Office Ergonomics Evaluation in a Naturalistic Work Environment

Insurance Services - Support Services
Washington State Department of Labor and Industries

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Summary

An ergonomics evaluation study was conducted for Insurance Services - Support Services within Washington State Department of Labor and Industries. The objectives of the study were:

1) To identify ergonomic risk factors that may be associated with updated technologies that the existing guidelines might not take into account.

2) To measure physical exposures to workers from current tasks and office equipment, and compare with historical trends.

In order to achieve the objectives, a 4-phase study design was developed. In Phase 1, a baseline survey was conducted to obtain subjective overall work and musculoskeletal health information. The survey was administered online and collected basic demographic information of the subjects, work history information, perceived musculoskeletal problems of different body parts, and psychosocial questions.

Phase 2 was designed to gather concurrent objective computer-specific activity measurements and subjective body discomfort perception for a period of 10 days for each participant. This was done by (1) using a program (RSIGuard) to register various computer use information, and (2) administering online daily body discomfort survey at the end of a work shift. Relationships between the two were explored.

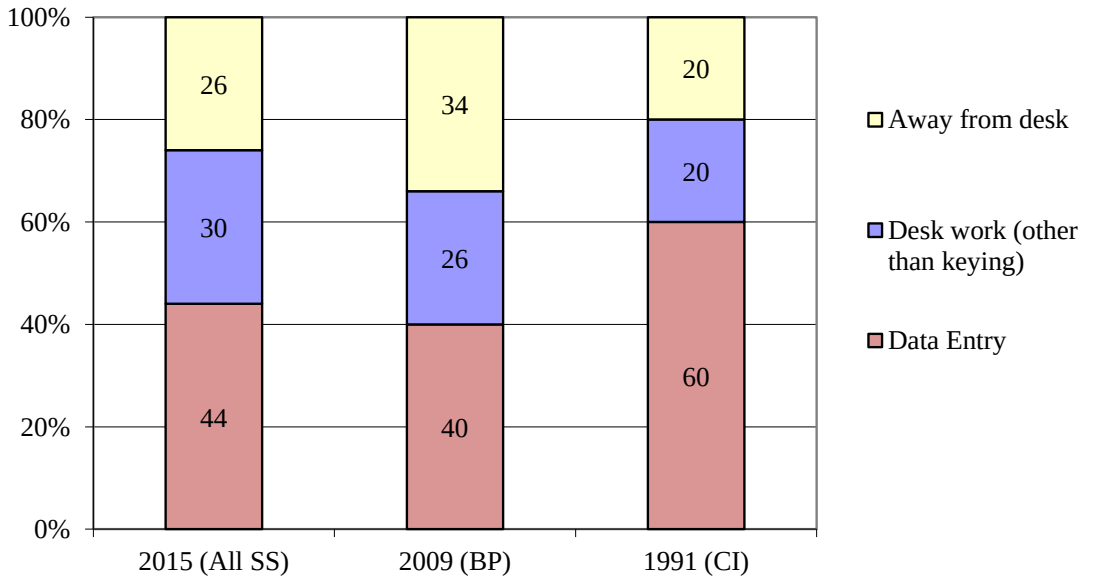
Phase 3 was designed to analyze typical work activities and postures through observations. This was done by using a time-lapse camera to capture images of task performances of workers during a complete typical work shift to obtain detailed task distribution information.

In Phase 4, physical exposure of extended keying period was evaluated using surface electromyography (EMG) on the shoulders and forearms. EMG technique is used to quantitatively measure muscle activation levels, indicating muscular efforts of the specific body parts, associated with different tasks. It helps to identify the intensities of parts of the whole job, or the postures used to perform certain jobs, and then identify potential stress sources.

Throughout this study, 20 Support Services employees participated in various phases. Nineteen participants finished the Phase 1 survey. Twelve enrolled for Phase 2, 13 for Phase 3, and 13 for Phase 4.

The results showed that workers spent a slightly more time on computers than 7 years ago, with an additional increase of other tasks at the desk. The employees were at their desk, sitting or standing, for about 74% of the time, and 44% of the work shift was spent for data entry in the current study. In comparison, 80% time at desk (performing data entry and other desk tasks) and 60% for data entry in the 1991 study.

Task Allocation Historical Comparisons



The overall static, median and peak muscle loading for the four muscles throughout all tasks were 4-11%, 8-24%, and 16-46% of maximum voluntary contraction (MVC) respectively. Corresponding limit values are known as 2%, 10% and 50% MVC, respectively. Although the average peak muscle loading did not exceed the limit, the average static and median loading did.

Working on the computer demanded the most static loading for the extensor than other tasks. Sorting, on the other hand, was the worst for the right trapezius. Claims Initiation and Bill Processing employees experienced more static loading at these two muscles than their Imaging colleagues did. Claims Initiation topped among the units in three of the four muscles for static loading.

Static muscle loading is usually resulted from holding the same posture for an extended period. This was the case for the wrist extensor (on the forearm) when the employees performing typing activities using the keyboards. The employees needed to hold her/his hands in slightly extended hand/wrist posture during typing. Positioning of the keyboard in a negative slope could be a solution to reduce the static forearm extensor loading. In addition, the sorting task demands the hand (typically the dominant hand, as monitored in this study) to grasp objects. This posts consistent static loading to forearm muscles. And in order to move the right arm back and forth, the right shoulder needs to generate the also consistent static loading.

The static shoulder loading might also be responsible for the relatively high shoulder complaints. According to the employees' survey, 79% of the employees reported having had pain, itching, stiffness, burning, numbness, or tingling in the shoulder regions in the last 12 months. This was much higher compared to the 31% in the 1991 study, or the 37% in the 2009 study. One of the future workplace improvements should probably be focused on lowering the static loading on the shoulder region for the employees.

Claims Initiation employees had to enter hand-written documents that did not go through the scanner for optical text recognition. One finding of particular interest was that the hand-written document quality (difficulty) affected static muscle loading. When entering employer report of accident forms, the static loading on the left trapezius and the flexor were statistically significant higher when the document difficulty level was equal or greater than 3 (on a scale of 1 to 5, 5 being the most difficult), compared when the level was lower than 3

According to the employees' survey, in general, 74% of the participants in the current study were satisfied with their current job situations. This was a slight improvement to what was found in the 2009 study (67%). They felt that they had little influence (in the responses to all four questions) over the decisions that affected their jobs. This was worse than the 2009 study.

In summary:

- Twenty people participated in this study for various phases. Fifteen percent of them were from Bill Processing, 40% from Claims Initiation, and 45% from Imaging.
- Time spent at the desk, or time spent for data entry have changed compared to those in 1991 and 2009. Workers spent more time on computers than in 2009.
- All participants reported some musculoskeletal issue. The prevalence rates for all surveyed body parts were all higher than in 2009.
- 29% of respondents reported missing work because of low back issues, and 25% due to shoulders.
- Ninety-five percent of the respondents reported eyestrain, dry or watery eyes, blurred vision, or other eye symptoms.
- Employees were generally satisfied with their current job conditions, but the lack of influence about their jobs, except the flexibility to arrange furniture, seemed an overwhelming issue that should not be neglected.
- Self-reported shoulder problems were prominent. These could be caused by relatively high static loading on the shoulder region. Reducing shoulder static loading should be the focus in future ergonomic improvement efforts.
- The difficulty of the documents that require manual data entry could affect static muscle loading.
- Workstations were mostly conforming to current guidelines. However, sit-stand function of the standard issued desks was not widely used.
- Further ergonomic improvements may need to go beyond the current office ergonomics guidelines.

Introduction

The Safety and Health Assessment and Research for Prevention (SHARP) program conducted a series of studies on workers in the Claim Initiation and Bill Processing units at the Washington State Department of Labor and Industries since the early 1990's (SHARP, 1991; SHARP, 1992; SHARP 2009). Those studies measured the magnitudes and distribution of musculoskeletal disorders (MSDs) associated with computer work using symptom questionnaires, physical examinations, nerve conduction tests, work observations, surface electromyography, computer activity logging and video observation. It was observed that the MSDs prevalence rates were 36% for hand/wrist, 22% for neck, 14% for shoulder and 8% for both elbow and back, which were higher than those observed in other studies of office workers in 1991 (SHARP, 1991).

Based on those findings, the studies recommended intervention methods including new ergonomic furniture and alternative work patterns (for example, the combination of claim keying jobs and phone conversation with customers). More importantly, the studies established guidelines that limit intensive keying to 5 hours a day and more frequent alternation between medium and low-paced keying jobs as an attempt to reduce the risks for hand/wrist and shoulder musculoskeletal disorders.

These guidelines had been actively adopted by the Claim Initiation Unit and other computer operation units at the Department of Labor and Industries. As a result, the prevalence rates of discomfort decreased significantly. Notably, the neck MSDs prevalence rate was reduced by 7% one year after the intervention (SHARP 1992). Employees gave positive feedback on alternative work schedules and less keying, new workstations and office furniture, and a new building.

The latest study at the Bill Processing unit examined the impact of working hours on workers' exposure to MSD risks (SHARP 2009). Results showed that 5-hour vs. 6-hour computer work had no significance on workers' exposure to MSD risks, although employees showed muscle fatigue signs within 2 hours after they started their daily work. The results provided guidance to the management to allow 5.5-hour daily computer work, and introduced more frequent breaks and annual discomfort survey among their employees.

Over the years, computer technologies have advanced at a much faster rate, as has the adaptation within the Insurance Services division. Newer, faster, and sometimes automatic equipment were recently put in service within various supporting units. The management of the Insurance Services - Support Services at the Department of Labor and Industries has requested that SHARP assess whether these technologies require changes to existing ergonomics guidelines, or whether they further address old and unresolved ergonomics issues or incur unforeseen adverse health problems. In addition to the two original units (Bill Processing and Claim Initiations) that participated in the early series of studies, other units within the same agency were also interested in the ergonomics evaluations of their job functions.

It is SHARP's perspective that latest technological developments in office environments and computer systems may pose different exposures to the employees. For example, digital scanning, optical character recognition (OCR) techniques, and text clipboard (copy and paste) functions significantly reduce keying demands. A faster pace could have increased the overall workload without employees realizing it. Further, the new technologies may require different operating postures not previously observed. These warrant up-to-date observations and evaluations.

The objectives of the present study were:

- To assess ergonomics risk factors that may be associated with updated technologies that the existing guidelines might not take into account.
- To measure physical exposures to workers from current tasks and office equipment, and compare with historical trends where available (Bill Processing and Claims Initiation).

Materials and methods

Study Design

This study consisted of four phases: (1) employee work and health survey, (2) computer activity exposure assessment and daily discomfort report, (3) observational task and ergonomics analysis, and (4) muscle activity assessment of task samples. This study was approved by the Washington State Internal Review Board (WSIRB) for the compliance with related federal, state, and local regulations.

Participants

A series of information sessions was conducted for all Support Services employees at the beginning of the project. SHARP researchers explained the background of the study, objectives, procedures, and answered questions. Volunteers were then enrolled after providing their signed informed consents. They chose to participate in one or more study phases. Altogether 20 participants participated various phases. They included three from Bill Processing (BP), eight from Claims Initiation (CI), and nine from Imaging units. One participant started Phase 1 in CI, but was transferred to Admin in Phases 2 and 3. Participants from the Imaging unit came from 4 different functional teams. For the purpose of data analysis, they were combined as a group, as there were only one or two participants from each of the four teams. Table 1 shows the demographic data of the study participants for each of the three phases.

Table 1. Demographic data of the study participant and the sex ratio.

Study phase	# of subjects (men/women)	Average age (range)	Average height (range)
1	19 (3/16)	44.4 (23-62)	5.4 (4.9-6.2)
2	12 (3/9)	43.7 (23-62)	5.5 (4.9-6.2)
3	13 (3/10)	44.6 (23-62)	5.5 (4.9-6.2)
4	13 (2/11)	45.9 (23-62)	5.3 (4.9-5.8)

Methods and procedures

Phase 1: Survey

A survey was conducted to obtain job and health information. The survey was administered through an online survey site (http://www.surveymonkey.com/) and the link to the survey questionnaires was sent to participants via emails. The survey collected basic demographic information, work history, self-reported musculoskeletal problems of different body parts, and psychosocial questions. The survey is presented in its entirety in Appendix A. Similar questions that were used in previous studies in the Support Services unit were included in the present survey.

Phase 2: Computer activity

Objective and quantitative computer use was recorded using a software (RSIGuard, Remedy Interactive Inc., http://www.rsiguard.com/index.htm), installed in each participant's computer.

The program ran in the background. Depending on the individual preference settings, the software could prompt the users to perform simple stretches, or to take short breaks. The main use for this study was its registered computer use summary, including keyboard use time, mouse use time, time using or not using computer, etc. The daily computer use information was collected for 10 complete workdays for each participant.

Concurrent daily body discomfort survey was filled at the end of each workday for the same 10-day period. The survey was again collected online using the same online survey service (http://www.surveymonkey.com/). A daily electronic calendar reminder prompted the participant shortly before the end of the participant's shift. The survey was one page long, and asked about discomfort levels at different body parts (Appendix B).

Phase 3: Task and posture analysis

The work activity and posture observation was conducted on a separate day. This was done using a camera to take time-lapse still images, one per minute, during a whole work shift. The camera was set to focus on the participant in the workstation. This observation day was chosen by the participant to represent a "normal work day".

Observation coding was performed afterwards to categorize task activities and body postures of each captured image. An analyst viewed individual images and coded various task activities, work postures, and equipment use. Distribution (% of time) of task activities and work postures were computed.

Phase 4: EMG

Physical exposure was evaluated using surface electromyography (EMG) technique. This non-invasive method monitors minuet electricity corresponding to muscle activity to represent the effort exercised by the muscles under surveillance. Surface EMG electrodes were placed on the left and right trapezius muscles on the shoulders, as well as the forearm flexor digitorum superficialis and extensor digitorum muscles of the dominant forearm (Figure 1). Cables carrying the signal ran from the electrodes to a battery-powered transmitter wore or carried by the participant. Signals were transmitted telemetrically to a receiver connected to a laptop computer for data collection and storage. EMG was sampled at 1,000 Hz (1,000 data points for second per muscle).

A calibration procedure was performed (Bao, Mathiassen, & Winkel, 1995, Bao, Silverstein, & Cohen, 2001) to obtain the maximal muscle activity level (MVC – maximal voluntary contraction) of each of the tested muscles. Muscle activities during work were expressed in terms of percentage of the MVC (%MVC), which is a measure of the muscle load relative to the employee's capacity of a particular muscle. Percent of MVC (%MVC) is a relative risk indicator of muscle loading. Work muscle activities were measured for up to two hours during a period of a typical normal work day. At the same time, a video camera was used simultaneously so that muscle activities could be associated to the various activities.

EMG data were bandpass filtered between 30 and 250 Hz, and smoothed using the root-mean-square method with a 100 ms window, for later analysis. The EMG distribution was calculated according to the amplitude probability distribution function (APDF). The static, median and peak

muscle load levels were obtained corresponding to the 10th(P10), 50th(P50) and 90th(P90) percentiles of the APDF curve (Jonsson, 1982).

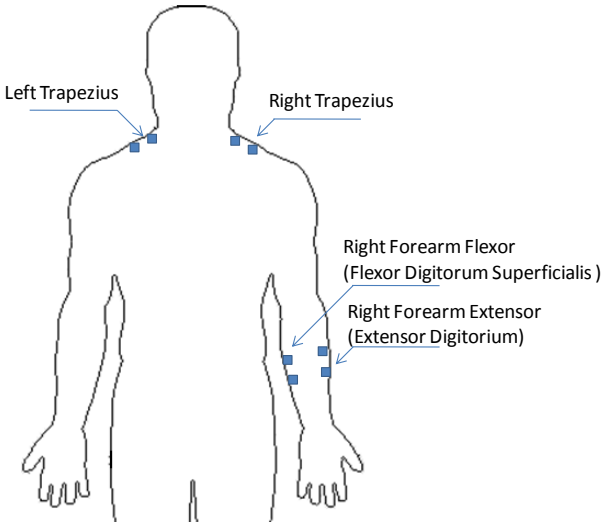


Figure 1. Placement of EMG electrodes

The main job duty for Claims Initiation employees is to enter two paper forms into the computer database: Report of Accident, and Employer Report of Accident. These forms are mostly handwritten and submitted by parties (physicians, employers, injured employees, or designated representatives) involved in a worker's compensation claim. The difficulty of the document (considering handwriting legibility, wordiness, etc.) was subjectively rated by the CI participant using a five-point scale (integers 1 being the easiest to 5 being the most difficult) upon entry completion.

Results

Phase 1: Survey

Nineteen participants (16 women and 3 men) filled out the survey. Three were from Bill Processing, 7 from Claims Initiation, and 9 from Imaging (2 Team A, 1 Team B, 3 Team C, 1 Team D, 1 Team N, and 1 Team O). They were all right handed. Their job tenure with Support Services ranged from less than one year to 26 years.

"Data entry" and "document analysis, review, and correction" are the major tasks on an average workday as reported by the participants (Figures 2-3 and Table 2). Both tasks involved intensive computer work. Imaging colleagues had a slightly even spread time among tasks, compared to their colleagues in the other two groups.

Key findings of Phase 1

*** All participants reported at least one musculoskeletal complaint.**

*** Most common musculoskeletal complaints were on shoulders, followed by necks, and low back.**

*** Employees were generally satisfied with their jobs.**

Table 2. Specific tasks spent on an average workday (mean and range in parentheses) comparison between the 2009 (Bao et al. 2009) and the current study.

Job activity	2009*	2015
Data entry	61 (range:5-100)%	51 (range: 0-100) %
Document analysis, review, correction	N/A	21 (0-80) %
Document preparation (pre-scanning)	N/A	12 (0-60) %
Keying	64 (5-100) %	(see Fig. 2 below)
Telephone	3 (0-20) %	4 (0-20) %

* Activities not mutually exclusive, therefore not adding up to 100%.

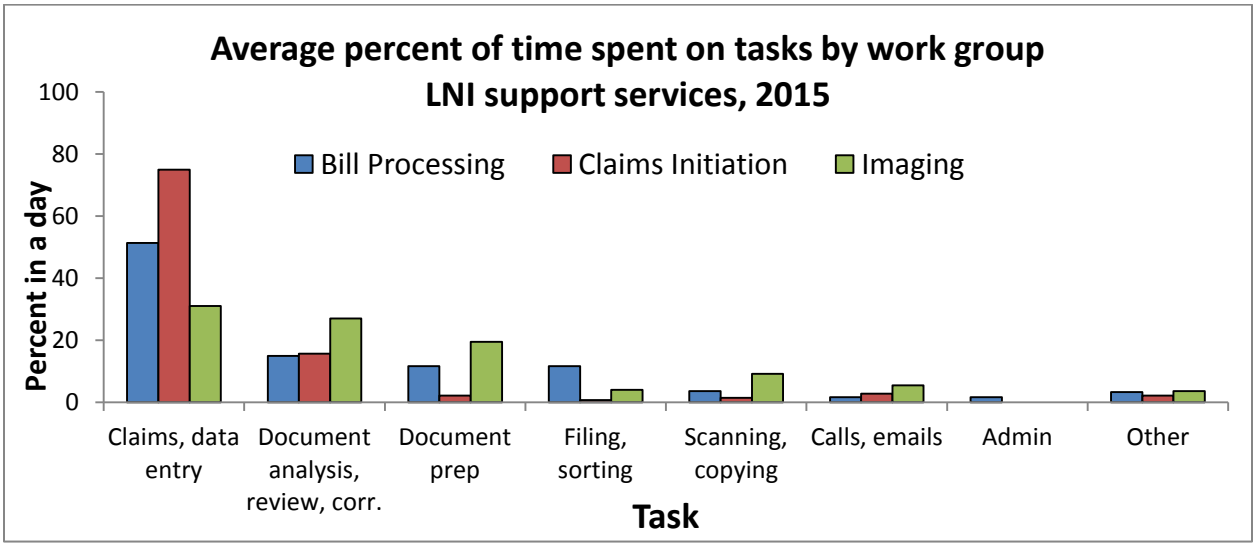


Figure 2. Self-reported percent of time spent on various tasks on a typical day among three study groups.

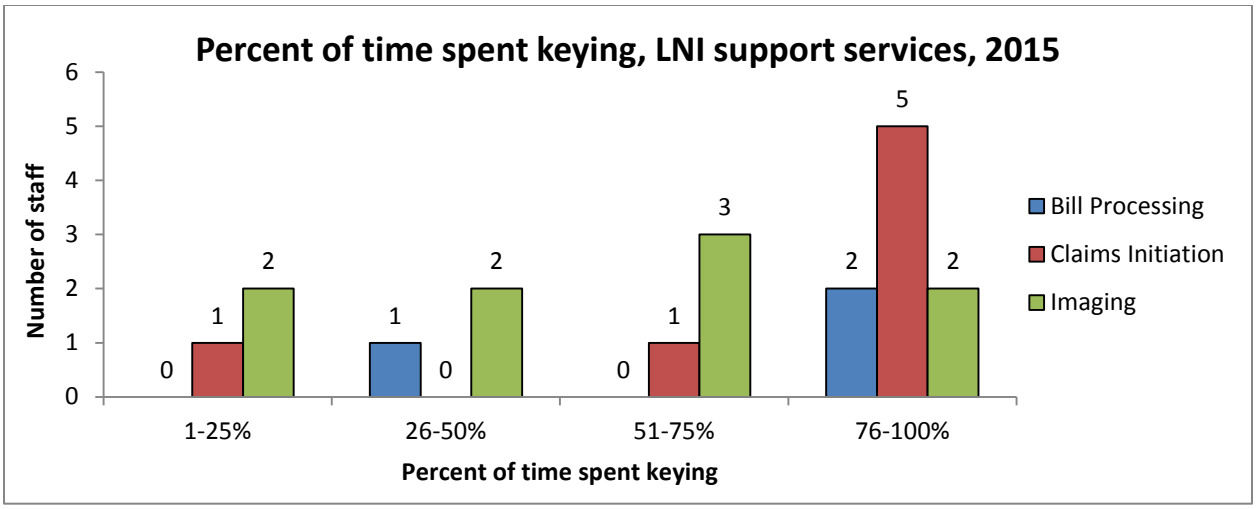


Figure 3. Percent of time in a typical day spent on keying reported by study participants of the three units.

The department issues standard computer accessories (monitor, keyboard, and mouse) for each employee. However, the internal safety and health program allows each individual to obtain necessary alternatives (e.g., ergonomics keyboard, vertical or trackball mouse) or additions (document holder, wrist rest, footrest, etc.) based on individual requests or ergonomics assessment recommendations. The participants reported their accommodations (Table 3). More than half of the participants (10 out of 19) tilted their keyboards using the keyboard's legs. Among the 10, only one chose to tilt the bottom up (negative tilt), while the other nine tilted the top up (positive tilt).

Table 3. Equipment used by participants

Equipment	2009	2015
Ergonomics keyboard	16%	37%
Trackball or vertical mouse	5%	37%
Dual monitors	90%	95%
Document holder	58%	58%
Wrist rests	58%	16%
Footrest	74%	47%
Headset	26%	42% (5 out of 12)

All participants (100%) reported having at least one musculoskeletal problem (pain, itching, stiffness, burning, numbness, or tingling) in the last year. All percentages were greater than those reported in 2009 (Table 4). Different from the 2009 study, where neck problems were most frequently reported, the current survey showed that shoulder issues were most common. When asked about the most serious or troublesome body part among which they reported, six of the participants indicated "shoulder", and four selected "hand/wrist". "Neck" was named by only two participants as the most troublesome issue.

Table 4. Prevalence rates (% participants) of reported musculoskeletal problems in the last 12 months

Body part	2009	2015
Neck	42%	58%
Shoulder	37%	79%
Elbow/forearm	16%	32%
Hand/wrist	11%	53%
Low back	37%	42%

Lengths and consequences due to the reported musculoskeletal problems varied by body parts (Table 5). Many of the participants who experienced musculoskeletal problems also had the problems in the last 7 days. More than half visited a doctor for their problems. Problems with the low back, shoulders and neck have caused workers missing working days. Few occasions were the workers who had problems assigned to light duty activities. Some workers who had problems reported certain activities could make their problems worse. The most often reported activities included prolonged sitting (especially in static/awkward postures), and keying in static/awkward posture.

Table 5. Characteristics and consequences of the reported musculoskeletal problems.

Measure	Neck (n=11)	Shoulders (n=15)	Elbows/ Forearms (n=6)	Hands/ wrists (n=10)	Low back (n=8)
Problem lasted for ≥ 6 months	36%	20%	0	0	0
Problem lasted for 1 week to 6 months	0	13%	50%	30%	13%
Problem lasted for 1 day to 1 week	18%	20%	0	10%	25%
Problem lasted for < 1 day	45%	47%	50%	60%	63%
Still experience problem in last 7 days	82%	67%	83%	50%	38%
Believed as results from the current job	64%	80%	67%	80%	63%
Visited doctor for the problem	91%	47%	50%	70%	50%
Missed work due to the problem (vs. 2009)	18% (13%)	13% (25%)	0 (0)	10% (0)	50% (29%)
Assigned to light duty activity (count)	0	0	1	2	1

Although not part of musculoskeletal concerns, the survey asked about their eye health that may be related to using the computer monitors. Ninety-five percent of them reported some or all of these symptoms in the past year: eyestrain (sore or tired eyes) (13), dry or watery eyes (7), blurred vision (5), burning, itching or red eyes (5), glare sensitivity (4), or double vision (3). Eleven of them reported headaches that further stemmed from these eye issues. In the immediate past 7 days of the survey, seven participants reported moderate level of eye discomfort, while 8 and 4 reported little and none eye discomfort, respectively.

The job stress results were similar to those from the 2009 study (Table 6). Most workers rarely or only occasionally felt conflicting demands with co-workers and short of time finishing their work, and very often felt that their supervisors were willing to listen to their work-related problems.

However, the percentage of feeling of being able to influence aspects of their jobs declined significantly over time. Overall, most participants were satisfied with their current job situations.

Table 6. Psychosocial aspects of jobs, current (vs. 2009) percentage of 19 responses. Green cells represent improvements (combined responses on one side of the scale) of more than 10 percentage points (roughly equivalent of 2 answers) compared to the 2009 results. Red cells indicate declines (worse) by more than 10 percentage points.

A: Job Stress

	Rarely	*Occasionally*	*Sometimes*	*Fairly often*	*Very often*
How often are you faced with conflicting demands of people you work with?	84% (56%)	5% (11%)	5% (33%)	5% (0%)	0% (0%)
How often is your supervisor willing to listen to your work-related problems?	5% (0%)	5% (0%)	5% (12%)	26% (18%)	58% (71%)
How often does your job leave you with too little time to get everything done?	37% (50%)	26% (6%)	16% (22%)	11% (17%)	11% (6%)

B: Influence

	Very little	*Little*	*Moderate amount*	*Much*	*Very much*
How much influence do you have over the amount of work you do?	37% (17%)	26% (11%)	11% (22%)	16% (33%)	11% (17%)
How much influence do you have over the availability of materials you need to do your work?	11% (28%)	26% (0%)	32% (17%)	21% (44%)	11% (11%)
How much do you influence the policies and procedures in your work groups?*	39% (22%)	33% (6%)	11% (22%)	11% (39%)	6% (11%)
How much influence do you have over the arrangement of furniture and other equipment at your workstation?*	11% (18%)	17% (0%)	22% (18%)	44% (47%)	6% (18%)

* One participant did not answer.

C: Satisfaction

	Not at all	*Not too much*	*Some what*	*Quite a bit*	*Very much*
How satisfied are you with the amount of influence you have over the decisions that affect your job?	11% (11%)	11% (11%)	37% (28%)	37% (28%)	5% (22%)
All in all how satisfied are you with your job?	5% (11%)	0% (6%)	21% (17%)	37% (11%)	37% (56%)

Phase 2: Computer activity

This phase consisted of both the subjective daily discomfort report and the objective registered computer activity summary. Participants reported an average of 5.7 hours of computer work with a 95% confidence interval (CI) of 5.4 - 5.6 hours. This was about 1 hour more than that reported in the 2009 study, when the average and 95% CI was 4.8 and 4.6 - 5.0 hours, respectively.

Key findings of Phase 2

*** On average, each employee spent about 3.7 hours on the computer per shift.**

*** Longer computer use was associated with higher shoulder and low back discomfort ratings, although discomfort levels were generally low.**

*** Work postures when performing data entry work on the computer were mostly of low risks.**

The computer activity monitoring software (RSIGuard), on the other hand, registered 3.7 (95%CI: 3.4 - 4.0) hours of computer use (Table 7). These numbers were about the same as in the 2009 study. In the current study, the registered hours were lower than the subjective estimates. There was a moderate correlation between the self-reported computer use time and RSIGuard registered hours (Pearson correlation coefficient: 0.6).

Computer use varied significantly by individual and work unit. Claims Initiation colleagues spent an average of 5.6 hours on computers a day, while Bill Processing, Admin, and Imaging spent 3.8, 3.8, and 3 hours, respectively (Table 8). Computer use hours were consistent during the 10-day period.

Table 7. The mean (standard deviation) registered computer activity per day in the 10-day period.

Parameter	2015	2009 Means
Computer use time (hours)	3.7 (±1.6)	3.8
Computer use proportion (% shift)	46.1 (±20)	N/A
Keyboard use time (hours)	2.7 (±1.4)	3.4
Keyboard use proportion (% shift)	33.7 (±18)	N/A
Mouse use time (hours)	2.3 (±1.1)	3.4
Mouse use proportion (% shift)	29.6 (±14)	N/A
Total keystrokes	11,226 (±8109)	22,000
Total mouse clicks	3,467 (±1864)	1,067

The continuous keyboard and mouse use times were defined as the cumulative durations in which two consecutive keystrokes/mouse clicks occur within a 20 second interval. Mouse clicks included not only mouse clicks but also mouse moves and wheel-spins. These corresponded to 2.7 hours of continuous keyboard use and 2.3 hours of continuous mouse use, both lower than the 2009 levels. The participants averaged 11,226 keystrokes a day, about half of the 2009 number at 22,046 (Table 7). The total number of mouse clicks was 3467, almost three times more than in 2009 (1,067) per shift.

Table 8. Average registered computer activity by units.

Parameter	Admin	Bill Processing	Claims Initiation	Imaging
Computer use time (hours)	3.8	3.8	5.6	3.0
Computer use per shift	50%	46%	70%	37%
Keyboard use time (hours)	1.9	3.2	4.1	2.1
Keyboard use per shift	26%	39%	51%	26%
Mouse use time (hours)	3.2	1.6	2.8	2.4
Mouse use per shift	41%	20%	35%	31%
Total keystrokes	12170	13088	16674	8092
Total mouse clicks	5075	2769	3568	3505

If comparing only the Bill Processing colleagues between the two studies (Table 7 right column and Table 8 middle column), the computer use time and keyboard use times were about the same. The mouse use time decreased to about half (3.4 hours in 2009 and 1.6 hours in 2015). However, keystrokes decreased, and the mouse clicks increased between the two studies.

Overall for all participants in the Support Services, the neck outranked the right shoulder for the daily discomfort ratings, with a scale 0 - 10, followed by low back, during the 10-day period (Table 9). Analysis of variance revealed that there was no significant report day effect. It means that the discomfort report was consistent among the 10 days for each participant. Bill processing employees had the highest discomfort among all participants for all body parts. Further, all discomfort ratings were higher than in 2009, when the identical self-reported discomfort scale (Borg 10-scale) was used.

Table 9. Daily body discomfort survey results

Body part	2015 Overall	2015 Imaging	2015 Bill Processing	2009 Bill Processing
Neck	1.75	1.76	3.28	0.51
Left shoulder	0.68	0.23	2.12	0.49
Right shoulder	1.44	0.97	3.59	1.55
Left elbow	0.40	0.11	1.28	0.04
Right elbow	0.86	0.31	2.59	0.12
Left hand	0.60	0.29	1.31	0.08
Right hand	1.30	0.93	2.76	0.23
Low back	2.09	2.35	3.05	0.43

Computer use parameters correlated to body discomfort ratings differently (Table 10). The total computer hours in a day significantly correlated to discomfort ratings for all body parts except for the neck and right hand/wrist. More keyboard use (both key strokes and length of time) was associated with higher the discomfort for various body parts. However, mouse use (clicks and length of time) affected the right and left side differently. Lower discomfort ratings were reported on the left shoulder, left elbow, and left hand/wrist when the total mouse uses were greater.

Table 10. Correlations between body discomfort rating and computer use parameters, Pearson correlation coefficient – including all data.

Body part	Computer Hours	Total Key Strokes	Total Mouse Clicks	Keyboard Hours	Mouse Hours
Neck	0.09	-0.00	-0.16	-0.06	-0.15
Left shoulder	**0.20***	**0.30***	**-0.28***	**0.31***	**-0.27***
Right shoulder	**0.23***	**0.23***	0.00	0.17	-0.09
Left elbow	**0.20***	**0.31***	**-0.22***	**0.28***	**-0.21***
Right elbow	**0.20***	**0.27***	-0.11	0.21	-0.15
Left hand/wrist	**0.30***	**0.37***	**-0.26***	**0.38***	**-0.19***
Right hand/wrist	0.15	**0.27***	**-0.33***	**0.22***	**-0.28***

* Significant at $p < 0.05$.

Phase 3: Task and posture analysis

On average, 499 (range: 468-509) time-lapse pictures on a given day were taken for each of the 12 participants. Pictures were analyzed frame by frame. The work activity and postures in each frame were coded for analysis. When the participant was not observed in a picture, the activity was not assigned, and marked as absent from picture.

Sitting averaged 65% per shift (Table 11). Standing averaged 9%, while 26% of the times the participants were outside of the camera view.

Table 11. Distribution of task activities, keyboard/mouse use, and work postures based on video observations (% of the shift)

Activity	2015 Observation % of shift (2009 result if available)
Sitting	65.4 (66.1)
Standing	8.7
Absent	25.9 (33.9)
Data Entry	42.6 (40.3, including viewing screen)
Viewing screen	1.6
Pre-scanning	9.7 (4.0, including sorting)
Hand sorting	0.3
Conversation/meeting	3.2 (3.5)
Using the phone	2.8 (1.3)
Reading/writing at desk	2.5 (9.5)
Micro breaks	1.9 (4.2)
Other	5.5 (3.9)

Posture at each body part was categorized into three risk levels, with 0 being no risk, 1 being some risk, and 2 being high risk. Levels 1 and 2 were combined to represent any risks observed and reported in Table 12. Neck had the highest observed risks among all body parts.

Two special risks were assessed: wrist placed on the desk edge (contact stress), and sitting with the back leaning forward (back not supported). Wrist-on-desk-edge was observed among four participants (ranging from one to 57 occurrences), while back leaning forward was observed on average eight times per shift for all participants (ranging from 0 – 35 occurrences).

Table 12. Average (minimum – maximum) observed risks as percent of shift assessed at 7 body parts.

Body Part	Risks observed % of shift (min-max)
Neck	21.0 (range: 3.4-52.4)
Back	3.0 (0-15.8)
Torso	2.3 (0-9.0)
Left arm	1.0 (0-4.3)
Right arm	1.6 (0-10.5)
Left hand	0.6 (0-2.0)
Right hand	2.2 (0-12.3)

Phase 4: EMG

An average of 73 (range 20 – 131) minutes of EMG data was analyzed for each participant. Three different muscle activity levels of the amplitude probability distribution function (APDF) analysis were performed and they represented (1) static loading (10^{th} percentile level or P10), (2) median loading (50th percentile level or P50), and (3) peak loading (90^{th} percentile level or P90) for the particular period of interest. Altogether, 13 participants with 111 distinct tasks and durations were identified and analyzed. Summary results are listed in Table 13.

Key findings of Phase 4

*** Static loading on forearm extensor and shoulder muscles were the main concerns.**

*** Static muscle loading was related to computer work.**

*** Difficulty of the hand-written documents for manual data entry was related to forearm flexor and shoulder muscle loadings.**

*** Sit-stand function was not related to any upper body muscle loading measures.**

Table 13. Overview of muscle activity study results. Numbers represent mean EMG (standard deviation) for the four muscles. They were normalized to respective muscular maximum voluntary contraction (MVC), expressed as %MVC.

Muscle	Static P10	Median P50	Peak P90
Extensor digitorum	10.7 (±6.4)	23.5 (±11.7)	46.4 (±22.8)
Flexor digitorum superficialis	3.7 (±3.2)	9.1 (±5.2)	29.6 (±12.7)
Trapezius (left)	4.1 (±3.9)	8.4 (±6.6)	15.7 (±11.0)
Trapezius (right)	4.1 (±3.9)	10.4 (±8.9)	20.9 (±17.6)

Muscle activities varied for different tasks (Figure 2). Extensor muscle at the forearm had the highest static loading while performing computer and other manual work. However, computer work had lower shoulder muscle static loading compared to sorting and all other activities. Among the three units (Bill Processing, Claims Initiation, and Imaging), the static loading on the muscles from computer work was different. Employees at Claims Initiation had the highest, compared to their colleagues, static loading on wrist flexor, extensor, and left trapezius (Figure 3). Bill Processing employees had higher static loading at the right trapezius than their colleagues.

For Claims Initiation employees, their job was mostly to enter two kinds of documents into the computer database: Report of Accident (ROA), and Employer Report of Accident (EROA). Document type was only significant on time to completion, as ROA was a longer form. Muscle activity (all static, median, and peak measures) was not affected by document type.

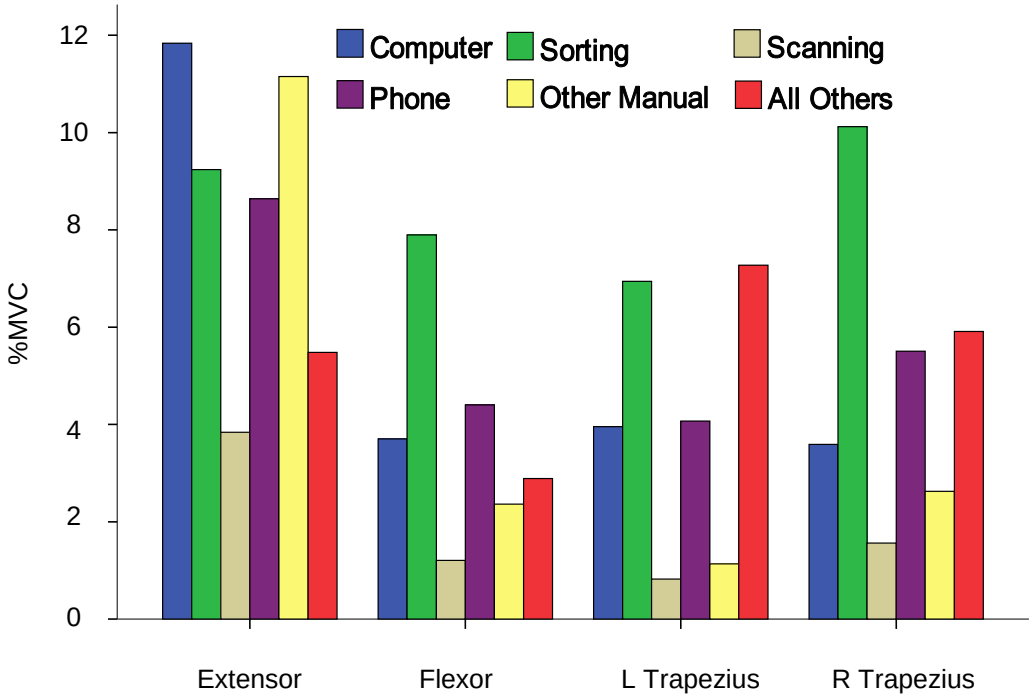


Figure 2. Mean static muscle activities (%MVC) when performing different activities. "Other Manual" included stamping, applying mailing labels, and other minor office tasks not included in the four defined categories. "All Others" included remaining activities, such as reading during breaks, reaching for water, snacking, conversation with colleagues, etc.

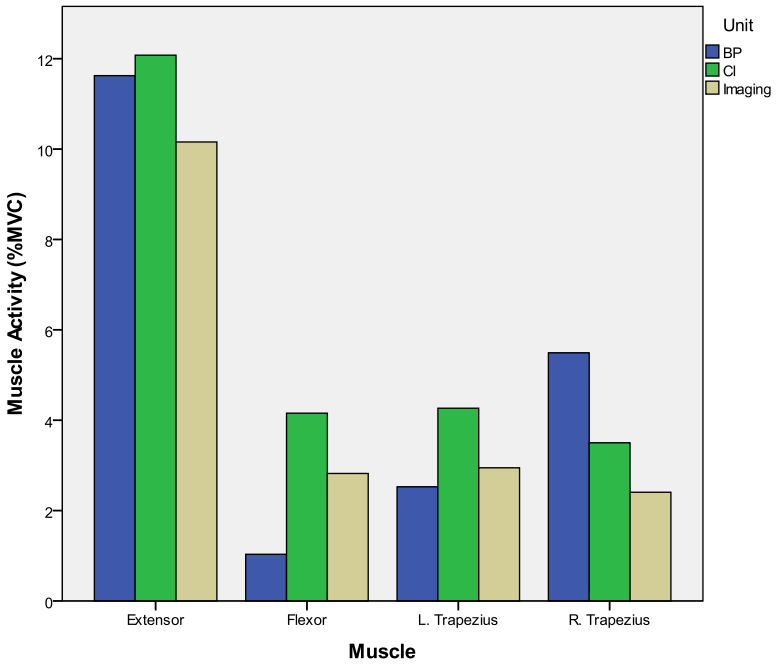


Figure 3. Static loading at four muscles for computer work among three Support Services units.

On the other hand, document quality score was found to affect muscle loading. During analysis, the 1-5 document scores were further consolidated into two levels: <3 or >=3. Such separation made the two groups of roughly equal size. There are 13 cases with scores <3 and 11 cases with >=3 among recorded EROA completions, and 8 cases for each level for ROA completions. When entering EROAs, the static loading on the left trapezius and the flexor were statistically significant higher when the document difficulty level was equal or greater than 3, compared when the level was lower than 3 (Table 14). Other muscles shared similar document difficulty effect, although not at a statistical significant level. Regardless of document type, longer completion time was associated with higher difficulty score (Table 15). Median loading at the left trapezius were significantly higher when the document score was equal or greater than 3.

Table 14. Static loading on the four muscles by document difficulty level and document type.

Document	Muscle	Level	Mean (%MVC)	SD (%MVC)	Difference (%MVC)	t-test	*p*-value
EROA	L. Trapezius	>= 3	7.10	2.86	5.29	5.39	**0.00**
		< 3	1.81	1.93			
	R. Trapezius	>= 3	4.17	1.68	0.12	0.11	0.92
		< 3	4.06	3.61			
	Flexor	>= 3	6.34	3.71	3.15	2.32	**0.03**
		< 3	3.19	2.80			
	Extensor	>= 3	12.10	2.77	3.79	1.89	0.08
		< 3	8.31	6.59			
ROA	L. Trapezius	>= 3	3.55	1.51	1.55	1.48	0.16
		< 3	1.99	2.54			
	R. Trapezius	>= 3	3.62	2.30	1.56	1.67	0.12
		< 3	2.06	1.28			
	Flexor	>= 3	5.46	4.04	2.14	1.13	0.28
		< 3	3.32	3.54			
	Extensor	>= 3	12.32	2.72	5.43	2.09	0.07
		< 3	6.89	6.82			

Table 15. Median loading on the four muscles and the average data entry time, by document difficulty level and document type.

Document	Muscle	Level	Mean (%MVC)	SD (%MVC)	Difference (%MVC)	t-test	p-value
EROA	Time (min)	>= 3	3.80	1.73	1.16	2.13	0.05
		< 3	2.64	0.55			
	L. Trapezius	>= 3	11.25	4.27	7.67	4.90	**0.00**
		< 3	3.58	3.41			
	R. Trapezius	>= 3	8.24	2.88	-1.10	-0.46	0.65
		< 3	9.35	8.05			
	Flexor	>= 3	13.47	5.92	4.26	1.90	0.07
		< 3	9.21	5.09			
	Extensor	>= 3	23.11	9.80	4.02	1.30	0.22
		< 3	19.09	3.33			
ROA	Time (min)	>= 3	9.90	3.83	3.32	2.23	0.05
		< 3	6.58	1.78			
	L. Trapezius	>= 3	6.62	1.89	3.08	2.20	**0.05**
		< 3	3.55	3.48			
	R. Trapezius	>= 3	9.52	5.15	5.41	2.81	**0.02**
		< 3	4.12	1.78			
	Flexor	>= 3	12.41	5.63	4.38	1.65	0.12
		< 3	8.03	4.95			
	Extensor	>= 3	20.48	7.47	0.68	0.15	0.89
		< 3	19.80	10.88			

All study participants were equipped with sit-stand workstations. They were free to adjust and chose posture during data collection. Four participants were observed performing their work in both sitting and standing postures. Their EMG data were further analyzed. Due to the lack of any statistical power from such a small sample size, only the summary data are presented (Table 16). For participant L13, standing resulted in higher (difference of more than 1% MVC) static and median muscle activity than sitting. For the remaining three participants, the posture effect was mixed. Many measures show negligible differences.

Table 16. Muscle static and median loading (in %MVC) at the four muscles among the four study participants while continuously sitting and standing performing identical tasks. Participant L11 had two comparable pairs, separated due to different tasks. Bold numbers indicate higher values (difference more than 1 %MVC) between the two postures.

ID	Posture	Time (s)	Left Trapezius			Right Trapezius			Flexor			Extensor		
			Static	Median	Peak	Static	Median	Peak	Static	Median	Peak	Static	Median	Peak
L09	Sitting	581	0.7	11.7	**21.4**	10.1	**24.2**	**41.4**	1.0	**6.0**	**13.2**	**9.2**	**15.7**	**27.4**
L09	Standing	528	**8.5**	12.0	16.9	**11.8**	19.3	29.0	0.8	4.1	11.7	7.4	13.9	25.3
L11	Sitting	519	0.6	1.4	**3.6**	2.3	**5.0**	**11.7**	1.4	5.7	27.7	1.6	12.2	30.8
L11	Standing	545	0.3	0.8	2.4	1.8	3.6	10.7	1.9	5.8	28.6	**3.4**	**14.5**	**32.3**
L11	Sitting	338	0.6	**1.7**	**3.2**	1.7	3.0	5.3	1.0	5.3	**35.3**	0.7	**14.1**	29.9
L11	Standing	380	0.1	0.7	2.0	1.7	3.3	5.5	1.4	5.5	25.8	**2.4**	13.1	**31.1**
L12	Sitting	566	0.9	**3.2**	**7.8**	0.5	**7.2**	**19.3**	1.7	3.3	8.5	1.8	16.3	31.9
L12	Standing	2384	0.8	1.9	3.9	0.4	2.5	10.0	1.7	3.8	9.2	**6.0**	**19.7**	**35.7**
L13	Sitting	366	3.1	7.6	16.8	0.6	2.4	4.4	0.7	2.4	12.1	11.9	18.6	28.6
L13	Standing	183	**8.6**	**11.7**	17.3	**3.1**	**5.2**	**7.7**	**3.6**	**9.6**	**28.0**	**24.6**	**31.9**	**42.2**

Other observations

Throughout our data collection, we observed the workstation setups against common ergonomics principles. Most were in acceptable compliance. Some minor issues were observed and listed in below.

- No stretching nor moving muscles regularly, except for two who used RSIGuard reminders.
- Bending neck to look down at items on the desk for extended periods. (reminder given)
- Palm on the desk edge while typing. (Contact stress issue. recommended to move keyboard back)
- Staring at computer screens with little or no movements for extended periods. (Static neck/shoulder loading issue. Recommended to have frequent micro-breaks and move neck/shoulder muscles)
- While sitting, leaning forward without using seat back for support. (back loading issue, recommend to have propter chair fitting, and awareness training to workers on the importance of back support).
- Monitor distance being too far, font size being too small. Eye exam and font size adjustment were recommended.
- Duel monitor placements being not optimal. (Awkward neck posture issue: recommend to have an ergonomics consultation from internal safety on monitor placement).
- Glare through windows, or lighting from the ceiling. (Vision and neck posture issues. Screen brightness adjustment recommended.)

Discussion and conclusions

Work activities

In the 1991 study, it was found that employees sat approximately 80% of the work shift and 60% of the work shift was spent on actual keying. The observations showed that the employees sat at their desk about 65% of the time, while 44% of the work shift was spent for data entry, both similar to the 2009 study (Table 11). Absence from the work area was minimal in the 1991 study, then about 34% in the 2009 study. In the current study, it was about 26%, slightly less than 2009 (Table 11). The amount time spent on computer work did not seem to change between 2009 and 2015 via time-lapse observations. However, the software registered less keyboard and mouse use times, less keystrokes, and more mouse clicks (Tables 7 and 8). This suggests that the technology advances during this period reduced the keystroke demands. It could be that the automation (OCR) reduces the burden for typing, and many data entry functions are replaced by mouse clicking and dragging rather than typing.

The 44% of time spent on computers corresponded to about 3.7 hours computer use per work shift of 8.5 hours according task analysis (Table 11). This figure was about the same as the RSIGuard registrations (Table 7). Of particular note is that Claims Initiations employees registered the highest computer use time, keyboard use time, total keystrokes, and total mouse clicks. Their jobs are traditional data entries from hard document copies. Self-reported survey also support this finding, as the employees were aware of their times on the computer (Figures 2 and 3). It is possible that this was related to the high complaint rate at the hand area among this unit (5 out of 7 reported positive hand pain).

Organizational concerns

In general, most participants in the current study were satisfied with their current job situations (Table 6C). Job stress maintained in a steady (and somewhat improving) trend compared to 2009 (Table 6A). However, the area of concern came from their influences over the decisions that affected their jobs (Table 6B). Similar job satisfaction results were found in both the 1991 and 2009 studies when employees reported at a relatively high level. However, the sense of lack of influence seemed to become worse over time.

On the positive side, in 1991, most employees indicated that they rarely or only occasionally faced conflicting demands or did not have enough time to get everything done. It was now 90% reporting negative about conflicting demands. Supervisory support in listening to work-related problems was encouraging. The majority of employees (84%) in the current study reported their supervisors were willing to listen to their work-related problems (Table 6A).

Workers' perceptions and self-reported musculoskeletal symptoms

Of concern were the self-reported musculoskeletal symptoms. Based on baseline survey (N=19), the prevalence rates of reported musculoskeletal problems in the last 12 months for all body parts alarmingly increased from the 2009 (Table 4) and 1991 (values not shown) studies. Currently, almost 4-fifth of the respondents had

Self-reported shoulder problem, as the major concern, worsened drastically compared to both the 1991 and 2009 studies.

shoulder discomfort of various degrees in the last 12 months. Similar trends were reported by the 13 participants in the 10-day Phase 3 study. For Bill Processing employees, the discomfort scores for all eight body parts were higher than in 2009 (Table 9). The shoulder problems might still be due to the relatively high static shoulder muscle loading as discussed previously. The static shoulder muscle loading during work should be addressed in order to reduce the shoulder problems. Some suggestions will be discussed later. Some of the self-reported musculoskeletal problems might not be related to the current work conditions as some of them were first experienced many years ago (Table 5).

About half of the survey respondents provided write-in comments (n=10). They were related to prolonged sitting/standing (2), the monotonous specific task (2), chairs and back supports (2), and the need of medical help (2), and question unrelated (2). As a comparison, in the 1991 study, significant concerns were mostly about poor workstations. There seemed to have been extensive changes in terms of ergonomic improvements of workstations.

Physical exposures

According to Jonsson (1982), a median trapezius EMG load level at or below 10%MVC, and a peak level at or below 50%MVC should be considered safe for this particular muscle. The measured trapezius muscle loading at the median and peak levels (Table 13) seemed to be not a health concern.

Currently there are no definitive thresholds for the forearm muscles in the scientific literature. Therefore, it is difficult to determine if the current exposures for these muscles were of health concern. However, the physical exposures, in terms of muscle loading, were affected by tasks and by units. Claims Initiations employees exhibited the greatest loading in the forearm for their routine tasks (Figure 3). Combined with the nature of their duties that they had to work on the computer (keying and mousing) for the most time (Figure 3 & Table 8) compared to their colleagues, special care should be given to prevent or reduce damaging exposures.

Hand/Wrist

For the wrist extensors, the static muscle loading measures exceeding the current guidelines. Longer computer and keyboard hours, and more keystrokes were correlated to higher hand/wrist pain reports (Table 10).

All of these could be the results of improper hand postures, or the lack of proper adjustment of the keyboard, or the slow rate of adaptation of ergonomics keyboards. From 2009 to 2015, the percentage of ergonomics keyboards increased from 16% to 37%. Most employees still used standard mice. While switching these accessories may not directly result in decreased muscle activities, but it remains a viable solution for employees complaining about hand/wrist pain or discomfort. As suggested in the previous 2009 report, negative keyboard tilt may reduce forearm muscle strain. We did not observe any adaptation of this strategy. Employees experience hand/wrist pains are encouraged to try this solution. Keyboard risers are available to achieve this strategy.

Shoulder

High static muscle loading can usually cause muscle fatigue, which is believed to be linked to the development of musculoskeletal disorders (Armstrong, 1993). The relatively high right shoulder static muscle loading of 2%MVC in the current study (Table 13) was likely to be responsible for the prevalent 79% shoulder complaints (Table 4). As part of their regular tasks, sorting caused the greatest shoulder loading as measured by EMG (Figure 2). Although activities categorized as "All Others" also resulted in higher shoulder activities, they were more irregular actions occurred in a much lower frequency and of shorter durations (e.g., reaching for facial tissues or objects, fixing hair, taking a snack bite).

Subject pain report on the shoulders correlated to also RSI registered computer hours, keystrokes, and for the left shoulder, keyboard hours (Table 10). Of particular note is that left shoulder complaints were negatively correlated to mouse use (Table 10). This means that the more the mouse uses, the less the reported left shoulder pain. This is reasonable as all of the study participants were right handed. While operating the mice using the right hand, the left hand, and hence the left shoulder, could have a temporary relief. This side effect was observed also for elbow and hand/wrist. Therefore, if the more tasks can be performed using mice, the more likely the left upper extremity can experience more relief from the muscle loading.

Document Effect

For Claims Initiation employees, no matter which document type, the more difficult the writing, the higher the muscle static and median loadings.

Because the Claims Initiation employees have to transfer hand written forms into computer database, one of the main tests in the study was to examine if the document difficulty (considering the legibility of the handwriting, the words used, etc.) affected muscle strains, both static and median measures. Based on their reported difficulty ratings, document type (ROA and EROA) was not a significant factor, but difficulty level was for several muscles. This means that document type had no influence on muscle activity. On the other hand, the higher the document difficulty level, the higher the mean muscle activities (Table 14). The differences were statistically significant for left Trapezius, static loading at the Flexor with EROA documents, and median loading at the right Trapezius for ROA documents. Due to the small sample size, some of the differences did not achieve a statistical significance level. However, the trends applied both for static and median muscle loading on the four muscles were observable.

Workstations

*** Workstations were generally in compliance of current ergonomics computer workstation guidelines.**

*** Further improvements beyond the guidelines may be needed to reduce static loadings and lower shoulder and neck complaints.**

Generally speaking, the workstations in the current study were, to a large extent, in compliance with the currently accepted general office ergonomics guidelines. This was quite different in the 1991 study when a substantial number of chairs were found to be broken (SHARP, 1991). Accessories were available to employees who were in need to perform the jobs (Table 3). Through observation, there were very few occasions when awkward postures resulted

from furniture or tasks were identified. The only issue worth mentioning was about the neck. Neck bending was observed mostly when the employees were not looking at the computer monitors. Instead, manual work such as pre-scanning, reading documents, or handling mails/applying mailing labels required the employees to look down on the desk. While for the short bouts of occurrence, it might not be a concern. However, if such task lasts for an extended period, for example, up to an hour, the bending posture would cause excessive loading to the neck and shoulder area.

Sit-Stand Workstation

Since the agency introduced the sit-stand workstation to all employees, at the time of the study, every participant was equipped with one. Based on the observation phase, sitting constituted the majority of the shift, at 65% (Table 11). While being absent may underestimate both sitting or standing, standing only took place in less than 9% of the observed photos. Prolonged sitting has been identified as a contributing factor for low back pain. With the current back pain prevalence at 42% (Table 4), alternating sitting and standing could be a solution to address this issue.

Among the participants, four used the standing function. EMG data were collected while they performed their tasks in both sitting and standing postures, and were analyzed. While examining only the static and median levels, there was no trend for different users at the four muscle sites (Table 16). That is, the current practice of sitting or standing did not offer any perceivable and general benefits for different users. One obvious reason is that there are currently no established guidelines about the amount (or proportion) of standing, the frequency of changes, timing of changes, etc. available for the users or for the ergonomist professionals. The users decide when they wish to stand, how often they stand, and the standing desk height. Therefore, it is not surprising that there is a lack of observable benefits.

During the computer work, we also found relatively high static loading on the forearm extensor muscle (Table 13 and Figure 2). The reason for that is probably the hand/wrist posture when using the keyboard. Most workers had their keyboard in a conventional slope position (i.e., the further side of the keyboard is slightly higher than the closer side of the keyboard, or positive slope). This keyboard position requires the hand/wrist assumes a slightly extended posture, which would result in higher static extensor muscle loading. Simoneau et al. (2003) studied the effort of different keyboard positions on the arm muscle activities and found that a slightly negative slope of keyboard placement could improve the hand/wrist extension posture and reduce forearm extensor muscle loading. Therefore using a negative slope keyboard placement might be an option for employees who want to reduce their forearm static loading.

It was noted that more than 37% of the employees used various ergonomics keyboards or split fixed angle keyboard (Table 3) among the 19 participants in study phase 1, increased from 16% in 2009. The small sample size did not have sufficient statistical power to prove the ergonomics keyboard and hand/wrist pain association, other studies have shown that split fixed angle keyboard could place the hand/wrist closer to a neutral posture (Baker & Cidboy, 2006, Marklin, Simoneau, & Monroe, 1999). Therefore, offering employees ergonomic keyboards might be a solution to hand/wrist concerns.

We observed that employees had their hand/arm supported (not hanging loose by the side) on the desk, which reduced the shoulder loads. As a result, their hands and wrists had to rest on the desk.

Only a fraction of the participants used special wrist rests (16%), compared to 58% in 2009. Prolonged direct contact between the wrist and a hard surface is not recommended, as the soft tissues on the palm side of the wrist can be easily stressed. This is a possible cause for hand/wrist pain. Several participants were even spotted when they lay their wrists at the desk edge during the phase 3 study. They were directly informed about this risk immediately.

One other risk that was identified during the observation phase was that several participants tended to lean forward close to the monitors, leaving the back unsupported. Upon notifications and further informal interviews, they cited the reason as habitual, unaware of this habit, or glare on the screen. Suggestions from the research team were provided to the individuals. However, it demonstrated that the awareness of office ergonomics principles may not reach all employees in a department. Certain refresher or training/awareness sessions may be necessary.

Conclusions

- Workers spent about the same time on computers as identified from our previous studies, with less keystrokes but more mouse clicks.
- Self-reported shoulder problems were significant, with 79% of participants having pain in the past 12 months. These could be caused by relatively high static loading on the shoulder region. Reducing shoulder static loading should be the focus in future ergonomic improvement efforts.
- Employees were generally satisfied with their current job conditions.
- Work postures and workstation layout were generally acceptable according to current office ergonomics guidelines.
- Sit-stand workstations were available, but were used only by a small proportion of the study participants. Among the 4 who were observed using both standing and sitting functions, the effect on muscle loading of the shoulder and forearm regions was not significant. There were no guidelines about the proper use or setup for the users after the desks were installed.
- For employees who had to enter hand-written documents into computer database, the document difficulty had some effect on muscle activities (loading).
- Further ergonomic improvements may need to go beyond the current office ergonomics guidelines. For example:
    - Ergonomics awareness training.
    - RSIGuard usage.
    - Proper employee task assignments in order to balance the workload.
    - Better hand/arm supports and alternative keyboard and mouse use.

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Appendix A

Baseline Survey

1. SHARP Work and Health Survey questionnaires

Dear LNI Insurance Services - Support Services colleague,

SHARP is conducting an office ergonomics study for the whole Support Services group. Your participation will help us understand job stresses and identify potential problems. It is important for you to participate so we have an accurate picture of your work in Support Services, however participation is voluntary and you may stop at any time. The result from this study will allow us to make recommendations for improvements to work conditions in Support Services.

Your individual responses are strictly confidential. Your supervisors will only be shown summary results, and will not see your individual responses.

It should take less than 30 minutes to go through the survey. You can skip questions you do not wish to answer, with the exception of several critical questions noted by an asterisk (*). If you have any questions, concerns, or comments, feel free to email Jim Lin at lija235@lni.wa.gov.

2. Personal Identification

***1. Your log-on id (aaaa235). We need to make sure that each survey is completed by a different person.**

2. Age

Years

***3. Sex**

- ◯ Male
- ◯ Female

4. Height

feet

inches

5. Weight

lbs

***6. Are you right or left handed?**

- ◯ Right
- ◯ Left
- ◯ Both (I'm ambidextrous)

3. Work history 1

7. When did you begin working in the Support Services group at L&I? Just use your best recall, enter '01' in the DD box if unsure about day of month.

	MM	DD	YYYY
month/day/year		/	/

*8. Are you currently ...

- ◯ Full time (35 - 40 hours per week)
- ◯ Part time (<34 hours per week). If part time, please enter average number of hours worked each week:

*9. What is your job title history in the Support Services of the Insurance Services?

	Work Group	Job title	No. of years at the job
Current job:			
Previous job 1:			

10. Please assign a percentage value to your current job activities on a typical day (the total should add up to 100).

Document preparation (%)	
Scanning, copying (%)	
Claims and other data entry (%)	
Document analysis, review, correction (%)	
Filing, sorting (%)	
Calls, emails (%)	
Administration, supervision (%)	
Other activities (%)	

4. Work history 2

11. In most jobs, the workload varies from day to day. In your job, what percent of your days are heavy workload days ?

- ◯ 0%
- ◯ 1 - 25%
- ◯ 26 - 50%
- ◯ 51 - 75%
- ◯ 76 - 99%
- ◯ 100%

12. In the last year, how many weeks did you work more than 5 days or more than 40 hours?

weeks

13. Do you usually work in the office all day?

- ◯ Yes
- ◯ No

14. If yes how many times, on average, do you get up and away from your work station in a day?

# of times

5. Keyboard activity

15. Do you primarily key from hard copy?

- ◯ Yes
- ◯ No

16. What percent of your time do you spend keying?

- ◯ 0%
- ◯ 1 - 25%
- ◯ 26 - 50%
- ◯ 51 - 75%
- ◯ 76 - 99%
- ◯ 100%

17. Do you consider yourself a

- ◯ touch (speed) typist
- ◯ "hunt & peck" typist

6. Keyboard use

18. Which keyboard do you currently use the most? Please use the pictures below for an example.

- ◯ Keyboard #1 Standard issue.
- ◯ Keyboard #2 Ergonomics variation (e.g., curved, split, etc.)
- ◯ Other keyboard (please specify)

1

2

19. How long have you used this keyboard?

Years

20. Do you tilt the keyboard?

- ◯ No, I did not adjust any keyboard legs and use it as is.
- ◯ Yes, tilted top (function keys) up.
- ◯ Yes, tilted bottom (the space key) up.

21. Have you used a different keyboard in the past year?

- ◯ Yes
- ◯ No

22. If Yes, why did you change?

- ◯ It's a recommended change (e.g., ergonomics assessment)
- ◯ Workstation/location change
- ◯ Equipment upgrade
- ◯ I requested the change
- ◯ Other (please specify)

23. How long did you use this other keyboard?

Years

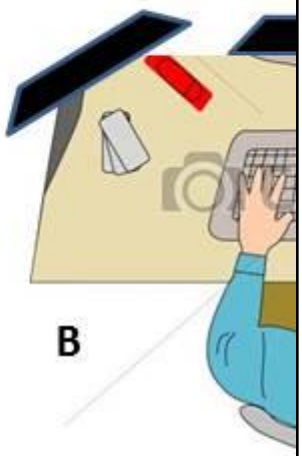
7. Monitor, eye health

24. What size of monitor(s) do you use? Standard IT issued monitor is 24". If you are not sure, the monitor model number may be found on the back of the monitor and the first 2 numbers typically indicate the size. For example, "P2412Hb" is for the standard issue 24" monitor.

	Size
Monitor 1 (primary)	
Monitor 2	

25. If you are using two monitors, how are they positioned? Please refer to the figures below.

- ◯ A. Primary monitor at the direct front center, secondary monitor on the right
- ◯ B. Primary monitor at the direct front center, secondary monitor on the left
- ◯ C. Two monitors equally spaced on the left and the right.



26. When was the last time you had your eyes examined by a doctor or another health care provider?

- ◯ 1 year ago or less
- ◯ 2 - 3 years ago
- ◯ 4+ years ago
- ◯ I've never had my eyes examined

27. In the past year, have you experienced any of the following symptoms while at your computer monitor? Choose all that apply.

- [ ] Headaches
- [ ] Sore or tired eyes (eye strain)
- [ ] Blurred vision
- [ ] Glare (light) sensitivity
- [ ] Dry or watery eyes
- [ ] Burning, itching, or red eyes
- [ ] Double vision

28. Please rate the level of discomfort you have experienced because of these eye-related symptoms during the past 7 days?

- ◯ None
- ◯ Little
- ◯ Moderate
- ◯ Bad
- ◯ Very bad
- ◯ Almost unbearable

8. Phone and other equipment

29. What percent of your time do you spend on the telephone?

- ◯ 0%
- ◯ 1 - 25%
- ◯ 26 - 50%
- ◯ 51 - 75%
- ◯ 76 - 99%
- ◯ 100%

30. If phone use is part of your job, how do you use use it at work? (check one answer)

- ◯ Hand - held receiver
- ◯ Headset
- ◯ Use both

31. If you use a headset at work, how long have you been using it?

Years

32. Which of the following special (not standard issued) equipment do you use on your job (please check all that apply)?

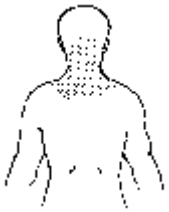
- ☐ Trackball mouse
- ☐ Vertical mouse
- ☐ Touch screen
- ☐ Glare reduction screen shield
- ☐ Document holder
- ☐ Task lighting
- ☐ Sit-stand desk
- ☐ Wrist support
- ☐ Arm rest (not on chair)
- ☐ Footrest
- ☐ Other (please specify)

33. If you are using a sit-stand desk, how often do you use it for standing?

- ◯ Almost never (~0%)
- ◯ Rare (~10%)
- ◯ Sometimes (~25%)
- ◯ About half (~50%)
- ◯ Usually (~75%)
- ◯ Almost always (~100%)

9. Neck 1

The Neck



34. In the past year, have you had pain, stiffness, burning, numbness, or tingling in the area shown on this diagram more than three times or lasting more than one week?

- ◯ Yes
- ◯ No

10. Neck 2

35. How long does each episode of NECK problem usually last?

- ◯ less than 1 hour
- ◯ 1 hour to 24 hours
- ◯ 25 hours to 1 week
- ◯ one week to 1 month
- ◯ 1 month to 6 months
- ◯ more than 6 months

36. How often do separate episodes of this NECK problem occur in the past year?

- ◯ daily
- ◯ once a week
- ◯ once a month
- ◯ every 2-3 months
- ◯ every 6 months

37. Have you had this NECK problem in the past 7 days?

- ◯ Yes
- ◯ No

38. Have you ever had an accident or sudden injury to your NECK such as whiplash, a fracture, or sudden "slipped disc"?

- ◯ Yes
- ◯ No

11. Neck 3

39. Do specific activities make this NECK problem worse?

- ◯ Yes
- ◯ No

If yes, please specify which activities:

40. When did you first notice this NECK problem? Just use your best recall, enter 01 in the DD box if unsure about day of month.

	MM	DD	YYYY
month/day/year		/	/

41. What job did you have when you first noticed this NECK problem?

- ◯ Current job
- ◯ Other job

If other, please specify:

12. Neck 4

42. Have you seen a doctor or other health care provider for this NECK problem?

- ◯ Yes
- ◯ No

43. If yes, how many times in the past year?

of times

44. Have you missed any workdays because of this NECK problem?

- ◯ Yes
- ◯ No

45. If yes, how many days in the past year?

days

46. Have you spent any days doing light or restricted work because of this NECK problem?

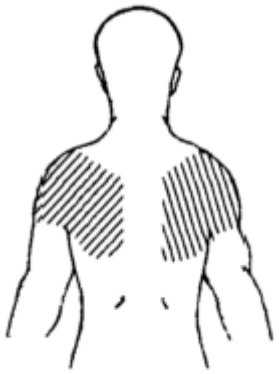
- ◯ Yes
- ◯ No

47. If yes, how many days in the last year?

days

13. Shoulder 1

Shoulders



48. In the past year, have you had pain, stiffness, burning, numbness, or tingling in the area shown on this diagram more than three times or lasting more than one week?

- ◯ Yes
- ◯ No

14. Shoulder 2

49. How long does each episode of SHOULDER problem usually last?

- ◯ less than 1 hour
- ◯ 1 hour to 24 hours
- ◯ 25 hours to 1 week
- ◯ 1 week to 1 month
- ◯ 1 month to 6 months
- ◯ more than 6 months

50. How often do separate episodes of this SHOULDER problem occur in the past year?

- ◯ daily
- ◯ once a week
- ◯ once a month
- ◯ every 2 - 3 months
- ◯ longer than every 3 months

51. Have you had this SHOULDER problem in the past 7 days?

- ◯ Yes
- ◯ No

15. Shoulder 3

52. Have you ever had an accident or sudden injury to your SHOULDER such as dislocation, fracture, or tendon tear?

- ◯ Yes
- ◯ No

53. Do specific activities make this SHOULDER problem worse?

- ◯ Yes
- ◯ No

If yes, please specify

54. When did you first notice this shoulder problem? Just use your best recall, enter 01 in the DD box if unsure about day of month.

	MM	DD	YYYY
month/day/year	/	/	

16. Shoulder 4

55. What job did you have when you first noticed this SHOULDER problem?

- ◯ Current job
- ◯ Other job

If other, please specify:

56. Have you seen a doctor or other health care provider for this SHOULDER problem?

- ◯ Yes
- ◯ No

57. If yes, how many times in the the past year?

of times

17. Shoulder 5

58. Have you missed any workdays because of this SHOULDER problem?

- ◯ Yes
- ◯ No

59. If yes, how many days in the past year?

of days

60. Have you spent any days doing light or restricted work because of this SHOULDER problem?

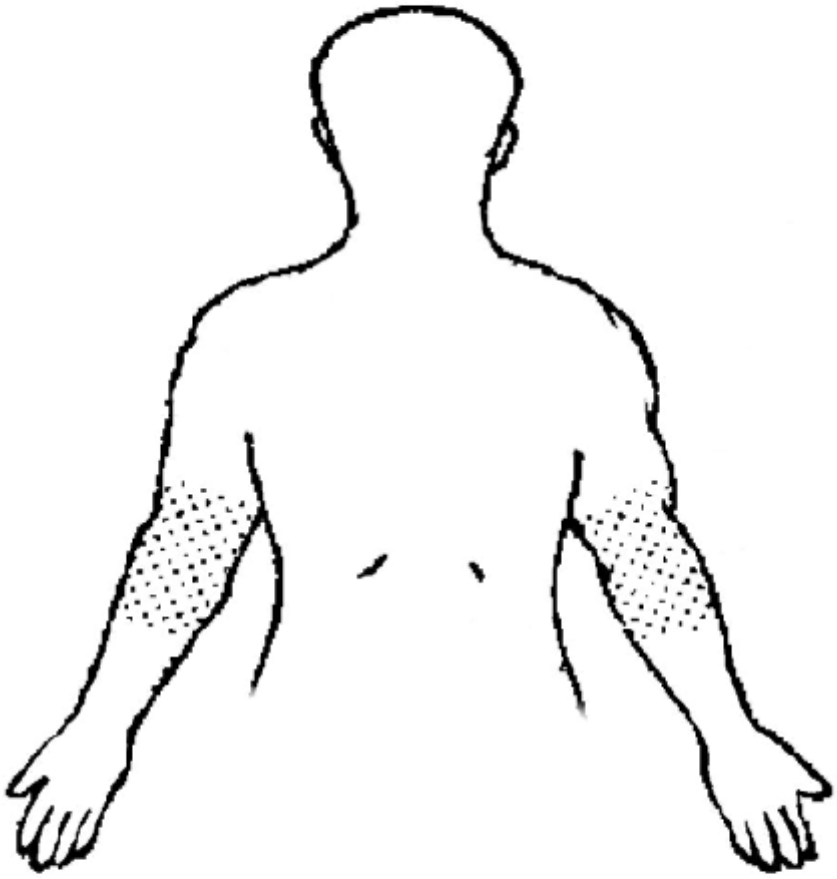
- ◯ Yes
- ◯ No

61. If yes, how many days in the past year?

of days

18. Elbow/Forearm 1

Elbow/Forearm



62. In the past year, have you had pain, stiffness, burning, numbness or tingling in the area shown on this diagram more than three times or lasting more than one week?

- ◯ Yes
- ◯ No

19. Elbow/forearm 2

63. How long does' each episode of ELBOW/FOREARM problem usually last?

- ◯ less than 1 hour
- ◯ 1 hour to 24 hours
- ◯ 25 hours to 1 week
- ◯ one week to 1 month
- ◯ 1 month to 6 months
- ◯ More than 6 months

64. How often do separate episodes of this ELBOW/FOREARM problem occur in the past year?

- ◯ daily
- ◯ once a week
- ◯ once a month
- ◯ every 2-3 months
- ◯ once more than3 months

65. Have you had this ELBOW/FOREARM problem in the past 7 days?

- ◯ Yes
- ◯ No

20. Elbow/forearm 3

66. Have you ever had an accident or sudden injury to your ELBOW/FOREARM such as dislocation, fracture, or tendon tear?

- ◯ Yes
- ◯ No

67. Do specific activities make this ELBOW/FOREARM problem worse?

- ◯ Yes
- ◯ No

If yes, please specify activities:

68. When did you first notice this ELBOW/FOREARM problem? Just use your best recall, enter 01 in the DD box if unsure about day of month.

	MM	DD	YYYY
month/day/year		/ /	

21. Elbow/forearm 4

69. What job did you have when you first noticed this ELBOW/FOREARM problem?

- ◯ Current job
- ◯ Other job

If other, please specify:

70. Have you seen a doctor or other health care provider for this ELBOW/ FOREARM problem?

- ◯ Yes
- ◯ No

71. If yes, how many times in the past year?

of times:

22. Elbow/forearm 5

72. Have you missed any workdays because of this ELBOW/FOREARM problem?

- ◯ Yes
- ◯ No

73. If yes, how many days in the past year?

of days:

74. Have you spent any days doing light or restricted work because of this ELBOW/FOREARM problem?

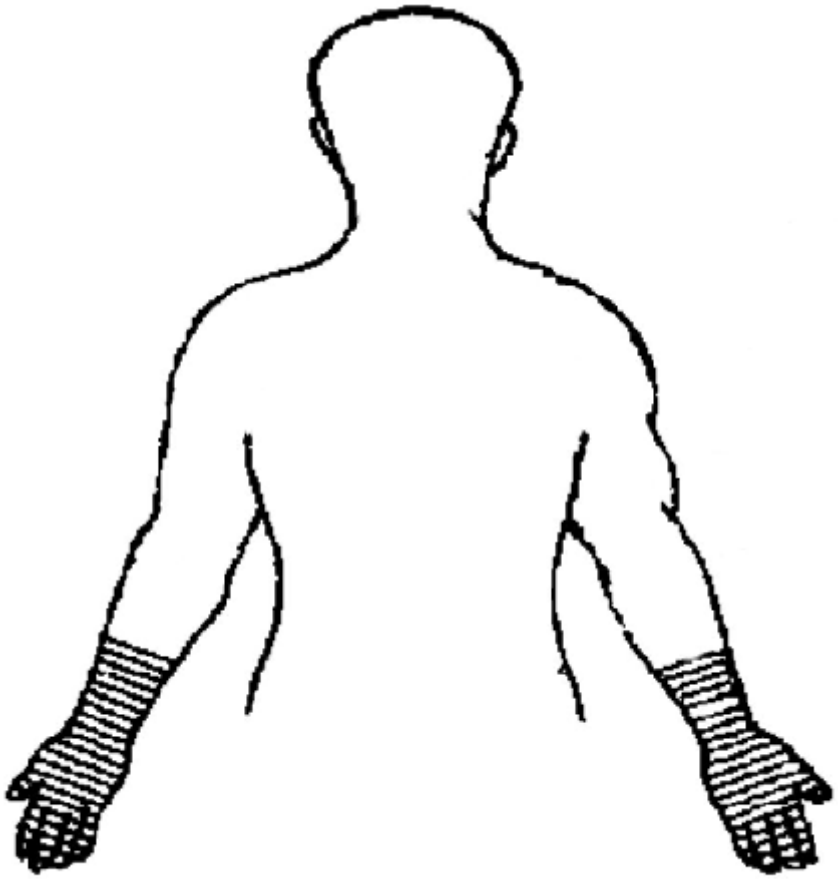
- ◯ Yes
- ◯ No

75. If yes, how many days in the past year?

of days:

23. Hand/Wrist 1

Hand/Wrist



76. In the past year, have you had pain, stiffness, burning, numbness or tingling in the area shown on this diagram more than three times or lasting more than one week?

- ◯ Yes
- ◯ No

24. Hand/wrist 2

77. How long does each episode of HAND/WRIST problem usually last?

- ◯ less than 1 hour
- ◯ 1 hour to 24 hours
- ◯ 25 hours to 1 week
- ◯ 1 week to 1 month
- ◯ 1 month to 6 months
- ◯ more than 6 months

78. How often do separate episodes of this HAND/WRIST problem occur in the past year?

- ◯ daily
- ◯ once a week
- ◯ once a month
- ◯ every 2 - 3 months
- ◯ once more than 3 months

79. Have you had this HAND/WRIST problem in the past 7 days?

- ◯ Yes
- ◯ No

80. Have you ever had an accident or sudden injury to your HAND/WRIST such as dislocation, fracture,or tendon tear?

- ◯ Yes
- ◯ No

25. Hand/wrist 3

81. Do specific activities make this HAND/WRIST problem worse?

- ◯ Yes
- ◯ No

If yes, please specify activities:

82. When did you first notice this HAND/WRIST problem? Just use your best recall, enter 01 in the DD box if unsure about day of month.

	MM	DD	YYYY
month/day/year		/ /	

83. What job did you have when you first noticed this HAND/WRIST problem?

- ◯ Current job
- ◯ Other job

If other, please specify:

26. Hand/wrist 4

84. Have you seen a doctor or other health care provider for this HAND/WRIST problem?

- ◯ Yes
- ◯ No

85. It yes, how many times in the past year?

of times:

86. Have you missed any workdays because of this HAND/WRIST problem?

- ◯ Yes
- ◯ No

87. If yes, how many days in the past year?

of days:

88. Have you spent any days doing light or restricted work because of this HAND/WRIST problem?

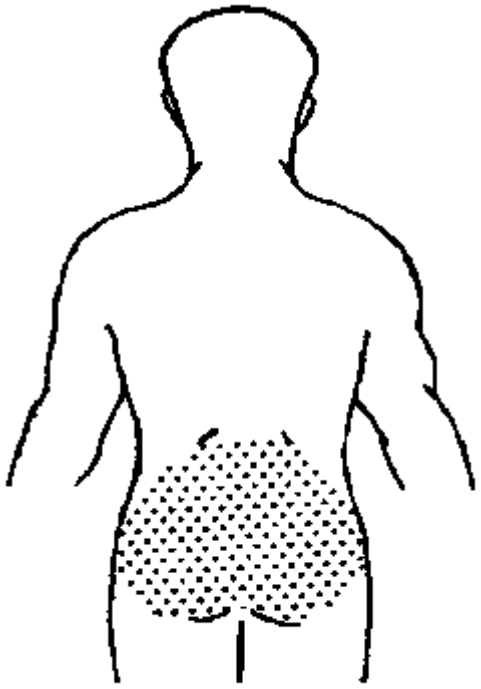
- ◯ Yes
- ◯ No

89. It yes, how many days in the past year?

of days:

27. Back 1

Back



90. In the past year, have you had pain, stiffness, burning, numbness or tingling in the area shown on this diagram more than three times or lasting more than one week?

- ◯ Yes
- ◯ No

28. Back 2

91. How long does each episode of BACK problems usually last?

- ◯ less than 1 hour
- ◯ 1 hour to 24 hours
- ◯ 25 hours to 1 week
- ◯ one week to 1 month
- ◯ one month to 6 months
- ◯ more than 6 months

92. How often do separate episodes of this BACK problem occur in the past year?

- ◯ daily
- ◯ once a week
- ◯ once a month
- ◯ every 2 - 3 months
- ◯ once more than 6 months

93. Have you had this BACK problem in the past 7 days?

- ◯ Yes
- ◯ No

29. Back 3

94. Have you ever had an accident or sudden injury to your BACK such as dislocation or fracture?

- ◯ Yes
- ◯ No

95. Do specific activities make this BACK problem worse?

- ◯ Yes
- ◯ No

If yes, please specify activities:

96. When did you first notice this BACK problem? Just use your best recall, enter 01 in the DD box if unsure about day of month.

	MM	DD	YYYY
month/day/year		/ /	

97. What job did you have when you first noticed this BACK problem?

- ◯ current job
- ◯ other job

If other, please specify:

30. Back 4

98. Have you seen a doctor or other health care provider for this BACK problem?

- ◯ Yes
- ◯ No

99. If yes, how many times in the past year?

of times:

100. Have you missed any workdays because of this BACK problem?

- ◯ Yes
- ◯ No

101. If yes, how many days in the past year?

of days:

102. Have you spent any days doing light or restricted work because of this BACK problem?

- ◯ Yes
- ◯ No

103. If yes, how many days in the past year?

of days:

31. Symptom 1

104. Of the problems you have just described, which do you consider to be the most serious or troublesome?

- ◯ I didn't report any problems above
- ◯ Neck
- ◯ Shoulder
- ◯ Elbow/forearm
- ◯ Hand/wrist
- ◯ Back

105. For the problem that bothers you the most, how would you describe the pain or discomfort it has caused you during the past 7 days?

◯ None ◯ Little ◯ Moderate ◯ Bad ◯ Very bad ◯ Almost unbearable

106. How would you describe the pain or discomfort this problem has caused you during your worst episode?

◯ None ◯ Little ◯ Moderate ◯ Bad ◯ Very bad ◯ Almost unbearable

32. Psychosocial factors

The following questions ask you to describe your job in terms of specific qualities.

107. Work environment:

	Rarely	Occasionally	Sometimes	Fairly often	Very often
How often do you face conflicting demands from people you work with?	◯	◯	◯	◯	◯
How often is your supervisor willing to listen to your work-related problems?	◯	◯	◯	◯	◯
How often does your job leave you with too little time to get everything done?	◯	◯	◯	◯	◯

108. Influence: the degree to which you determine what is done by others and have freedom to determine what you do yourself.

	very little	little	moderate amount	much	very much
How much influence do you have over the amount of work you do?	◯	◯	◯	◯	◯
How much influence do you have over the availability of materials you need to do your work?	◯	◯	◯	◯	◯
How much do you influence the policies and procedures in your work groups?	◯	◯	◯	◯	◯
How much influence do you have over the arrangement of furniture and other equipment at your workstation?	◯	◯	◯	◯	◯

109. Job satisfaction.

	not at all	not too	some what	quite a bit	very much
How satisfied are you with the amount of influence you have over the decisions that affect your job?	◯	◯	◯	◯	◯
All in all how satisfied are you with your job?	◯	◯	◯	◯	◯

33. Final stage

110. Anything you think would help relieving your symptoms or improving overall work health?

111. Is there anything else you would like to add?

34. Thank you!

Thank you very much for your time.
You can safely close this window.

Appendix B

Daily Discomfort Survey

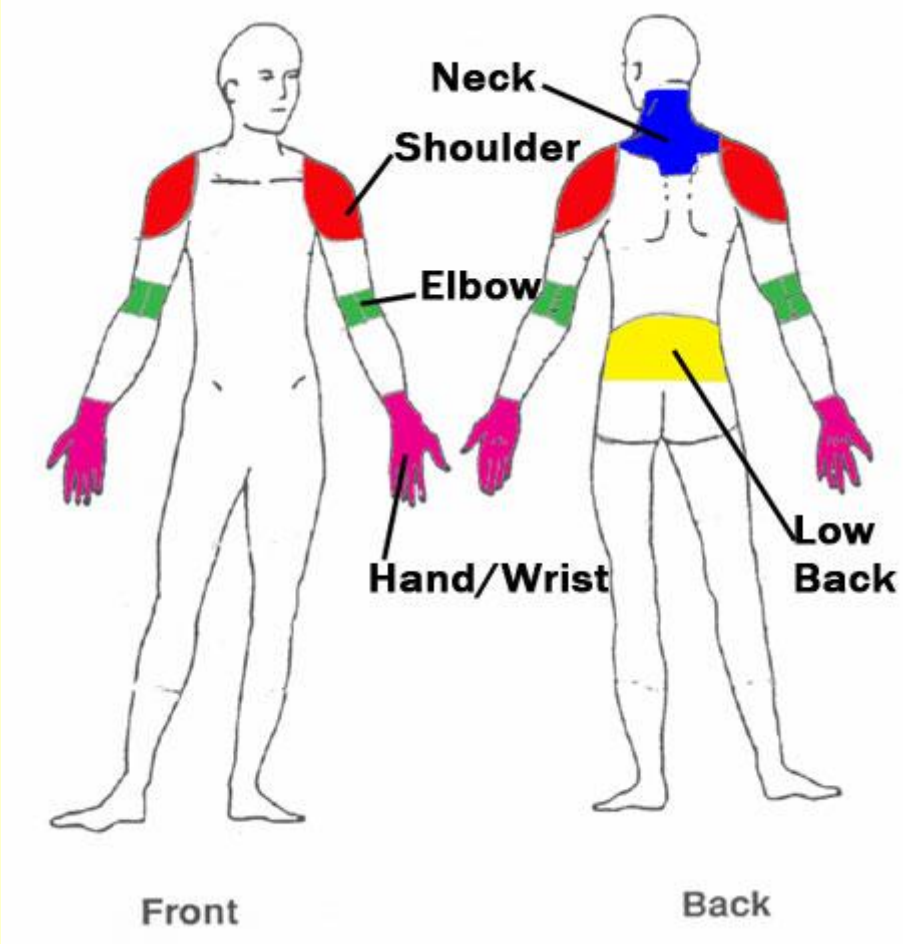
This is a survey about your discomfort level (0 - lowest discomfort, 10 - highest discomfort). Please complete this at the end of your shift on each day during the study. Thanks for your cooperation. If you have any questions or concerns, please email Jim Lin at lija235@lni.wa.gov.

Your log-on id:

How many hours do you think you spent on your computer today?

Please rate your discomfort level for each of the body parts:

	Neck	Left shoulder	Right shoulder	Left elbow	Right elbow	Left hand/wrist	Right hand/wrist	Low back
10 Maximum discomfort	☐	☐	☐	☐	☐	☐	☐	☐
9 Very, very high	☐	☐	☐	☐	☐	☐	☐	☐
8 Very high	☐	☐	☐	☐	☐	☐	☐	☐
7 High	☐	☐	☐	☐	☐	☐	☐	☐
6	☐	☐	☐	☐	☐	☐	☐	☐
5 Somewhat high	☐	☐	☐	☐	☐	☐	☐	☐
4 Moderately high	☐	☐	☐	☐	☐	☐	☐	☐
3	☐	☐	☐	☐	☐	☐	☐	☐
2 Light	☐	☐	☐	☐	☐	☐	☐	☐
1 Very light	☐	☐	☐	☐	☐	☐	☐	☐
0.5 Very, very light	☐	☐	☐	☐	☐	☐	☐	☐
0 No discomfort at all	☐	☐	☐	☐	☐	☐	☐	☐


Neck
Shoulder
Elbow
Hand/Wrist
Low
Back
Front
Back