Evidence-based prevention of musculoskeletal disorders

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Evidence for the work-relatedness of musculoskeletal disorders? - there is lots!

NIOSH (1997) review of more than 600 studies concluded:

“A substantial body of credible epidemiologic research provides strong evidence of an association between MSDs and certain work-related physical factors when there are high levels of exposure and especially in combination with exposure to more than one physical factor (e.g., repetitive lifting of heavy objects in extreme or awkward postures.”

There is compelling evidence from numerous studies that as the amount of biomechanical stress is reduced, the prevalence of musculoskeletal disorders at the affected body region is likewise reduced. This evidence provides further support for the relationship between these work activities and the occurrence of musculoskeletal disorders.
Evidence for the work-relatedness of musculoskeletal disorders? - there is lots!

National Research Council (2001)

“a rich and consistent pattern of evidence that supports a relationship between the workplace and the occurrence of musculoskeletal disorders of the low back and upper extremities. This evidence suggests a strong role for both the physical and psychosocial aspects of work.”

National Research Council (2001). *Musculoskeletal disorders and the workplace: Low Back and Upper Extremities*. Panel on Musculoskeletal Disorders and the Workplace, Commission on Behavioral and Social Sciences and Education; Board on Human-Systems Integration; Institute of Medicine; Division of Behavioral and Social Sciences and Education; National Research Council.
Evidence for the work-relatedness of musculoskeletal disorders? - there is lots!

Review of longitudinal epidemiological investigations (da Costa & Viera, 2010):

“The most commonly reported biomechanical risk factors with at least reasonable evidence for causing WMSD include excessive repetition, awkward postures, and heavy lifting.”

Evidence for the work-relatedness of musculoskeletal disorders? - there is lots!

“strong evidence for an association between shoulder complaints and manual material handling (MMH) ..., vibration ..., trunk flexion or rotation ..., and working with hands above shoulder level ....”

Mayer, J., Kraus, T., & Ochsmann, E. (2012). Longitudinal evidence for the association between work-related physical exposures and neck and/or shoulder complaints: a systematic review. International Archives Occupational and Environmental Health, 85, 587–603
Two, three year longitudinal studies. Sterud & Tynes (2013) concluded:

“highly demanding jobs, prolonged standing and awkward lifting were the most consistent and important predictors of low back pain”

Coenen et al, (2013) followed up 1745 workers and concluded:

“cumulative back loads assessed by video and force measurements is a significant risk factor for low back pain”


Is there a safe lifting technique? and can it be trained?

Full squat increases lumbar compressive force, energy expenditure, quadriceps force & knee instability

“Most controlled studies of training have shown it to be ineffective in reducing accidents and injuries related to lifting” (NIOSH, 1981; p.146)
Is there a safe lifting technique? and can it be trained?

“There is ... no justification for advocating lifting from a full squat posture. ... lifting from semi-squat postures ... allows a pattern of interjoint coordination which appears to be functional in reducing muscular effort. Lifting training is generally ineffective...”

(Burgess-Limerick, 2003)
Evidence for the effectiveness of lifting training? - THERE IS NONE.

“A large-scale, randomized, controlled trial of an educational program to prevent work-associated low back injury found no long-term benefits associated with training.”


“little evidence supporting the effectiveness of technique and educational based manual handling training. There was considerable evidence that principles learnt during training are not applied in the working environment...”

Evidence for the effectiveness of lifting training? - **THERE IS NONE.**

“limited to moderate evidence that, on average, there was **no significant difference** in reports of back pain, back-related disability or absence from work between groups who received training on **proper lifting techniques** and assistive devices and those who received exercise training, back belts or **no training**.”


“the evidence suggests manual handling **training** is **not effective** at causing a change in employee’s manual handling behaviour following training or at reducing WRMSDs.”

If not training, then what?

**Identify** hazardous manual tasks and **eliminate** them.

If the tasks cannot be eliminated, **redesign** them to **reduce exposure** to:

- High exertion
- Awkward postures
- Static tasks
- Repeated similar movements
- Long duration
- Heat, Cold,
- Vibration
- Psychosocial factors
  (eg., stress, time pressure, conflict with peers /)
Redesign opportunities & principles

✔ Work area design
  Work height, space, reach distance, work flow, adjustability

✔ Load design
  Size, shape, weight, stability, location, height

✔ Tool design
  Size, weight, handles, grips, trigger, vibration

✔ Mechanical aids
  Hoists, trolley, conveyers

★ Analyse and **evaluate** MSD risk
★ Estimate likely risk reduction
★ Solutions must be easier & faster, and at least as effective as current practice
★ Document **productivity** cost-benefit
★ Link to business drivers (quality/customer experience)
★ Check for new hazards

**Participation of the workers is key - Participatory Ergonomics**
Participatory what?

Participatory ergonomics means people being actively involved in designing workplace changes which will improve their productivity, safety, and health.

or as John Wilson put it:

“involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes to achieve desirable goals”

Randomized controlled trial of PErforM, a participatory ergonomics intervention designed to reduce the risks of injury associated with manual tasks.

48 small to medium sized workplaces audited by inspectors using ManTRA, then randomly assigned to Experimental and Control groups.

Decreased manual task risks 9 months post-intervention
Evidence for the effectiveness of participatory ergonomics? - There is some.

Reducing Musculoskeletal Risk in Open Cut Coal Mining

**6. COAL SAMPLING**

**BEFORE:**

- **COSTS:** N/A
- **COPYRIGHT:** No
- **DESCRIPTION:** Design Control

Repositioned chute dispensers required amount of coal sample into bucket on raised platform.

**LIMITATIONS & BENEFITS:**

Avoided postures are reduced, platform allows for sliding of bucket rather than picking up, reducing forceful exertions. Some exertion is required to slide bucket along platform due to friction. Reduced friction by improving bucket and/or platform surface will assist with sliding.

Easily retrofitted.

**OTHER APPLICATIONS:**

**SOLUTION:**

- **COSTS:** N/A
- **COPYRIGHT:** No
- **DESCRIPTION:** Design Control

Repositioned chute dispensers required amount of coal sample into bucket on raised platform.

**LIMITATIONS & BENEFITS:**

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**OTHER APPLICATIONS:**

**RISK RATING:**

<table>
<thead>
<tr>
<th>Element</th>
<th>Action</th>
<th>Description</th>
<th>Level</th>
<th>Level</th>
<th>Level</th>
</tr>
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<tbody>
<tr>
<td><strong>Awkward Posture</strong></td>
<td>Neutral</td>
<td>Neutrally uncomfortable</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Forceful Exertions</strong></td>
<td>Neutral</td>
<td>Neutrally uncomfortable</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Exertion</strong></td>
<td>Neutral</td>
<td>Neutrally uncomfortable</td>
<td>4</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**TASK DETAILS:**

Operator bending forward to lift heavy samples of coal in buckets.

**MANUAL TASKS RISK FACTORS:**

Potentiel exertions: lower back, shoulders, hand & arms

Awkward posture: picking up load from ground level.

**OTHER HAZARDS:**

Walking with awkward load increase risk of trip injury

**RISK RATING:**

<table>
<thead>
<tr>
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<th>Level</th>
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<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Awkward Posture</strong></td>
<td>4</td>
<td>1</td>
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<td>4</td>
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<tr>
<td><strong>Exertion</strong></td>
<td>4</td>
<td>1</td>
<td>1</td>
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</tbody>
</table>


2002-2004

Evidence for the effectiveness of participatory ergonomics? - There is some.
Implementation of the Participative Ergonomics for Manual tasks (PErforM) programme at four Australian underground coal mines

Robin Burgess-Limerick\textsuperscript{a}, Leon Straker\textsuperscript{b}, Clare Pollock\textsuperscript{c}, Gary Dennis\textsuperscript{a}, Sue Leverit\textsuperscript{d}, Suzanne Johnson\textsuperscript{e}

\textsuperscript{a}School of Human Movement Studies, The University of Queensland, Australia
\textsuperscript{b}School of Physiotherapy, Curtin University of Technology, Australia
\textsuperscript{c}School of Psychology, Curtin University of Technology, Australia
\textsuperscript{d}Minerals Industry Safety and Health Centre, The University of Queensland, Australia

\textsuperscript{e}E-mail address: robin@hms.uq.edu.au (R. Burgess-Limerick).

Risk assessment

<table>
<thead>
<tr>
<th>Exertion</th>
<th>1 No effort</th>
<th>2</th>
<th>3 Moderate force &amp; speed</th>
<th>4</th>
<th>5 Maximum force or speed</th>
</tr>
</thead>
</table>

Awkward posture

<table>
<thead>
<tr>
<th>Posture</th>
<th>1 All postures neutral</th>
<th>2</th>
<th>3 Moderately uncomfortable</th>
<th>4</th>
<th>5 Very uncomfortable</th>
</tr>
</thead>
</table>

Vibration

<table>
<thead>
<tr>
<th>Vibration</th>
<th>1 None</th>
<th>2</th>
<th>3 Moderate</th>
<th>4</th>
<th>5 Extreme</th>
</tr>
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</table>

Duration

<table>
<thead>
<tr>
<th>Duration</th>
<th>1 &lt; 10 minutes</th>
<th>2</th>
<th>10-30 min</th>
<th>3</th>
<th>30 min – 1 hr</th>
<th>4</th>
<th>1 – 2 hrs</th>
<th>5</th>
<th>&gt; 2 hrs</th>
</tr>
</thead>
</table>

Repetition

<table>
<thead>
<tr>
<th>Repetition</th>
<th>1 No repetition</th>
<th>2</th>
<th>3 cycle time &lt; 30 s</th>
<th>4</th>
<th>5 cycle time &lt; 10 s</th>
</tr>
</thead>
</table>

Lessons learned

- Management commitment & visibility
- Risk analysis & \textbf{evaluation} required
- Site champion role is key
- Supervisor buy-in
- Communication
- Documentation of success (and not)
**Before - Static grinder**

- This task involves welding 2 rail sections together and then grinding the weld so that the rail profile is maintained. Each grind took 5 - 20 mins and there was up to 30 welds per shift.
- The grinder in use had a static grinding mechanism so the worker had to lean over to grind the side of the rail whilst supporting the weight of the 68 kg grinder (pictured). Additionally, lifting the heavy grinder on and off the ruck and carrying it to the track could also be difficult.

  - Hot, humid, localised vibration & sometimes time pressures with limited time for track closures.

**Profile Grinding Train Rail Joints**
A new grinder was constructed, where the grinding disc moved around the rail by turning a wheel whilst the operator stayed upright (pictured), (i.e. no bent over postures are required). The grinder also had an outrigger so the grinder’s weight is self supported at all times.

- More powerful motor which more than doubled productivity.
- Dead man safety switch installed, and an electric motor to wind the grind head down, with a ‘set button’ so that the maximum depth can be set to prevent ‘dipping’ the rail (i.e. less error).

### Risk Reductions

<table>
<thead>
<tr>
<th>Body Part</th>
<th>Acute</th>
<th>Cumulative</th>
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</thead>
<tbody>
<tr>
<td>Shoulders</td>
<td>0%</td>
<td>30%</td>
</tr>
<tr>
<td>Arms</td>
<td>67%</td>
<td>53%</td>
</tr>
<tr>
<td>Back</td>
<td>75%</td>
<td>61%</td>
</tr>
<tr>
<td>Legs</td>
<td>33%</td>
<td>38%</td>
</tr>
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</table>

**Legend**
- low
- moderate
- high
- extreme
- S shoulders
- A arms
- B back
- L Leg

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### LAYING BITAC TAPE ON ASPHALT

**Before - Laying tape manually**

- BiTac multi-laminate tape is used across structural joints in the asphalt mat, which is often laid over many kilometres.
- E.G. - Cooroy/Bielby project required 64 km of tape to be laid.
- Each 36 m long roll weighs 11.5 kg. (Note: 64 km = 1,700+ rolls).
- A minimum 2-person task with one worker holding the roll and walking backwards with an awkward crouched posture, whilst the other worker retrieves the used backing tape for disposal.
- 5 - 7 mins per roll, for 2 - 3 hours at a time, every 2 weeks.

**After - Laying with the new ‘RollRunner’ trolley**

- A customised 3-wheeled trolley was developed by Kockums from design controls developed by Boral workers and a ‘Viva - Health at work’ ergonomist during a participative ergonomics workshop.
- The new (and relatively inexpensive) control not only drastically reduced the risk of musculoskeletal injury, but also had significant reductions in the time required to lay the product.

### Risk Reductions

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<tr>
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### Exertion Exposure Posture Movement

**ErgoAnalyst Report: Gary - BiTac Trolley**

**Proposed Control Risk Analysis: Kockums Trolley**

**Exertion Exposure Posture Movement**

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<th></th>
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<tbody>
<tr>
<td>Shoulders</td>
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<td></td>
</tr>
<tr>
<td>Arms</td>
<td>5 / 8</td>
<td></td>
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**ViVA HEALTH at WORK**

KOCKUMS Bulk Systems
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RIO TINTO WEIPA: The Value Proposition of Good Work Design

Sara Pazella, Robin Burgess-Limerick, Tim Horberry, Gary Dennis, and Christian Wakeling

a Minerals Industry Safety Health Centre, University of Queensland, St Lucia, Queensland, AUSTRALIA,
b Monash University Accident Research Centre, Monash University, Melbourne, AUSTRALIA
c ErgoEnterprises; d Rio Tinto Weipa

ABSTRACT

Investigations were undertaken at a North Queensland mining organisation with a high level of maturity associated with good work design and participatory ergonomics practices. Lead and lag indicator reports and industry award reports were reviewed. Semi-structured and unstructured interviews were conducted with management, program coordinators and workers during a site visit. A formative process was undertaken during the investigation to determine achievements and areas for improvement, with retrospective review and consensus achieved from organisation representatives at various levels of management. Two case studies were highlighted in this paper to illustrate their good work design initiatives, one describing hand injury reduction rates and the other addressing biomechanical risk reduction for low back injury.

INTRODUCTION

What is Good Work Design?

Good Work Design represents work that provides for harmonious safe, health, and productive work that also supports the creative contributions of a diverse work team. It is underpinned by the tenets of human centred design and participative ergonomics, and advances Total Worker Health® (Sorensen et al, 2016).

Good Work Design encompasses and provides for:

1. Critical event management
2. Significant task, equipment, and work systems design or re-design
3. Strategies to optimise health & well-being
4. Social connection
5. The attainment of enterprise goals for good business performance (throughout the supply chain)
6. Good governance supported by effective knowledge systems
7. The promotion of social and environmental sustainability

To achieve good work design we need to know what “good” looks like. One may extend this line of thinking to ask: at what point have we achieved optimum performance and can it get any better?

To advance good work design, we may strive to understand the elements that contribute to positive performance. There are a range of variable circumstances such as the inherent nature of humans,
Successfully Implementing a Global Participative Ergonomics Program across Rio Tinto

Gary Dennis PhD CPE, Robin Burgess-Limerick PhD CPE and Ian Firth MSc FAIOH COH

History
Rio Tinto Alumínium (RTA) implemented the ErgoAnalyst Participative Ergonomics program in 2010 and it was adopted as the preferred level 3 assessment tool to address musculoskeletal and hand injuries across Rio Tinto globally in 2011. In subsequent years ErgoAnalyst has been adopted by the Coal, Iron Ore, Minerals, Ports and Technology businesses in 34 sites across Australia, North America, Europe and Africa.

Implementing the ErgoAnalyst Program
Selected Rio Tinto OH&S staff were trained by ErgoEnterprises to become EA-Facilitators via a range of 1 and 3 day face-to-face training packages that were supported by on-line training videos and resource materials. These EA-Facilitators then facilitated the identification, assessment and control processes in consultation with the workers as ‘task experts’. Additional training to become an EA-Specialist was also available so that they could train their own staff ‘in-house’. The ErgoAnalyst process (below) was then used to develop effective controls for the ‘Top 5’ hazardous tasks in each work area per year, and shared through the ErgoAnalyst database and a Rio Tinto elboom via 3-page ‘Green Banners’ that describe and illustrate the benefits of the control.

ErgoAnalyst Process

Number of Tasks Analysed using ErgoAnalyst per Year

Sharing Solutions: ‘Green Banners’
265 solutions with 1-page ErgoAnalyst pre-post risk analyses have been developed and shared across Rio Tinto via the elboom, primarily from the Bauxite and Alumina (B&A) sites of RTA.

Injury Statistics

Results
Between 300 and 400 manual tasks have been assessed each year and the number of tasks that have had effective controls implemented has steadily increased, exceeding 200 in 2014. Over the same time period there have been decreases in musculoskeletal injuries and illnesses and these decreases have been greatest at sites where ErgoAnalyst has been most actively used to develop controls (e.g. RTA - B&A, see graph above). There have also been significant productivity benefits associated with many of these controls. Additionally, when these controls are shared these benefits can be easily replicated throughout the company without the need to re-analyse the task.

Elements Essential to Success
• Standardised risk assessment process across the business.
• Training that allowed OH&S staff to internally implement the system with improved understanding of what causes injury and how to facilitate effective risk assessments and controls development.
• Visual tool that engages the workers and allows them to understand the factors that cause both acute and cumulative risk, so that they can become involved in risk assessment and controls development.
• KPIs set to address the ‘Top 5’ hazardous tasks for each area per year.
• A centralised data-base to document and share across the business.

What is required next?
Ensure that even more controls are shared across the business (and externally where appropriate) via the 1-page ‘Green Banners’.

International Ergonomics Association
19th Triennial Congress. Melbourne, 9-14 August, 2015
Evidence for the effectiveness of participatory ergonomics? - There is some.

“participatory approaches were often but not always successful”
Silverstein & Clark (2004) Interventions to reduce work-related musculoskeletal disorders. J. Electromyography & Kinesiology, 14, 135-152

“PE interventions had a small, positive impact on musculoskeletal symptoms”

“A PE approach can improve risk factors related to WRMSD, and meaningful worker participation in the process is an important aspect for the success of such interventions.”
Evidence for the effectiveness of participatory ergonomics? - There is some.

“partial to moderate evidence that PE interventions have a positive impact on: musculoskeletal symptoms, reducing injuries and workers' compensation claims, and a reduction in lost days from work or sickness absence.”


“a systematic approach to ergonomic hazard identification, quantification and control implementation, in conjunction with requirements to establish an ergonomic process at each manufacturing plant, may be effective in reducing risk of MSD and acute injury outcomes among workers in targeted jobs”

Ingredients for preventing musculoskeletal disorders

- management commitment, at all levels = resources
- a participatory process to eliminate, or redesign, hazardous tasks
- risk analysis, evaluation, and communication tools
- training for participants and facilitators (site champions)

Management commitment is the most important factor. Senior management commitment is essential but not sufficient. Middle management and supervisors must be on-board, and stay on board.
Participatory ergonomics: Evidence and implementation lessons

Robin Burgess-Limerick

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Thank you

Robin Burgess-Limerick PhD CPE FHFESA

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