Effectiveness of a Participatory Workplace Risk Assessment Team in Reducing the Risk and Severity of Musculoskeletal Injury

Philip J.W. Carrivick1,2, Andy H. Lee2 and Kelvin K.W. Yau3

1Department of Occupational Health, Sir Charles Gairdner Hospital, Australia
2School of Public Health, Curtin University of Technology, Australia and
3Department of Management Sciences, City University of Hong Kong, Hong Kong

Abstract: Effectiveness of a Participatory Workplace Risk Assessment Team in Reducing the Risk and Severity of Musculoskeletal Injury: Philip J.W. Carrivick, et al. Department of Occupational Health, Sir Charles Gairdner Hospital, Australia—This study evaluates the effectiveness of a participatory workplace risk assessment team (the intervention) in reducing the rate and severity of musculoskeletal and non-musculoskeletal injuries among a cohort of 137 cleaners within a hospital setting. The date, workers’ compensation claims cost and hours lost from work were obtained for each injury occurring during the 4-yr pre-intervention and 3-yr post-intervention period. The age, gender and hours worked during the study period, were ascertained for every cleaner whether injured or not. For musculoskeletal injuries, the intervention was associated with significant reductions of two-thirds in injury rate, 65% in workers’ compensation claims cost per hour worked, and 40% in hours lost per hour worked. Cleaners also experienced a significant two-third post-intervention reduction in non-musculoskeletal injury rate; but the corresponding changes in severity rates were not significant. The intervention supports the adoption of a participatory approach to reducing the rate and consequence of musculoskeletal injuries in the workplace.

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Correspondence to: P. J.W. Carrivick, Department of Occupational Health, Sir Charles Gairdner Hospital, Hospital Avenue, Nedlands, WA 6009, Australia

Participatory ergonomics is an increasingly utilized tool over the past two decades to improve working conditions, productivity and product quality. In recent years there has also been a requirement within manual handling legislation and codes of practice for worker participation in the management of injury risk1,2, the ultimate aim being the reduction of morbidity from musculoskeletal disorders3).

It has been noted that few studies examine the effectiveness of participatory ergonomics in reducing the risk of occupational injury and disease4,5). The majority of the literature concerns with workplace case studies that describe the implementation phase of participatory ergonomics. Although a reduction in occupational injuries has been demonstrated in some studies6–16), the effectiveness of participatory ergonomics in reducing the frequency or severity of work-related musculoskeletal disorders is seldom evaluated17–20). Furthermore, evidence on the capacity of workers to effectively assess injury risk has not been firmly established21–23).

A 7-yr quasi experimental study was recently undertaken to examine injury incidence and severity among a population of hospital cleaners, before and after exposure to injury risk control strategies recommended by a peer group risk assessment team24). A significant reduction in total injury count was observed for the population, but a change in severity, as measured either by the total compensation cost or the total number of hours lost from injury, was not demonstrated. A limitation of the original study was that the change in individual risk could not be measured, as only aggregate level data were available. Moreover, the original study only investigated the causal mechanism of injury, with particular focus on the hazard of manual handling. Since then, individual level data have been obtained for all cleaners employed during the observational period. It has also been possible to determine whether or not the injuries incurred were musculoskeletal in nature. This paper assesses the post-intervention change in the rate and severity of musculoskeletal injuries experienced by the cohort of cleaners employed for some time in both pre- and post-intervention periods, after adjusting for confounding factors that may influence the injury risk.
Methods

Participatory ergonomics intervention

The intervention was the application of an iterative injury risk identification, assessment and control process by the participatory ergonomics team, with a focus on injuries caused by manual handling. The aim of the team was to achieve a sustained reduction in injuries for all staff within the Cleaning Services Department. The team comprised 4 cleaning staff, 2 safety and health representatives, 2 supervisors, and an ergonomist employed by the hospital. The ergonomist trained the team in the identification, assessment and control of hazards, and provided injury data and professional support. The intervention commenced on 1 November 1992, and the team met bimonthly over the next three years. Team meetings considered injury/hazard reports, checklists, the determination of areas of risk, recommendations for the control of hazards, future risk management strategies, and action to be undertaken from previous meetings. The duration of each meeting was approximately one hour. In addition to regular meetings, team members undertook a variety of other activities. These ranged from informal liaison with general cleaning staff, ad hoc meetings, and working parties to deal with difficult issues or the evaluation of potential new equipment. Some activities involved liaison with parties external to Cleaning Services, such as personnel from Engineering Services.

Items for the identification of risk, namely workplaces, equipment and tasks, were selected for assessment either because a duty was common, or because injury data indicated an ongoing risk of injury, or there existed a perception from occupational experience that a duty was dangerous. A wide range of potential risks for musculoskeletal injury was identified for further analysis. Examples include: the prolonged mopping, vacuuming and buffing of floors; difficult to clean floor surfaces (requiring repetitive movements); the moving and cleaning of patients’ beds; the lifting of objects from high shelves and frequent dusting of objects above head height. Items were allocated to sub-groups of the team, who used a checklist for preliminary assessment. The checklist included actions and movements; workplace and workstation layout; working posture and position; duration and frequency of manual handling, and location of loads and distance moved; weight and forces; characteristics of loads and equipment; work organisation; work environment; skills and experience; and age and clothing. Usually two members were involved in the assessment and checklist completion time ranged from 15 to 30 min. Team meetings considered the completed checklists in association with other information; such as injury data, communication from other cleaners or with non-cleaning staff (e.g. engineers). Risk was assessed on the likelihood (low, medium or high) and severity (minor, moderate or severe) of injury to a cleaner, and the number of cleaners at risk of injury. Risk reduction strategies were considered according to the hierarchy of hazard control (i.e. elimination, substitution, engineering controls, administrative changes and personal protective equipment). The majority of recommendations for control were accepted and subsequently implemented by the hospital.

One example, to elucidate the process, is that of floor buffing. This activity was selected for risk assessment because it was a ubiquitous duty. Much of the hospital’s floor covering was made of linoleum, and 25 buffer machines were utilised to keep the surface clean. To wash and scrub an area of floor, the operator moved a water and detergent-filled machine from side to side by pulling, preferentially, on either end of a handlebar while flat circular pads (attached to a drive plate) in the machine head rotated rapidly on the floor. When scrubbing was complete, the pads were changed and the buffers were used as floor polishing machines. The amount of floor buffing undertaken by a cleaner varied on a given day and over a shift cycle. That is, a cleaner might buff for his/her entire shift, or do little or none. General discussions with cleaners revealed that the use of buffing machines required considerable force, particularly by the operators’ upper limbs and trunk, to move and control them. Novice users considered training inadequate, and the machines unwieldy and hard to control. Experienced users found buffing tiring and difficult to sustain for long periods. Additionally, machines were poorly maintained and many vibrated excessively. Injury data revealed nine injuries associated with buffing occurred in 1992: including to the shoulder, neck, back, elbow and wrist. One injury was an upper limb fracture. The team concluded that there was a medium risk of a moderate musculoskeletal injury from buffing; and that most cleaners were exposed to the risk. A number of controls were introduced to reduce the risk of injury. Firstly, skills training was formalised (in contrast to previous ‘on the job’ training) to cover the theoretical and practical aspects of safe buffing. Secondly, cleaning duties were restructured to reduce the risk of injury due to the repetitive nature of the task. Although this resulted in more cleaners undertaking buffing each day, the duration of buffing duties was reduced to a maximum of two hours per shift. Thirdly, the buffing machines were numbered and entered onto an Engineering Services planned maintenance program. Finally, the Head of Cleaning Services was given authority, and a budget by the hospital’s executive committee, to select new floor surfaces across the hospital as old floor surfaces became worn and required replacing. Consequently, after consultation with other stakeholders, new floor surfaces began to be purchased that required less cleaning per se and less buffing (for example, low pile carpet instead of easily scuffed linoleum).
The study group

The 137 cleaners employed during the observational period, and who at some stage worked both before and after the intervention, formed the study group (27% of the cleaner population). The study group was followed through 36 months until 31 October 1995; after which time, complete hospital employment data were not available. However, employment data were able to be retrieved back 52 months from intervention to the beginning of the 1988/89 financial year (1 July 1988). Data were obtained from personnel records, fortnightly financial records, incident data sheets, and insurer workers’ compensation files. Ethical clearances were obtained from the study hospital personnel records, and the authors’ respective institutions. Confidentiality of records was maintained.

Outcome variables

Lost time injury* (LTI)—a new workers’ compensation injury resulting in a shift or more off work. Only LTI were included for analysis. The nature of the LTI (the type of hurt or harm) was classified as musculoskeletal (MSK) or non-musculoskeletal (NMSK), with MSK referring to the “nerves, tendons, muscles and supporting tissues of the body”.

Duration*—working hours ever lost from an LTI.

Claims cost*—the total workers’ compensation cost of an LTI. It includes lost salary, medical costs, legal costs, travel costs, rehabilitation costs and common law settlements. Final costs for each claim were adjusted to the July 1998 consumer price index.

Hours worked—number of hours actually worked (does not include leave, extra payment for overtime etc).

Group incidence rate—LTI per 10,000 h worked by the group.

Group claims cost rate—claims cost per LTI per 10,000 h worked by the group.

Group duration rate—duration per LTI per 10,000 h worked by the group.

Frequency rate—LTI per hour worked by each cleaner.

Duration rate—Hours lost from LTI per hour worked by each cleaner.

Claims cost rate—Workers’ compensation cost per hour worked by each cleaner.

Age—age at commencement of study (at commencement of intervention all subjects were 4.34 yr older).

Gender—gender of the cleaner.

* If a worker ever returned to work from an LTI, but later lost time or had further costs attributable to that LTI, the event was treated as a recurrence of injury. For recurrent events the associated claims cost and duration were attributed to the original injury. To allow maturation of claims cost and duration after injury and to account for recurrent events, compensation data were not determined until three years after the observational period.

Statistical analysis

Group descriptive intervention data are first presented; to provide an overview of any pre-post change in the claims cost and duration per LTI, as well as the number, claims cost and duration of LTIs per 10,000 h worked collectively.

Individual-level data were then assessed. The number of hours worked provided an indication of individual exposure. Univariate analysis was first utilized, to explore potential changes in injury rates. In view of the skewness of the duration and claims cost rates, a log transformation was undertaken prior to analyses. The log-transformed rates were found to follow approximately a normal distribution.

A Generalized Linear Mixed Models (GLMM) approach was next applied to adjust for the effect of potential confounding variables (age and gender) on pre- and post-intervention MSK and NMSK injury rates. In analysing longitudinal data, the GLMM method has been widely adopted in the statistical literature to handle correlated repeated measures. In the current context, observations were obtained in both pre- and post-intervention for the same subject. The anticipated correlation can be modelled explicitly by random effects attached to each individual within the GLMM formulation. Neglecting such data dependency can lead to biases in the regression coefficients which directly affect the statistical significance of risk factors, resulting in misleading inferences and erroneous conclusions.

To model frequency rate based on the GLMM approach, Poisson distribution with logarithmic link function was assumed, whereas the identity link function was chosen to relate the covariates to the log-transformed duration and claims cost rates. The GLMM analysis was undertaken using the SAS procedure GLIMMIX.

Results

Descriptive statistics

For the cohort of 137 cleaners the mean age at start of study was 37.38 (SD 9.74) and 77% were female. Considerable variation in the amount of hours worked was observed, averaging 4251 h (SD 2250) pre-intervention and 3612 h (SD 1542) post-intervention. The group experienced a total of 59 LTI (46 MSK, 13 NMSK) in the 4.25 yr pre-intervention period and 15 LTI (11 MSK, 4 NMSK) during the 3 yr of intervention. The group incidence, duration, and claims cost rates are presented in Table 1.

No statistical significance can be attached to the pre-post differences. The apparent increase in post NMSK duration and claims cost is due to a particular LTI which incurred 93% and 98%, respectively, of the total duration and claims cost in the post-intervention period.
Table 1. Descriptive statistics at aggregate level

<table>
<thead>
<tr>
<th></th>
<th>MSK</th>
<th>NMSK</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Group incidence rate</td>
<td>0.790</td>
<td>0.222</td>
</tr>
<tr>
<td>Group duration rate*</td>
<td>8.489</td>
<td>7.923</td>
</tr>
<tr>
<td>Group claims cost rate*</td>
<td>5.775</td>
<td>5.130</td>
</tr>
</tbody>
</table>

*Logarithmic scale per 10,000 h worked.

Table 2. Pre- and post-intervention univariate analysis (N=137)

<table>
<thead>
<tr>
<th>LTI nature</th>
<th>Pre-intervention</th>
<th>Post-intervention</th>
<th>Pre-Post</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SE)</td>
<td>Mean (SE)</td>
<td>95% CI</td>
</tr>
<tr>
<td>Frequency rate (per 10,000 h worked)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSK</td>
<td>0.720 (0.134)</td>
<td>0.299 (0.116)</td>
<td>(0.071, 0.770)</td>
</tr>
<tr>
<td>NMSK</td>
<td>0.204 (0.061)</td>
<td>0.078 (0.040)</td>
<td>(-0.021, 0.274)</td>
</tr>
<tr>
<td>Duration rate (logarithmic scale per 10,000 h worked)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSK</td>
<td>2.200 (0.177)</td>
<td>1.617 (0.146)</td>
<td>(0.172, 0.995)</td>
</tr>
<tr>
<td>NMSK</td>
<td>1.427 (0.115)</td>
<td>1.388 (0.111)</td>
<td>(-0.256, 0.336)</td>
</tr>
<tr>
<td>Claims cost rate (logarithmic scale per 10,000 h worked)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSK</td>
<td>2.926 (0.273)</td>
<td>1.816 (0.198)</td>
<td>(0.494, 1.727)</td>
</tr>
<tr>
<td>NMSK</td>
<td>1.668 (0.169)</td>
<td>1.483 (0.148)</td>
<td>(-0.255, 0.625)</td>
</tr>
</tbody>
</table>

Table 3. Intervention incidence rate ratios (95% confidence intervals) based on GLMM analysis (N=137)

<table>
<thead>
<tr>
<th>Frequency rate</th>
<th>Duration rate</th>
<th>Claims cost rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MSK</td>
<td>NMSK</td>
</tr>
<tr>
<td></td>
<td>0.353</td>
<td>0.367</td>
</tr>
<tr>
<td></td>
<td>(0.220, 0.504)</td>
<td>(0.229, 0.589)</td>
</tr>
<tr>
<td></td>
<td>2.359*</td>
<td>4.972*</td>
</tr>
</tbody>
</table>

*variance of random effects.

Injury, claims cost and duration rates

Univariate analysis

The standard paired t test is applied to compare pre and post mean rates, results of which are given in Table 2. While the reductions in MSK mean rates are clearly significant, the observed declines in NMSK mean rates are not.

GLMM analysis

Results showed that other than the pre-post intervention variable, both age and gender are not significantly associated with the response variables. For brevity, only the incident rate ratios for the intervention parameter are reported in Table 3. The intervention has been very successful in reducing both MSK and NMSK injury risk. The post-intervention injury risk is approximately 1/3 of the pre-intervention for both MSK and NMSK LTI. The participatory ergonomics team is also found to be effective in reducing the MSK injury severity, in terms of duration and claims cost rates, with reductions of about 40% and 65% respectively. However, the observed changes in NMSK severity rates are not significant. The variances of random components are generally large, demonstrating the importance of incorporating the random effects in the model for adjusting the within subject variation.

Discussion

In considering the results, it is first noted that univariate analysis is often employed to evaluate the effectiveness of intervention strategies in the occupational health setting. However, such analysis neither adjusts for the potential effects of confounding factors nor accounts for the
underlying correlation structure between observations of
the same subject, which may result in spurious levels of
significance. In this study, findings from univariate analysis
(Table 2) are consistent with those from GLMM (Table
3); except that univariate analysis fails to detect a significant
reduction in NMSK frequency rate, thus incurring a Type
II error as a consequence of the lack of adjustment.

Overall, the results indicate a clear association between
the participatory ergonomics intervention and a reduction
in both risk and severity of MSK injuries. The
simultaneous decline in NMSK frequency rate partly
reflects that, despite the focus on manual handling, other
workplace hazards were considered concurrently by the
team. It also demonstrates that the reduction in
musculoskeletal injuries has not translated to an increase
in risk for other injury types.

This study indicates that the adoption of a consultative
team approach can be effective in reducing the human
and economic burden of such disorders. However, it is
recommended that further longitudinal studies of larger
sample size, and with comparison groups, in a variety of
workplaces, be undertaken to confirm the robustness of
the participatory approach.

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