SMI MISHC
Minerals Industry Safety
& Health Centre

# Evidence-based practice for the prevention of work-related MSDs: A Personal Journey

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

Extensive review by NIOSH in 1997. The 591 page document included detailed analysis of more than 600 studies. The conclusions included:

"*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**.*"

Bernard, B.P. (Ed) (1997). *Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back*. DHHS (NIOSH) Publication 97-141.

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

US National Research Council (1998):

"*The positive relationship between the occurrence of musculoskeletal disorders and the conduct of work is clear.*"

*"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****.*"

National Research Council (1998). *Work-Related Musculoskeletal Disorders: A Review of the Evidence. Steering Committee for the Workshop on Work-Related Musculoskeletal Injuries: The Research Base*, Committee on Human Factors, National Research Council.



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

National Research Council again (2001)

"*The positive relationship between the occurrence of musculoskeletal disorders and the conduct of work is clear.*"

*"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!**

A more recent review (da Costa & Viera, 2010) restricted to longitudinal epidemiological investigations concluded that:

"*Risk factors with at least reasonable evidence of a causal relationship for the development of work-related musculoskeletal disorders include:* ***heavy physical work****....*

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

da Costa, B.R., & Viera, E.R. (2010). Risk factors for work-related musculoskeletal disorders: A systematic review of recent longitudinal studies. *American Journal of Industrial Medicine, 53*, 285-323.



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

Most recent evidence is from two three year longitudinal studies. Sterud & Tynes (2013) concluded that:

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

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

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


Sterud, T., Tynes, T., (2013). Work-related psychosocial and mechanical risk factors for low back pain: a 3-year follow-up study of the general working population in Norway. *Occupational and Environmental Medicine, 70*, 296-302.

Coenen, P., Kingma, I., Boot, C., Twist, J., Bongers, P., & van Dien, J. (2013). Cumulative Low Back Load at Work as a Risk Factor of Low Back Pain: A Prospective Cohort Study. *Journal of Occupational Rehabilitation, 23*, 11-18.

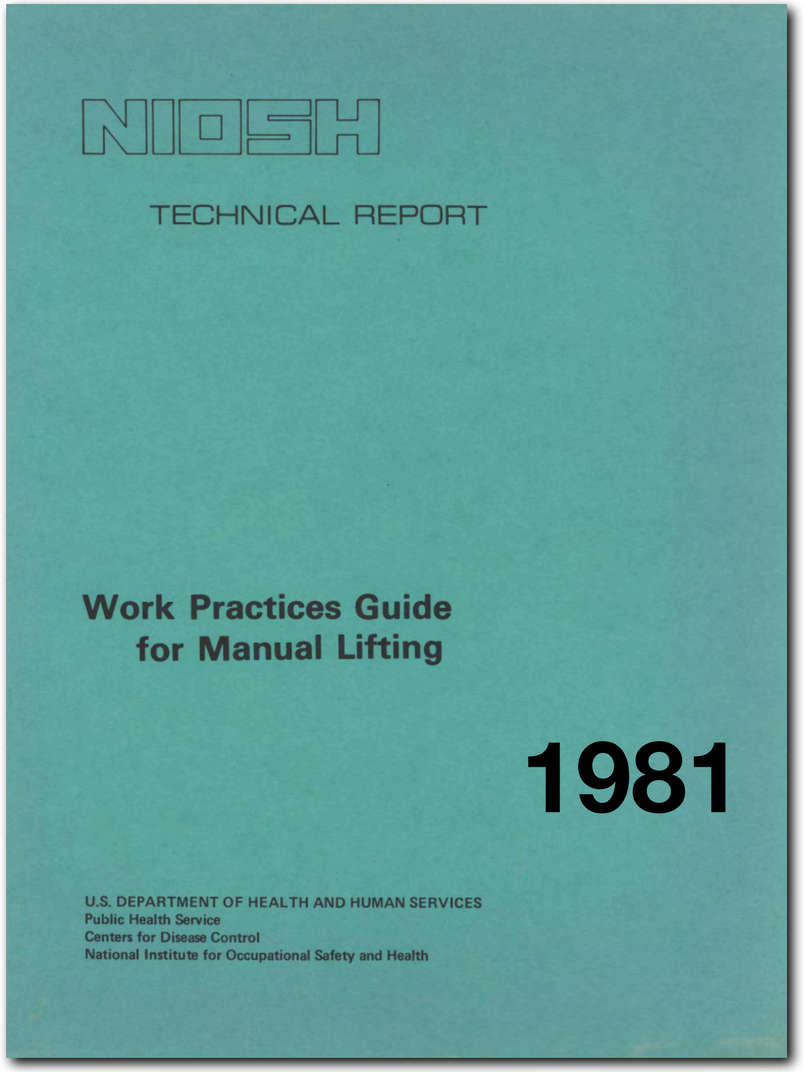



# How can work-related musculoskeletal disorders be prevented?

## “Safe lifting” training is common - does it work?



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



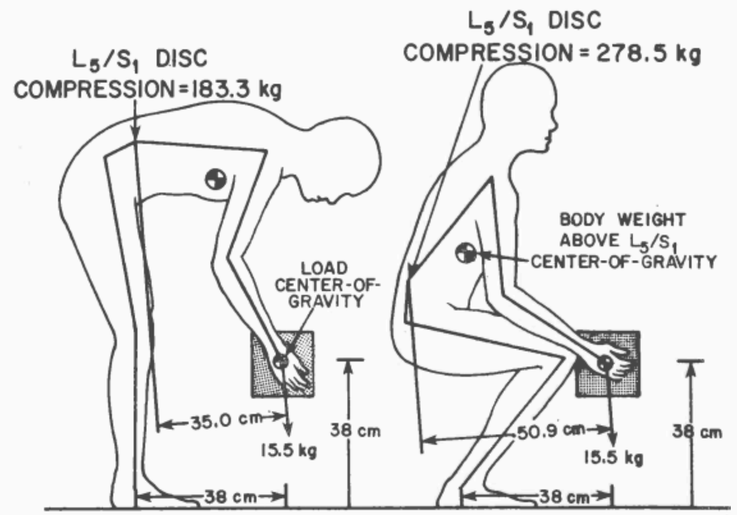




Figure 3.8: Low Back Compression Associated with Two Lifting Postures (Park and Chaffin, 1974).

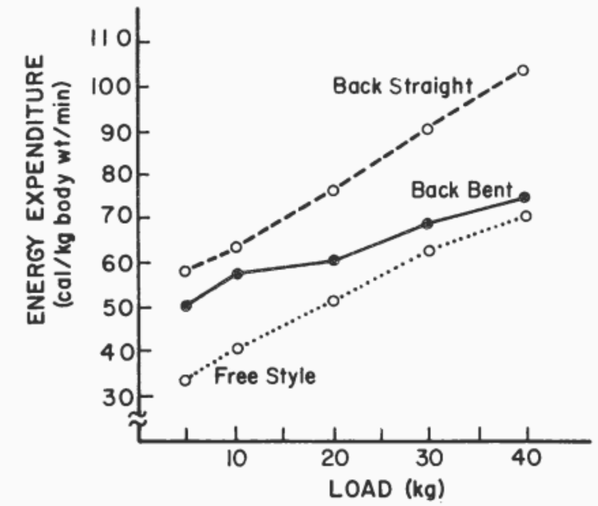



Figure 4.3: Metabolic Rate for Different Postures (Brown, 1971).

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?

HUMAN FACTORS, 1995, 37(2), 395–411

Self-Selected Manual Lifting Technique: Functional Consequences of the Interjoint Coordination

ROBIN BURGESS-LIMERICK,[1] BRUCE ABERNETHY, ROBERT J. NEAL, *and* VAUGHAN KIPPERS, *University of Queensland, Australia*

ELSEVIER

International Journal of Industrial Ergonomics 31 (2003) 143–148

International Journal of Industrial Ergonomics

www.elsevier.com/locate/ergon

Squat, stoop, or something in between?

Robin Burgess-Limerick*

*School of Human Movement Studies, The University of Queensland, Brisbane, Qld. 4072, Australia*



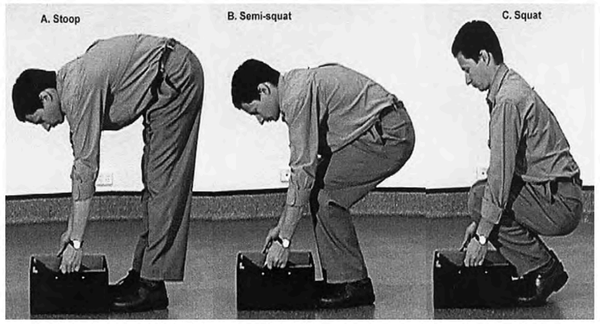



Fig. 1. Demonstration of a stooped posture (A), a semi-squat posture (B), and a full squat posture (C).

HUMAN FACTORS, 1997, 39(1), 141–148

Toward a Quantitative Definition of Manual Lifting Postures

ROBIN BURGESS-LIMERICK[1] *and* BRUCE ABERNETHY, *University of Queensland, Australia*

ELSEVIER

International Journal of Industrial Ergonomics 22 (1998) 367–372

International Journal of Industrial Ergonomics

Effect of load distance on self-selected manual lifting technique

Robin Burgess-Limerick*, Bruce Abernethy

*Department of Human Movement Studies, University of Queensland, Brisbane, Queensland 4072, Australia*

"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**."

Daltroy et al (1997). A controlled trial of an educational program to prevent low back injuries. *New England Journal of Medicine, 337*, 322-328.

"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..."

Haslam et al. (2007) *Manual handling training. Investigation of current practices and development of guidelines*. http://www.hse.gov.uk/research/rrhtm/rr583.htm



# 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**."

Martimo et al. (2007) Manual material handling advice and assistive devices for preventing and treating back pain in workers. *Cochrane Database of Systematic Reviews 2006*, Issue 2. http://www.cochrane.org/reviews/en/ab005958.html

"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."

Hogan, et al., (2014). The effect of manual handling training on achieving training transfer, employee's behaviour change and subsequent reduction of work-related musculoskeletal disorders: a systematic review. *Ergonomics, 57*, 93-107.



# If not training, then what?

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

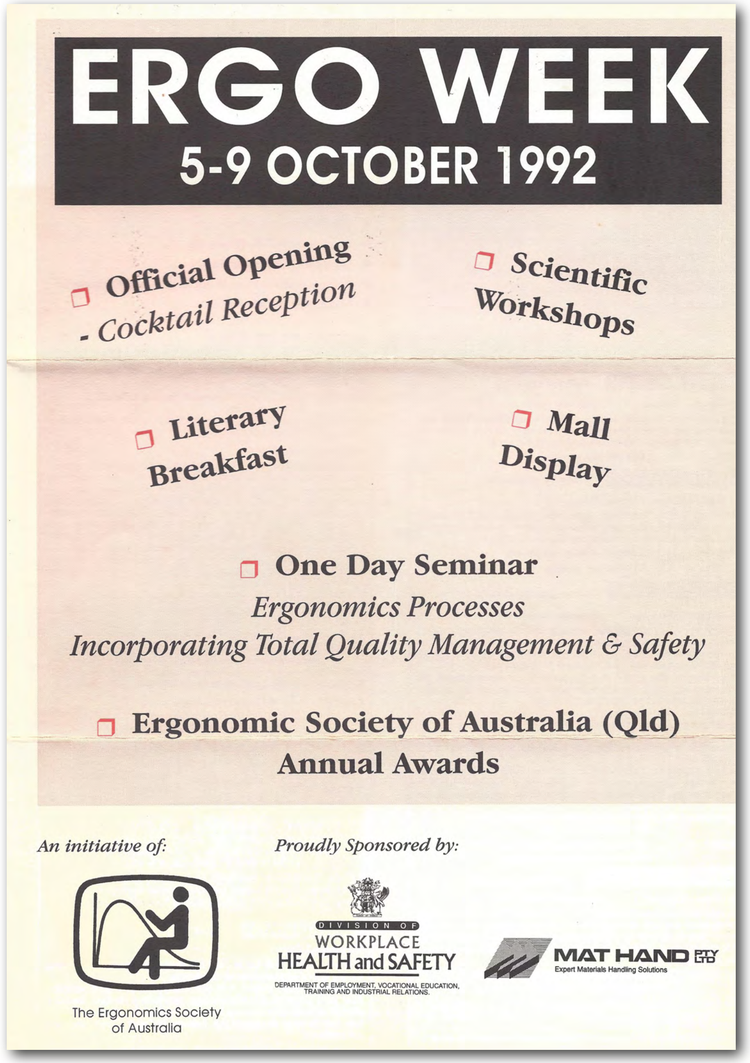
If the potentially harmful tasks cannot be eliminated, **redesign** the tasks to **reduce exposure to** the task characteristics which increase injury risk

- High exertion
- Awkward postures
- Static or repeated similar movements
- Long duration
- Heat, Cold, Vibration
- Stress, time pressure

Ensure participation of those involved - **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*"

Wilson, J.R. (1995). Ergonomics and participation. In Wilson, J.R., & Corlett, E.N. (Eds.), Evaluation of Human Work (2nd ed.). Taylor and Francis, London.



# Evidence for the effectiveness of participatory ergonomics? **- There is some.**

ERGONOMICS, 5 FEBRUARY, 2004, VOL. 47, NO. 2, 166–188

Taylor & Francis
Taylor & Francis Group

**A randomized and controlled trial of a participative ergonomics intervention to reduce injuries associated with manual tasks: physical risk and legislative compliance**

L. STRAKER†*, R. BURGESS-LIMERICK‡, C. POLLOCK§ and R. EGESKOV¶

†School of Physiotherapy, Curtin University of Technology, Australia

‡School of Human Movement Studies, The University of Queensland, Australia

§School of Psychology, Curtin University of Technology, Australia

¶Department of Industrial Relations, Queensland, Australia

THE UNIVERSITY OF QUEENSLAND AUSTRALIA · Queensland Government Department of Industrial Relations · Curtin University of Technology · WorkCover QUEENSLAND · Australian Government National Health and Medical Research Council

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

**2000-2004**

# Evidence for the effectiveness of participatory ergonomics? **- There is some.**

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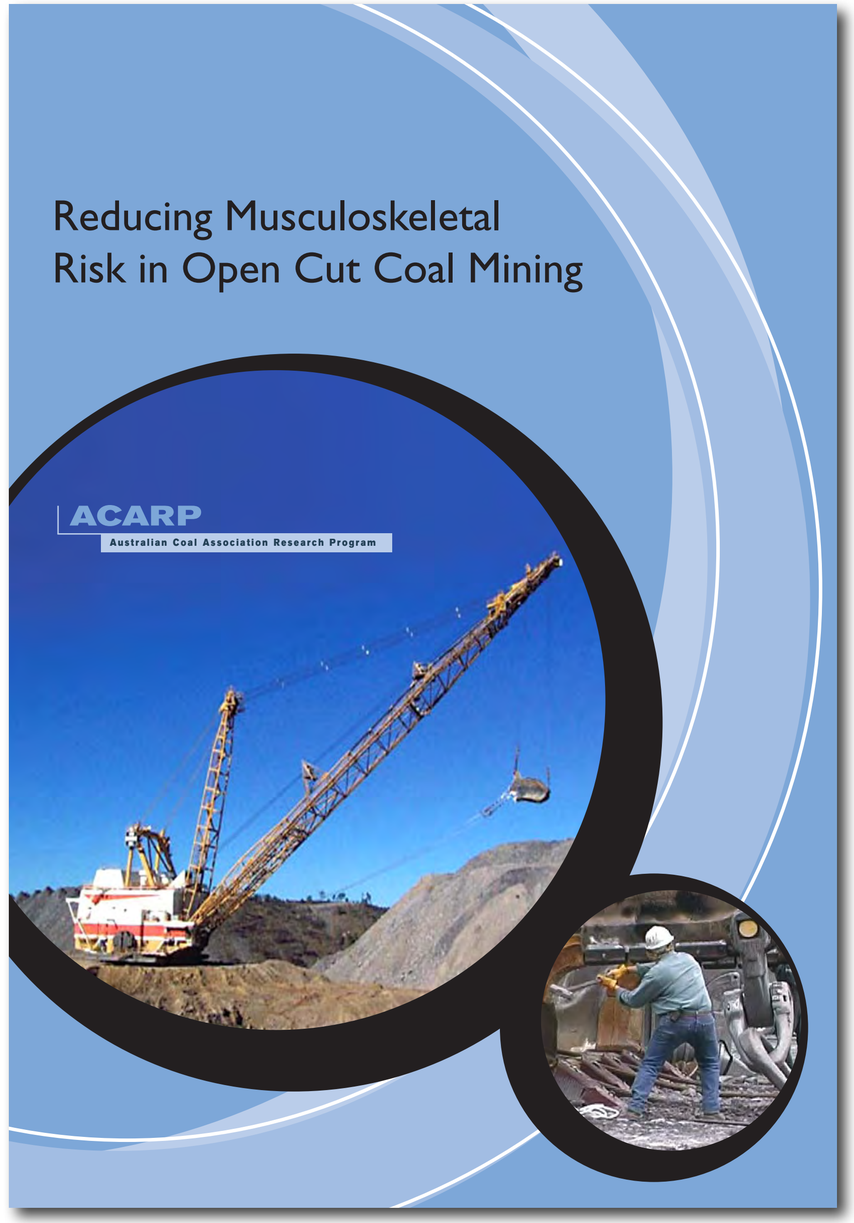
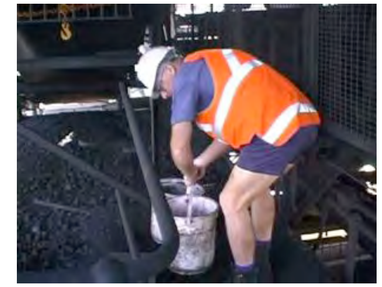
Burgess-Limerick, R., Leveritt, S., Nicholson, M & Straker, L. (2004). Australia Coal Association Research Program project C11058

**2002-2004**




## 6. COAL SAMPLING

***BEFORE:***



***TASK DETAILS:***
Operator bending forward to lift heavy samples of coal in buckets.

***MANUAL TASKS RISK FACTORS:***
Forceful 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:***

| | | | | |
|---|---|---|---|---|
| EXERTION | | | | |
| 1 None | 2 | 3 Moderate | 4 | 5 Maximum |
| AWKWARD POSTURE | | | | |
| 1 Neutral | 2 | 3 Moderately uncomfortable | 4 | 5 Very uncomfortable |
| VIBRATION | | | | |
| 1 None | 2 | 3 Moderate | 4 | 5 Extreme |
| DURATION: MINUTES | | | | |
| 1 < 10 min | 2 10-30min | 3 30 min – 1 hr | 4 1 – 2 hrs | 5 > 2 hrs |
| REPETITION | | | | |
| 1 None | 2 | 3 cycle time < 30 s | 4 | 5 cycle time < 10 s |

***SOLUTION:***

*COSTS: N/A* *COPYRIGHT: No*

***DESCRIPTION:*** Design Control
Repositioned chute dispenses required amount of coal sample into bucket on raised platform.

***LIMITATIONS & BENEFITS:***
Awkward 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:***

***RISK RATING:***

| | | | | |
|---|---|---|---|---|
| EXERTION | | | | |
| 1 None | 2 | 3 Moderate | 4 | 5 Maximum |
| AWKWARD POSTURE | | | | |
| 1 Neutral | 2 | 3 Moderately uncomfortable | 4 | 5 Very uncomfortable |
| VIBRATION | | | | |
| 1 None | 2 | 3 Moderate | 4 | 5 Extreme |
| DURATION: MINUTES | | | | |
| 1 < 10 min | 2 10-30min | 3 30 min – 1 hr | 4 1 – 2 hrs | 5 > 2 hrs |
| REPETITION | | | | |
| 1 None | 2 | 3 cycle time < 30 s | 4 | 5 cycle time < 10 s |

# Evidence for the effectiveness of participatory ergonomics? **- There is some.**

ELSEVIER

Available online at www.sciencedirect.com
ScienceDirect

International Journal of Industrial Ergonomics 37 (2007) 145–155

International Journal of INDUSTRIAL ERGONOMICS
www.elsevier.com/locate/ergon

## Implementation of the Participative Ergonomics for Manual tasks (PErforM) programme at four Australian underground coal mines

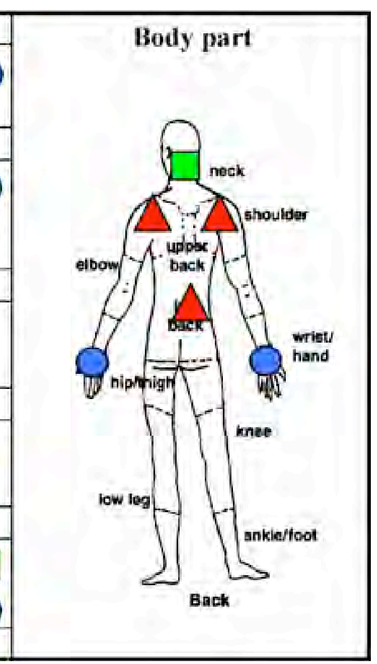
Robin Burgess-Limerick[a,*], Leon Straker[b], Clare Pollock[c], Gary Dennis[a], Sue Leveritt[d], Suzanne Johnson[a]

[a]*School of Human Movement Studies, The University of Queensland, Australia*
[b]*School of Physiotherapy, Curtin University of Technology, Australia*
[c]*School of Psychology, Curtin University of Technology, Australia*
[d]*Minerals Industry Safety and Health Centre, The University of Queensland, Australia*

Available online 11 December 2006

### Risk assessment

| Exertion | | | | |
|---|---|---|---|---|
| 1 No effort | 2 | 3 Moderate force & speed | 4 | 5 Maximum force or speed |
| **Awkward posture** | | | | |
| 1 All postures neutral | 2 | 3 Moderately uncomfortable | 4 | 5 Very uncomfortable |
| **Vibration** | | | | |
| 1 None | 2 | 3 Moderate | 4 | 5 Extreme |
| **Duration** | | | | |
| 1 < 10 minutes | 2 10-30 min | 3 30 min – 1 hr | 4 1 – 2 hrs | 5 > 2 hrs |
| **Repetition** | | | | |
| 1 No repetition | 2 | 3 cycle time < 30 s | 4 | 5 cycle time < 10 s |




## Lessons learned

- ☑ Management commitment & visibility
- ☑ Risk analysis & evaluation required
- ☑ Site champion role is key
- ☑ Supervisor buy-in
- ☑ Communication
- ☑ Documentation success (and failures)

CS Health & Safety Trust

**2002-2005**

# Evidence for the effectiveness of participatory ergonomics? **- There is some.**

Vulcan Materials (USA)

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NIOSH National Institute for Occupational Safety and Health

Vulcan Materials Company

CDC Workplace Safety and Health

IC 9509 INFORMATION CIRCULAR/2009

2009

**Ergonomics Processes**
Implementation Guide and Tools for the Mining Industry


Department of Health and Human Services
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

NIOSH

2006-2007

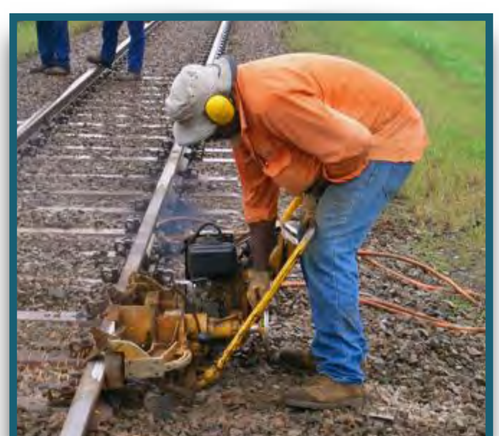
THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

SMI MISHC
Minerals Industry Safety & Health Centre

# PROFILE GRINDING TRAIN RAIL JOINTS

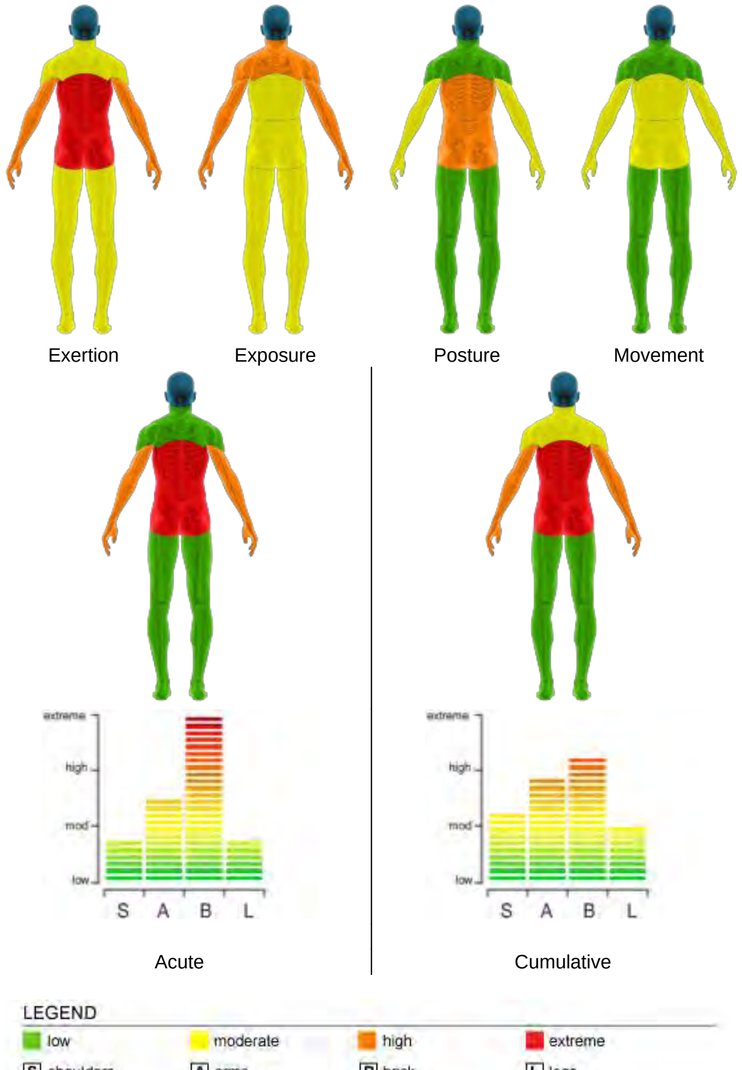
## Before - Static grinder

- 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 wight 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.

***Pinch Point***




QueenslandRail

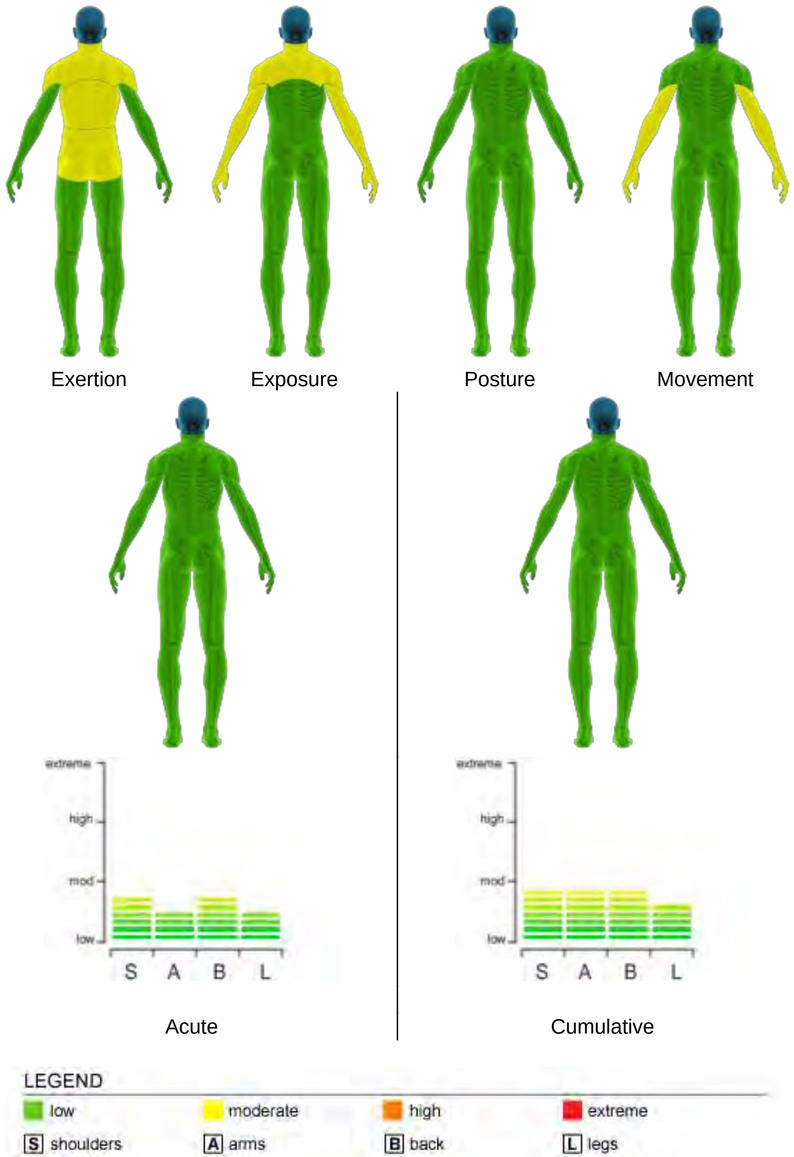
ERGO ANALYST

# After - New grinder with a movable grinding disc

- 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

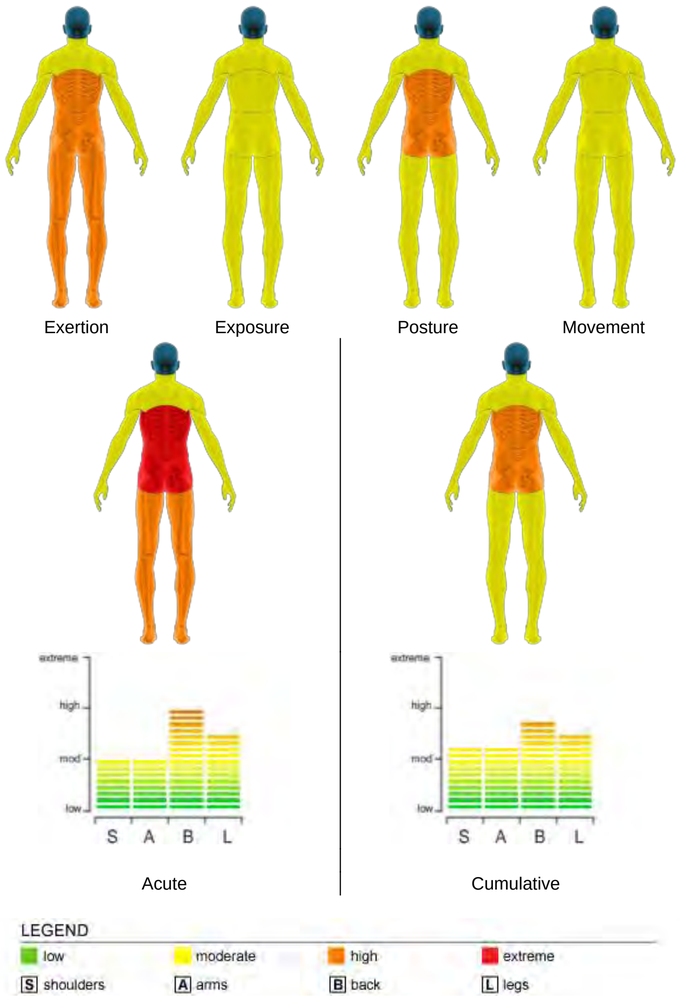
| | Acute | Cumulative |
|---|---|---|
| Shoulders : | 0% | 30% |
| Arms : | 67% | 53% |
| Back : | 75% | 61% |
| Legs : | 33% | 38% |



# 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.

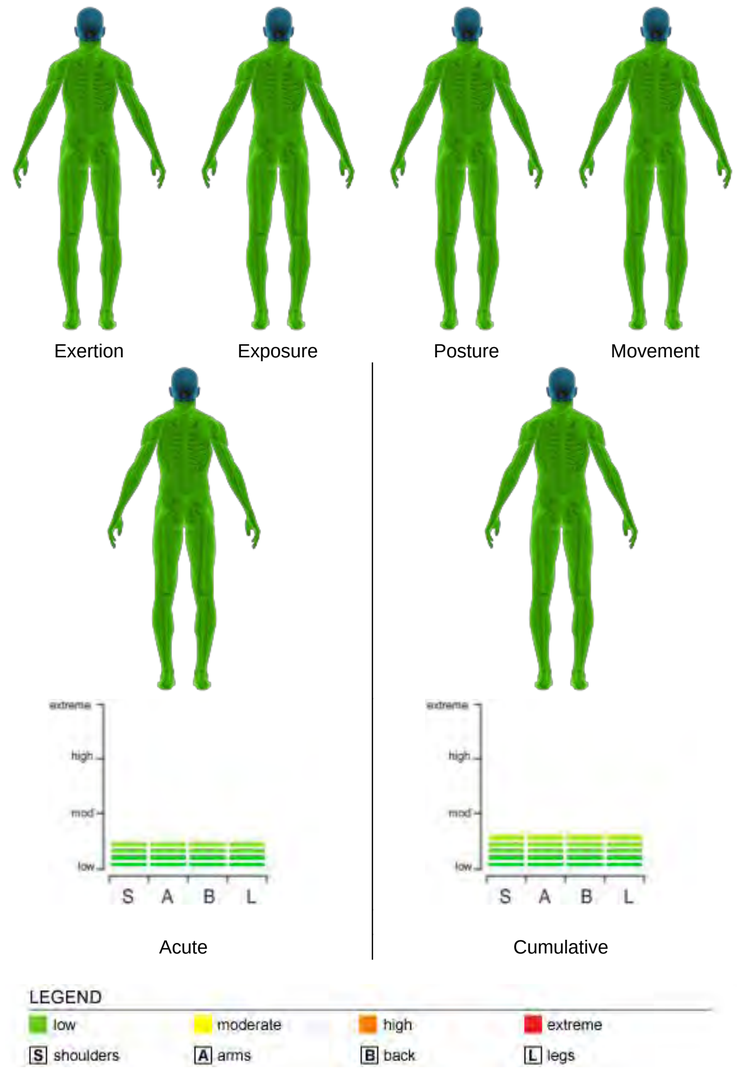


# After - Laying with the new 'RollRunner' trolley

- 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

| | Acute | Cumulative |
|---|---|---|
| Shoulders : | 50% | 50% |
| Arms : | 50% | 50% |
| Back : | 75% | 64% |
| Legs : | 67% | 58% |



# 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"

Cole et al (2005) *Effectiveness of participatory ergonomic interventions: A systematic review.* Institute for Work and Health, Toronto.

"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."

Rivilis et al (2006). Evaluation of a participatory ergonomic intervention aimed at improving musculoskeletal health. *Am. J Ind. Med, 49*, 801-810.



# 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."

Rivilis et al (2008). Effectiveness of participatory ergonomic interventions on health outcomes: a systematic review. *Applied Ergonomics, 39*, 342-358.

"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"

Cantley, et al., (2014). Effect of systematic ergonomic hazard identification and control implementation on musculoskeletal disorder and injury risk. *Scandinavian Journal of Work Environmental Health, 40*, 57–65.



# Why are participatory approaches "**often but not always successful**"?

ERGO ENTERPRISES

## 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

Contact : gdennis@ergoenterprises.com.au or via www.ergoanalyst.com

RioTinto

### History

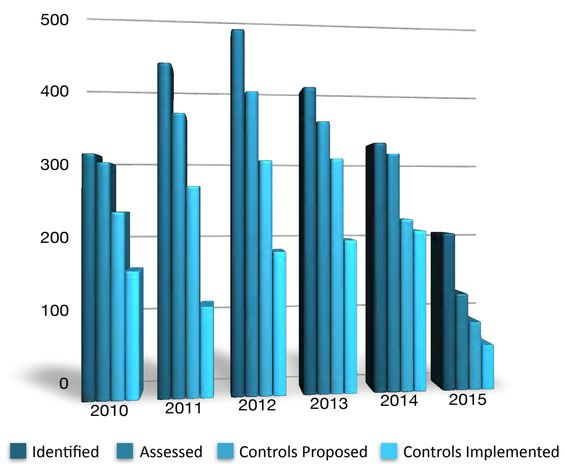
Rio Tinto Aluminium (RTA) implemented the ErgoAnalyst Participative Ergonomics program in 2010 and it was adopted as the preferred level 3 assessment tool to address musculoskeletal and hand injuries across Rio Tinto globally in 2011. In subsequent years ErgoAnalyst has been adopted by the Coal, Iron 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 eRoom via 1-page 'Green Banners' that describe and illustrate the benefits of the control.

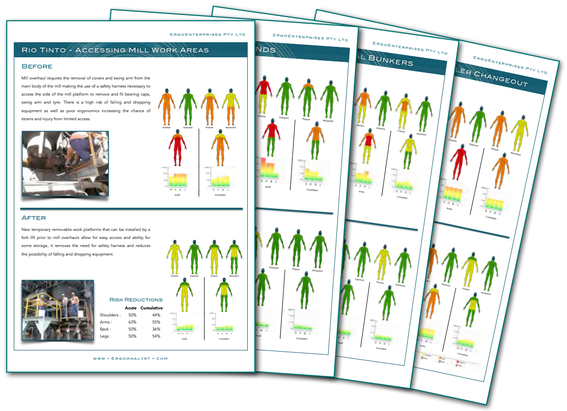
### ErgoAnalyst Process


### Number of Tasks Analysed using ErgoAnalyst per Year

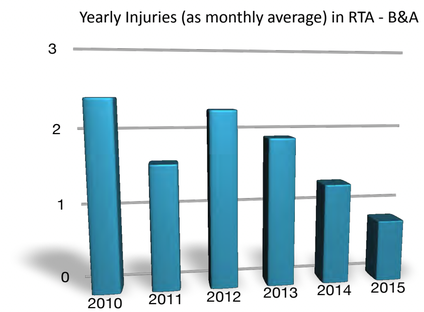



### Sharing Solutions : 'Green Banners'

265 solutions with 1-Page ErgoAnalyst pre-post risk analyses have been developed and shared across Rio Tinto via the eRoom, 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
http://ergonomics.uq.edu.au/download/IEA2015poster.pdf

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# RIO TINTO WEIPA: The Value Proposition of Good Work Design

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# RioTinto Weipa

## Good Work Design Survey

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- 1200 workers
- 20 trained manual tasks assessors
- Target of 30 task re-designs per year
- Communicate, Celebrate

## Ingredients for preventing musculoskeletal disorders (and improving productivity)

- ☑ 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.

Copy of slides at: http://ergonomics.uq.edu.au/download/MSDkeynote.pdf