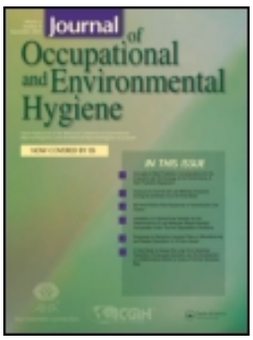

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Comparison of Ergonomist, Supervisor, and Worker Assessments of Work-Related Musculoskeletal Risk Factors

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In primary prevention efforts to reduce the incidence of work-related musculoskeletal disease (MSD), many employers will use supervisor or worker assessments for initial evaluation of MSD risk factors. This cross-sectional study examined the ability of supervisors and workers to accurately assess the presence of MSD risk factors at four work sites in four different industries, examining five jobs that represented six primary categories of risk factors: posture, force, repetition, impact, lifting, and vibration. Thirty-seven supervisors and 55 workers assessed the jobs they oversee or perform through the use of a 14-item questionnaire. Their assessments were compared with detailed ergonomist job analyses to determine their accuracy in identifying the presence or absence of MSD risk factors. In assessing the absence or presence of all risk factors, agreement with the ergonomist was found 81% of the time for supervisors and 77% of the time for workers. Overall, supervisors and workers overestimated the presence of risk in assessing the jobs. Supervisors and worker assessments appear promising in recognizing risk in initial ergonomic assessments.

Keywords employer assessment, ergonomics, regulation, risk factors

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INTRODUCTION

Because of the association between workplace exposure to biomechanical risk factors and work-related musculoskeletal disorders (MSDs),[1–3] the prevalence of these injuries, and the cost to industry in medical expenditures and lost work time, employers have several reasons to initiate actions that reduce risk factors in their workplaces. There is evidence that (1) many MSDs are preventable, (2) prevention is the most effective means of reducing MSDs, and (3) workplace actions such as screenings and surveillance are the most successful means of prevention.[4–8]

Reducing physical risk factors for work-related MSDs requires employer action, beginning with the initial identification of potential risk factors. Risk factor assessments can be performed by formally trained ergonomists or other professionals hired by the employer,[9,10] the workers themselves,[10–12] or other employees with varying familiarity with the jobs they assess. Types of assessment include: *observational methods* used by one or more trained observers who record on a checklist or computer at regular, timed intervals specific details of risk factors they have observed;[13,14] *direct assessment methods* that use manual devices or electronic equipment such as goniometers,[14,15] electromyographers (EMG),[16,17] and accelerometers[18] to evaluate postural and muscle strain, motion, and body angles; and *self-report methods* to obtain worker observations of workload, postural discomfort, or work stress through the use of surveys, log books, rating scales, or interviews.[13,19–21]

We postulate that as an initial step in identifying MSD risk factors in the workplace, many employers will use non-ergonomist employees, particularly supervisors or workers, to assess job tasks through observational methods. Recent regulations have required that employers undertake such a "checklist" approach to evaluating the workplace.[22] We found a lack of information to compare the adequacy of management-selected personnel to perform ergonomic assessments. The aim of this study was to measure the comparative ability of employers, represented by their supervisors and workers, to assess the MSD risk factors present in the jobs at their workplace.

SUBJECTS AND METHODS

This cross-sectional study examined the ability of supervisors and workers to assess accurately the presence or absence of MSD risk factors, compared with an ergonomist. Industries were chosen to identify jobs within each of six

primary categories of risk factors: posture, force, repetition, impact, lifting, and vibration. The study was approved by the Department of Social and Health Services Human Research Review Board.[23]

Study Sample

Studies were conducted in four industries: (1) an electronics manufacturing plant, (2) a small grocery store with two locations, (3) a warehouse, and (4) an office setting. Specific work sites were selected for recruitment convenience and geographic proximity; all but three of the work sites agreed to participate. The number of employees per work site ranged from 10 to several hundred. Five jobs were selected jointly with the employers for appropriateness in the study. Workers and supervisors of those jobs were invited to participate in the study. Fifty-five of approximately 58 potentially eligible workers and all 37 supervisors invited to participate were included in the study. The ergonomist identified individual workers for potential inclusion in the study based on their working in a targeted job at the time of the ergonomist's observation/visit. The jobs observed were manual assembly of electronic instruments, grocery stocking and cashiering (checking), warehouse order filling and stock replenishment, and office document scanning and indexing.

TABLE I. Types, Criteria, and Definitions of Moderate and High Risk, Based on Cumulative Time in 8-Hour Workday

Type and Specific Criteria of Risk Factor	Moderate Risk[A]	High Risk[B]
Awkward Posture		
1. Hand(s) above head or elbow(s) above shoulder	>2 hrs	>4 hrs
2. Neck bent >30° or Back bent >30°	>2 hrs	Neck bent >45° >4 hrs or back bent >30° >4 hrs or >45° >2 hrs
3. Squatting	>2 hrs	>4 hrs
4. Kneeling	>2 hrs	>4 hrs
High Hand Force		
5. Pinching an object weighing >2 lbs/hand or pinching with a force of >4 lbs/hand	>2 hrs	>4 hrs or >once/min >4 hrs or combined with >3 hrs of repetitive motion or combined with >3 hrs of wrists: flexed >30° or extended >45° or in ulnar dev >30°
6. Gripping object(s) weighing >10 lbs/ hand or gripping with a force of >10 lbs/hand	>2 hrs	
Highly Repetitive Motion		
7. Repeating the same motion with the neck, shoulders, elbsows, wrists, or hands every few seconds	>2 hrs	>6 hrs or >2 hrs combined with high hand force and wrists: flexed >30° or extended >45° or ulnar dev >30° and high hand force)
8. Performing intensive keying	>4 hrs	>7 hrs or combined with >4 hrs of wrists: flexed >30° or extended >45° or in ulnar dev >30°
Repeated Impact		
9. Using the hand or knee as a hammer >10 times/hr	>2 hrs	Hand or knee as hammer >once/min >2 hrs
Heavy, Frequent, or Awkward Lifting		[D]
10. Lifting objects weighing >75 lbs >once or >55 lbs >10 times/day	[C]	
11. Lifting objects weighing >10 lbs >twice/min	>2 hrs	
12. Lifting objects weighing >25 lbs above shoulders, below knees, or at arms length >25 times/day	[C]	
Moderate to High Hand-Arm Vibration		[D]
13. Using impact wrenches, carpet strippers, chain saws percussive, or other hand tools with high vibration	>30 mins	
14. Using grinders, sanders, jig saws, or other hand tools with moderate vibration	>2 hrs	

[A] Moderate risk assessed by supervisors, workers, and ergonomist.
[B] High risk assessed by ergonomist only.
[C] One occurrence in day meets criterion.
[D] High risk categories not applied for these risk factors.

Definitions of Risk

Supervisors, workers, and the ergonomist assessed jobs for the presence of "moderate risk" as defined in Table I and based on the Washington State Ergonomics Rule implemented in July 2002.[22] [Editor's note: Rule was repealed by voter initiative in November 2003 and now serves as a voluntary guideline.] Most of the moderate risk factors were defined in this study by a 2-hour time period during which the risk factor was present. The Washington State Ergonomics Rule risk factor assessment is performed in two separate steps. First, jobs are evaluated by employers to determine whether any risk factor is present at a "moderate" level, defined as being in the "Caution Zone" by the rule. Only the jobs that are found to meet the criteria at a moderate level of risk are assessed to determine if they meet the criteria at a "high" level of risk. In this study, workers and supervisors assessed jobs only at the moderate risk level. To provide information in addition to assessing the jobs at the moderate level, the ergonomist assessed exposures at the high risk level. Comparisons were made between the assessments of the ergonomist, supervisors, and workers at the moderate risk level only. For the purposes of assessing agreement, comparisons were made at a present or absent level, agreement that there was no risk or that there was moderate risk.

Worker and Supervisor Assessment Methods

Supervisors and workers assessed the six primary categories of MSD risk factors via a questionnaire containing 14 yes/no questions, to increase validity over questions with more options.[9,12] Participants were instructed to complete the questionnaire based on their assessment of one particular job on a typical workday, including task rotations if applicable, for an 8-hour shift based on cumulative time of exposure. Each of the questions asked, "Does the job entail . . . " and listed the MSD risk factors, accompanied by a diagram. Intrarater reliability between the two questionnaires administered several weeks apart revealed Kappa values for most of the risk factors in the good to excellent reproducibility range (Kappa $>$ .4).[24]

Ergonomist Assessment Methods

Task Analysis

The ergonomist conducted a preliminary survey of the component tasks of each job before making the systematic ergonomic assessment of the complete job cycle. Measurements of force and weight were derived through the use of a force matching technique.[25,26] Workers whose work required them to pinch or grip an item mimicked force on either a hydraulic hand dynamometer (JAMAR Model 5030J1, Sammons Preston Inc., Bolingbrook, Ill.) or hydraulic pinch gauge (JAMAR Model 7498-OS, Sammons Preston Inc., Bolingbrook, Ill.). The average of three measurements was used; the worker performed the actual work task between each measurement. Scales weighed gripped items suspected of weighing more than 10 lbs (Health-O-Meter Model 470, Sunbeam Products, Bridgeview, Ill.) and pinched items suspected of weighing more than 2 lbs (Chatillon Torque Gauge Model DFIS, Itin Scale Co., Brooklyn, N.Y.).

Work Sampling

A trained ergonomist used a modified work sampling technique to observe an individual's work for a specified time.[19] The presence or absence of each risk factor was noted in an instantaneous "snapshot" observation during the first few seconds of each minute in the sampling period, for each worker observed. Each observation of a risk factor was equated to 1 minute of risk exposure. The number of risk factor observations was summed across the observation period and then extrapolated to 8 hours to reflect the risk factor level in the overall job. The ergonomist observations at the four work sites established the reference with which the supervisors' and workers' assessments were compared.

Each task was monitored for 2 hours (i.e., 120 observations). Multitask jobs such as the electronics job (four tasks) and the office job (two tasks) were monitored for 2 hours per task. The data collection periods were selected to be representative of a day's risk exposure. In calculating the standard error, with 120 observations, the error rate was estimated to be 5% or less.

For all sites but the warehouse, in-person work sampling was possible while the tasks were performed. Because the warehouse work included numerous lifts of varying, unpredictable weights and originating at various heights and distances from the body, two 1-hour video recordings were made and later assessed using the same work sampling technique.

Ergonomics Training and Dual Ergonomist Assessments

Most of the ergonomist assessments were performed by one ergonomist. Prior to data collection a second ergonomist simultaneously observed workers until consistent interrater agreement of 90% was achieved. The primary ergonomist in the study was a graduate student in ergonomics at the time of data collection. The second ergonomist, possessing doctoral training in ergonomics and substantial experience in task analysis and ergonomic assessment methods, participated in ongoing consultation throughout the job assessment process. Workers and supervisors also rated their familiarity with the field of ergonomics (very familiar/somewhat familiar/know very little about it/never heard of it).

Reliability measures of the primary ergonomist assessments were obtained through interobserver rating. The two ergonomists simultaneously performed separate, synchronized work sampling to indicate the level of agreement between them. Comparison of 3 hours of work sampling, or 180 samples per ergonomist, resulted in 11 of 12 risk factor Kappas with a good ($>$.4) reproducibility rating[24] and all 12 risk factors above 92% agreement.

Statistical Methods

Kappas and percent agreement were used for interrater comparison between the two ergonomists and for intrarater comparison between the two questionnaires completed by each of

the participants. Sensitivity, specificity, and positive predictive values were calculated from the questionnaires. SPSS software (Version 10.0, SPSS Inc., Chicago, Ill.) was used for most statistical analysis. Because of the low level of variability of some of the risk factors, StatXact software (Version 4.0.1, Cytel Software, Cambridge, Mass.) was also used.

RESULTS

Ergonomist Work Sampling Results

The ergonomist determined that of the five jobs assessed, four presented at least one moderate MSD risk factor, as defined in this study. The most commonly identified risk factors were neck/back bending and repetition, each present in three jobs (Table II). The only other risk factor noted in any of the jobs was lifting 25 lbs.

Comparison Between Ergonomist, Supervisors, and Workers

A majority of the supervisors agreed with the ergonomist in all 14 risk factors, and a majority of the workers agreed with the ergonomist in all but 1 risk factor (Tables III and IV). Every supervisor found at least one risk factor to be present in the job they supervised. The ergonomists determined that one job, grocery store checking, was free of MSD risk factors as defined for this study. Seventy-seven percent of the supervisors reported being somewhat or very familiar with the field of ergonomics vs. 59% of the workers.

Electronics Manufacturing

Ergonomist analysis of the electronics-manufacturing job revealed two risk factors: repetitive motion and bent neck/back (Table II). Though analyzed separately by the ergonomist, Work Areas A and B were treated as one job in subsequent analyses for the purposes of the study. Area A exposed workers to repetition (370 min per 8-hour day, and Area B to 329 min per 8-hour day), putting the job well within the definition of moderate risk (Table I), and meeting the 6-hour per day definition for high risk in Area A and nearly meeting it in Area B. Bent neck/back was present 172 min in Area A and 58 min in Area B, posing a moderate risk factor in one area but not the other.

In electronics manufacturing, 82% of the supervisors and 44% of the workers correctly identified the presence of bent neck/back as a risk factor in the work performed (Table III). Repetition was correctly identified as a risk factor by 73% of the supervisors and 78% of the workers. Nearly half the workers (44%) thought pinching was a risk factor, whereas 82% of the supervisors correctly disagreed. Within the five jobs, the electronics-manufacturing supervisors obtained the highest accuracy score, 92% correctly identifying which risk factors were and were not present in the jobs they supervise.

TABLE II. Risk Factor Frequency per 8-Hour Workday, by Job

	Electronics Mfg.		Grocery Store			
Risk Factor	**Area A**	**Area B**	**Checking**	**Stocking**	**Office**	**Warehouse**
Hand above head	3	7	0	12	0	4
Elbows above shoulder	9	11	0	24	0	0
Left wrist bent	8	12	45	4	32	12
Right wrist bent	4	22	72	14	0	12
Neck bent	170[B]	46	69	144[B]	81	208[B]
Back bent	2[B]	12	3	38[B]	0	20[B]
Squatting	0	0	0	32	0	0
Kneeling	0	0	0	24	0	0
Pinch 2 lbs object[A]	0	0	21	26	2	0
Pinch 4 lbs force[A]	8	56	5	0	8	24
Grip 10 lbs object/force	9	3	0	12	24	32
Repetition	370[A]	329[B]	99	6	215[B]	148[B]
Hand as a hammer	0	3	0	0	0	0
Knee as a hammer	0	0	0	0	0	0
Weight lifted[C]	0	0	0	14	0	80[B]
Position lifted[C]	0	0	0	2	0	80[B]
Tool vibration	1	3	0	0	0	0

Note: Based on number of 1-min observations, extrapolated to 8-hour day.
[A] Pinch 2 lbs object and Pinch 4 lbs force combine to form one risk factor.
[B] Denotes risk factors that met or exceeded risk definition.
[C] Weight lifted and position of lift combine to form one risk factor.

TABLE III. Number of Supervisors and Workers Identifying Each Risk Factor Presence, Compared with Ergonomist Assessment

	Electronics Mfg			Grocery Stocking			Grocery Checking			Office Setting			Warehouse		
Risk Factor	Spvr 11	Wrkr 9	Ergo	Spvr 7	Wrkr 3	Ergo	Spvr 5	Wrkr 6	Ergo	Spvr 12	Wrkr 33	Ergo	Spvr 2	Wrkr 4	Ergo
Arms overhead	1	1	N	2	1	N	0	1	N	1	2	N	1	1	N
Neck/back bent	9	4	Y	2	2	Y	0	6	N	6	16	N	1	1	Y
Squat	0	0	N	1	3	N	0	0	N	0	0	N	1	1	N
Kneel	0	0	N	2	2	N	0	0	N	0	0	N	1	0	N
Pinch	2	4	N	1	0	N	0	2	N	1	9	N	0	1	N
Grip	2	0	N	2	1	N	2	1	N	1	3	N	1	0	N
Hammering	1	2	N	0	0	N	0	0	N	0	0	N	1	1	N
Repetition	8	7	Y	3	2	N	4	3	N	8	27	Y	1	1	Y
Keying	0	3	N	0	0	N	2	2	N	1	26	N	0	0	N
Lift 75/55 lbs	0	1	N	2	0	N	0	1	N	0	0	N	2	3	N
Lift 25 lbs	0	0	N	1	3	N	1	1	N	1	0	N	1	1	Y
Lift 10 lbs	0	2	N	3	2	N	3	0	N	1	2	N	1	3	N
High vibration	1	0	N	0	0	N	0	0	N	0	0	N	0	1	N
Mod vibration	0	0	N	0	0	N	0	0	N	0	0	N	0	2	N
Agreement with ergonomist	92%	84%		78%	64%		83%	80%		90%	86%		61%	71%	

Notes: Spvr = Supervisors, Wrkr = Workers, Ergo = Ergonomist.
Numbers in columns represent the number of supervisors and workers who identified each risk factor as present.
Y = Presence and N = absence of each risk factor as determined by the ergonomist.

Electronics-manufacturing workers were 84% accurate, the second highest level of accuracy among the workers of the five jobs.

Grocery Store Stocking

The ergonomist found the grocery store stocking job required work with the neck or back bent (Table II). Analysis of the job tasks revealed 182 min of back or neck bending exposure for an 8-hour day, exceeding the criteria for moderate risk factor by 52% (Table I). Back or neck bending was correctly identified as a risk factor by only two of the seven supervisors and two of the three workers (Table III). Three of the seven supervisors misidentified the use of repetitive motion and lifting 10 lbs as required in the stocking job, compared with two of the three workers who felt these risks were part of their job. Supervisors of grocery store stocking were 78% accurate and the workers 64% accurate in their overall identification of the 14 risk factors.

Grocery Store Checking

Grocery store checking was the only job analyzed that did not reveal the presence of any of the 14 defined risk factors (Table II). All six workers and none of the five supervisors observed the neck/back bending risk factor (Table III). Three of the five checking supervisors felt the job required repetitive lifting of 10 lbs, which was correctly recognized by all six of the workers as not the case. Overall, supervisors were 83% accurate and workers 80% accurate in their level of detection. Because the grocery stores included in the study were smaller and did less business than many, the level of risk to which checkers were exposed may not be representative of this job throughout the industry.

Office Setting

Office workers were exposed to repetitive motion, primarily hand and wrist motion, 215 min per 8-hour day, exceeding the 2-hour definition for moderate risk by 180% (Tables I and II). Repetition was correctly identified as a risk factor in the office setting by 67% of the supervisors and 82% of the workers (Table III). Half the supervisors and workers felt neck/back bending was a risk factor in the office but was not found to be so by the ergonomist. A majority of the workers (79%) also believed their job entailed intensive keying, which 92% of their supervisors correctly recognized was not present in the performance of their jobs. Office supervisors were 90% accurate in identifying risk factors, the second highest among supervisors of the five jobs analyzed. At 86%, office workers obtained the highest accuracy among the five groups of workers assessing risks in their jobs.

Warehouse

The 228 min of neck and back bending observed in the warehouse job exceeded the 2-hour moderate risk definition by 90% and the 148 minutes of repetitive motion exceeded the

TABLE IV. Test Characteristics of Supervisor and Worker Observations, Compared with Ergonomist Assessment

	Supervisor Observations (n = 37)								Worker Observations (n = 55)							
	Risk Factor "Present"				Risk Factor "Not Present"				Risk Factor "Present"				Risk Factor "Not Present"			
Risk Factor	Agree	(TP)[A]	Disagree	(FN)[B]	Agree	(TN)[C]	Disagree	(FP)[D]	Agree	(TP)[A]	Disagree	(FN)[B]	Agree	(TN)[C]	Disagree	(FP)[D]
		(%)		(%)		(%)		(%)		(%)		(%)		(%)		(%)
Arms overhead	·	·	·	·	32	(86)	5	(14)	·	·	·	·	49	(89)	6	(11)
Neck/back bent	10	(27)	8	(22)	11	(30)	8	(22)	11	(20)	8	(14)	18	(33)	18	(33)
Squat	·	·	·	·	35	(95)	2	(5)	·	·	·	·	51	(93)	4	(7)
Kneel	·	·	·	·	34	(92)	3	(8)	·	·	·	·	53	(96)	2	(4)
Pinch (w)[E]	·	·	·	·	33	(89)	4	(11)	·	·	·	·	38	(70)	16	(30)
Grip	·	·	·	·	29	(78)	8	(22)	·	·	·	·	50	(91)	5	(9)
Hammering	·	·	·	·	35	(95)	2	(5)	·	·	·	·	52	(95)	3	(5)
Repetition	17	(46)	8	(22)	5	(13)	7	(19)	35	(64)	11	(20)	4	(7)	5	(9)
Keying (s,w)[E]	·	·	·	·	33	(92)	3	(8)	·	·	·	·	23	(43)	31	(57)
Lift 75/55 lbs (w)[E]	·	·	·	·	33	(89)	4	(11)	·	·	·	·	49	(91)	5	(9)
Lift 25 lbs (2 w)[E]	1	(3)	1	(3)	32	(86)	3	(8)	1	(2)	3	(6)	45	(85)	4	(8)
Lift 10 lbs	·	·	·	·	29	(78)	8	(22)	·	·	·	·	46	(84)	9	(16)
High vibration	·	·	·	·	36	(97)	1	(3)	·	·	·	·	54	(98)	1	(2)
Mod vibration	·	·	·	·	37	(100)	0	(0)	·	·	·	·	53	(96)	2	(4)

[A] TP = true positive.
[B] FN = false negative.
[C] TN = true negative.
[D] FP = false positive.
[E] One (unless noted otherwise) data point missing from supervisor(s) and/or worker (w).

definition for moderate risk by 25% (Tables I and II). At the rate of exposure during the time observed, a worker would perform 80 lifts within the "lift 25 lbs" risk definition in the course of an 8-hour day, thus greatly exceeding the moderate risk criteria, but the exposure could vary considerably depending on the type and amount of lifting in a given day. In the warehouse, both supervisors and a majority of workers identified lifting as a risk factor. Of all the supervisors, the warehouse supervisors were the least accurate (61%) at risk identification; the warehouse workers were 71% accurate.

Test Characteristics

The validity of the questionnaire as a screening instrument and the ability of supervisors and workers to detect risk factors were assessed using sensitivity, specificity, and positive predictive value measures (PPV). The ergonomist assessment was considered the standard; Table IV shows risk factor-specific test characteristics. Of the three risk factors noted to be present in any of the jobs, the supervisors used the questionnaire most effectively to detect the presence of repetition, with a sensitivity of 68%, followed by bent neck/back at 60%, and lifting 25 lbs at 50%. Worker sensitivity was highest in detection of repetition at 76%, neck/back bending at 44%, and also the lowest for lifting 25 lbs at 25%.

The questionnaire and supervisors' ability to correctly identify jobs where the particular risk factors were not present, specificity, was highest for the 25 lbs lift risk factor at 91%, 65% for neck/back bending, and lowest for repetition at 42%. Comparably, worker specificity was 92% for lifting 25 lbs and 44% for both repetition and neck/back bending. The proportion of supervisors detecting MSD risk factors also found by the ergonomist, or positive predictive value, was greatest for repetition at 71%, 67% for neck/back bending, and only 25% for lifting 25 lbs. Workers cited repetition as present 88% of the time that the ergonomist did, neck/back bending 24%, and lifting 25 lbs 20%.

Taking the assessment collectively, every supervisor believed at least one risk factor was present in the jobs they supervised. Hence, the sensitivity of the assessment instrument in supervisors' hands, to detect any risk found by the ergonomist, was 100%. The specificity was 0%.

DISCUSSION

Supervisor Assessments

This study is a small-scale assessment of supervisor accuracy in identifying MSD risk factors using a simplified approach involving yes/no choices. Supervisor assessment is a reasonable first step in an employer's effort to reduce MSD occurrence in their workplaces. This step may become more widespread as certain regulatory frameworks, such as the Washington State standard,[22] require that an employer undertake such an assessment. It is likely that for whatever reason the assessment is conducted, an employer finding of an MSD risk factor based on a supervisor or worker assessment would result in additional and potentially more costly investigation or action. Actions might include expert ergonomist consultation or work reorganization or reengineering.

The findings of this study indicate that supervisors can effectively identify the presence or absence of specific risk factors in their jobs, relative to objective criteria. In assessing the absence or presence of all risk factors, agreement with the ergonomist was found 81% of the time for supervisors. Supervisors tended to overestimate the MSD risk, and though supervisors and their use of the assessment instrument was highly sensitive in identifying risk, its specificity in identifying particular risks for each job was low.

Every supervisor believed there was at least one of the defined risk factors present in the jobs they rated and overestimated the amount of risk found by the ergonomist's analysis that showed that one of the five jobs was free of risk as defined in the study. Given this sensitivity of the questionnaire (100%), the instrument as used may be biased toward finding risk factors. It demonstrates that apprehension about using such an assessment tool to identify MSD risk factors in a job for fear of a supervisor's propensity to overlook risk factors may be unfounded. From a public health perspective, the lack of false negative error of the screening tool for overall detection of risk, for example supervisors missing risk factors when they are indeed present, is a positive attribute of the supervisors' use of the instrument. On the other hand, the instrument was nonspecific (specificity 0%) in determining whether a job had at least one risk factor. Given the potential expense of a response to a positive risk factor assessment, efforts to understand and reduce false positive results should be undertaken.

The relatively high number of false positive errors indicates the possible presence of a bias toward finding a risk factor. This bias, if present, could potentially be reduced through additional training of the assessors. It is possible that a more precise measure of specificity could be obtained by extra efforts to reduce this potential bias and by explicitly including jobs in the study with a lower prevalence of risk factors (four of the five jobs in this study had at least one risk factor).

While we made every effort to present information in a balanced manner, it is possible that some supervisors or workers, due to the context of the study, felt compelled to answer yes to at least one of the 14 yes/no questions, thereby indicating the presence of at least one risk factor. In a setting of employer-directed assessments in response to a regulation, with potentially substantial costs resulting from a positive finding, it is possible that a bias away from reporting risk factors could occur. The effects of bias, likely from varied sources and for varied reasons on the part of employees conducting MSD risk factor assessment, are likely to remain a challenge.

Employers have objected to the requirement that they conduct such an assessment as a preliminary step in evaluating jobs due to the amount of time required to assess each job.[27] Ninety-three percent of the supervisors reported completing the assessment in less than half an hour, with nearly two-thirds completing it in less than 15 min. The time used by

supervisors in this study indicates that it may not be a costly endeavor.

Worker Assessments

We found a relatively high level of agreement between supervisors and workers in their ability to identify risk factors both in their agreement with the ergonomist in identifying which risk factors were present and their overall accuracy in recognizing when risk was or was not present.

One might expect that workers would overestimate risk in comparison with their supervisors; we did not find this to be true. In their overall accuracy in identifying risk as present or absent in their jobs, workers were comparable to their supervisors and may be considered by employers as viable assessors of MSD risk. Of the two most prevalent risk factors found by the ergonomist, like the supervisors, workers most accurately identified repetition as a risk factor and were 18% more accurate than supervisors in recognizing its presence in the jobs they performed and 10% less likely to falsely assess its presence. Workers were only somewhat less accurate (7%) than supervisors in correctly identifying neck/back bending and as accurate as supervisors in recognizing lifting as a risk in their jobs.

The highest accuracy was achieved with infrequently observed risk factors (e.g., hand or knee used as a hammer, use of vibrating tools, squatting, and kneeling); these were correctly not observed by 96% of the participants. It is likely that these risk factors are easily discernible if present in the job tasks. Risk factors not specifically dictated by job performance requirements (e.g., neck/back bending or other postural factors), which can be somewhat transparent to a relatively untrained observer, seem to be less reliably accounted for in their presence or absence. Keying was the most discrepant risk factor, with 92% of the supervisors but only 43% of the workers accurately recognizing its absence.

Ergonomist Assessments

The "gold standard" in this study, derived from ergonomist work sampling, may be subject to misclassification. While efforts were made to sample at times representative of a typical day's risk exposure, this may not have been fully successful. Highly heterogeneous tasks may require lengthier sampling for representative assessment. Ideally, more frequent work sampling sessions and observing more workers at random times on several days would lend increased confidence to the findings.

The ergonomist's work sampling method, generalized from 2 hours of observation, may exclude risks that supervisors or workers know to be present. Evaluating the lifting risk factors is an example—employees may have known that a certain amount of lifting took place during an average day, but it was not observed during ergonomist work sampling. In this example, misclassification of the gold standard results in reduction of the estimated positive predictive value for that risk factor.

The training of the primary ergonomist was comparable to similar interobserver studies.[28,29] The interrater agreements were respectably high, however, which lends confidence to the findings, though the interrater level of agreement was strongly influenced by the high number of risk factors infrequently observed. The observational method used to determine the presence of risk, because of its subjectivity, may be less reliable than a direct measurement method. However, assessment on a present or absent scale requires less precision, and observational assessment should be adequate to assess moderate risk.

The level of familiarity of workers and supervisors with ergonomics may have influenced their success in identifying risk factors. Eighteen percent more supervisors than workers were somewhat or very familiar with ergonomics, which may partially explain their increased accuracy in recognizing risk. Keyserling[30] found that risk factors given relatively minor coverage in ergonomic training of in-plant assessors may have received less attention when instigating corrective actions, and that after learning about risk factors associated with MSDs an ergonomic checklist served as a prompt to not overlook more subtle risk factors.[31] Others have suggested that broad institution of training in ergonomics may be an important early step in any program to prevent work-related musculoskeletal disorders.[32]

Jobs were selected for inclusion in the study specifically to represent the six main categories of risk. Because we preferentially oversampled jobs with risk factors, the jobs chosen do not represent the universe of all jobs. The results may not be generalizable to lower risk industries.

CONCLUSION

Supervisors and workers were reasonably accurate in detecting risk in the jobs they perform and supervise. Most of the time they agreed with the ergonomist regarding the presence or absence of risk factors found to be present in any of the jobs. There are remaining concerns over the insensitivity of the lay assessment in detecting specific risk factors (repetition and neck/back bending detected by the ergonomist were not reported by 14 to 22% of the supervisors and workers). However, this is balanced by supervisors' report of at least one risk factor present in each job.

Additional research is necessary to better understand and reduce the sources of error and bias in supervisor and worker assessments. Nevertheless, the use of employees in initial risk factor assessments seems justified at this time as a simple, first step to identify exposure in the workplace, at limited cost to the employer. It is acknowledged that the context of lay assessment is likely to be a source of bias to the accuracy of the assessment. Supervisors and workers appear promising in their ability to accurately recognize risk in initial ergonomic assessments.

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