International Journal of Industrial Ergonomics 42 (2012) 384–391

Contents lists available at SciVerse ScienceDirect

International Journal of Industrial Ergonomics

journal homepage: www.elsevier.com/locate/ergon

A comparison of productivity and physical demands during parcel delivery using a standard and a prototype electric courier truck

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ARTICLE INFO

Article history:
Received 25 December 2010
Received in revised form
15 December 2011
Accepted 10 April 2012
Available online 9 May 2012

Keywords:
Occupational biomechanics
Low back
Shoulders
Mechanical exposure
Electromyography
Interventions
Trucking

ABSTRACT

Courier drivers are at risk for the development of fatigue and Musculoskeletal Disorders (MSDs) due to frequent awkward lifting and carrying of parcels. A functional prototype of a redesigned courier truck represented a potentially valuable engineering control to reduce courier drivers' MSD risk. Specifically, the prototype courier truck was evaluated for its ability to reduce double-handling of packages between carts and the truck, decrease the lifting of carts on/off the truck and reduce lifting packages in awkward positions. Ten courier drivers performed a simulated delivery route with 18 stops while surface electromyography of the forearms, shoulders and lumbar spine were monitored with a simultaneous video recording. Low back loading for each lift was calculated based upon video analysis. The prototype courier truck showed substantial and statistically significant reductions in total delivery time (−29.5%), and the reduction was especially noticeable for stops using a cart. The cumulative compression and integrated electromyograms also showed reductions for the prototype courier truck. Peak and average loads did not, however, change appreciably. The prototype courier truck met the first three goals; however, it did not measurably affect the demands of lifting and moving packages within the truck itself. Further development is intended to address this issue.

Relevance to industry: The redesign of this transportation equipment achieved some reductions in mechanical loading as well as improvements in productivity.

1. Introduction

Work related musculoskeletal disorders (MSDs), such as low back and shoulder pain, and the disability they cause, are a serious concern in many workplaces. In Ontario they are the number one cause of lost time claims reported to the Ontario Workplace Safety and Insurance Board (WSIB, 2007). This problem is especially worrying for mail couriers and other workers in the transportation sector. In 2008, the Transportation Health and Safety Association of Ontario (THSAO), an industry association, reported the highest frequency rate of MSDs compared to all Health and Safety Associations in Ontario (WSIB, 2008). Also, transportation and equipment operators specifically had the highest amount of lost time claims compared to all other occupations in Ontario for 2007 (~29%) (WSIB, 2007).

From 2006 to 2008 the sector reported between 3090 and 3183 lost time MSD claims per year. These injuries have accounted for 149,000–254,000 lost time days per year with direct lost time costs of $19.8–33.3 million per year. The most common MSD claims involve the workers' back and spine, in which 1509–1590 lost time claims have been approved per year from 2006 to 2008. These back and spine injuries have had direct costs of $9.5–16.5 million dollars annually. Shoulder MSDs are the third most common MSD claim with 293–330 approved lost time claims per year for the THSAO. These MSDs have the second highest direct cost ($3.0–6.7 million dollars per year) (WSIB, 2008).

Courier drivers are especially susceptible to MSDs due to the necessary work demands of lifting, lowering and moving heavy packages, high frequency of lifting, lifting with awkward postures, inadequate grip available on packages exacerbating lifting difficulty, carrying packages long distances, opening doors while holding packages, adverse weather or environmental conditions leading to slips and falls, sitting and vibration associated with driving, and high step heights required to climb into and out of the vehicle.

There are few alternative work practices available to reduce the risk of injury while still maintaining an acceptable level of work performance. This leaves courier truck redesign as a potentially important engineering intervention which could reduce loads on

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0169-8141/$ – see front matter
doi:10.1016/j.ergon.2012.04.003

the body and the risk of injury. It is of interest not only whether a redesign reduces loads but also, in order to judge its likely effect, the magnitude of the reduction is of interest (Wells et al., 2009). Further, the design of courier trucks has not changed recently.

As part of a larger researcher-workplace collaborative project in the transportation sector, an ergonomic change team (Laing et al., 2005) at two courier companies identified parcel delivery and pickup by courier drivers as a job requiring further investigation to reduce risks of injury. Based upon our interaction with the teams, in parallel with detailed task analyses and route rides, we believe an improved design of a courier truck should aim to:

1) Avoid unnecessary handling of the packages. This is commonly due to setting down packages in order to open or close and lock or unlock doors;
2) Reduce the lifting of packages from carts to the back of the truck (double-handling) and lifting of packages from the back of the truck to carts;
3) Decrease the lifting of heavy carts on/off of the truck;
4) Reduce the lifting of packages with awkward postures.

Recently a Canadian company designed a new battery powered courier truck called the "LightSpeed Quicksider" that was specifically designed to improve the working conditions and productivity of courier drivers and reduce the vehicle's impact on the environment. A functional prototype of the truck was available for evaluation, and as it represented a potentially valuable engineering control, its ability to reduce the risk of courier drivers developing MSDs was of interest to the sector. Overall, the physical layouts of the parcel area of the prototype courier truck and the standard courier truck were similar with respect to the placement and number of shelves. The main differences between the standard and prototype courier truck included:

1) Automatic and powered opening/closing and (un)locking doors that eliminates setting packages down to open and close the doors as well as eliminating the effort required to open and close the back and side doors.
2) The front of the truck kneels (lowers) when the truck is turned off thereby reducing the front step height and facilitating entry and exit of the cart through the front door.
3) The rear of the truck kneels (lowers) to ground level which enables the push cart to be rolled (not lifted) on/off while loaded with packages. This eliminates setting packages down on the floor of the truck before loading them to or from the cart.
4) No lip on the interior shelving which slightly decreases the vertical height packages need to be lifted.
5) A redesigned cart and docking station.

The prototype courier truck has the potential to decrease fatigue and MSD risk by reducing the physical demands required when delivering parcels and to improve the drivers' productivity by removing non-value added tasks, such as locking/unlocking and opening/closing doors.

The purpose of this study was to compare the performance and physical demands when delivering packages using a standard courier truck, the Utilimaster Parcel Delivery Step Van, and the prototype courier truck, LightSpeed Quicksider.

1.1. Hypotheses

It was hypothesized that compared to a standard courier truck, the prototype courier truck would result in lower magnitude of MSD risk factors. Specifically:

1) Less time spent performing the "in" and "out" phases (which includes lifting, lowering, handling, retrieving and positioning packages while in the back of the truck)
2) Fewer total number of lifts/lowers
3) Fewer total number of lifts/lowers in demanding zones which would require awkward postures
4) Fewer total number of lifts/lowers which are rated as "above guidelines" by evaluation tools
5) Lower peak and cumulative loading on the lumbar spine
6) Lower static, mean, peak and cumulative muscle loading on the low back, shoulder, and forearm musculature.

2. Methods

2.1. Participants

A convenience sample of 10 full-time courier drivers from one courier depot volunteered to participate in the study. The drivers' average age was 38.8 ± 7.6 years; average height was 1774 ± 39 mm; and average weight was 96.3 ± 12.9 kg. Informed consent for all participants was obtained using procedures approved by the University of Waterloo Research Ethics Board.

2.2. Delivery tasks

Because of the high variability in the package mix and deliveries observed during route rides by the research team, as well as the limited availability of the prototype, we chose to perform the evaluation using a simulated delivery route. A simulated cargo of packages was setup based upon the company's operational data and information gathered from route rides by members of the research team. It included a mix of box sizes, weights of boxes, the number of boxes per stop, the door the driver had to use (side or back) and whether a cart was used for delivery and pickup. The simulated delivery route had 18 stops, took approximately 20 min to complete and included:

- 9 pickup stops and 9 delivery stops
- 42 boxes; 6 small boxes, 26 medium boxes and 10 large boxes
- Box weights: 8×2 kg boxes, 18×8 kg boxes, 8×15 kg boxes, 8×20 kg boxes
- 8 stops with 1 box and 10 stops which had multiple boxes (4 with 2 boxes, 4 with 3 boxes and 2 with 6 boxes)
- 12 stops used the side door and 6 stops used the back door
- 8 stops used a cart and 10 stops did not

2.3. Instrumentation

Four color surveillance video cameras (Fact Canada Consulting Ltd., Model 8101CB) were placed in and around the trucks to ensure all aspects of the delivery activities would be captured on video, Fig. 1. These four channels of video were recorded for the entire trial for both truck conditions. One camera was positioned in the front of the truck (above the driver looking at the seat and the side door), two were positioned in the back of the truck (one facing the front and one facing the back of the truck), and one wireless camera was mounted outside the truck to observe the back and side doors and other work outside the truck.

Surface electromyography (EMG) was collected bilaterally from sites overlying the upper trapezius, extensor digitorum and lumbar erector spinae using self-adhesive silver-silver chloride electrodes (Medicotest Blue Sensor N-00-S electrodes). These muscles were selected in order to capture demands of the distal upper extremity, shoulder and lower back which were identified as highly loaded body parts during previous observations of courier drivers. The