

COMPARISON OF ERGONOMIC RISK ASSESSMENT OUTPUT IN A HIGH RISK SAWMILL OCCUPATION: SAW FILER

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ABSTRACT

Ergonomic risk assessment methods which consider multiple physical exposures in an integrated model of risk prediction are often used to direct intervention. Risk of musculoskeletal injury associated with performance of a job has been observed to vary by the worker assessed and the risk assessment methodology used. This study examines the agreement between risk assessment methods calculated using quantified exposure information when multiple workers performing the same job are assessed. The quantified exposure information from 15 workers performing the saw filer job was used to calculate the RULA, REBA, ACGIH TLV, Strain index, and OCRA assessments. The saw-filer position was chosen for assessment in this study given the high rate of upper extremity MSIs observed during the period reviewed. Meaningful disagreement in risk assessment scores both between workers within assessments, and between methods was observed. Percentage agreement between methods were observed to vary between 0 and 80% indicating risk levels assigned by the methods may not agree and caution in application is warranted.

INTRODUCTION

In 2003, a review of Workers Compensation Board claims revealed the significant impact of musculoskeletal injuries (MSI) on the sawmill industry of Alberta, Canada (Jones and Kumar, 2004a). In the period reviewed, MSIs accounted for \$2,842,851 in claims costs and 13,600 days lost, more than any other injury category. MSIs to the upper extremity accounted for a higher percentage of claims than any other body part. The role of physical exposures in the precipitation of musculoskeletal injury (MSI) has been established (US Dept. Health and Human Services 1997). Industrial prevention efforts often look to ergonomic risk assessments to identify problem exposures and direct intervention. Little agreement currently exists between authors in terms of the physical exposures which should be considered, and the role of the exposures in the precipitation of MSI (Jones and Kumar, 2004b). As a result of this lack of consensus there is a need to examine the comparability of ergonomic risk assessment methods. Few studies are available which compare the results of multiple assessment methods in the same worker population (Drinkaus et al., 2003; Bao et al., 2006). No studies which have sought to compare multiple risk assessment methods have done so based on quantified demands information. Studies which present and compare the risk assessment scores of multiple methods are needed to assess agreement between methods.

The objective of this study is to examine the percentage of agreement between five ergonomic risk assessment methods (RULA, REBA, quantitative ACGIH TLV, Strain index, OCRA) used to assess 15 workers performing the saw filer job (McAtamney and Corlett, 1993; Moore et al., 1995; Colombini, 1998; Grieco, 1998; Occhipinti, 1998; Hignett et al., 2000; University of Michigan, 2005). Examination of the agreement between risk assessment methods within a job sheds light on the ability of the work site evaluator to obtain a similar risk assessment result should two methods be used to assess the same occupation.

The saw filer position was selected for evaluation, given the high number of upper extremity musculoskeletal injuries recorded in the 6 years of the review. Average annual incidence of recordable musculoskeletal events in the saw filer operator ranged from 0.12 to 0.86 per person year worked in the four facilities examined (Jones and Kumar, 2006).

METHODS

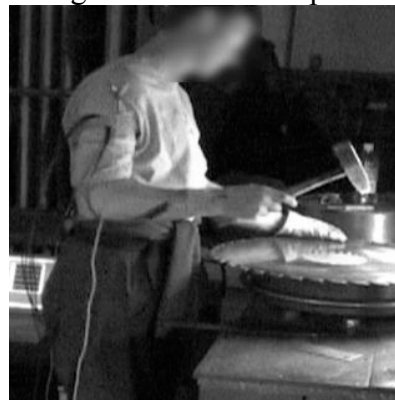
Task description

The function of the saw-filer job is to maintain the condition of round saws, ban saws and chipper knives necessary to enable the sawmill facility to operate efficiently. The primary task of the saw-filer is to tension and correct imperfections in round saws. Both the correction of imperfections and tensioning of the round saw require the saw-filer strike the body of the round saw with a 1.13 kg. hammer. Time required to correct imperfections and tension the round saw varies by round saw. The physical exposures used to calculate the risk assessment methods described in this study were measured during the primary task only; hammering of round saws (imperfection correction and tensioning). The primary hammering task of the saw-filer is illustrated in figure 1.

Subject selection

Workers presently performing the saw-filer position were recruited at four sawmill facilities. Subjects were excluded from the study if they reported; injury to the upper extremity within the last 12 months, generalized musculoskeletal or neuromuscular problems, or the inability to understand and follow instructions. The experimental protocol was approved by the University Health Research Ethics Board. 15 subjects volunteered to take part in the study out of the population of 15 (100% participation rate).

Figure 1: Saw filer operator



Data collection

Motion Data acquisition. Motion at the wrist was assessed using two pre-calibrated electrogoniometers placed on the wrist and forearm reported by the subjects as used primarily to hammer saws. Biometrics™ bi-axial SG-65 and uni-axial Q-150 electrogoniometers were used. Electrogoniometers were applied as per the users' manual recommendations. Further description of the methodology used to collect motion information is described in Jones and Kumar (2006). Postures used in the calculation of the risk assessment reflect those required to perform the primary task only.

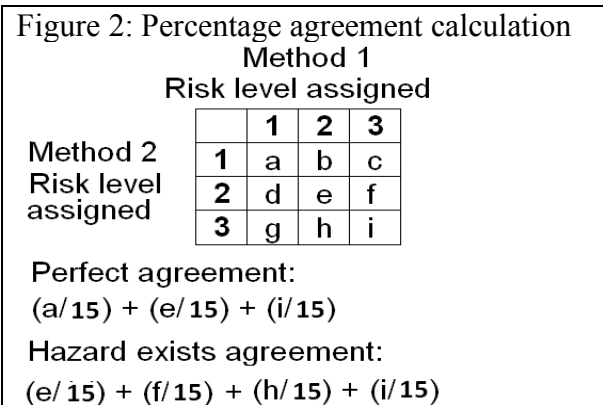
Exertion data acquisition. Surface electromyography (EMG) was used to determine the muscle activity associated with maximum and job simulated exertions. A Delsys Bagnoli 8 EMG system was used. Single differential bipolar electrodes with bar shaped silver detection surfaces (1 cm length x 1mm width) spaced 1 cm apart were used. The EMG traces obtained during job simulated and maximal contraction trials were full-wave rectified, averaged, and linear envelope-detected from the raw EMG signals. The extensor carpi radialis (ECR) and flexor carpi radialis (FCR) were assessed for the radial deviation component and the flexor carpi ulnaris (FCU) was evaluated for the ulnar deviation component of the hammering task. The average value resulting from the muscles assessed during the job simulated radial deviation trial and the job simulated ulnar deviation trial were divided by the peak EMG values obtained on the maximum voluntary contraction (MVC) comparisons to arrive at % MVC required to perform the radial and ulnar deviation components of the task. %MVC values specific to the two task components were then averaged to derive a %MVC value for the hammering task. Further description of the methodology used to derive %MVC is described in Jones and Kumar (2006). Following motion data collection (during job performance) workers were asked; "whether during the cycle there were job actions that required muscular effort of the upper limbs?" Workers were then asked to rate the actions from one to ten using the Borg CR-10 scale (Borg, 1982). Borg ratings were then averaged and used in the ACGIH TLV, SI and OCRA assessments.

Risk assessment methods. The risk assessment methods were calculated according to the primary literature describing their application (McAtamney and Corlett, 1993; Moore et al., 1995; Occhipinti, 1998; Hignett et al., 2000; University of Michigan, 2005). The quantified ACGIH TLV, SI and OCRA procedures allow the evaluator to define exertion either using %MVC required or using the Borg Cr-10 scale. Jones and Kumar 2007 reported that significantly different risk levels are derived from the ACGIH TLV and the OCRA assessment in this population when %MVC is substituted for Borg score. For this reason the risk levels derived using both exertion variable definitions are used in the percentage agreement comparisons reported. Reclassification of the RULA and REBA risk levels was necessary to enable the percentage agreement comparisons. Table 1 describes the risk index scores used to classify three risk levels in the methods assessed.

Table 1: Risk level classification

	Risk index scores		
	Level 1	Level 2	Level 3
RULA	1,2	3-6	7
REBA	0	2-7	8-15
TLV MVC	1	2	3
TLV Borg	1	2	3
SI	0-3	3.1-7.0	>7.1
OCRA MVC	<.75	>.75-4.0	>4.0
OCRA Borg	<.75	>.75-4.0	>4.0

Percentage agreement. Percentage agreement was assessed using two techniques. Percentage of agreement “at-risk” was calculated by dichotomizing risk level output into “no risk” (level 1) and at-risk (level 2 or 3) comparisons. Risk level output of the ergonomic risk assessment is used in industrial ergonomic initiatives to prioritize jobs for intervention. The implication of disagreement between methods is the inappropriate assignment of risk leading to inappropriate intervention. Given the important implication of disagreement between methods it is necessary to evaluate the percentage of perfect agreement in addition to “at-risk” agreement. Percentage of “perfect” agreement was calculated by considering only those cases of exact agreement. Derivation of the percentage agreement scores reported is illustrated in figure 2.



RESULTS

Subject characteristics

The mean age, height and weight of subjects were 44 yrs (S.D. 9.5 yrs), 178 cm (S.D. 7.5 cm), and 86.1 kg. (S.D. 14.84 kg.) respectively. Mean work experience at the saw-filer position at time of assessment was 11.5 years (S.D. 6.83 yrs.). All subjects assessed were male.

Percentage agreement

The frequency of risk levels assigned by method is presented in table 2. Percentage of agreement (perfect and hazard exists) is presented in table 3.

Table 2: Frequency of risk levels assigned

	Risk level assigned		
	1	2	3
RULA	0	0	15
REBA	0	3	12
TLV MVC	15	0	0
TLV Borg	8	4	3
SI	0	11	4
OCRA MVC	1	10	4
OCRA Borg	1	5	9

Table 3: Percentage agreement: Perfect agreement no brackets, hazard exists in brackets

	RULA	REBA	TLV MVC	TLV Borg	SI	OCRA MVC	OCRA Borg
RULA		80%(100%)	0%(0%)	20%(47%)	27%(100%)	27%(93%)	60%(93%)
REBA	80%(100%)		0%(0%)	33%(47%)	20%(100%)	20%(93%)	40%(93%)
TLV MVC	0%(0%)	0%(0%)		53%(0%)	0%(0%)	7%(0%)	7%(0%)
TLV Borg	20%(47%)	33%(47%)	53%(0%)		13%(47%)	20%(47%)	27%(47%)
SI	27%(100%)	20%(100%)	0%(0%)	13%(47%)		80%(93%)	47%(93%)
OCRA MVC	27%(93%)	20%(93%)	7%(0%)	20%(47%)	80%(93%)		67%(93%)
OCRA Borg	60%(93%)	40%(03%)	7%(0%)	27%(47%)	47%(93%)	67%(93%)	

DISCUSSION

The findings of this study emphasize the limited agreement between published ergonomic risk assessment methods and the need for studies which are able to compare the relative predictive validity of the different methods. Examinations capable of identifying the most predictive model are needed to begin to explore the correct role of the various physical exposures in the causation of MSI. The implication of disagreement between methods is the incorrect assessment of risk and/or identification of problem exposures. Our findings of limited agreement are similar to those reported Bao et al. (2006) and opposed to those reported Drinkaus et al. (2003) Drinkaus et al. (2003) found limited agreement between the RULA and Strain Index methods (Kappa score 0.11). The Drinkaus et al. (2003) study however examined 244 assembly tasks of varying levels of risk. Given our study examined only one high risk occupation conclusions regarding the agreement between the Strain Index and RULA across varying levels of risk may not be drawn. Importantly, the authors of the ACGIH TLV state that professional judgment should be used to recommend TLV reductions when risk factors not considered by the TLV (such as posture). No risk level reductions due to the presence of risk factors not considered by the original models were performed in this study. Limitations of this study include the small sample

size and the inclusion of only at-risk jobs. Strengths of this study include the largely quantified exposure assessments from which the methods examined were calculated.

CONCLUSION

This study has demonstrated the limited agreement between published ergonomic risk assessment methods used to assess an at-risk sawmill job. Considerable variation in the ability to identify at-risk jobs as at-risk was identified between methods. Wide variation in risk levels assigned to a single job by different methods speaks to the lack of agreement between methods. A universally accepted and validated method is yet to emerge.

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