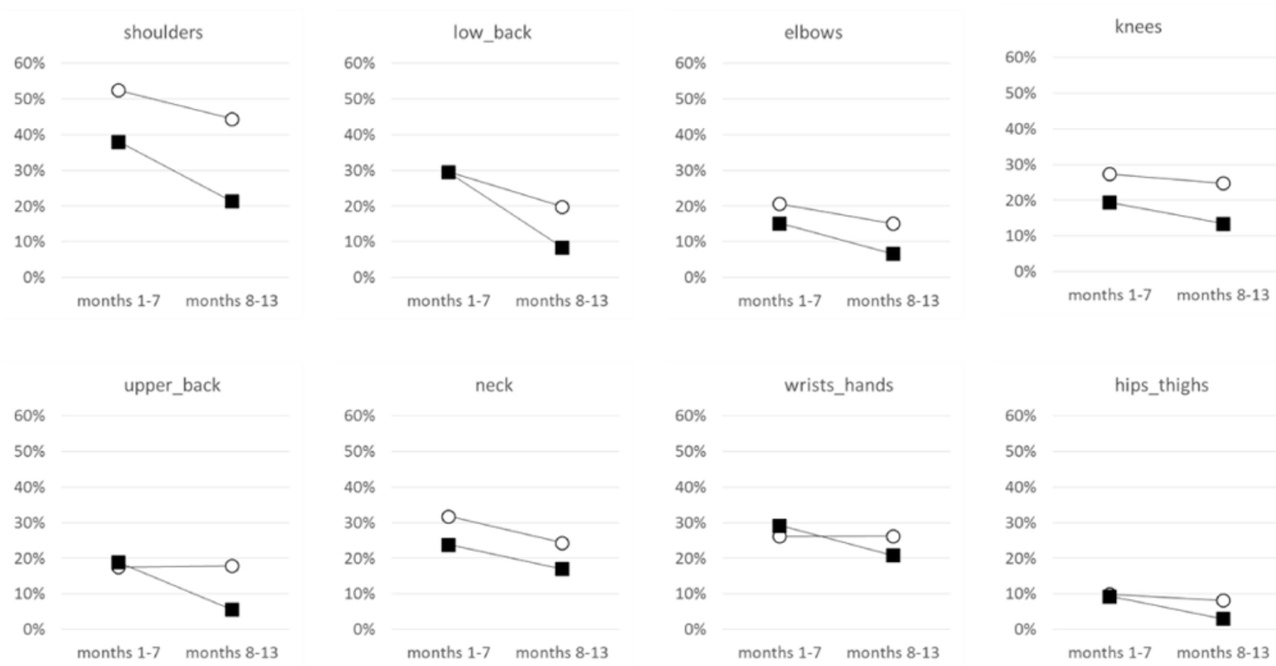

Figure 6.

Percentage of responses reporting "*trouble at any time during the last 7 days*" (NORDICQ). Averages shown for months 1-7 (prior to Exercise), and months 8-13 (during Exercise), by group (–○– Controls, –■– Exercise).

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Table 1

Baseline (T1) months 1-7 and intervention period (T2) months 8-13 averages for Exercise (Exercise) and Control (C) groups. Calculations were performed by first averaging each individual's scores for the relevant time period then calculating the group means and standard deviations.

	T1		T2	
	Exercise	**C**	**Exercise**	**C**
age in years (mean ± s.d.)	33.3 ± 8.61	37.4 ± 10.26	→	→
age in years (range)	18 – 48	19 – 57		
SRQ (mean ± s.d.)	83.8 ± 12.1	81.1 ± 12.3	87.5 ±12.3	74.0 ± 20.8
DASH (mean ± s.d.)	12.1 ± 13.2	16.0 ± 12.0	8.3 ± 11.8	21.2 ± 18.2
Nordic questionnaire (% having shoulder trouble in last 12 months)	64.5%	89.6%	54.9%	92.1%
Nordic questionnaire (% prevented from doing normal work because of shoulder trouble – last 12 months)	22.3%	26.1%	25.7%	41.6%
Nordic questionnaire (% having shoulder trouble in last 7 days)	38.0%	52.5%	21.4%	44.4%