CDC Workplace Safety and Health

Ergonomic Evaluation of Loaders and Hashers at a Postal Processing and Distribution Center

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DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
NIOSH National Institute for Occupational Safety and Health

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Abbreviations

3DSSPP	University of Michigan's 3-dimensional static strength prediction program
DCF	Disc compression force
GPMC	General purpose mail container
HDCS	Hash delivery conveyor system
HETAB	Hazard Evaluations and Technical Assistance Branch
HHE	Health hazard evaluation
LI	Lifting index
MSD	Musculoskeletal disorder
NAICS	North American Industry Classification System
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
P&DC	Processing and distribution center
RNLE	Revised NIOSH lifting equation
RWL	Recommended weight limit
TMS	Tray management system
USPS	United States Postal Service
WMSD	Work-related musculoskeletal disorder

Highlights of the NIOSH Health Hazard Evaluation

The National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation at the United States Postal Service Seattle Processing and Distribution Center (P&DC) in Seattle, Washington. NIOSH investigators evaluated potential ergonomic hazards among employees on the East Dock Hash Delivery Conveyor System. A site visit was performed in November 2007.

What NIOSH Did

- We watched and videotaped workers loading and hashing mail.
- We used special equipment to re-create the jobs to see if the tasks could injure workers.

What NIOSH Found

- The current hashing job does not pose as much risk to workers as the old hashing job.
- The current hashing job could be improved to further reduce the risk.
- The general-purpose mail containers loading job had a high risk of workers developing low back pain.

What Seattle P&DC Managers Can Do

- Managers should move shelving in the hashing area to make space for empty containers, eliminating 180° twists. The top chute of the hashing station should be moved to eliminate mail being dumped at or above shoulder level.
- Managers should move the tray management system (TMS) conveyor in front of the hashing worker to eliminate 180° lifts.
- If the TMS conveyor cannot be moved, managers should lower the TMS conveyor height to 32 inches to eliminate elevated shoulder postures.
- Managers should install cushioned mats on the floor in the loading area. Non-slip material should be installed on the hashing area footrests.
- Managers should increase the number of workers in the loading and hashing area to allow for rotation through the jobs. If workers are moved from other areas, managers should make sure they are properly trained.
- Managers should look at the system that feeds tubs/trays down the gravity conveyor lines as these stations were loaded unevenly at times.
- Managers should replace the roller conveyors on hash lines 1, 3, and 4 with ones similar to those used on hash line 2. This will help the movement of tubs/trays and eliminate extended reaches and push/pull forces for stuck containers.

Summary

Both loaders and hashers are exposed to a combination of risk factors for developing musculoskeletal disorders. Risk factors include heavy lifts and awkward postures. Improved reach heights and distances as well as station reorganization would reduce the physical stress associated with these jobs.

On March 16, 2007, NIOSH received an HHE request from the management at the USPS Seattle P&DC to evaluate potential ergonomic hazards among workers at the Seattle, Washington P&DC. The redesign of the East Dock Hash Delivery Conveyor System area and a previous HHE request by employees prompted the request.

During November 27–28, 2007, NIOSH investigators held an opening conference with representatives from USPS management and the National Postal Mail Handlers Local 316. NIOSH ergonomic specialists toured the HDCS area to observe loading and hashing (sorting) tasks specified in the request.

The ergonomics evaluation indicated that workers are exposed to risk factors for developing musculoskeletal disorders due to heavy lifts and awkward postures. The employees were at elevated risk of injury while performing loading tasks, as measured by the RNLE and 3DSSPP. Recommendations for reducing the risk of injury include improving the heights and horizontal reach distances of the lifts during loading and reorganization of the hashing stations.

Keywords: NAICS 491110 (Postal Service), repetitive motions, awkward postures, lifting, sorting/hashing, ergonomics, USPS

What Seattle P&DC Employees Can Do

- Employees should work safely and lift properly. For example, prior to lifting, disengage the door or drop the netting on the general purpose mail containers to avoid bending over at the waist when lifting.
- Employees should not lift tubs/trays over the front conveyor onto the back conveyor in the loading area. This increases the reach distance, which increases the hazard of the loader job.
- Employees should not push tubs or trays down the gravity conveyor lines. Additional weight from the tubs/trays increases the force required to pull the container to be hashed.
- Employees should actively participate on safety and ergonomic committees.
- Employees should report injuries and unsafe work conditions to the union and management.

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Introduction

On March 16, 2007, NIOSH received an HHE request from management at the USPS P&DC to evaluate potential ergonomic hazards among workers in Seattle, Washington. The redesign of the East Dock HDCS area and a previous HHE request by employees prompted the request.

During November 27–28, 2007, NIOSH investigators conducted a site visit at the USPS P&DC in Seattle, Washington. The site visit was delayed due to scheduling conflicts for both NIOSH and Seattle P&DC. On November 27, 2007, NIOSH investigators held an opening conference with management and union officials from the National Postal Mail Handlers, Local 316. NIOSH ergonomic specialists observed loading and hashing (sorting) tasks in the East Dock HDCS area. Investigators also recorded video of workers performing job tasks for use in subsequent analyses. On November 28, 2007, NIOSH investigators held a closing conference and provided preliminary recommendations to management and union officials.

Process Description

The HHE request specified evaluation of redesigned work tasks in the East Dock HDCS area. Previously, when workers received mail tubs/trays in GPMCs and hampers, they sorted the mail into other GPMCs and hampers based upon mail type (Figure 1). Workers were required to walk around carrying the tubs/trays and sort the mail. Due to the inefficiency of this system, management redesigned this area into loading and hashing stations.

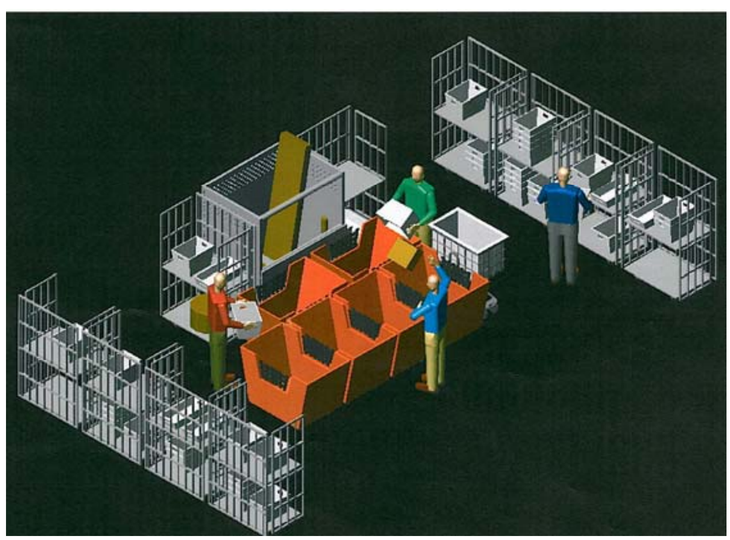

Figure 1. Computer-aided design of old hashing (sorting) area.

Loading

In the redesigned system, loaders receive GPMCs and hampers from the East Dock. They remove the tub/trays from the GPMCs and hampers and load them onto two conveyor systems—one lower and one upper (Figure 2). The lower, powered conveyor transports the mail to the hashing stations. The upper, powered conveyor transports the mail to a worker who transfers it to the TMS. The two ball transfer sections in front of the conveyors have systems that stop the conveyor to allow the loaders to insert tubs/trays without being hit by tubs/trays loaded from preceding workstations.

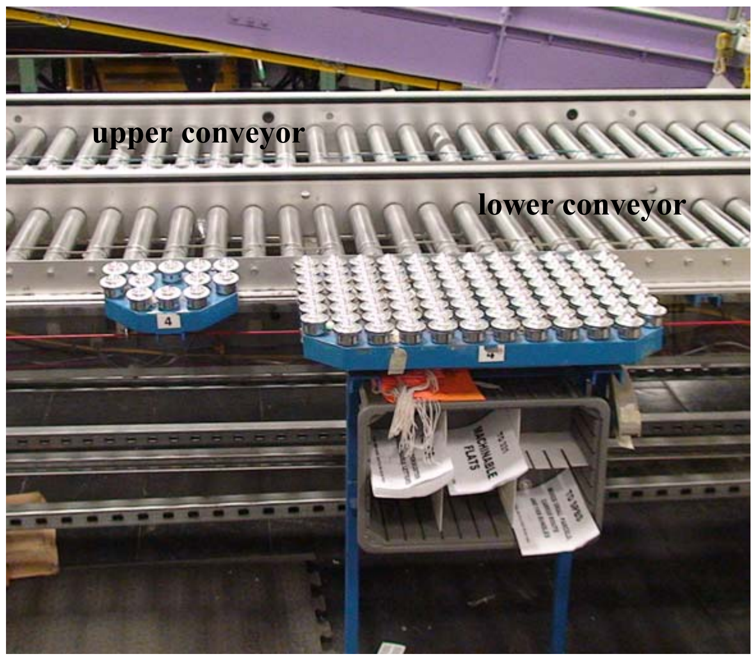

Figure 2. Loading station powered conveyor lines.

Hashing (Sorting)

The East Dock HDCS area has four hashing stations (Figure 3). Each hashing workstation has a gravity-fed conveyor on the left side that is connected to the lower powered conveyor from the loading stations. Workers receive tubs/trays from the loading stations via the gravity-fed conveyor. Seattle P&DC engineers designed the system to evenly distribute the tubs/trays to the different stations, as well as limit the number of tubs/trays on the gravity-fed conveyors. Limiting the number of tubs/trays decreases the amount of weight on the bottom tub, thus reducing the force required to slide the tub from the conveyor to the sorting area. Workers slide a tub/tray from the conveyor, sort through the contents, and distribute to other tubs, trays, and chutes based upon mail type. Directly in front of the worker are two chutes where workers dump mail. On the left and right side of the worker are various size tubs/trays where the worker places mail. Once a tub/tray is full, the worker must lift the tub and turn around to place it on another powered conveyor system that transports it to the TMS.

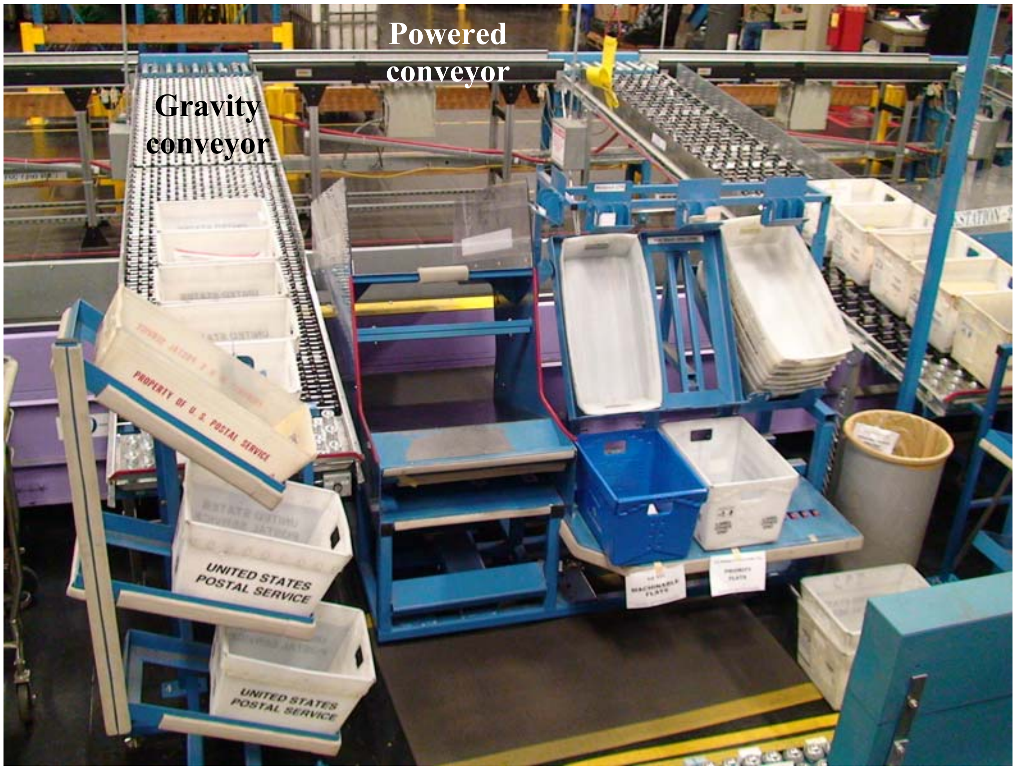

Figure 3. Hashing (sorting) station showing the powered conveyor and the gravity conveyor.

Equipment Used in Mail Handling

GPMCs

GPMCs are used to transport mail to different areas within the P&DC. Workers in the HDCS area receive some mail from the East Dock in GPMCs. All GPMCs have some sort of netting or cage to keep tubs and trays inside the cart during transportation. The two types shown in Figure 4 have drop-down netting that can be removed as the worker removes layers of tubs/trays to eliminate reaching over the netting or cage. The USPS has a rule that no tubs or trays should be stacked higher than the sides of the GPMC. This rule is to limit overhead reaching.

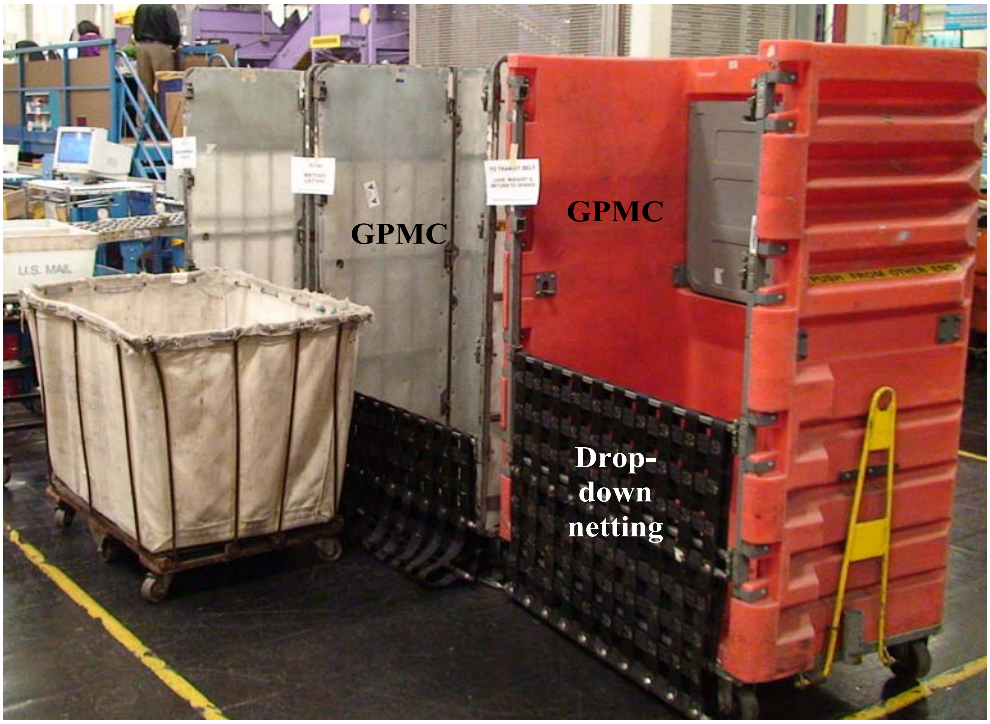

Figure 4. Two types of GPMCs with drop-down netting and a cloth hamper

Hampers

Hampers are also used to transport tubs/trays of mail within the P&DC. Workers in the HDCS area also receive mail from the East Dock in hampers. Two types of hampers were observed during our evaluation: cloth and plastic (Figure 5). The plastic hamper has black netting on the sides that allows the work to bend into the hamper when performing a lift. The cloth hampers do not have this feature. Workers in the HDCS area showed the investigators a hamper tilter that can be used with either cloth or plastic hampers. However, it was not being used because the workers stated that there was no space for it in the current Hash layout.

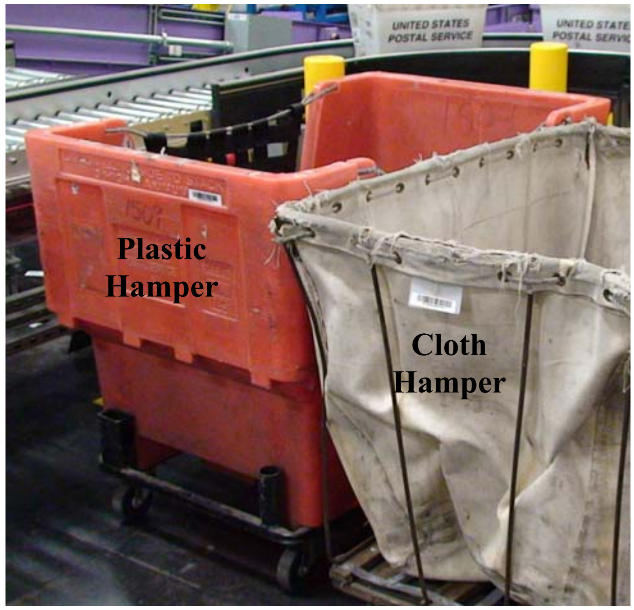

Figure 5. An example of a plastic hamper with netting (left) and a cloth hamper

Tubs/Trays

Tubs and trays are used to move mail throughout the P&DC (Figure 6). Tubs are used for oversized mail, and trays are used for letter-size mail. The USPS has a rule that no mail should be placed in tubs above the handles of a tub, to keep the handles available for use when lifting.

Figure 6. Examples of tubs and trays used to distribute mail through the P&DC

Assessment

The NIOSH ergonomics evaluation consisted of walking through the facility to observe job tasks specified in the HHE request: loading and hashing (sorting) tasks in the HDCS area. NIOSH investigators recorded digital videos, lift frequencies, working heights, and reach measurements to document the tasks performed by the workers. The ergonomics tools used to evaluate the physical risk factors for WMSDs were biomechanical outputs obtained from lab-simulated postures evaluated using 3DSSPP [Chaffin 1995] and recommendations for acceptable lifting weights as determined by the RNLE [Waters 1994]. Appendix A contains a description of the ergonomics evaluation criteria the investigators used, as well as a detailed description of the analysis methods. NIOSH investigators reviewed OSHA Form 300 Logs of Work-Related Injuries and Illnesses from 2003–2007. NIOSH investigators also held confidential interviews with a random sample of workers in the HDCS area.

Results & Discussion

Job Analyses

Table 1 shows the DCF obtained from the 3DSSPP and the LI values obtained from analyzing tasks using the RNLE. The weight used in the analyses was the average weight as estimated by the workers (22 lbs). A duration of 2 hours was used for calculating LIs due to observations that the workers seemed to work continuously for about 2 hours without a break.

Table 1. Disc Compression Forces (DCF) and Lifting Index (LI) results for lab-simulated East Dock HDCS tasks

Task	DCF (lbs)	LI
Old Job	726	3.0
Loader – GPMC	506	3.6
Loader – Hamper	173	2.2
Hash – Worker A	271	1.6
Hash – Worker B	235	1.6

One of the workers performed a simulation of the old hashing job. The management had set up an area similar to the layout of the previous conditions. NIOSH investigators used this worker's simulation video for the analysis of this task.

Two loading tasks were recorded for comparison of the various loading conditions. NIOSH investigators were informed that a hamper tilter was available in the area but was not used because there was not enough space for it. NIOSH investigators observed workers not removing the sides of the GPMCs and hampers and leaning over into them to retrieve tubs/trays.

NIOSH investigators recorded video and performed analyses on two workers performing hashing tasks for comparison of work style. The main difference in style was where workers placed the empty tubs after hashing the mail. NIOSH investigators observed Worker A placing the empty tub right beside the hashing station and Worker B placing the empty tub on the tub cart behind the hashing station. Also, when placing tubs/trays on the TMS after hashing, workers had to turn 180° and lift the container onto the roller ball table.

Every lifting job task evaluated exceeded the recommended LI of 1.0, and two job tasks surpassed a LI of 3.0, which is considered to be hazardous for nearly all workers. LIs between 1.6 and 2.2 indicated an elevated risk of low back injury as compared to jobs that have a LI ≤ 1.0 [Waters 1994]. DCFs followed a similar trend as the LIs, but none exceeded 770 lbs. Any DCF exceeding 770 lbs is above the back compression design limit and indicates an elevated risk of low back injury [Chaffin 1995].

An average weight of 22 lbs and a duration of 2 hours were estimated and used for the above calculations. Workers lifting containers that weigh more than 22 lbs, with the postures analyzed, may produce back compression forces that exceed the NIOSH recommended back compression upper limit of 1,430 lbs [NIOSH 1981]. Also, if workers perform these job tasks for more than 2 hours continuously, then the LI for the hashing jobs would be higher, posing a higher risk of developing low back injury.

Walk-through Observations and Employee Concerns

Loading

Toward the end of the shift, to process mail by the designated deadline, a worker crosses over the conveyor line in the loading area and presorts some of the tubs/trays before reaching the hashing (sorting) stations. In addition, when the front conveyor is backed up, the workers lift tubs/trays over the front conveyor line onto the back conveyor. These two actions increase the lift frequency and reach distance, respectively; therefore further increasing the LI for the loader job.

NIOSH investigators noted loading stations with no mats for workers to stand on. The hashing stations had built-in footrests; however, the surface was worn and slippery and did not allow the workers to utilize them to change body positions. Prolonged standing, without mats and/or the ability to change postures, can cause pain in the muscles of the legs, back, and neck.

Hashing

NIOSH investigators observed the gravity conveyor lines in the HDCS area over-loaded (more than 6–7 tubs/trays) due to workers pushing mail down the gravity conveyors to clear up the line for loaders to add more. At other times, the hashing stations seemed to be unequally loaded, resulting in more tubs/trays on certain lines than on others. Also, it was noted that hash station 2 had a new roller conveyor. The new roller conveyor had more rollers, which facilitated the movement of tubs/trays down the gravity conveyor line, thereby reducing the number of stuck tubs/trays that workers had to reach to pull down to the sorting area.

NIOSH investigators observed a large amount of mail thrown or dumped in the top chute of the hashing station, which is located at or above shoulder level for some workers. The mail included usually large packages and envelopes and required forward flexion of the back and extended arm postures to throw into the top chute.

Review of OSHA 300 Logs

Review of the OSHA Logs indicated that most entries occurring in East Dock workers were due to MSDs (not including acute injuries such as fractures, laceration, punctures or contusions). OSHA Logs documented three MSDs for East Dock workers in 2007 (two lower extremity, one chest); none in 2006; one in 2005 (one upper extremity); none in 2004; and five in 2003 (two upper extremity, two lower extremity, one chest).

Conclusions

On-site assessments and interviews at the Seattle P&DC are the basis for the following conclusions and recommendations. The new hashing job had lower LI and DCF values than the old job. Although the old job was simulated for the purposes of job analysis, NIOSH researchers believe that the actual old job may have posed greater musculoskeletal disorder risks to workers. The loading job from GPMCs had the largest LI among all the current jobs analyzed. This indicates a high risk of workers developing low back pain and injury. The current hashing jobs had the lowest LIs of all the current jobs analyzed. However, some improvements to the HDCS area could be made to further reduce the LI to below 1.0.

It is important to restate that an average weight of 22 lbs and a duration of 2 hours were estimated and used for the calculations. Workers lifting containers that weigh more than 22 lbs, with the postures analyzed, may produce DCFs that exceed the NIOSH recommended limit. Also, if workers perform these job tasks for more than 2 hours continuously, then the LI for the hashing jobs would be higher. General recommendations, as well as recommendations for reducing the DCF and LI, follow.

Recommendations

The following recommendations are offered to help reduce the risk for development of work-related musculoskeletal disorders for employees in the East Dock HDCS area. The preferred method of controlling ergonomic hazards is to provide engineering controls that redesign the workstation and/or job task to reduce or eliminate the risk of WMSDs. Recommendations 1 through 5 provide suggestions for engineering controls. Administrative controls or policies designed to limit workers' exposures to hazardous conditions can be used temporarily until engineering controls are implemented. Recommendations 6 and 7 provide suggestions for administrative controls. In addition, NIOSH investigators recommend training employees to recognize ergonomic hazards and asking them to participate in the process of identifying hazards and making job modifications. Recommendations 8 and 9 will help achieve these goals. While implementing all of these recommendations over a period of time is optimal, even implementing some of them along with other administrative controls would be beneficial in reducing workers' risk of WMSDs.

Recommendations (continued)

1. Readjust shelving in the hashing area to make space for workers to place empty containers. This will eliminate 180° twisting that occurs when placing empty containers in their current location. Also, the top chute of the hashing station should be readjusted to eliminate dumping mail at or above shoulder level.
2. Relocate the TMS conveyor in front of the worker. This will eliminate 180° lifts to place full containers on the TMS conveyor. This would require raising the area, or using a platform to provide sufficient clearance for the TMS conveyor.
3. If recommendation #2 is not possible, lower the TMS conveyor height from 37" to 32". This will eliminate elevated shoulder postures when lifting full containers onto the TMS conveyor.
4. Replace the roller conveyors on gravity lines leading to hash stations 1, 3, and 4, similar to hash station 2. This will facilitate the movement of tubs/trays down the conveyors, thus eliminating reaching to push or pull tubs/trays on the conveyors.
5. Reevaluate the system that feeds tubs/trays down to the hash stations. The stations were occasionally unequally loaded.
6. Install antifatigue mats in the loading area and non-slip material on the footrests in the hashing area.
7. Add workers to both the loading and hashing areas to allow rotation of employees through all the job tasks (dock, loading, and hashing).
8. Train employees to recognize WMSDs and instruct them in work practices that can ease the task demands or burden.
9. Management and employees should jointly address ergonomic issues routinely and periodically evaluate the effectiveness of implemented engineering and administrative controls.

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Appendix A: Ergonomic Evaluation Criteria

The term MSD refers to conditions that involve the nerves, tendons, muscles, and supporting structures of the body. WMSDs are a major component of the cost of work-related illness in the United States. A substantial body of data exists providing strong evidence of an association between MSDs and certain work-related factors (physical, work organizational, psychosocial, individual, and sociocultural). The multifactorial nature of MSDs requires a discussion of individual factors and how they are associated with WMSDs. There is strong evidence that working groups with high levels of static contraction, prolonged static loads, or extreme working postures involving the neck/shoulder muscles are at increased risk for neck/shoulder MSDs [NIOSH 1997]. There is also strong evidence that job tasks that require a combination of risk factors (highly repetitious, forceful hand/wrist exertions) increase risk for hand/wrist tendonitis [NIOSH 1997]. Lastly, there is strong evidence that low-back disorders are associated with work-related lifting and forceful movements [NIOSH 1997]. A number of personal factors can also influence the response to risk factors for MSDs including: age, gender, smoking, physical activity, strength, and anthropometry. Although personal factors may affect an individual's susceptibility to overexertion injuries/disorders, studies conducted in high-risk industries show that the risk associated with personal factors is small compared to that associated with occupational exposures [NIOSH 1997].

In all cases, the preferred method for preventing/controlling work-related musculoskeletal disorders is to design jobs, workstations, tools, and other equipment to match the physiological, anatomical, and psychological characteristics and capabilities of the worker. Under these conditions, exposures to task factors considered potentially hazardous will be reduced or eliminated.

The specific criteria used to evaluate the biomechanical and injury risk factors of job tasks at USPS were the biomechanical outputs obtained from the University of Michigan's 3DSSPP [Chaffin 1995] and recommendations for acceptable lifting weights as determined by the RNLE [Waters 1994].

The 3DSSPP is a computerized model that can be used to evaluate the physical demands of a job. Typical inputs to the model are the magnitude and direction of forces at the hands, angles of body segments, and anthropometric selection such as gender and population size percentiles. The model outputs moments at the joints of the body, percentages of the chosen population able to sustain the inputted loads, and disc compression forces at the low back. For the purposes of this HHE, the 3DSSPP was used to evaluate the biomechanical demands of the loading and hashing tasks.

The RNLE is a tool for assessing the physical demands of two-handed lifting tasks. In brief, the equation provides a recommended weight limit and a lifting index for a lifting task, given certain lifting conditions. The RWL is the weight that can be handled safely by almost all healthy workers in similar circumstances. The LI is the ratio of the actual load lifted to the RWL. Lifting tasks with a LI ≤ 1.0 pose little risk of low back injury for most workers. Tasks with a LI > 1.0 may place an increasing number of individuals at risk of low back injury. The consensus opinion of an expert panel, described in the RNLE report, is that tasks with a LI > 3.0 pose a risk of back injury for most workers.

Analysis Method

To calculate the risk of injury posed by job tasks using the RNLE and the 3DSSPP, physical measurements must be taken from the worker and the task being performed. Use of the RNLE requires a measure of the position of the object with respect to the body at the beginning and end of the lift, the height to which the object is lifted, the frequency of the lift, and the angle of any twist the body makes while lifting. The 3DSSPP requires body segment angles as inputs so that the posture of the worker performing the task can be duplicated. In both cases, the weight of the object being lifted or moved during the job task must be recorded. Because obtaining these measurements can be tedious, time-consuming, and at time infeasible, NIOSH investigators now obtain injury risk outputs from the RNLE and the 3DSSPP through input of postural information from subjects simulating job tasks in a laboratory (see Figure A1) using a position and orientation measurement system. The system features commercially available body position and orientation measurement hardware (Flock of Birds, Motion Star, Ascension Inc., 1999) and Motion Monitor software (Innovative Sport, Chicago IL, 2003).

Figure A1. Instrumented “simulator” assuming a work posture on the simulation platform

The motion capture system is capable of determining the position and orientation of the body segments by transmitting a pulsed direct current magnetic field that is simultaneously measured by all sensors located within 3 meters of the transmitter. From the measured magnetic field characteristics, the system independently computes the position and orientation of each sensor which is subsequently sent to the motion capture software program (Motion Monitor, Innovative Sports Inc.). The position and orientation data are further processed with a link segment model for calculating the posture variables needed for use by 3DSSPP and RNLE. The data are transmitted from 13 sensors attached with Velcro straps to various body segments of the person simulating the job of interest. The simulator stands on a platform that is surrounded by a magnetic field and assumes the various postures of the worker performing the job task, which are projected on a screen behind the platform. Figure A1 shows how the jobs are simulated in the lab. A NIOSH study has shown that the accuracy and reliability of the method is at least on par or better than manual posture specification method for using 3DSSPP and RNLE (Lu et al., 2007).

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Acknowledgments and Availability of Report

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a) (6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a) (6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

This report was prepared by Jessica Ramsey of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS) and Ming-Lun (Jack) Lu of Organizational Science and Human Factors Branch, Division of Applied Research and Technology. Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway. Health communication assistance was provided by Stefanie Evans.

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