THE ERGONOMICS CENTER OF NORTH CAROLINA
Advancing the Science of Ergonomics in the Workplace™
NC STATE UNIVERSITY
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VIA E-mail: vep1@cdc.gov

February 28, 2011

Vern P. Anderson, PhD
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Dear Dr. Anderson:

Thank you for your support of the Ergonomics Center of North Carolina (ECNC). It has certainly been a pleasure working with you over the course of the WRT Manual Materials Handling Demonstration Projects. Please find enclosed a report summarizing and detailing the Northern Region Project (NIOSH Contract No: 214-2009-M-32431). The host site selected for this project was part of a large superstore chain and was located in Glen Allen, Virginia.

Please feel free to review and pass along to the appropriate parties. Also, please do not hesitate to call should you have questions concerning this report, my direct line is (704) 483-2837. I look forward to hearing from you.

Best Regards,

Jeff Hoyle

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WRT Manual Material Handling Demonstration Project: "Work Smart at the Right Height"

Northern Region: NIOSH Contract No: 214-2009-M-32431

Prepared for

National Institute for Occupational Safety and Health

February 28, 2011

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1. Executive Summary

Background Summary. The Ergonomics Center of North Carolina (ECNC) housed within North Carolina State University partnered with a large superstore chain that has retail locations in the northern region of the United States. The host site selected for this Northern Region Project was located in Glen Allen, Virginia. The primary purpose of the demonstration project was to demonstrate the efficacy of manual materials handling (MMH) equipment in the retail trade sector that would reduce the bending, stooping, and overhead reaching associated with loading and storing materials in retail stores. More specifically, the purpose of this report was to outline the methods and show the ***Pre-*** versus ***Post-intervention*** results in terms of ergonomics risk, usability feedback, body discomfort, and productivity for the interventions introduced and tested.

Methods Summary. Based on company incident data and management input, the replenishment of goods process was chosen to be evaluated as part of the MMH demonstration project. More specifically, the two key focus areas were the following:

1. *Trailer Unload*
2. *Stocking*

Pre-intervention data collection consisted of on-site observation, task analysis, ergonomic risk evaluation, body part discomfort surveys as well as basic time studies of targeted process(es) to prioritize tasks based on ergonomic risk and time spent (% of process) in an attempt to maximize potential ergonomic and productivity benefits. Interventions to trial were researched, brainstormed, proposed, and agreed upon by corporate and store-level personnel to gain buy-in on all levels of the company prior to introduction. ECNC worked with third party material handling equipment vendors to provide either “off-the-shelf” equipment or “retrofitted” equipment to the application or requested desires of the host site superstore. Once finalized and shipped to the host-site store in Glen Allen, Virginia, the equipment was introduced to store-level personnel and a brief training session was conducted to ensure proper use of equipment and address any safety precautions.

A six-week phase-in time was allocated to allow employees to gain experience using the new equipment and to minimize potential Hawthorne Effects prior to post-intervention data collection. Post-intervention data collection included the same protocol as previously stated in the “pre-intervention” phase, but also included equipment usability feedback from host-site personnel. Depending on the task type and applicability, pre- vs. post-intervention ergonomic risk differences were assessed using the Lumbar Motion Monitor and corresponding Low Back Disorder Risk Model[1,2,3], the 3-Dimensional Static Strength Prediction Program[5], the 1991 Revised NIOSH Lifting Guide[7,8], Liberty Mutual Manual Materials Handling Guidelines[6], and/or Rapid Upper Limb Assessment[4]. Final results were shared with both corporate and store-level stakeholders to promote buy-in, answer any questions related to the project, and to discuss path-forward details.

Results Summary. Four different interventions were introduced and evaluated at the host-site retail store in Glen Allen, Virginia (see Table 1.1):

1. Mobile Work Platform
2. Height Adjustable Pallet Jack (battery powered)
3. Height Adjustable Lift Cart (battery powered)
4. Self-Leveling Cart (spring-loaded)

Table 1.1: ***Manual Materials Handling Interventions Tested***

			
Mobile Work Platform	***Height Adjustable Pallet Jack (Battery Powered)***	***Height Adjustable Lift Cart (Battery Powered)***	***Self-Leveling Cart (Spring-Loaded)***

All four interventions were trialed and evaluated for different applications. The mobile work platform was used inside the trailer in the back room to allow associates to reach and lift items without exceeding 70" in vertical reach height. The height adjustable pallet jack, height adjustable lift cart, and self-leveling cart were used for different product types both in the back room during trailer unload as well as stocking on the sales floor. The height adjustable pallet jack was used primarily for loading and transporting higher volume bulk cartons weighing between 15 and 39 lb (i.e. chemicals and detergents). The height adjustable lift cart was used primarily for lower volume bulk cartons weighing greater than 40 lb (i.e. furniture). Finally, the self-leveling cart was used primarily for higher volume non-bulk cartons weighing between 15 and 30 lb (i.e. consumables / groceries).

The height adjustable pallet jack, height adjustable lift cart, and self-leveling cart were all routinely used by store personnel during truck unload and stocking activities. In summary, all three of these interventions showed a reduction in ergonomic risk level, a reduction in reported discomfort, improved or maintained productivity, and reported positive usability feedback by store employees. The mobile work platform, however, was only used once or twice (if any) for very short durations (1 to 1.5 minutes) during the entire truck unload process. When the mobile work platform was used, there was a reduction in ergonomic risk; yet showed a productivity loss and reported mixed usability feedback. No significant discomfort was reported for this task either pre- or post-intervention for the mobile platform.

Conclusion Summary**.** While this project served as a pilot study involving a limited number of participants, equipment applications, and over a relatively condensed trial period (6-weeks), future studies are needed to help validate such equipment in the whole-sale and retail trade sector. However, pilot results from this study certainly show promise that such "load-elevating" equipment may have both ergonomic and productivity benefits in the retail trade sector.

2. Introduction

2.1 Background

Safety incidents are common among the retail trade sector. According to the Bureau of Labor Statistics, there were 4.3 injuries/illnesses per 100 full-time retail employees reported in 2008. Overexertion and strain/sprain injuries are the most common type and nature of incidents. Many of these incidents result from material handling activities such as lifting/lowering, carrying, and pushing/pulling. Eighty (80%) of employees in whole-sale and retail trade (WRT) engage in manual materials handling (MMH) tasks.

Therefore, the primary emphasis of the demonstration project was to ultimately reduce or potentially prevent overexertion injuries caused by material handling activities. Overexertion injuries leading to shoulder and back injuries are the leading musculoskeletal complaint, the most costly, and frequently the basis for the most lost time on a job. As a result, particular focus was placed on prevention of trunk and shoulder injuries for these tasks. Moreover, as this workforce ages and the workforce becomes more diverse (i.e., older, smaller, female, etc.), MMH activities that include bending, lifting and carrying pose a risk of musculoskeletal disorders (MSDs) as well as slips, trips, and falls.

2.2 Purpose

The purpose of this project was to undertake and complete the following three tasks:

(1) Identify a workplace in the WRT sector located within the **northern region of the U.S.**
(2) Identify/select appropriate workplace solutions/best practices for one or more of those workplaces
(3) Implement and evaluate the intervention to determine its effectiveness.

The interventions tested herein included engineering solutions that would reduce excessive bending or reduce vertical reach heights for specific MMH applications. It should be noted that such devices are likely not the complete solution to MSD problems associated with MMH, but they do introduce new technology into jobs that have not changed in decades. Once newer MMH assisted equipment is introduced, the greater the opportunity to introduce additional lifting/supporting equipment to reduce the loading of flatbed carts, dollies and pallets.

In summary, to identify and demonstrate the value of a "breakthrough" intervention as it applies to retail environments was our ultimate goal. More specifically, the purpose of this report was to outline the methods and show the ***Pre-*** versus ***Post-intervention*** results in terms of ergonomics risk, usability feedback, body discomfort, and productivity for the interventions introduced and tested.

3. Methods

3.1 Project Steps

The following steps were undertaken as part of the WRT MMH demonstration study:

1.	A retail host site was identified, corporate and store-level personnel were introduced to the project, and a basic timeline for project implementation was documented and approved
2.	Services agreement contract finalized between ECNC and host-site company finalized and approved through legal department and management stakeholders
3.	NCSU Institutional Review Board application submitted and approved to grant permission to collect objective and subjective data from host-site employees during intervention testing
4.	Reviewed host company injury/accident logs to help determine departments, job positions, and processes to focus on for implementing a MMH improvement
5.	Discussed with corporate, store-level and department management to get their feedback on processes to observe or focus on for MMH improvement
6.	Performed pre-intervention observation, task analysis, ergo risk factor analysis and confirmation as well as basic time study of targeted process(es) to prioritize tasks based on ergonomic risk and time spent (% of process) in an attempt to get the biggest bang for the buck from a potential ergo risk reduction and productivity improvement standpoint
7.	Reviewed current vendor products (e.g. MH solutions) on the market that may address the tasks of concern from pre-intervention analysis of current-state processses
8.	Proposed possible solutions to corporate and site-stakeholders to gain input on which MH solutions to trial
9.	Worked with MH vendor to provide existing product and/or retrofit MH solution to application/needs of client
10.	Introduced and trained host-site on the use of MH solution, allowed 6-week phase-in time before collecting post-intervention data
11.	Followed up with host-site during phase-in time to ensure that new equipment was being used and was functioning properly
12.	Performed post-intervention observation, task analysis, ergo risk evaluation, time study, and collected subjective feedback from workers on usability and body part discomfort
13.	Shared results with corporate and site stakeholders to promote buy-in and discuss path-forward / next-steps

3.2 Ergonomic Analysis and Evaluation

3.2.1 Lumbar Motion Monitor (LMM) and Low-Back Disorder (LBD) Risk Model

Figure 3.1. A worker wearing a lumbar motion monitor (LMM).

The Lumbar Motion Monitor (Figure 3.1), or LMM, was used to help evaluate the height adjustable pallet jack, the height adjustable lift cart, and the self-leveling cart when palletizing in the back room. Pre- vs. post-intervention results were averaged across a minimum of 5 trials of the participant performing each of the evaluated tasks. The LMM is a lightweight exoskeleton of the spine that is worn during the performance of lifting and material handling tasks. The patented LMM (The Ohio State University) was developed to provide an accurate method of tracking dynamic back motion in three-dimensional space. The LMM, along with information on the work environment, was used to predict the level of low back disorder risk for a given task. The five trunk motion and workplace factors that make up the Low-Back Disorder Risk Model include:

- Lift frequency
- Maximum load moment
- Average twisting velocity
- Maximum lateral velocity
- Maximum sagittal flexion

More than 400 repetitive lifting jobs were studied in 48 varied industries to compile this risk model. Existing medical and injury records in these industries were examined so that specific jobs historically categorized as either high-risk or low-risk for reported occupationally-related low back disorder could be identified[1,2,3]. Ergonomic risk level to the back was determined for tasks defined by the following categories:

- Probability of High Risk Group Membership ≤ 30% = **Low** risk
- Probability of High Risk Group Membership 31-60% = **Moderate** risk
- Probability of High Risk Group Membership > 60% = **HIGH** risk

3.2.2 Three-Dimensional Static Strength Prediction Program (3DSSPP)

The 3DSSPP™ software (Version 6.0.4 used in this effort) developed by the University of Michigan was also used to evaluate ergonomic risk level. This software was used to statically model tasks, using limited female and male anthropometry, descriptions of posture and the force loading at the hands (Figure 3.2). This program was used to estimate the static compressive forces on the low back and the strength capability requirements of a given task. Based upon posture, anthropometry and the external load magnitude and direction at the hands, this software also estimates the required moments at multiple joints of the body and compares those computed moments to predicted mean strengths at each of the joints. Strength as expressed by the program is the ability to resist or generate a moment about a joint. The strength prediction equations are based upon gender and joint position and are independent of anthropometry and body weight.

Figure 3.2. Screen capture of the 3DSSPP application. In the illustration above, a two-handed lift of 48 lbs is modeled using the anthropometry of a 95% male.

3.2.3 Revised (1991) NIOSH Lift Equation

When the LMM was not appropriate to use due to space constraints and/or employee interference (e.g. using the mobile work platform inside the trailer), the NIOSH Lifting Equation was used to assess pre- and post-intervention ergonomic risk level for the back. The NIOSH Lift Equation was created to help evaluate lifting activities in an attempt to prevent low back pain and injuries in workers whose job tasks require unassisted lifting of materials. The product of seven measurements provides the Recommended Weight Limit (RWL) for a specific task. The RWL is the weight, under the described conditions, that nearly all healthy workers could lift for a substantial period of time. The RWL is calculated from a Load Constant (LC) of 51 lbs. combined with six lifting multipliers. This load constant is considered to be the maximum load that nearly all healthy workers should be able to lift under optimal conditions.

The Lifting Index (LI) is a ratio that provides a relative estimate of the level of physical stress associated with a particular manual-lifting task. It is calculated by dividing the actual weight of the object being lifted (L) by the RWL (LI = L/RWL). With the LI, comparisons may be drawn regarding the physical stress of the lifting activity and a potential risk level associated with them. This information is useful in the prioritization of interventions when a program has a limited budget for control options. The general decision guideline for the Lifting Index is as follows:

- If **LI ≤ 1**, the lift is acceptable for nearly all workers (**Low** risk)
- If **1 < LI ≤ 3**, there is an elevated risk for some fraction workers - changes should be considered (**Moderate** risk)
- If **LI > 3**, there is an elevated risk for nearly all workers - lift should be redesigned (**HIGH** risk)

3.2.4 Liberty Mutual Manual Materials Handling Guidelines

A set of design tables for evaluating manual handling tasks produced by Liberty Mutual Insurance was utilized to assess risk levels for any carrying and/or pushing/pulling tasks. These guidelines and the acceptable weights or forces are based on psychophysical data. Given the task parameters, if the specific task was above or below the acceptable force or weight, the task was considered **HIGH** or **Low** risk, respectively.

3.2.5 Rapid Upper Limb Assessment (RULA)

Researchers at the Institute for Occupational Ergonomics at the University of Nottingham, Nottingham, United Kingdom developed the Rapid Upper Limb Assessment (RULA) tool. RULA is a task assessment tool designed for evaluating the shoulders, elbows and hands/wrists. It was developed to accomplish the following:

- To provide a quick assessment tool for exposure to risk factors related to the upper limb disorders;
- To identify efforts associated with posture, force exertion and static or repetitive tasks that may contribute to muscular fatigue;
- To produce an outcome that could be included into a broader ergonomics assessment.

RULA uses basic descriptive guidelines to assign numerical values to postures and forces. These initial values were used to obtain a “Grand Score” which is the overall score of the evaluation. The Grand Score can range between 1 and 7 inclusive with higher scores indicative of higher risk for upper extremity MSD development (see below). When appropriate, RULA was used to compare tasks pre- and post-intervention for upper extremity risk:

- Grand Score ≤ **4**, Posture acceptable if not maintained or repeated for long periods (**Low** risk)
- Grand Score = **5-6**, Investigation and changes required soon (**Moderate** risk)
- Grand Score = **7**, Investigation and changes required immediately (**HIGH** risk)

3.3 Discomfort Survey

Participants were asked to rate their subjective level of discomfort on a 0 to 10 modified CR10 Borg scale[1] (*Appendix A*) for seventeen different body parts from their head to the feet. A rating of 0 = no reported discomfort and a rating of 10 = maximal discomfort. Discomfort ratings were collected at the beginning of the shift and every two hours thereafter over the course of their shift.

3.4 Usability Feedback

Usability feedback and comments were also recorded from employees that used the interventions. A usability questionnaire using a scale from 1 to 6 measuring strength of agreement (1 = strongly disagree to 6 = strongly agree) was administered to collect subjective feedback on how employees perceived the new equipment made the job safer, easier, and faster (*Appendix A*). Ratings were also given to push/pull ease, adjustability, and if employees recommended the intervention(s) to management and other retailers. Anecdotal comments were also recorded by employees on likes and potential improvement opportunities of equipment.

3.5 Productivity

Work sampling and time study techniques were used to calculate pre- vs. post-intervention productivity differences. Video was captured of processes and specific applications both pre- and post-intervention. Task analyses were performed to determine average task time differences across a set number of boxes/cartons unloaded or stocked. Total time savings for the application was then estimated by adding up the task time differences and multiplying by the average number of boxes/cartons and pallets or flat-beds in the tested application that are typically unloaded or stocked on a trailer delivery.

3.6 Participants

Participants included experienced trailer unload and stocking associates recruited from the Richmond, VA retail store. Volunteers had to have a minimum of 3 months experience in such positions to participate. Other criteria for exclusion were: (1) previous back or shoulder injury, (2) previous knee injury, (3) medical problems that would interfere with a person's ability to perform a repetitive lifting task, (4) under 18 or over 50 years old, and (5) unable to lift 50 lbs.

Verbal permission from area supervisors was sought prior to recruiting subjects. However, supervisors were not present during recruitment, and it was stated both verbally and in the Informed Consent Form that participation is voluntary and would not affect participants' employment.

In an effort to minimize process disruption and due to the fact that certain store employees were assigned to specific tasks and product types for trailer unload and stocking activities, it was only possible to collect data on a limited number of employees. For example, since the stocking of furniture was assigned to one specific employee, pre- vs. post-intervention LMM, 3DSSPP, and time study data to evaluate the height adjustable lift cart for stocking was only collected on one participant. Thus, statistical analysis was not performed on results.

4. Results

4.1 Problem Magnitude and Project Focus

Based on company incident data as well as corporate and store-level management input, the replenishment of goods process was chosen to be evaluated as part of the MMH demonstration project. According to company incident data, replenishment of goods accounted for 35% of store incidents and 45% of store workers compensation costs. In 2009, there were a total of 25,000 store incidents with a total incurred cost of $69 million. Of those incidents, replenishment of goods accounted for 9,000 incidents (36% of total) and $31 million (45% of total costs).

More specifically, the key focus areas within the replenishment of goods process were the following:

- *Trailer Unload*
- *Stocking*

From 2009-2010, strains and sprains accounted for 35% of incidents in those focus areas. Among those strains and sprains, the back resulted in the greatest percentage of incidents (48%) and greatest percentage of incurred costs (43%).

4.2 Interventions Tested

Four different interventions were introduced and evaluated at the host-site retail store in Glen Allen, Virginia (see Table 4.1):

1. Mobile Work Platform
2. Height Adjustable Pallet Jack (battery powered)
3. Height Adjustable Lift Cart (battery powered)
4. Self-Leveling Cart (spring-loaded)

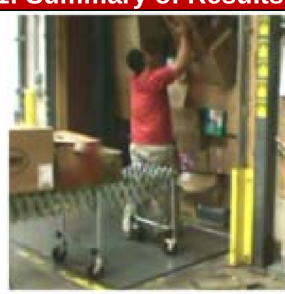
Table 4.1: *Manual Materials Handling Interventions Tested*

Mobile Work Platform	***Height Adjustable Pallet Jack (Battery Powered)***	***Height Adjustable Lift Cart (Battery Powered)***	***Self-Leveling Cart (Spring-Loaded)***
			
List Price: $710	**List Price:** $3,740	**List Price:** $2,395	**List Price:** $1,325
Specifications • Capacity: 800 lb. • Handrails • Wheels: 6 • Steps: 3 • Platform height:30" • Platform width: 24" • Platform length: 36" • Base:30" W x 48" L	**Specifications** • Capacity: 3,300 lb. • Drive: manual (push) • Lift: electric • Fork length: 48" • Raised fork height: 31.5" • Lowered fork height: 3.5" • Weight: 310 lb • Power: 12 V DC	**Specifications** • Capacity: 1,100 lb. • Drive: manual (push) • Lift: electric • Platform size: 30" W x 48" L • Raised height: 36.5" • Lowered height: 10.5" • Vertical travel: 26" • Smooth Rolling Casters and Floor Lock	**Specifications** • Capacity: 1,100 lb. • Drive: manual (push) • Lift: spring-loaded • Platform size: 30" W x 48" L • Raised height: 31.5" • Lowered height: 15" • Vertical travel: 16.5" • Smooth Rolling Casters & Caster Locks

4.3 Mobile Work Platform Results

A summary of results from introducing the mobile work platform is highlighted in Table 4.1 below.

Table 4.1: Summary of Results for Mobile Work Platform

 **Mobile Work Platform**	 **PRE-Intervention** →  **POST-Intervention**
Intervention Description	• A mobile work platform (30" height) was trialed inside the trailer to allow associates to reach and lift items without exceeding 70" in vertical reach height. The platform had three-steps, hand and guard rails, and locked in place when weight was applied.
Application / Observations	• Observations noted that the mobile work platform was only used once or twice per trailer unload for 1 to 1.5 minutes of lifting per use.
Ergonomics Risk	• If used, ergonomics risk reduced from **HIGH** to **Moderate** (Back)[7,8] for 15-45 lb cartons, and **HIGH** to **Moderate** (Shoulders)[4] for 9-30 lb cartons. • If used, ergonomics risk reduced from **HIGH** to **Low** (Back)[7,8], and **HIGH** to **Moderate** (Shoulders)[4] for average carton weights (14 lb).

Body Discomfort	• No significant discomfort reported for task (before or after), slight decrease in Upper Back & Shoulder discomfort (2 associates)
Usability Feedback	• Mixed / neutral usability feedback (2 associates)
Productivity	• Productivity loss of 1 minute per use

4.3.1 Ergonomics Risk Results

The mobile work platform was introduced in an attempt to reduce the overhead vertical reaching required by employees working inside the trailer. Once introduced, video surveillance and on-site data collection visits noted that the mobile work platform was only used once or twice per trailer unload for only 1 to 1.5 minutes of lifting per use. However, when employees did use the mobile platform, ergonomic analyses showed that risk reduced from **HIGH** to **Moderate** for the low-back[7,8] when lifting 15 to 30 lb cartons from high elevations and **HIGH** to **Moderate** for the shoulders and upper extremities[4] when lifting 9 to 30 lb cartons. In addition, low-back risk reduced from **HIGH** to **Low** when lifting average carton weights of 14 lb or less when the mobile platform was used[7,8] (Table 4.2). Differences were due solely to a reduction in vertical reach when lifting as no differences in horizontal reach, asymmetry, or average lift frequency were observed.

Table 4.2: PRE- vs. POST-Intervention Ergonomic Risk Results (Mobile Work Platform)

Job Task	Analysis Tool Used	PRE-Intervention Results (without mobile platform)	POST-Intervention Results (with mobile platform)
Manual lift of high elevation cartons / boxes from inside trailer to mobile conveyor (Back Room)	NIOSH LE[7,8] (Back)	**HIGH risk** Lift Index = **INFINITE** (any weight lifted above 70")	**Moderate risk** Lift Index = **2.04** (max wt.=30 lb) **Low risk** Lift Index = **0.95** (avg. wt.=14 lb)
	RULA[4] (Shoulders, arms, hands/wrists)	**HIGH risk** Left = **7**; Right = **7** (max and avg. weights)	**Moderate risk** Left = **5**; Right = **5** (max and avg. weights)

4.3.2 Body Discomfort Results

Average discomfort ratings for both pre- and post-mobile work platform introduction fell below 1 on the 0 to 10 scale for the two associates working inside the trailer. Therefore, it was determined that no significant benefit could be shown in terms of a reduction in discomfort by introducing the mobile platform.

4.3.3 Usability Feedback Results

Video surveillance and on-site observations noted that the mobile work platform was only used once or twice per trailer unload for 1 to 1.5 minutes of lifting per use. As shown in Figure 4.1 and Table 4.3, there was mixed usability feedback on the mobile work platform. Positive responses centered around safety and ease of use; however, negative responses centered around slowing employees down. Neutral responses were reported for recommending to management, purchasing, and other retail locations.

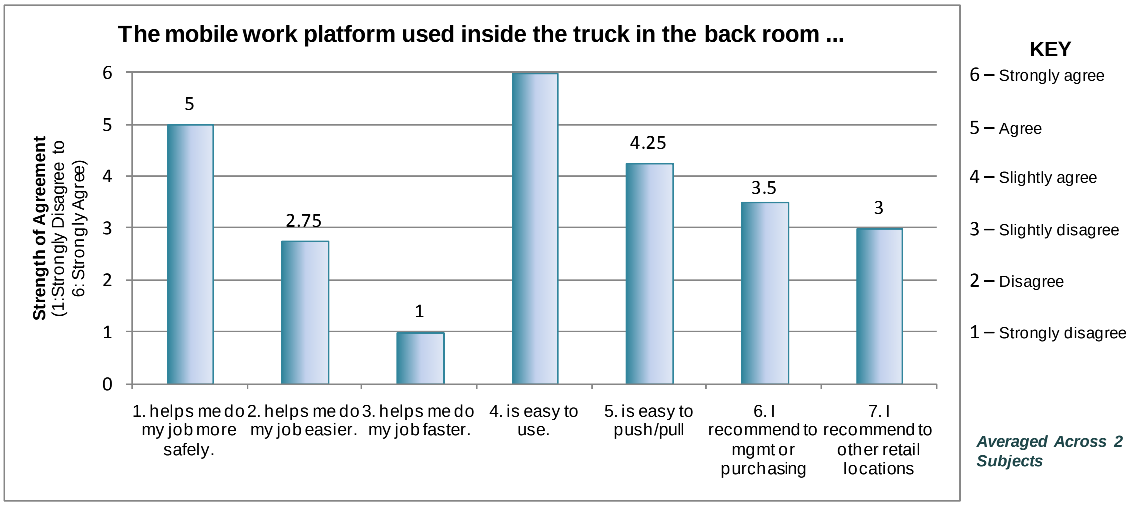


Figure 4.1. Usability feedback on mobile work platform (2 participants).

Table 4.3: Employee comments concerning mobile work platform

Subject ID	Comments / Feedback
S02	It [mobile work platform] is useful for fragile and bulky high items in truck
	It's nice to use when pulling bulk (few items) in back room in place of personnel lifter [i.e. Wave]
	I would recommend to others for infrequent use but not a whole lot of the day
	It does NOT make it quicker
S07	It's a good help when products are highly stacked in trailer, especially to help pull out when items are jammed into trailer
	It does slow me down
	I don't feel it has much of an impact on my discomfort

4.3.4 Productivity Results

Time study data showed a loss of 1-minute in productivity per use of the mobile work platform. In essence, at this store, it would take employees an average of 1-minute to retrieve, position the mobile platform inside the trailer, and walk up the steps prior to lifting product to the conveyor below. Once working on the platform for short durations of 1 to 1.5 minutes, there was no difference in productivity pre- vs. post-intervention condition as average lift frequency was unchanged.

4.4 Height Adjustable Pallet Jack (Battery Powered) Results

A summary of results from introducing the height adjustable pallet jack is highlighted in Table 4.4 below.

Table 4.4: Summary of Results for Height Adjustable Pallet Jack

 **Height Adjustable Pallet Jack**	 **PRE-Intervention** →  **POST-Intervention**
Intervention Description	• A height adjustable pallet jack (battery-powered) was implemented to minimize back flexion when lifting cartons to/from pallets and cutting open cartons during trailer unload and stocking activities.
Application / Observations	• Used primarily for loading, transporting, and stocking higher volume, bulk cartons weighing between 15 and 39 lb (i.e. chemicals and detergents).
Ergonomics Risk	• Ergo risk ↓ from **HIGH** to **Moderate** (Back)[2-4]; **HIGH** to **Low** (Knees)[6] for lifts from line to pallet o Max compressive force on spine ↓ **71%** from 1,453 lb to 422 lb (palletizing)[6] • Ergo risk ↓ from **Moderate** to **Low** (Back)[6,8-9]; **HIGH** to **Low** (Knees)[6] for lifts from pallet to shelf o Max compressive force on spine ↓ **55%** from 1,056 lb to 468 lb (stocking)[6]
Body Discomfort	• Reported Low Back discomfort ↓ **50%**, Upper Back discomfort ↓ **65%** (3 associates)
Usability Feedback	• Strong positive usability feedback and highly recommended (4 associates)
Productivity	• Productivity **neutral** (palletizing – trailer unload in back room) • Productivity ↑ **2.2 sec savings/carton** (stocking – store floor)

4.4.1 Ergonomics Risk Results

A height adjustable pallet jack (battery-powered) was implemented to minimize back flexion when lifting cartons to/from pallets and cutting open cartons during trailer unload and stocking activities. Store personnel used this device primarily for loading, transporting, and stocking higher volume, bulk cartons weighing between 15 and 39 lb. More specifically, the loading and stocking of chemical and detergent cartons was the application observed and evaluated for the height adjustable pallet jack. Ergonomic risk results are summarized for the height adjustable pallet jack in Table 4.5 below.

Table 4.5: PRE- vs. POST-Intervention Ergonomic Risk Results (Ht. Adjust. Pallet Jack)			
Job Task	**Analysis Tool Used**	**PRE-Intervention Results** (with standard pallet jack)	**POST-Intervention Results** (with ht. adjust. pallet jack)
Manual lift from trailer unload conveyor to bottom of pallet (Palletizing in Back Room)	LMM / LBD Risk Model[2-4] (Back)	**HIGH risk** Probability of High Risk Group Membership for LBDs = **75.7%** (max weight = 39 lb)	**Moderate risk** Probability of High Risk Group Membership for LBDs = **55.9%** (max weight = 39 lb)
	3DSSPP[6] (Back)	**HIGH risk** Low back compressive force = **1,453 lb** Back strength % capable = **50%** (max weight = 39 lb)	**Low risk** Low back compressive force = **422 lb** Back strength % capable = **98%** (max weight = 39 lb)
	3DSSPP[6] (Knees)	**HIGH risk** Knee strength % capable = **0%** (max weight = 39 lb)	**Low risk** Knee strength % capable = **99%** (max weight = 39 lb)
Manual lift of individual items from bottom of pallet to shelves (Stocking on Store Floor)	NIOSH LE[8-9] (Back)	**Moderate risk** Lift Index = **1.76** (max weight = 10 lb per hand)	**Low risk** Lift Index = **0.93** (max weight = 10 lb per hand)
	3DSSPP[6] (Back)	**Moderate risk** Low back compressive force = **1,056 lb** Back strength % capable = **64%** (max weight = 10 lb per hand)	**Low risk** Low back compressive force = **468 lb** Back strength % capable = **95%** (max weight = 10 lb per hand)
	3DSSPP[6] (Knees)	**HIGH risk** Knee strength % capable = **13%** (max weight = 10 lb per hand)	**Low risk** Knee strength % capable = **93%** (max weight = 10 lb per hand)

As shown in Figures 4.2 and 4.3 below, ergonomic risk differences were due in large part to reduced sagittal / forward flexion when the height adjustable pallet jack was used. The horizontal reach distance and resultant maximum moment was also reduced with the height adjustable pallet jack. Lastly, reductions in average twist velocity and maximum lateral velocity also contributed to lowering overall low-back risk. Since space constraints on the chemical stocking aisles did not allow use of the LMM to assess low back risk, the NIOSH Lift Equation and 3DSSPP was used instead.

***Low Back Disorder (LBD) Risk Model:** 39 lb max weight assumed*

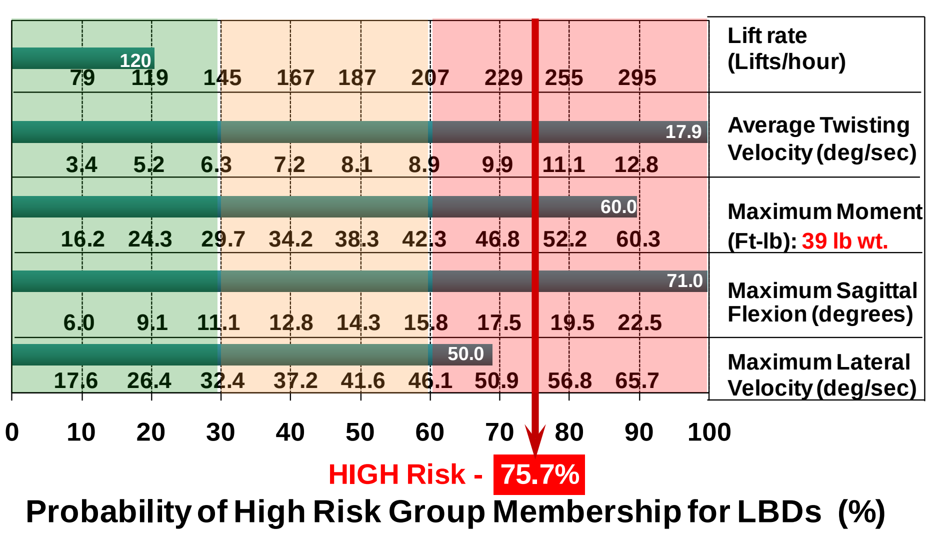


Figure 4.2: PRE-Intervention LBD Risk Model Results[2-4]. Trailer unload in back room: Lift carton (39 lb) from conveyor line to bottom layer of pallet on floor.

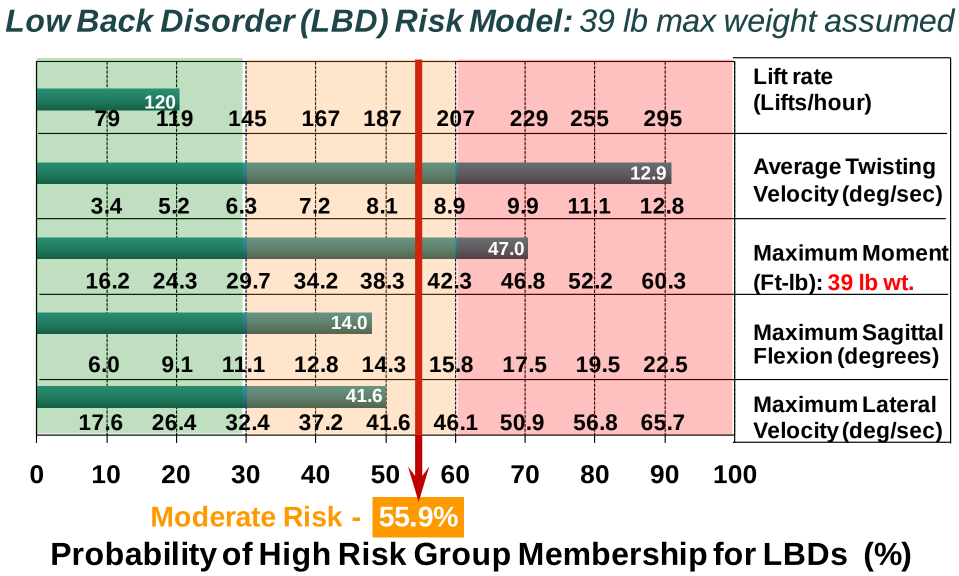


Figure 4.3: POST-Intervention LBD Risk Model Results[2-4]. Trailer unload in back room: Lift carton (39 lb) from conveyor line to elevated pallet on height adjustable pallet jack.

4.4.2 Body Discomfort Results

As shown in Figure 4.4 below, reported Low Back discomfort decreased by 50% from 1.08 to 0.54 and Middle Back discomfort decreased by 65% from 1.42 to 0.50. However, it should be noted that the reported discomfort was relatively low both pre- and post-intervention as the discomfort rating scale ranged from 0 to 10.

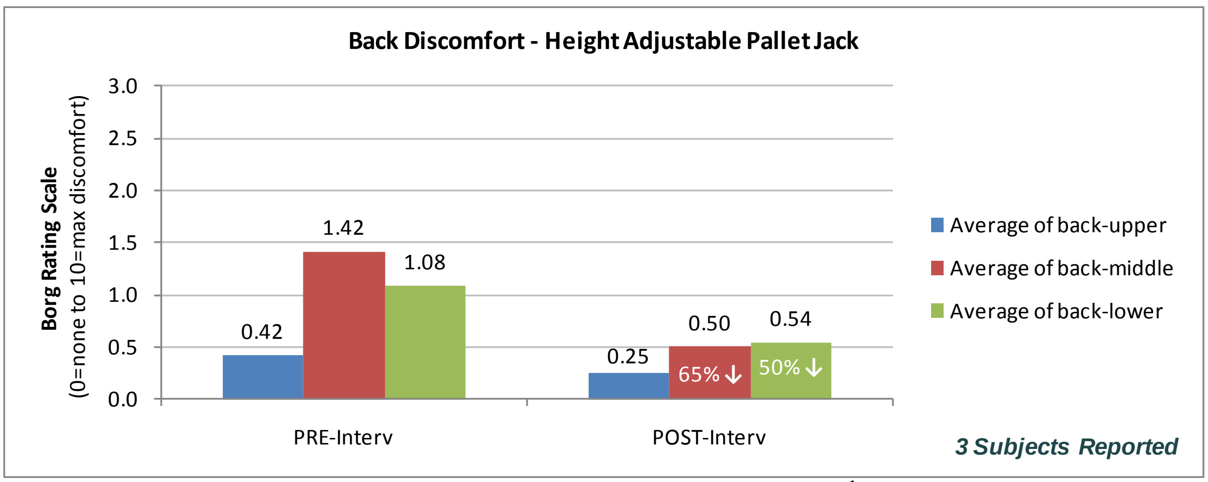


Figure 4.4: PRE- vs. POST-Intervention Back Discomfort Results[1]. Using the height adjustable pallet jack in the back room for trailer unload and stocking on store floor.

4.4.3 Usability Feedback Results

Video surveillance and on-site observations noted that the height adjustable pallet jack was routinely used in the back room and on the stock floor. It was primarily used for loading, transporting, and stocking higher volume, bulk cartons weighing between 15 and 39 lb (specifically, chemicals and detergents). As shown in Figure 4.5 and Table 4.6 below, four store employees reported strong positive usability feedback and highly recommended the height adjustable pallet jack.

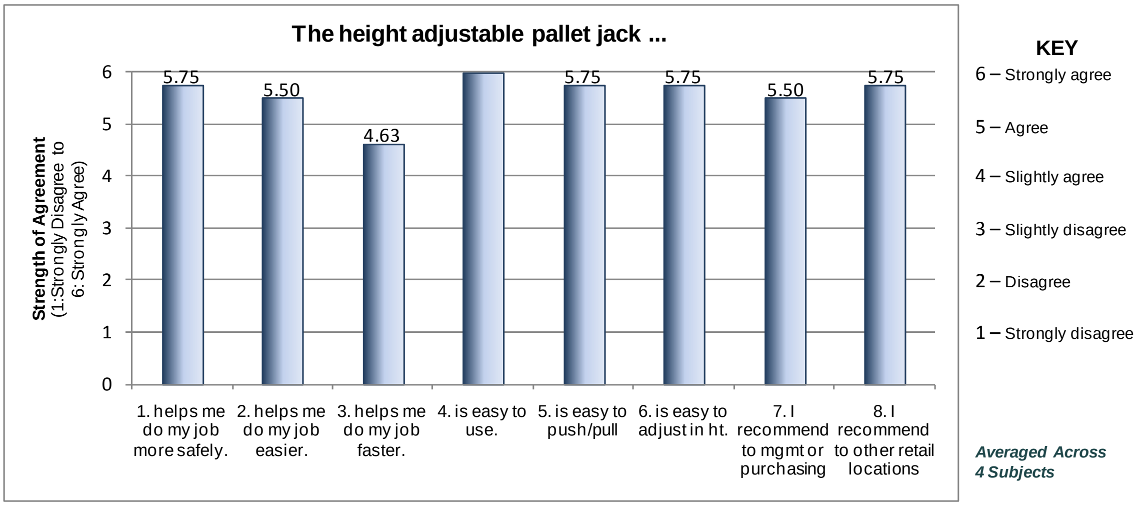


Figure 4.5. Usability feedback on height adjustable pallet jack (4 participants).

Table 4.6: Employee comments concerning height adjustable pallet jack

Subject ID	Comments / Feedback
S03	I like the new pallet jack - I don't need to bend as much when using it
	I don't have trouble getting underneath pallets when using it
	I do have to lower it to push/pull the pallet
	I have to evenly distribute products on pallet when using new pallet jack
S04	The push-button height adjustable flat is easier to use than the new pallet jack in furniture aisles
S05	It made it easier to stock furniture
	It's good
S08	It does help with less bending
	It helps with back and knee discomfort, I feel more comfortable when I use it
	It seems to move slightly slower than normal pallet jack

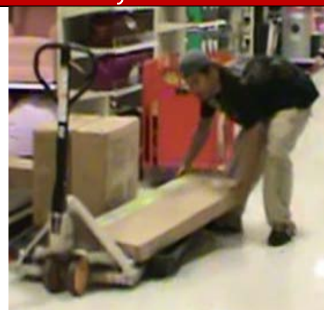
4.4.4 Productivity Results

Time study data showed that the height adjustable pallet jack was productivity neutral during the trailer unload in the back room. The average time savings from reduced bending to load the bottom two to three layers of cartons on a pallet was countered by the added time taken to position the pallet jack under the pallet and raise/lower the forks to the appropriate level. However, the fact that there was no productivity loss in the back room was viewed as a positive outcome.

Time study data from stocking of chemicals on the store floor showed a productivity improvement with the use of the height adjustable pallet jack. On average, there was a **2.2 sec savings per chemical carton stocked**. Such an improvement resulted from a reduction in bending time to cut open and lift individual items (i.e. detergent bottles) from cartons on the bottom two layers of the pallet. The added time to raise and lower the pallet jack was factored into this time savings. Estimated savings per shift from one associate using the height adjustable pallet jack is **6 minutes** (assuming 6 pallets stocked).

4.5 Height Adjustable Lift Cart (Battery Powered) Results

A summary of results from introducing the height adjustable cart is highlighted in Table 4.7 below.

Table 4.7: Summary of Results for Height Adjustable Pallet Jack	
 **Height Adjustable Lift Cart**	 **PRE-Intervention**  **POST-Intervention**
Intervention Description	• A height adjustable lift cart (battery-powered) was implemented to minimize back flexion when lifting cartons to/from pallets or flatbed carts during trailer unload and stocking activities.
Application / Observations	• Used primarily for loading, transporting, and stocking lower volume, bulk cartons weighing greater than 30 lb (i.e. furniture).
Ergonomics Risk	• Ergo risk ↓ from **HIGH** to **Moderate** (Back)[2-4]; **HIGH** to **Low** (Knees)[6] for lifts from conveyor line to pallet/flat-bed cart o Compressive force on spine ↓ **53%** from 1,452 lb to 675 lb if 45 lb wt. lifted (palletizing)[6] • Ergo risk ↓ from **HIGH** to **Low** (Back[6], Hands/Wrists[6], Knees[6]); **Moderate** to **Low** (Elbow, Shoulder) for lifts and carries from pallet to shelf vs. slide with ht. adjust. flat o Compressive force on spine ↓ **62%** from 1,452 lb to 546 lb if 45 lb wt. is slid to shelf vs. lifted (stocking)[6]
Body Discomfort	• Reported Low Back discomfort ↓ **50%**, Middle Back discomfort ↓ **68%**, & Knee discomfort ↓ **40%** (3 associates)
Usability Feedback	• Strong positive usability feedback and highly recommended (3 associates)
Productivity	• Productivity ↑ **0.25 sec savings/carton** (palletizing) • Productivity ↑ **4.7 sec savings/carton** (stocking)

4.5.1 Ergonomics Risk Results

A height adjustable lift cart (battery-powered) was implemented to minimize back flexion when lifting cartons to/from pallets or flat-bed carts during trailer unload and stocking activities. Store personnel used this device primarily for loading, transporting, and stocking lower volume, bulk cartons weighing greater than 30 lb and as much as 118 lb. More specifically, the loading and stocking of furniture cartons was the application observed and evaluated for the height adjustable lift cart. Ergonomic risk results are summarized for the height adjustable lift cart in Table 4.8 below.

Table 4.8: PRE- vs. POST-Intervention Ergonomic Risk Results (Ht. Adjust. Lift Cart)			
Job Task	**Analysis Tool Used**	**PRE-Intervention Results** (with standard pallet jack)	**POST-Intervention Results** (with ht. adjust. lift cart)
Manual lift from trailer unload conveyor to bottom of pallet or flat-bed cart (Palletizing in Back Room)	LMM / LBD Risk Model[2-4] (Back)	**HIGH risk** Probability of High Risk Group Membership for LBDs = **80.3%** (lift weight = 45 lb)	**Moderate risk** Probability of High Risk Group Membership for LBDs = **59.5%** (lift weight = 45 lb)
	3DSSPP[6] (Back)	**HIGH risk** Low back compressive force = **1,452 lb** Back strength % capable = **41%** (lift weight = 45 lb)	**Low risk** Low back compressive force = **675 lb** Back strength % capable = **91%** (lift weight = 45 lb)
	3DSSPP[6] (Knees)	**HIGH risk** Knee strength % capable = **4%** (lift weight = 45 lb)	**Low risk** Knee strength % capable = **99%** (lift weight = 45 lb)
Manual lift and carry of carton from bottom of pallet or flat-bed cart to shelves (Stocking on Store Floor)	3DSSPP[6] (Back)	**HIGH risk** Low back compressive force = **1,452 lb** Back strength % capable = **41%** (lift weight = 45 lb)	**Low risk** Low back compressive force = **546 lb** Back strength % capable = **95%** (slide force = 20 lb total)
	3DSSPP[6] (Knees)	**HIGH risk** Knee strength % capable = **4%** (lift weight = 45 lb)	**Low risk** Knee strength % capable = **92%** (slide force = 20 lb total)
	LM MMH[7] (whole body - carry)	**HIGH risk** Recommended carry weight limit of 35 lb exceeded	**Low risk** Carry eliminated due to cart use

As shown in Figures 4.5 and 4.6 below, ergonomic risk differences were due in large part to reduced sagittal / forward flexion when the height adjustable lift cart was used. The horizontal reach distance and resultant maximum moment was also reduced with the height adjustable pallet jack. Lastly, a reduction in average twist velocity also contributed to lowering overall low-back risk. Maximum lateral velocity remained relatively unchanged pre- and post-intervention. On the stock side, employees used the height adjustable lift cart to slide the furniture cartons directly onto the shelf, thereby eliminating the lift and carry entirely, and reducing the ergonomic risk to **Low**. Thus, only 3DSSPP and LM MMH tables could be used to assess stock-side ergonomic risk differences.

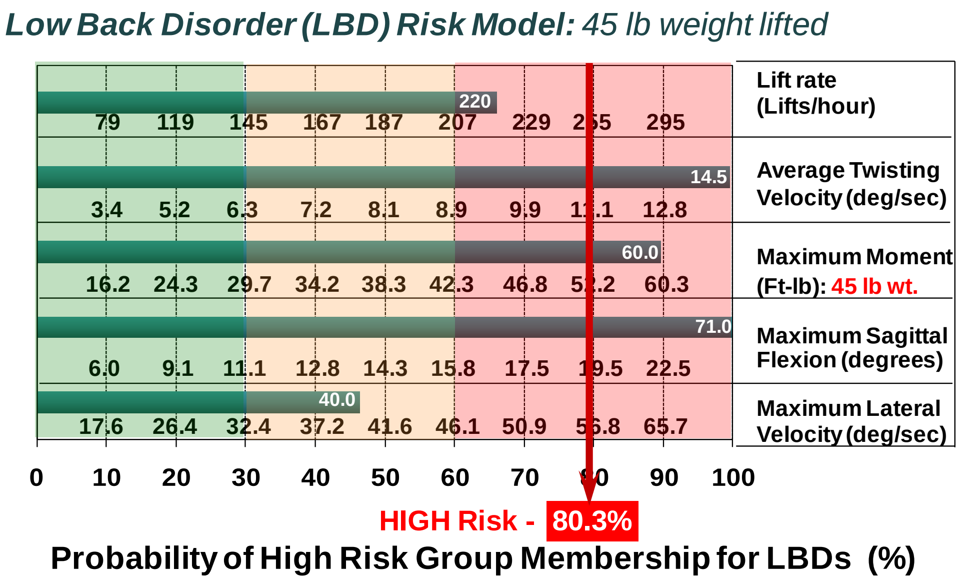


Figure 4.5: PRE-Intervention LBD Risk Model Results[2-4]. Trailer unload in back room: Lift carton (45 lb) from conveyor line to bottom of pallet.

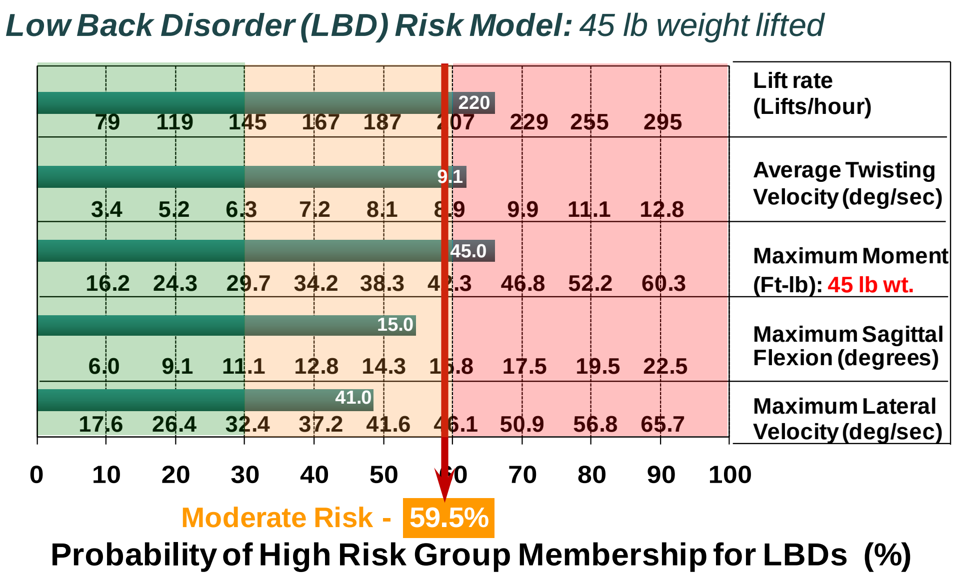


Figure 4.6: POST-Intervention LBD Risk Model Results[2-4]. Trailer unload in back room: Lift carton (45 lb) from conveyor line to elevated height adjustable cart.

4.5.2 Body Discomfort Results

As shown in Figure 4.7 below, reported Low Back discomfort decreased by 50% from 1.17 to 0.58 and Middle Back discomfort decreased by 68% from 1.54 to 0.50. However, it should be noted that the reported discomfort was relatively low both pre- and post-intervention as the discomfort rating scale ranged from 0 to 10.

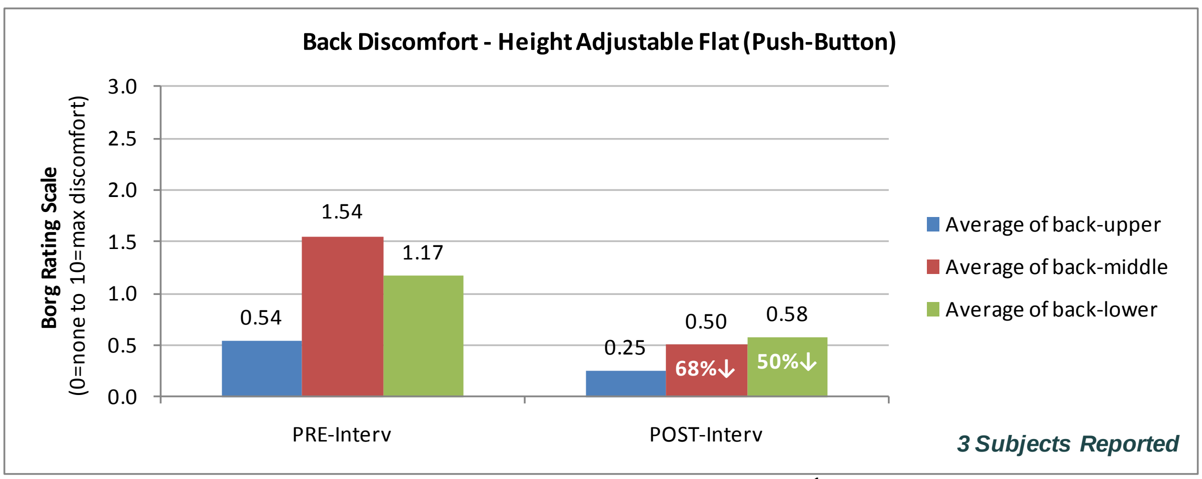


Figure 4.7: PRE- vs. POST-Intervention Back Discomfort Results[1]. Using the height adjustable lift cart in the back room for trailer unload and stocking on store floor.

4.5.3 Usability Feedback Results

Video surveillance and on-site observations noted that the height adjustable lift cart was routinely used in the back room and on the stock floor. It was primarily used for loading, transporting, and stocking lower volume, bulk cartons weighing 30-118 lb (specifically, furniture). As shown in Figure 4.8 and Table 4.9 below, three store employees reported strong positive usability feedback and highly recommended the height adjustable lift cart.

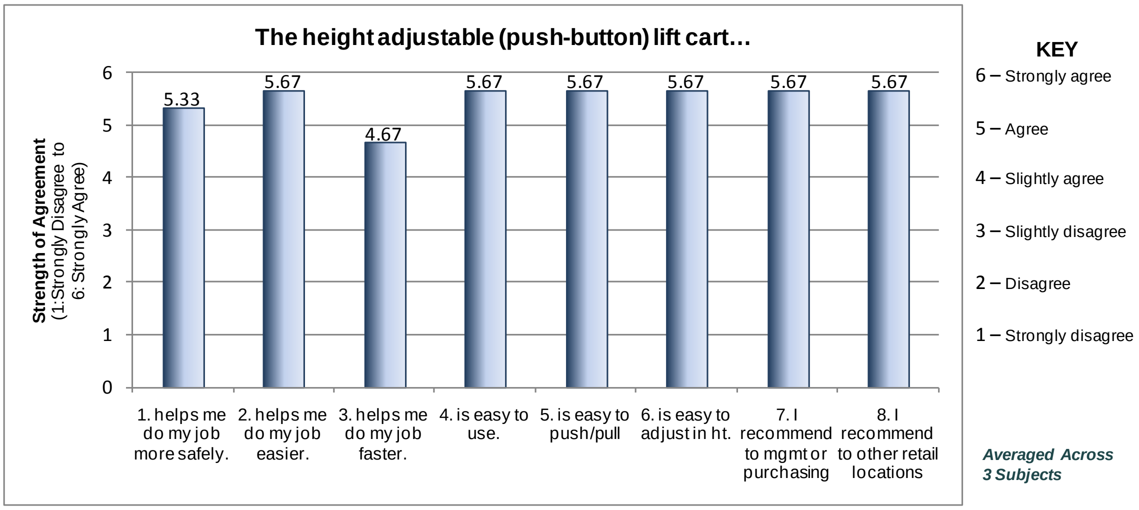


Figure 4.8. Usability feedback on height adjustable lift cart (3 participants).

Table 4.9: Employee comments concerning height adjustable lift cart

Subject ID	Comments / Feedback
S04	The equipment works well
	It's a lot safer
	It helps with physical work - less bending and lifting
S05	It made it easier to stock furniture
	It's good
	The brake is a little difficult to lock and unlock, unless I wear steel toed shoes
S07	It does help because you can just slide furniture onto the shelf instead of lifting it
	It does make it a lot easier

4.5.4 Productivity Results

Time study data from palletizing in the back room during trailer unload showed a very slight productivity improvement with the use of the height adjustable lift cart. On average, there was a **0.25 sec savings per furniture carton unloaded** to the lift cart vs. a pallet on the floor. Time savings from reduced bending to load the bottom half of furniture cartons on a pallet was countered by the added time taken to raise/lower the cart to the appropriate level. Again, the fact that there was no productivity loss in the back room was viewed as a positive outcome.

Time study data from stocking furniture on the store floor showed a productivity improvement with the use of the height adjustable lift cart. On average, there was a **4.7 sec savings per furniture carton stocked**. Such an improvement resulted from a reduction in bending time to lift furniture cartons from the bottom half of the pallet and the reduced walk / carry time to / from the staged pallet at the end of the aisle as done during the pre-intervention process. The added time to position, raise / lower the lift cart, and slide the carton onto the shelf was factored into this time savings. Estimated savings per shift from using a height adjustable lift cart for furniture is **11.6 minutes** (assuming 5 furniture pallets / flat-beds stocked).

4.6 Self-Leveling Cart (Spring-Loaded) Results

A summary of results from introducing the self-leveling cart is highlighted in Table 4.10 below.

Table 4.10: Summary of Results for Self-Leveling Lift Cart

 **Self-Leveling Cart (Spring-Loaded)**	 **PRE-Intervention**  **POST-Intervention**
Intervention Description	• A self-leveling lift cart (spring-loaded) was implemented to minimize back flexion when lifting cartons to/from flatbed carts during trailer unload and stocking activities.
Application / Observations	• Used primarily for loading, transporting, and stocking higher volume, non-bulk cartons weighing between 15 and 30 lb (i.e. consumables / groceries).
Ergonomics Risk	• Ergo risk ↓ from **HIGH** to **Moderate** (Back)[2-4]; **HIGH** to **Low** (Knees) for lifts from line to flat o Compressive force on spine ↓ **62%** from 1,459 lb to 556 lb if 30 lb wt. lifted (palletizing)[6] • Ergo risk ↓ by **37%** but remains **Moderate** (Back)[8-9] for lifts from flat to carry ht. (23-30 lb) o Compressive force on spine ↓ **54%** from 1,124 lb to 519 lb if 30 lb wt. lifted (stocking)[6] • Ergo risk ↓ from **Moderate** to **Low** (Back)[8-9] for lifts from flat to carry ht. (15-22 lb)
Body Discomfort	• Reported Low Back discomfort ↓ **62%** (3 associates)
Usability Feedback	• Strong positive usability feedback and highly recommended (4 associates)
Productivity	• Productivity ↑ **1.0 sec savings/carton** (palletizing) • Productivity ↑ **1.33 sec savings/carton** (stocking)

4.6.1 Ergonomics Risk Results

A self-leveling lift cart (spring-loaded) was implemented to minimize back flexion when lifting cartons to/from flat-bed carts during trailer unload and stocking activities. Store personnel used this device primarily for loading, transporting, and stocking higher volume, non-bulk cartons weighing between 15 and 30 lb. More specifically, the loading and stocking of consumables / grocery cartons was the application observed and evaluated for the self-leveling lift cart. Ergonomic risk results are summarized for the self-leveling lift cart in Table 4.11 below.

Table 4.11: PRE- vs. POST-Intervention Ergonomic Risk Results (Self-Leveling Lift Cart)			
Job Task	**Analysis Tool Used**	**PRE-Intervention Results** (with standard flat-bed cart)	**POST-Intervention Results** (with self-level lift cart)
Manual lift from trailer unload conveyor to bottom of flat-bed cart (Palletizing in Back Room)	LMM / LBD Risk Model[2-4] (Back)	**HIGH risk** Probability of High Risk Group Membership for LBDs = **73.2%** (lift weight = 30 lb)	**Moderate risk** Probability of High Risk Group Membership for LBDs = **54.9%** (lift weight = 30 lb)
	3DSSPP[6] (Back)	**HIGH risk** Low back compressive force = **1,459 lb** Back strength % capable = **74%** (lift weight = 30 lb)	**Low risk** Low back compressive force = **556 lb** Back strength % capable = **92%** (lift weight = 30 lb)
	3DSSPP[6] (Knees)	**HIGH risk** Knee strength % capable = **4%** (lift weight = 30 lb)	**Low risk** Knee strength % capable = **99%** (lift weight = 30 lb)
Manual lift of carton from bottom flat-bed cart to carry position (Stocking on Store Floor)	NIOSH LE[8-9] (Back)	**Moderate risk** Lift Index = **2.13** (lift weight = 30 lb) **Moderate risk** Lift Index = **1.47** (lift weight = 15-22 lb)	**Moderate risk** Lift Index = **1.35** (lift weight = 30 lb) **Low risk** Lift Index = **1.00** (lift weight = 15-22 lb)
	3DSSPP[6] (Back)	**Moderate risk** Low back compressive force = **1,124 lb** Back strength % capable = **23%** (lift weight = 30 lb)	**Low risk** Low back compressive force = **519 lb** Back strength % capable = **94%** (lift weight = 30 lb)
	3DSSPP[6] (Knees)	**HIGH risk** Knee strength % capable = **0%** (lift weight = 30 lb)	**Low risk** Knee strength % capable = **99%** (lift weight = 30 lb)

As shown in Figures 4.9 and 4.10 below, ergonomic risk differences were due in large part to reduced sagittal / forward flexion when the self-leveling lift cart was used. The horizontal reach distance and resultant maximum moment was also reduced with the self-leveling lift cart. Lastly, a reduction in average twist velocity also contributed to lowering overall low-back risk. Maximum lateral velocity remained relatively unchanged pre- and post-intervention.

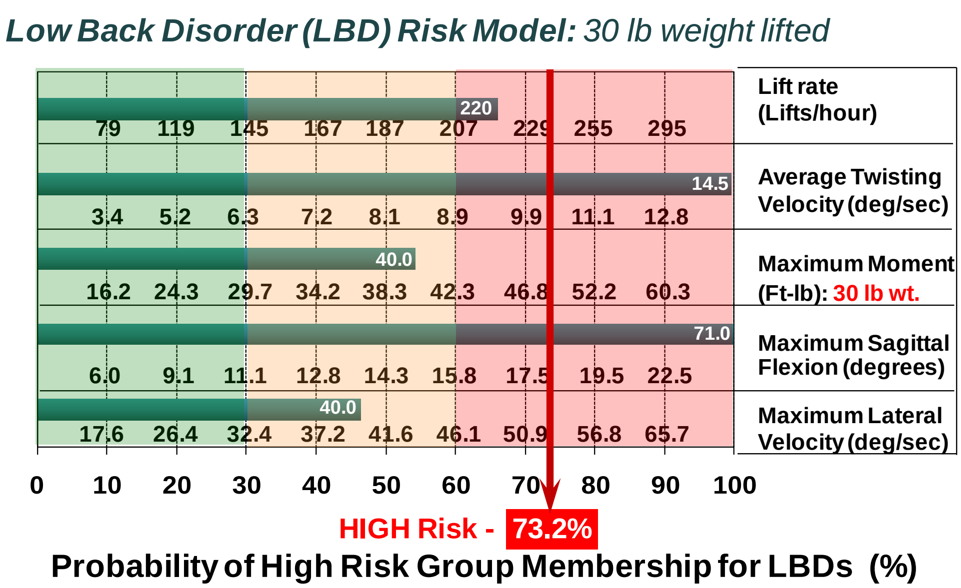


Figure 4.9: PRE-Intervention LBD Risk Model Results[2-4]. Trailer unload in back room: Lift carton (30 lb) from conveyor line to bottom of flat-bed cart.

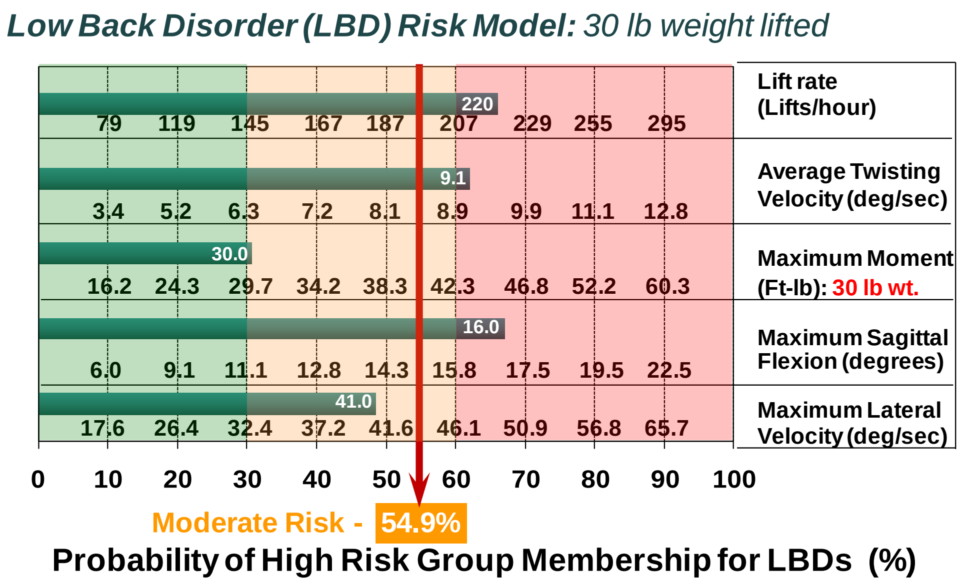


Figure 4.10: POST-Intervention LBD Risk Model Results[2-4]. Trailer unload in back room: Lift carton (30 lb) from conveyor line to self-leveling lift cart.

4.6.2 Body Discomfort Results

As shown in Figure 4.11 below, reported Low Back discomfort decreased by 62% from 1.42 to 0.54. No other body parts reported ratings greater than 1.0. Again, it should be noted that the reported discomfort was relatively low both pre- and post-intervention as the discomfort rating scale ranged from 0 to 10.

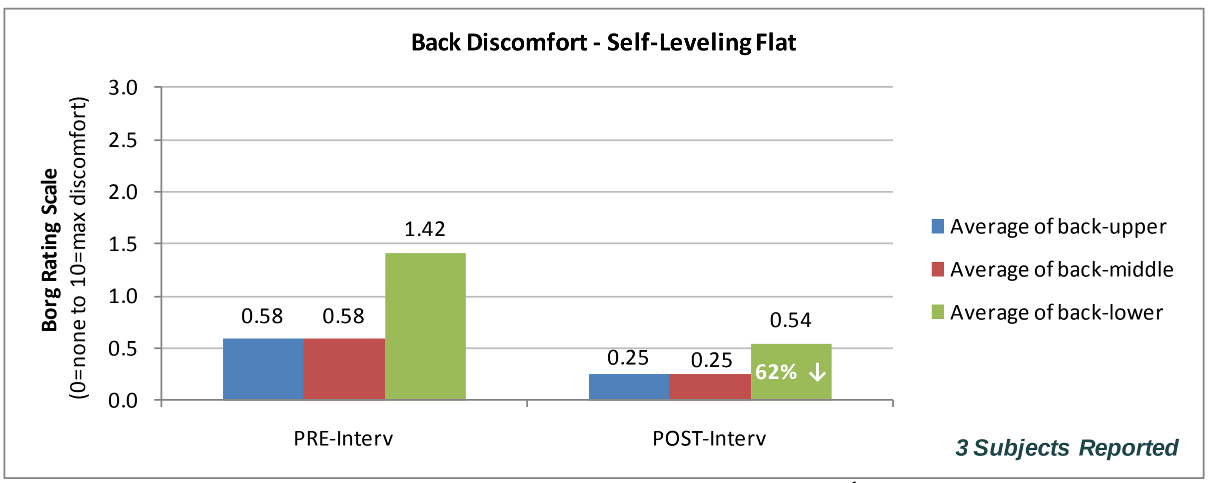


Figure 4.11: PRE- vs. POST-Intervention Back Discomfort Results[1]. Using the self-leveling lift cart in the back room for trailer unload and stocking on store floor.

4.6.3 Usability Feedback Results

Video surveillance and on-site observations noted that the self-leveling lift cart was routinely used in the back room and on the stock floor. It was primarily used for loading, transporting, and stocking higher volume, non-bulk cartons weighing 15-30 lb (specifically, consumables / groceries). As shown in Figure 4.12 and Table 4.12 below, three store employees reported strong positive usability feedback and highly recommended the height adjustable lift cart.

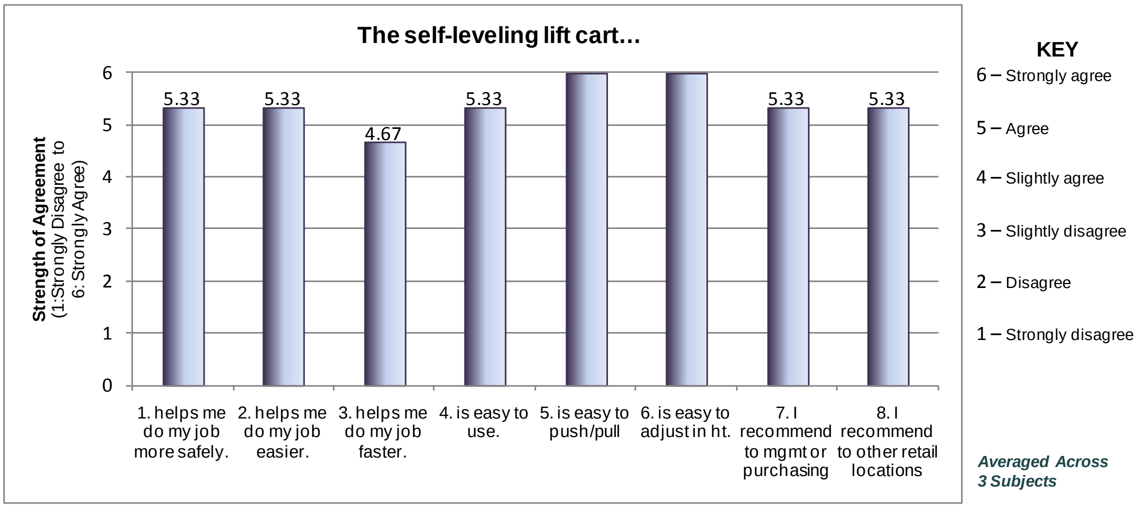


Figure 4.12. Usability feedback on self-leveling lift cart (3 participants).

Table 4.12: Employee comments concerning self-leveling lift cart

Subject ID	Comments / Feedback
S01	I like that the self-leveling lift cart adjusts by itself
	I also like that it is light and easy to maneuver throughout the aisles
	I did not like the fact that it is shorter than our normal flat beds that we use
S06	I like the way it rolls, it's very smooth and it's quiet
	It helps me out with my back
	Sometimes I'll use it for back-stock in place of the Crown [fork truck], & I don't have to block off the whole aisle
S08	It cuts the amount of bending by half
	What it's supposed to do, it does well, which is reduce bending
	The lowest and highest stuff [on the new flat] was at core level
	The handle could be adjustable or higher
	Brakes are a little awkward when using them in back room

4.6.4 Productivity Results

Time study data from palletizing in the back room during trailer unload showed a productivity improvement with the use of the self-leveling lift cart. On average, there was a **1.0 sec savings per grocery carton unloaded** to the lift cart vs. a standard flat-bed cart. Since no time is required to raise / lower the self-leveling lift cart, time savings was purely from reduced bending time to load the bottom half of cartons at an elevated position.

Time study data from stocking grocery cartons on the store floor also showed a productivity improvement with the use of the self-leveling cart. On average, there was a **1.33 sec savings per grocery carton stocked**. Such an improvement resulted from a reduction in bending time to lift cartons from the bottom half of the cart to load into a grocery cart or to bowl out to the appropriate aisle location. Estimated savings per shift from using a self-leveling lift cart for consumables / grocery is **7.0 minutes** (assuming 6 grocery flat-beds stocked).

4.7 Equipment Improvement Opportunities

Throughout this pilot demonstration project, there were a few potential improvement opportunities to the equipment introduced that were noted by store personnel, corporate stakeholders, and/or the ergonomics practitioner leading the project. A bulleted list of potential improvements was compiled below:

- ***All Interventions***
  - Bumpers needed on corners to prevent potential ankle injuries and damage to aisles
  - Guarded or shielded pinch points on scissor lifts

- ***Height Adjustable Pallet Jack:***
  - The forks did not go as low as standard pallet jacks (3.5" vs. 3.0"), making it a little more difficult to get underneath some pallets
  - Padding the auto locking casters to prevent scratching or damaging the sales floor

- ***Height Adjustable Lift Cart <u>and</u> Self-Leveling Lift Cart***
  - Enlarge the lift platform to the same size as existing flatbed cats (30" W x 60" L)
  - Handles could be higher or adjustable

- ***Height Adjustable Lift Cart***
  - Floor lock was difficult to engage and disengage [without steel-toed shoes]

- ***Self-Leveling Lift Cart***
  - Caster locks on self-leveling lift cart were a little awkward to use in back room

4.8 Limitations of Project

This project served as a pilot study with a limited number of participants, equipment applications, and over a relatively short period of time (6-week trial period). Therefore, it cannot be said that results showed statistically significant differences with adequate statistical power. Constraints that limited participant involvement and data collection across multiple store personnel included: (1) minimizing process disruption and productivity demands and (2) specific store employees were assigned to specific tasks and product types, thus we were limited on the number of experienced personnel to collect accurate pre- vs. post-intervention data. Future studies are recommended across more participants and more superstores.

5. Conclusions

In summary, pilot results from this study certainly show promise that such "load-elevating" equipment may have both ergonomic and productivity benefits in the retail trade sector. Three of the four interventions introduced showed a reduction in ergonomic risk level, a reduction in reported discomfort, improved or maintained productivity, and reported positive usability feedback by store employees. Such findings lend support that manual material handling improvements are possible and may prove beneficial in retail environments that have not changed in decades.

Disclaimer: It should be noted that The Ergonomics Center of North Carolina served as an unbiased entity of North Carolina State University throughout this project. It is not our intention to recommend or endorse a particular equipment manufacturer, vendor, or specific product. Services rendered were purely for evaluation purposes and future testing and/or intervention implementation is at the discretion of the host company.

6. References

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APPENDIX A: Usability and Discomfort Survey

Usability Questionnaire

Subject ID:
Date:

Please rate the following statements on a scale of 1-6 where your rating indicates your agreement with the statement.

1. Strongly disagree
2. Disagree
3. Slightly disagree
4. Slightly agree
5. Agree
6. Strongly agree

Baseline and During Shift

The new MMH equipment used in my job…	
1. helps me do my job more safely.	
2. helps me do my job easier.	
3. helps me do my job faster.	
4. is easy to use.	
5. record **Comments** below.	

After Shift is Completed

1. The implemented MMH assist equipment was easy to push/pull _____
2. The implemented MMH assist equipment was easy to adjust in height _____
3. I would recommend this MMH assist equipment to my management or purchasing agent _____
4. I would recommend this MMH equipment to other retail locations performing similar tasks _____
5. **Comments** about MMH assist equipment (Use **Back** of page if needed)

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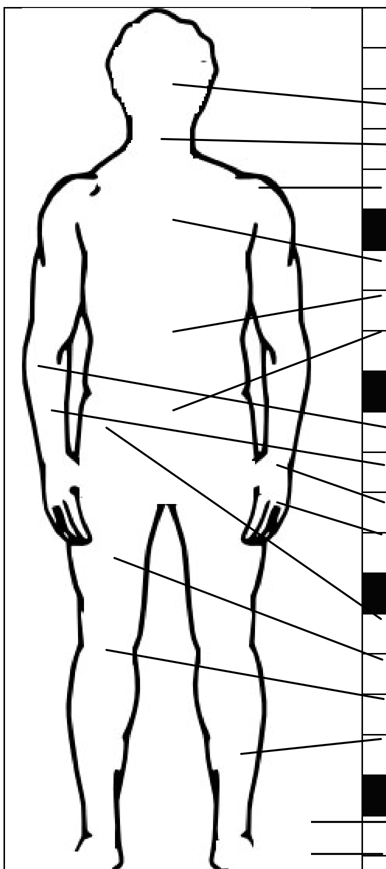
Discomfort Data (Pre- & Post-Intervention)

Please rate the level of **discomfort** in each area of your body using the Borg scale below.

Subject ID:
Date:

Rating	Description
0	No discomfort at all
0.3	
0.5	Just noticeable discomfort
0.7	
1	Very little discomfort
1.5	
2	Light discomfort
2.5	
3	Moderate discomfort
4	
5	Strong discomfort
6	
7	Very strong discomfort
8	
9	
10	Extremely strong ("Maximal")
*	Absolute Maximal



		+0 h	+2 h	+4 h	+6 h	+8 h
	Whole body					
	Head					
	Neck					
	Shoulder					
	Back - upper					
	Back - middle					
	Back - lower					
	Elbows					
	Forearms					
	Wrists					
	Hands					
	Hips					
	Upper legs					
	Knees					
	Lower legs					
	Ankles					
	Feets					