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Time Study for the Power Stow Rollertrack Conveyor for Airport Baggage Handling

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Abstract

A time study was conducted to evaluate the operation efficiency and the risk of musculoskeletal disorders (MSDs) for using the Power Stow Rollertrack Conveyor (PSRC) for baggage handling in the cargo holds of narrow-bodied aircrafts. The PSRC employs a retractable roller conveyor from a belt loader to provide powered transportation for loading and unloading baggage in the cargo holds. Thirteen baggage handlers at the Boston Logan International Airport participated in the data collection, which involved videotaping their work postures and methods during baggage handling operations in the cargo holds of the Boeing 737 and 757 aircrafts. Results showed that the PSRC provided improved efficiency in handling baggage, especially for unloading baggage by about 2 bags per minute. There was no significant difference in the total time spent on the risk factors for MSDs, such as lifting, pushing and pulling tasks per person for each bag between PSRC users and non-users.

Keywords

Musculoskeletal Disorder, Airport baggage handling, Lifting, Cargo hold

Introduction

Among the industry sectors classified by the U.S. Bureau of Labor Statistics (BLS) in 2019, the transportation and warehousing industry sector had the second highest incidence rate (4.4%) of nonfatal occupational injuries and illnesses involving days away from work. The injury incidence rate (6.5%) for the air transportation sub-industry sector was 1.1% greater than the second highest sector-based injury rate (4.4%). Of the recordable injuries, musculoskeletal disorders (MSDs) accounted for the majority of the injury cases (BLS, 2020).

A previous study showed that 85% of the injuries in the air transportation industry are directly related to baggage handling (Dell, 1998). Over half of baggage handlers reported pain in the shoulders, knees and lower back (Dell, 1997). Bern at al. (2013) reported that with increasing years of employment as a baggage handler there was increased reporting of injuries to the back, elbows, shoulders, knees and wrists. The finding indicates a dose-response relationship with cumulative exposure and duration of employment. Brauer et al., (2019) found that baggage handlers with 20 years of employment or more had a two-fold incident rate of low back pain compared to baggage handlers with less than 3 years of employment. Mikkelsen et al., (2016) and Thygesen et al., (2016) found an increased incidence of hospital admissions due to meniscal lesions in the knees and subacromial shoulder disorders among baggage handlers compared to a reference group and the incidence increased with years of employment.

A survey showed that the average weight of checked bags handled at a large airport in the United States was about 32 lbs with approximately 3% of the bags exceeding 50 lbs (Lu et al., 2018). The average baggage weight, however, may vary significantly, depending on the flight traffic and passenger volume. In addition to heavy baggage weights, baggage handling involves many other ergonomic risk factors, such as awkward postures, high lifting frequencies, fast body movements, and mental stress (ARTEX, 1980; Hogwood, 1996; Berube, 1996; Dell, 1997; Rosskam, 2007).

Among many baggage handling tasks, working in the restricted cargo holds of narrow-bodied aircrafts is considered high risk for MSDs (Weston et al. 2020). Dell (1998) indicated manual baggage lifting and handling with restricted working posture is usually the only option available to load and unload baggage in the cargo holds of narrow-bodied

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Figure 1. The belt loader (credit: NIOSH).

Figure 2. The portion of the Power Stow Rollertrack Conveyor (PSRC) is extended to the inside of the cargo hold of a narrow bodied aircraft (credit: NIOSH).

aircraft. Dell (1998) further suggested that when it comes to aircraft design, aircraft manufacturers are only concerned about range, payload and low fuel burn. In recent decades, the health and financial costs of injuries to baggage handlers have generally not been factored into the design process, especially for narrow-bodied aircrafts. Consequently, the MSD incidence rates caused by the poor aircraft cargo design have been high among airport baggage handlers. To reduce these risk factors for MSDs and increase baggage handling efficiency, after-market controls have been invented. Among the interventions, the Power Stow Rollertrack Conveyor (PSRC) provides a unique retro-fitting solution to existing belt loaders that are used to transport baggage from carts in the tarmac area to the cargo holds of aircrafts.

The PSRC employs a retractable roller conveyor from a belt loader (Figure 1) to provide powered transportation for loading and unloading baggage in the cargo holds. The PSRC (Figure 2) works as a traditional belt loader except it has a retractable, semi-automatic roller conveyor from the belt loader. Figure 2 shows the extended roller conveyor used in a cargo hold. The extended roller conveyor provides powered transportation for loading and unloading baggage to and from stacking areas in the cargo hold, as opposed to manual transfer from the cargo hold door to the stacking areas without the use of the PSRC. The head (a small, tilting ramp) of the PSRC can be adjusted by two levers to stay in a range between the bottom of the conveyor to approximately the baggage handler's shoulder height, which can facilitate stacking baggage in the cargo hold. Typically, the baggage handler would guide the head of the roller conveyor to an empty space in the stacking area, followed by pushing/pulling the bag off the conveyor to complete loading/stacking the bag. For unloading bags from the cargo hold, the baggage handler is required to move or lift bags in the stacking areas to the PSRC, which then automatically transports bags to the belt loader all the way down to the area where other baggage handlers transfer the bags to a baggage cart.

The researchers from NIOSH were asked by a safety and health manger for a large airline company to assess the efficiency and associated risks of MSDs during a trial of the PSRC at the Boston Logan International Airport. Because of the limited time and access to the PSRC, the NIOSH researchers decided to conduct a time study as a preliminary investigation.

Methods

Data collection

Data for the time study was collected by videotaping baggage handlers' work in the cargo holds of two different types of aircraft (Boeing 737 and 757). Prior to data collection, study participants' consents were obtained in accordance with the NIOSH institutional review board. The body motion and posture of participating ramp baggage handlers working in the aircraft cargo holds were videotaped using a Sony digital camcorder (Model DSR-SR 300, Sony Inc.). One to two study participants (i.e. baggage handlers) were videotaped in each video, depending on the baggage handling set-up. Generally, one baggage handler was required to operate the PSRC, while two were needed for handling bags in the cargo hold without the PSRC. Sometimes for small loads/unloads without the PSRC, only one baggage handler was needed. For the time study, 13 participants were videotaped in 15 videos during two full days of video sampling.

Data Analysis

The collected video data were analyzed using the Multimedia Video Task Analysis (MVTA™) software program. The MVTA™ program helps automate time and motion analyses of visually discerned activities through an interactive graphical user interface. Digital video files can be reviewed in the MVTA program for the user to assign arbitrary events that are discerned by interactively identifying terminal break points in the timed activity. Break points are characteristic occurrences that define the start and end of an event. The video may be reviewed at any speed and in any sequence

Figure 3. The records and events defined in the MVTA program for the time study (Credit: NIOSH).

(real-time, slow motion, fast motion, or frame-by-frame in either forward or reverse direction). These functions were used until a clear identification of one of seven pre-defined events was made by the first author. We used the time report generated by the MVTA™ program for this time study. Figure 3 shows a screen shot of the MVTA program interface. Each row in the left panel of the window in Figure 3 represents a record. In the present study, there were two records: number of bags and type of manual materials handling (MMH).

An event in the MVTA analysis is referred to as a body motion breakpoint during baggage handling. For example, the event for the "Number of Bags" record in Figure 3 is the starting point of handling each bag. The total number of bags observed in the video can be calculated by the number of starting points of handling each bag. The average frequency of handling bags was determined by calculating the total number of bags handled divided by the length of the video. The events for the "Type of MMH" record were defined as the starting or ending points of each MMH task. In other words, each event was either the starting or ending point of a lifting, pushing or pulling task. The event "no MMH" was also used for marking idle time. The event "Null" was used for marking video frames where the study participant was out of view of the video frame (i.e., unseen). By manually marking the start and end of each MMH task, the total time spent on each MMH task observed in the video was calculated. Subsequently, the total time for all MMH tasks was determined by summing the time durations for all corresponding MMH tasks observed in the video. The variable "percentage (%) time of MMH" was calculated by the total time spent on lifting, pushing and pulling tasks divided by the length of the video.

Results

Time Study

A total of 15 videos on 13 participants were recorded. The mean and standard deviation of the lengths of the videos were 7.8 and 4.4 minutes, respectively. Although the mean of the recording times was short, it appeared to match the typical process time for fast loading and unloading baggage for narrow-bodied planes during a weekday flight turnaround. The time study data by MMH task is summarized in Tables 1–2 and 3-4 for loading and unloading baggage, respectively. The frequency variable in these tables is the frequency of bag transfer.

Table 1. The mean values of the frequency and the number of MMH tasks for loading baggage to the Boeing 737 and 757 cargo holds.

Use of PSRC	Frequency (per min)	No. of lifts	No. of pushes	No. of Pulls
No (n=5)	7.0	26.2	8.8	18.4
Yes (n=6)	7.6	16.3	29	10.5

Table 2. The mean values of the length of time for MMH tasks for loading baggage to the Boeing 737 and 757 cargo holds.

Use of PSRC	Lift time (sec)	Push time (sec)	Pull time (sec)	%time of MMH
No (n=5)	30.1	9.1	21.9	18.0
Yes (n=6)	19.1	33.6	11.2	11.6

Table 3. The mean values of the frequency and the number of MMH tasks for unloading baggage from the Boeing 737 and 757 cargo holds.

Use of PSRC	Frequency (per min)	No. of lifts	No. of pushes	No. of Pulls
No (n=5)	9.4	24.3	48.7	50
Yes (n=6)	11.4	13.3	3.8	58

Table 4. The mean values of the length of time for MMH tasks for unloading baggage from the Boeing 737 and 757 cargo holds.

Use of PSRC	Lift time (sec)	Push time (sec)	Pull time (sec)	%time of MMH
No (n=5)	24.2	38.3	53.9	30.1
Yes (n=6)	8.4	4.0	77.4	28.3

Overall comparison of MMH tasks for baggage handling with and without PSRC

Results showed that the mean frequency of bags unloaded from the cargo holds with the PSRC was 2 bags greater than that without PSRC, while the mean frequency values for the two baggage handling methods were similar for loading to the cargo holds. For both methods, unloading was more efficient than loading bags in terms of bag transfer frequency. For both loading and unloading baggage using the PSRC, the

number of lifts was smaller than without using the PSRC. For loading baggage with the PSRC, the number of pushes was greater (29 vs. 8.8), while the number of pulls was smaller (10.5 vs. 18.4). In contrast, for unloading baggage with the PSRC, the number of pushes was smaller (3.8 vs. 48.7), while the number of pulls was greater (58 vs. 50). The time spent on the MMH tasks exhibited the same trends.

The percentage time of MMH tasks indicated the amount of work required during a normal cycle time of the entire baggage loading or unloading process. For the purpose of comparison between the two handling methods, the percentage of time spent on MMH was used. Results showed that the percentage time of the MMH involved in using the PSRC was smaller for both loading and unloading baggage, as compared with complete manual operation. Interpretation of the data, however, should be cautious because the percentage time of MMH was related to the frequency of baggage transportation, which may be determined by other factors, such as the speed of loading/unloading baggage to/from baggage carts and the number workers in the cargo holds. A direct comparison between the two baggage handling methods is described below.

Aircraft-specific comparison of MMH tasks for baggage handling with and without PSRC

Data presented in Tables 1–4 were the average data across different operations in two types of aircraft. To accurately compare the efficiency of the two baggage handling methods with and without the PSRC, the same work condition controlling for the frequency of baggage transportation and the number of workers should be applied. On the basis of availability of the MVTA analysis data, loading/unloading baggage in the same Boeing 737 cargo holds (i.e. same work condition) was used for this comparison. Tables 5 and 6 show the results of loading and unloading baggage for this analysis. The total percentage time for MMH for each bag with the PSRC for both loading and unloading baggage was about one half of that without the PSRC for both loading and unloading baggage operations. If the percentage time for MMH tasks per bag was divided by the number (two) of baggage handlers, the MMH time per bag per person for both baggage handling methods would be comparable regardless of loading or unloading baggage. This finding can be interpreted as the MMH time required for handling each bag is about the same for both methods, but the total labor required for using the PSRC is about one half of that for the current baggage handling without using the PSRC.

Table 5. The time for MMH tasks for each bag for loading baggage to the Boeing 737 cargo holds.

Use of PSRC	Lift time (sec)	Push time (sec)	Pull time (sec)	%time of MMH
No (n=2)	1.62	0.62	1.22	3.46
Yes (n=1)	0.4	0.75	0.58	1.73

Table 6. The time for MMH tasks for each bag for unloading baggage from the Boeing 737 cargo holds.

Use of PSRC	Lift time (sec)	Push time (sec)	Pull time (sec)	%time of MMH
No (n=2)	1.0	0.8	1.7	3.5
Yes (n=1)	0.21	0.18	1.24	1.63

Discussion

The study findings suggest that the PSRC provided improved efficiency in handling baggage in the cargo holds of narrow-bodied aircraft, especially in unloading baggage from the cargo holds by 2 bags per min, as compared with complete manual operation. If the percentage time for all MMH tasks was used for comparison, using the PSRC involved slightly less percentage time for both loading (6.4%) and unloading (1.8%) baggage operations. According to Tables 5 and 6, there was no significant difference in the percentage time for the MMH tasks per person for each bag between PSRC users and non-users, under the circumstances that the baggage handling with the PSRC was performed by one worker, while baggage handling without the PSRC was performed by two workers. Keep in mind that the percentage of MMH time may not be a good risk indicator as the risks of lifting and pushing/pulling for MSDs may differ. Pushing/pulling baggage in the narrow-bodied airplanes may result in less risk than lifting, such as spinal loads.

The participating airline company decided to assign one worker to the cargo holds when the PSRC was used, and two workers for the same operation without the PSRC. It is understood that the company considered investing the PSRC in large scale during the evaluation period and decided to eliminate one worker to examine the efficiency of the PSRC. As shown in our findings, by eliminating one worker in the cargo hold for using the PSRC, the risk of MSDs may not reduce in terms of the percentage time for MMH tasks per bag per person.

One main limitation of the study is a lack of comprehensive risk assessment for MSDs. For example, some other aspects of the MMH, such as the dynamics of the MMH and postures associated with the MMH, are highly relevant to the overall risk of MSDs for baggage handling in the cargo holds of narrow-bodied aircrafts (Weston et al, 2020). These factors were not measured in this time study and should be investigated further for an appropriate MSD risk assessment. It was observed that the trunk posture of the handler appeared to be less dynamic for most of time while handling baggage with the PSRC, when compared with the trunk postures for manually lifting and handling bags without the PSRC in the cargo holds.

Due to the nature of the study, the study partner (the large airline company) granted a short period (two weekdays) for

the time study. Because of the small sample size without any random sampling strategy nor a control group, the study findings should not be generalized for a large scale application without considering other factors that may contribute to the risk of MSDs. In addition, the MVTA analysis was performed only by the first author without examining potential observation errors for quality control. For a large scale MVTA analysis, the inter-rater reliability of the MVTA analysis is suggested. Moreover, the heart rates of baggage handlers were not monitored in the initial assessment. The heart rate monitoring may suggest physiological strain that cannot be assessed by the MVTA or a postural analysis. Nevertheless, the study provides valuable insight into the use of the PSRC as a potential for an effective ergonomics intervention. We recommend initiating a separate study to systematically investigate the health and cost benefits of using the PSRC as well as other engineering control technology that may reduce the risk of MSDs in baggage handlers working in the ramp area.

Conclusion

This is the first published time study to provide information on the efficiency of using the PSRC as well as some insight into the risk of MSDs associated with baggage handling in the cargo holds of narrow-bodied aircrafts. The percentage of time spent on MMH required for handling each bag is about the same with and without the PSRC, but the total labor required for using the PSRC is one half of that for complete manual baggage handling without using the PSRC.

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of NIOSH, Centers for Disease Control and Prevention (NIOSH/CDC). Mention of any company or product does not constitute endorsement by NIOSH/CDC.

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