MUSCULOSKELETAL DISCOMFORT IN CRANE AND FORKLIFT OPERATORS IN A NEW ZEALAND PORT

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ABSTRACT

A Port Nelson health and safety advisor raised musculoskeletal discomfort concerns for the operators of port cranes and forklifts, suspecting under-recognition of the risks and room to learn from international efforts for mitigation. A range of vehicles used for loading and unloading containers from ships and moving containers around the dockyard are driven 24 hours, 7 days per week, as per the demands of shipping schedules, weather, tides and goods transportation. The NZ Department of Labour's Musculoskeletal Panel provided funding for literature review, work system assessment, and the identification of possible interventions for this work group. It was recognised that the operators of other (non-port) machinery may also be implicated.

NZ injury data indicated that crane operators have high rates of reported musculoskeletal disorders (arm, neck, shoulder and lower back). Literature suggested that operator discomfort is a known problem with recognised risk factors including whole body vibration and positioning. Work system assessment (n = 6) identified a mature and skilled operator workforce; with on-job training as standard. Neck, shoulder and hip/thigh/buttock pain was prevalent, with wrist/hand, lower back, knee, and upper back discomfort also common. Work was often on-call, and shifts and work periods were long with little task variety, for up to 65 hours per week. Education for the prevention and self-management of discomfort was not covered in training, with evidence for only informal/anecdotal methods of coping with risks.

The interventions identified for addressing discomfort risks included: the development of effective workplace systems for recognising and mitigating discomfort risks; addressing work patterns; factors around the design, maintenance and use of equipment/seating; and manager/worker education in best practice for discomfort prevention and management. Consequent to completion of this work an across-industry resource targeting cabin-based operators is in production.

KEY WORDS

Musculoskeletal discomfort; crane operator; forklift operator; cabin operations; work system; port industry.

INTRODUCTION

An experienced Port Nelson health and safety advisor recognised that operators of high stackers, cranes, forklifts and on-ship cranes are exposed to physical demands that may place them at risk of musculoskeletal discomfort (MSD) related to work activities. He believed that the sustained and constrained arm and hand postures of

bilateral joystick operation, in conjunction with a range of head up, head down and/or head turned postures (depending on the machinery and task) were placing operators at risk of MSD. This health and safety advisor acknowledged that the MSD risk factors were poorly understood within the New Zealand port industry, and potentially in other industries where similar machine operation tasks are performed. Modest funding was consequently obtained from the Department of Labour's Musculoskeletal Panel to investigate MSD risks for crane and forklift operators (CFOs) in ports, and to gain an understanding of the international recognition and mitigation of such risks.

It is noted that the term 'musculoskeletal disorder' (MSD) is used as an overarching description that is inclusive of musculoskeletal discomfort or pain, and more specific injury diagnoses. Such discomforts, pains or injuries are of a 'muscles and bones' origin, where the problem has come on over time, or perhaps appears to have been traumatic but is likely related to cumulative exposure to a range of contributory factors. This fits with the contemporary 'discomfort, pain and injury' context promoted by ACC.

METHOD

A three stage approach was used for this study. Literature review included the analysis of New Zealand injury data (ACC), and identifying the numbers of crane and forklift drivers in the country. Port operations were reviewed via a range of internet and literature sources, and the equipment typically used in New Zealand ports was identified. An ergonomics literature search was completed to understand what is currently known about the MSD risks of port machine operators and to identify international design activities and standards of relevance.

Following literature review, a work system assessment was completed to identify MSD risk factors for CFOs in the port environment. This included interviews with (n = 6) CFOs to gather a range of subjective data around age, work experiences, work hours, and perceptions of discomfort; and to consider their perceptions of discomfort causes and likely means of resolution. Discomfort questionnaires, musculoskeletal assessment, and anthropometric data gathering were completed, and CFOs were observed carrying out work tasks. Video and photographic recording allowed later postural analyses. System reviews with management staff allowed an understanding of port health and safety processes, and knowledge of current industry best practice for addressing MSD within the workplace.

The final stage was integration of the literature review and work system assessment findings to identify the contributory factors NZ CFOs are exposed too. This allowed development of a range of intervention recommendations.

FINDINGS

Literature Review

Crane and forklift operator numbers

The number of NZ crane and forklift operators was estimated from a number of sources. Statistics NZ identified 18 industry classification groups that include crane operators, and 20 that include forklift operators. Using 2007 data and taking the two 'most relevant' groups for each job type estimated a possible 2,530 crane operators

and 4,360 forklift operators. New Zealand Transport Agency figures for forklift endorsements (Class 1 or Class 2) identified almost 162,000 'F' endorsements. Crane operators are not required to have a license or endorsement, but two NZ Qualifications Authority National Certificates cover crane operation (one specific to piling and foundation operations, and the other more generic with strands in mobile, overhead and tower crane operation). It was estimated that perhaps 500 people had completed the NZQA qualification, with the further estimation of approximately 900-1000 mobile crane operators, and 120-150 tower crane operators. Industry Training Organisation (Tranzqual) sources showed that for 'stevedoring services' and 'port and water transport terminal operations' a total of 72 people were employed as crane, hoist or lift operators, and 72 were forklift drivers (2008 data).

These findings suggest that there is around 1,092-1,222 crane operators (with about 72 in ports), and 162,000 forklift operators nationwide. It is acknowledged that forklift operators may be found in a wide variety of workplaces with some likely to operate forklifts only intermittently, and others intensively and for long durations.

NZ ports and equipment

The 12 NZ ports (Whangarei, Auckland, Tauranga, Napier, Wellington, New Plymouth, Nelson, Lyttelton, Westport, Timaru, Dunedin, and Bluff) were reviewed via the internet. Most ports operate on a 24 hour day, 365 days per year basis, and the ports vary in size and capacity. Port functioning is impacted by tides, weather, seasonal demands and shipping schedules.

Whilst all ports appear to have forklifts, some ports have no immediately available cranes and require vessels to have their own cargo handling gear (ship's cranes) or to hire equipment. Some larger ports have 'post-panamax' sized ship-to-shore cranes and others have a range of container cranes or mobile harbour cranes. Other port facilities include berthage, container yards, fumigation sheds, silos for grains and liquids etc, timber handling equipment and storage areas, terminal services, plug-in facilities for 'reefers' (refrigerated containers), road and rail services, and other equipment such as straddle carriers, container handlers, sky-stackers and reach-stackers. Cranes may be capable of twin lift (two containers), and use spreaders that allow them to pick up different sized containers.

Injury data

The NZ ACC data for injury claims for CFO's for 2005, 2006 and 2007 (ACC Data Request Service, 2009) was reviewed. However the occupational class 'forklift operator' is a rolled up group which also includes 'Straddle-Truck Operator' and 'Tow Truck Operator' – and it is not possible to differentiate between these occupations.

Data on MSDs was combined from the injury diagnosis categories of sprain or strain; soft tissue injury (contusion, strain, sprain, internal organ); gradual process (local inflammation) and gradual process (compression syndrome). It is noted that some of these recorded injuries may include diagnoses that are not accepted as MSDs – particularly for contusions and internal organ injuries. Further work could be undertaken to 'cleanse' the data to consider only those injury diagnoses that *are* MSD.

Using the 2007 MSD injury claims data for crane operators (48 new claims) and the worker population estimation, gives an MSD incidence rate of 39-44 per 1000 FTEs - a

figure that is quite high. In contrast, using these data sources for forklift operators (278 MSD injury claims in 2007), gives a low MSD incidence rate of 1.7 per 1000 FTE. It is recognised that the estimations used to determine the population sizes may skew this result.

A UK field study (Shaw and Quarrie, in Hanson (ed), 1999) into musculoskeletal risk factors in dock crane drivers reported *'an increasing number of crane drivers reporting musculoskeletal problems'*. For the three main dock crane types - quayside cranes, rubber-tyred gantries, and straddle carriers - there are around 1000 UK operators.

For forklifts, a 1992 Australian report (Rechnitzer and Larrson) identified 'overexertion' as 18% of total injuries, with 'driving the vehicle' the harmful exposure in 50% of cases, and the manual 'handling of heavy forklift equipment' the cause for a further 20%. Other international studies of forklift injuries did not appear to consider MSD incidents.

MSD risk factors

Key documents acknowledging the MSD risks that CFOs are exposed to in the course of their work were from the UK Health and Safety Executive (2002) lists key risk factors as: awkward postures, length of work time spent in that posture, vibrational jolts and shocks, repeated/continuous use of muscle force to maintain posture, and psychosocial factors (shift work, working in isolation, working to tight deadlines). It was noted that straddle carrier drivers are most at risk. Further, this HSE report states that the main body parts affected in dock crane drivers are the lower back, neck and shoulder, with one HSE study reporting MSD prevalence for crane operators as: 44-77% neck, 44-64% shoulder, and 67-86% lower back problems. A number of risk-controlling interventions were suggested: improving driving position (closed circuit television, cab relocation, mirrors, prone lying, sit-stand operation and kneeling, adjustable seats, swivel seats, better seat adjustment); reducing whole body vibration (by improvements to seating, the maintenance of the boom joint, and the maintenance of quay and container park surfaces); improving visibility (cleaning cab windows); reduced work periods and/or task rotations; training of drivers for optimal use of seat adjustments and musculoskeletal awareness; and monitoring for MSD problems. It was acknowledged that the visual demands of task location and the cab created some limitations to intervention options.

A recent HSE 'guidance note' (2009) clarifies that an 'associated hazard' that inspectors should be aware of in the load on/load off container cargo sectors, is '*MSD in crane operators'*, thus clearly acknowledging this as a known risk area.

Posture and awkward positioning risk factors were recognised in a study of forklift trucks, forestry machine and crane drivers by Eklund et al (1994), and Van Riel et al's 1995 study of straddle carrier drivers, crane operators and office employees. Window design, the geometry of seating and controls, and work organisation factors creating long periods of static work were noted.

The understanding of whole body vibration and whole body shock appears to be an emerging issue in this field. A 2004 literature review (Kittusamy and Buchholz) found few studies addressing operators of construction equipment, and in 2008 a review by Waters et al determined that there is a possible causal relationship between working as a heavy vehicle driver and the development of lower back disorders. Both studies

recognised the need for more work in the area and pointed to improved design for heavy equipment vehicles.

Interest in the cab design of forklifts and cranes was evidenced in the range of literature. Cab design topics identified included: the postural implications of visual demands and the use of closed circuit television; joystick design; seat design for vibration control; control layout; air quality and temperature control; and noise.

Work System Assessment

To identify MSD risk factors experienced by NZ CFOs in a port environment a work system assessment was completed. This included interviews with CFOs and managers, discomfort questionnaire, musculoskeletal assessment, anthropometric data gathering, analysis of work postures using Rapid Upper Limb Assessment (RULA), and work station layout and equipment review.

CFO Interviews

All operators interviewed were males, with an average age of 46 years and most with 20-25 years machine driving experience. Forklift operators worked 40 plus hours per week, 7.00am - 5.30pm weekdays, with occasional weekend work and longer hours over the April-June apple season. In contrast, crane operators are on-call/casual workers, completing an average of 30-50 hours per week, up to 65 hours. These operators recognised that long shifts, irregular hours, and occasional double work periods within the same 24 hour period impacted negatively on social lives, fitness, and family relationships. Most crane operators worked solely in this role, though one also carried out maintenance work and enjoyed the change, suggesting that more task variety would make the job less stressful. CFOs generally worked for periods of 2-3 hours (up to 4 hours) before a 30 minute/1 hour break. (No toilet facilities are available on cranes).

All CFOs had received only on-job training, with the exception of driver license endorsement as required for forklift use. Education for the prevention or self-management of MSD was neither a component of induction training or specific on-job training for CFOs. CFOs knowledge on the prevention and management of MSD was from anecdotal sources, or based on ‘common sense’. This might include tips and beliefs on seating set-up and posture; visual issues; reach to controls; length of work periods; long work hours and irregular shifts/fatigue; cognitive strain from tasks; physical strains; personal/home stressors; and the sedentary nature of work.

Manager interviews

Whilst managers recognised that CFOs are highly skilled operators critical to efficient port functioning, they also acknowledged that MSD prevention and management processes within ports perhaps lags behind current best practice. Documentation (hazard registers, operating procedures, training information, injury reporting processes) did not include sound identification of MSD contributory factors and the means to mitigate these risks. There appeared to be gaps in management awareness of MSD issues; the processes for review, planning, training and hazard management for MSD; systems for the early reporting of discomfort; and some injury management aspects.

Discomfort questionnaire and musculoskeletal assessment

A discomfort questionnaire indicated that neck, shoulder and hip/thigh/buttock pain was prevalent (66% - 83% of CFOs) for the workers interviewed, with wrist/hand, lower back, knee, and upper back discomfort also commonly experienced (33% - 50% of CFOs). Musculoskeletal assessment was generally unremarkable.

Anthropometry

Anthropometric data revealed that these CFOs were taller than the 50th percentile NZ male (45-60 years of age) in stature measures, generally exceeding the 95th percentile measures – thus they are 'relatively tall'. They are also similarly 'relatively broad shouldered' (mostly larger than 95th percentile), and 'long armed' (most over 95th percentile), with 'large hands'.

Workstation layout

Workstation layout and equipment was considered via a checklist (Jorgensen, Kittusamy and Aedla, 2007) with many seating adjustability and suitability issues identified (particularly for ship's cranes), and a range of issues in regards to vision - glare, reflection, window cleanliness, posture for vision, cameras for vision.

Postural analyses

Postural analyses were carried out with RULA, with findings suggesting: the importance of fully supported and adjustable seating in all control cabins; the use of micropauses; need for joystick position adjustment; benefit of hands-free radio telephone use; improved (more neutral) resting wrist/hand positions; task variation; camera screen re-positioning; and window cleanliness. Other observations included that use of the circular crane-leveller was easier to use than the linear model; that the constant holding of deadman switches was of concern; and that the layout of equipment and reference material in the crane/forklift cabin may require review for optimal positioning and function.

DISCUSSION

Knowledge of MSDs in crane and other heavy equipment operators is evidenced in a range of international literature. It is a known problem with risk factors (including whole body vibration and posture/positioning issues) that are increasingly understood, including multi-factorial or 'systems' approaches to MSD causation. MSDs of the arm, neck, shoulder and lower back of many machine operators appears to be a common experience for CFOs.

Despite limitations in the accuracy of both CFO numbers and MSD incidents in NZ, the apparently high incidence rate of 39-44 per 1000 FTE suggests that concern regarding MSD incidences for crane operators is warranted. The intensity and duration of crane operation tasks in the port environment further suggests that port crane operators may be at greater risk.

It appears that cab design struggles to adequately address the demanding visual nature of the tasks performed and the complexity of machine operation interfaces. Machines are now designed to carry out many tasks operated from within the relative safety of the cab, but the physical and mental workload of the operator carrying out these tasks may as yet be poorly understood or addressed, at least within NZ ports.

The difficulties in addressing crane cab design are further complicated by the small market size and the high cost and long life of cranes. Within the limitations of this project relevant cab design standards were not identified or referred to, and this should be carried out in further work on this topic.

RECOMMENDATIONS AND CONCLUSIONS

The contributory factors identified via literature review and work systems assessment were used to develop recommendations for a range of interventions - as expected from a multi-factorial, ergonomics approach. In keeping with current approaches to prevention of MSD it was recommended that changes be made across a number of contributory factors for more success than applying only single mode interventions. A total of 43 itemised recommendations were made, and are summarised following. The recommendations encompass solutions addressing all levels of hazard control - for example introducing a range of break-taking practices to *eliminate* or *minimise* the sustained and sedentary work hazard.

A primary recommendation is for all levels of port managers, health and safety staff, and health and safety representatives to receive education in the contemporary knowledge regarding MSD - such as ACC's 'preventing and managing discomfort, pain and injury' (DPI) training. Further to this is the recommendation for development of MSD prevention and management resources specific to machine operation. (A stakeholder group from transport, agriculture, forestry, and port industries consequently met in April 2010 to develop material for an ACC funded 'WorkSmart Tips' web resource relevant to cab-based operations. This is nearing web publication, and is relevant to cab based operators working in many industries).

Integrating MSD knowledge and processes into port management is recommended. Thus all training, health and safety systems, early reporting processes, hazard identification systems, rehabilitation and medical services will use integrated and consistent approaches to preventing and managing MSD. It was suggested that the benefit of 'wellness' approaches to mitigate some MSD risks should be appreciated.

Also key to managing MSD risks for CFOs is their pattern of work. Thus it is necessary to ensure that shift length, length of work periods, and break taking habits and patterns are optimal.

Recommendations regarding equipment included: the provision of seat adjustment accessories; improved ship's crane seating; processes to ensure cleanliness of windows; and efforts to address reflections on windows and computer screens. It was recognised that there is a need to link with Maritime New Zealand regarding ship's crane conditions.

Further investigation of user anthropometry, seating design standards, seat use and machine interfaces will inform seat and cabin layout and design specifications, and equipment purchasing and retrofitting decisions. Specific investigation of the design and use of deadman switches, joysticks, steering wheel operation and other interfaces is suggested. Further ACC injury data analysis may also be informative.

This broad work system study identified a range of MSD contributory factors relevant to machine operators in general, and more specifically to crane and forklift operators

within port environments. The challenge from such research is to gain buy-in from the target industry, and it is acknowledged that this has as yet been only partially successful for this project. The further areas of research identified have potential for usefully informing a number of NZ cab-based industries regarding MSD prevention. This project highlights for ports (and other machine operating industries) the key MSD contributory factors (hazards) that should be addressed for safe and healthy working practices.

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