VIA E-mail: vep1@cdc.gov

March 4, 2011

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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 Southern Region Project (NIOSH Contract No: 214-2009-M-32435). The host site selected for this project was part of a large grocery store chain and was located in South Carolina.

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,

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

Southern Region: NIOSH Contract No: 214-2009-M-32435

Prepared for

National Institute for Occupational Safety and Health

March 4, 2011

THE ERGONOMICS CENTER OF NORTH CAROLINA
*Advancing the Science of Ergonomics in the Workplace*SM

NC STATE UNIVERSITY

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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 grocery store chain that has retail locations in the southern region of the United States. The host site selected for this Southern Region Project was located in South Carolina. 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, productivity, and estimated return-on-investment (ROI) for the interventions introduced and tested.

Methods Summary. Based on company incident data and management input, Grocery Stocking Clerks were targeted for this MMH demonstration project. More specifically, the two processes of focus were the following:

1. *Grocery Stock Clerk: Breakdown Pallets in Back Room, Transfer to Sales Floor*
2. *Grocery Stock Clerk: Stocking on Sales Floor*

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 grocery store. Once finalized and shipped to the host-site store in South Carolina, 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. Three different interventions were introduced and evaluated at the host-site retail store in South Carolina (see Table 1.1):

1. Pallet Disc Turntable and Alternative Sorting Strategy in Back Room
2. Height Adjustable Pallet Jack (electric - battery powered)
3. Stock and Roll Carts (Adjustable Height Platform)

Table 1.1: *Manual Materials Handling Interventions Tested*		
		
Pallet Disc Turntable (Back Room)	***Height Adjustable Pallet Jack (Electric - Battery Powered)***	***Stock and Roll Carts (Adjustable Height Platform)***

All three interventions were trialed and evaluated for different applications. The pallet disc turntable was used in conjunction with an alternative sorting-U pallet layout strategy in the back room in an attempt to reduce reaches and minimize walk time when downstacking non-bulk pallets to sorted pallets. The height adjustable pallet jack and "Stock and Roll" carts were used on the sales floor for stocking cartons. Although the stock and roll carts were used to stock multiple non-bulk carton aisles, the primary focus of this study were the canned goods and sauces aisles. For these focus aisles, the height adjustable pallet jack was used in combination with the stock and roll cart to stock goods.

The height adjustable pallet jack and "Stock and Roll" carts were both routinely used by store personnel during stocking activities. In summary, both interventions showed a reduction in ergonomic risk level, a reduction in reported discomfort, improved or maintained productivity, and reported positive usability feedback by experienced Stock Clerks. However, it is noteworthy to clarify that the "Stock and Roll" carts showed a substantial improvement in stocking productivity, while the height adjustable pallet jack proved to be more productivity neutral. On the other hand, the pallet disc turntable was only used twice during pallet breakdown and sorting activities in the back room. When the pallet disc turntable was used in combination with a sorting-U strategy, there was a reduction in ergonomic risk and an improvement in productivity; however, the benefits seemed to be due primarily to the sorting-U pallet layout strategy as associates rarely rotated pallets on the pallet disc when working in the sorting-U layout. In addition, the pallet disc reported mixed usability feedback and some safety concerns from store personnel.

Conclusion Summary. While this project served as a pilot study involving a limited number of participants, equipment applications, and was conducted over a relatively condensed trial period, 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 back 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 **southern 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, minimize horizontal reach distances when lifting, and/or eliminate manual carries 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, productivity, and estimated return-on-investment (ROI) 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.	Collected and analyzed company workers' compensation claim data to estimate potential return-on-investment (ROI) and payback periods for the interventions introduced
14.	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 both the height adjustable pallet jack and the "Stock and Roll" carts. 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)

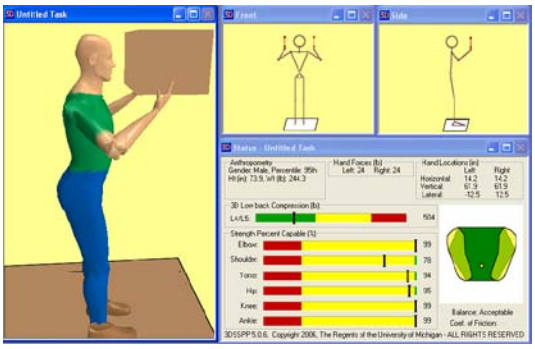


Figure 3.2. Screen capture of the 3DSSPP application. In the illustration above, a two-handed lift of 48 lbs is modeled using the anthropometry of a 95% male.

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.

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 pallet disc turntable in the back room), the NIOSH Lifting Equation and 3DSSPP 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 limit, 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 was used as a task assessment tool for evaluating the shoulders, elbows and hands/wrists during pre-intervention task analysis and risk assessment for overhead or extended reaching. 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 pallets and boxes/cartons sorted, transported, and stocked. Total time savings for the application was then estimated by adding up the task time differences and multiplying by the average number of pallets sorted and/or cartons stocked by grocery stocking personnel on a daily basis.

3.6 Participants

Participants included experienced Grocery Stock Clerks recruited from the host-site 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 lb.

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 was 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 grocery stocking aisles on a daily basis, it was only possible to collect data on a limited number of employees. In other words, since the chosen grocery stocking tasks for this project was assigned to one specific employee, pre- vs. post-intervention LMM, 3DSSPP, and time study data to evaluate the height adjustable pallet jack in combination with stock and roll cart was only collected on one specific participant that stocked the canned goods and sauces aisles. However, usability feedback and discomfort data was collected across multiple grocery stock clerks that were exposed to the interventions (especially the stock and roll carts). In addition, LMM data were collected from one associate that used the height adjustable pallet jack (by itself on occasion) to stock bulk items on sales floor shelves. 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 Grocery Stock Clerks were targeted for this MMH demonstration project. According to 2009 company strain/sprain accident data, 22% of incidents, 24.2% of lost-days, and 18.8% of restricted days resulted from strain/sprain claims in the back room or on the grocery sales floor. Grocery Stock Clerks, Assistants, and Trainees accounted for a large portion of such incidents with 11.3% of all incidents across all job titles. Among all strain/sprain incidents, the back resulted in the greatest percentage of incidents (44.1%) and accounted for 25.4% and 57.2% of lost and restricted days, respectively.

More specifically, the two processes of focus for this study were the following:

1. *Grocery Stock Clerk: Breakdown Pallets in Back Room, Transfer to Sales Floor*
2. *Grocery Stock Clerk: Stocking on Sales Floor*

4.2 Interventions Tested

Three different interventions were introduced and evaluated at the host-site retail store in South Carolina (see Table 4.1):

1. Pallet Disc Turntable and Alternative Sorting Strategy in Back Room
2. Height Adjustable Pallet Jack (electric - battery powered)
3. Stock and Roll Cart (Adjustable Height Platform)

Table 4.1: *Manual Materials Handling Interventions Tested*

Pallet Disc Turntable (Back Room)	*Height Adjustable Pallet Jack (Electric - Battery Powered)*	*Stock and Roll Carts (Adjustable Height Platform)*
		
List Price: $980	**List Price:** $3,740	**List Price:** $795
Specifications • Capacity: 4,000 lb. • Turntable height: 7/8” • Turntable Diameter: 43-3/8” • Turntable Diameter: 48-3/8” • Weight: 220 lb. • Turntable is lockable	**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** • Platform Capacity: 75 lb. • Spring-pin adjustable height platform • Platform adjustable between ~20” to 53” • Handles on 3-sides of platform • Four swivel casters (directional locks on front

4.3 Pallet Disc Turntable (with Sorting-U Pallet Layout Strategy)

A summary of results from introducing the pallet disc turntable in conjunction with an alternative sorting-U pallet layout strategy is highlighted in Table 4.2 below.

Table 4.2: Summary of Results for Pallet Disc Turntable + Sorting-U Pallet Layout Strategy

 **Pallet Disc Turntable (with Sorting-U Pallet Layout Strategy)**	 **PRE-Intervention**  **POST-Intervention**
Intervention Description	• A pallet disc turntable was used in conjunction with an alternative sorting-U pallet layout strategy in the back room in an attempt to reduce reaches and minimize walk time when downstacking non-bulk pallets to sorted pallets. With this strategy, the three Stock Clerks all downstacked from one unsorted pallet at a time that was placed on the pallet turntable versus everyone downstacking from a separate pallet.
Application / Observations	• Observations and video surveillance noted that the pallet disc turntable was only used twice during pallet breakdown and sorting activities in the back room over the course of the 6-week trial period. However, the sorting-U pallet layout strategy in which Stock Clerks downstacked from one unsorted pallet at a time was routinely followed. Benefits seemed to be due primarily to the sorting-U strategy as associates rarely rotated pallets on pallet disc when working in sorting-U pallet layout.
Ergonomics Risk	• If used, Ergo risk ↓ **by 20%**, but remained **HIGH** (Back)[8,9] for lifts from non-sorted pallets in the back room (heaviest weights = 60 lb); o Compressive force on spine ↓ **47%** from 1,729 lb to 911 lb if 60 lb wt. lifted [6] • If used, Ergo risk ↓ **by 20%** from **HIGH** to **Moderate** (Back)[8,9] for lifts from non-sorted pallets in the back room (average weights = 20 lb) o Compressive force on spine ↓ **37%** from 1,235 lb to 783 lb if 20 lb wt. lifted [6] • If used, Ergo risk ↓ from **HIGH** to **Low** (Knees)[6] for lifts from non-sorted pallets in back room (heaviest and average weights)
Body Discomfort	• Reported Back & Knee discomfort ↓ **≥ 39%** (4 associates)
Usability Feedback	• Mixed usability feedback due to safety concerns of pallet disc (4 associates)
Productivity	• Productivity ↑ **12.5%** (pallet breakdown & sort time in back room) = **20.1 min total savings/day** (total combined savings across 3 associates performing breakdown)

4.3.1 Ergonomics Risk Results

A pallet disc turntable was introduced in conjunction with an alternative sorting-U pallet layout strategy in the back room in an attempt to reduce reaches and minimize walk time when downstacking non-bulk pallets to sorted pallets. With this strategy, the three Stock Clerks all downstacked from one unsorted pallet at a time that was placed on the pallet turntable versus everyone downstacking from separate pallets (see Figure 4.1). Once introduced, video surveillance and on-site data collection visits noted that the pallet disc turntable was only used twice during pallet breakdown and sorting activities in the back room over the course of the 6-week trial period. However, the sorting-U pallet layout strategy was routinely followed. Ergonomic risk results are summarized for the pallet disc turntable combined with the sorting-U pallet layout strategy in Table 4.3 below.

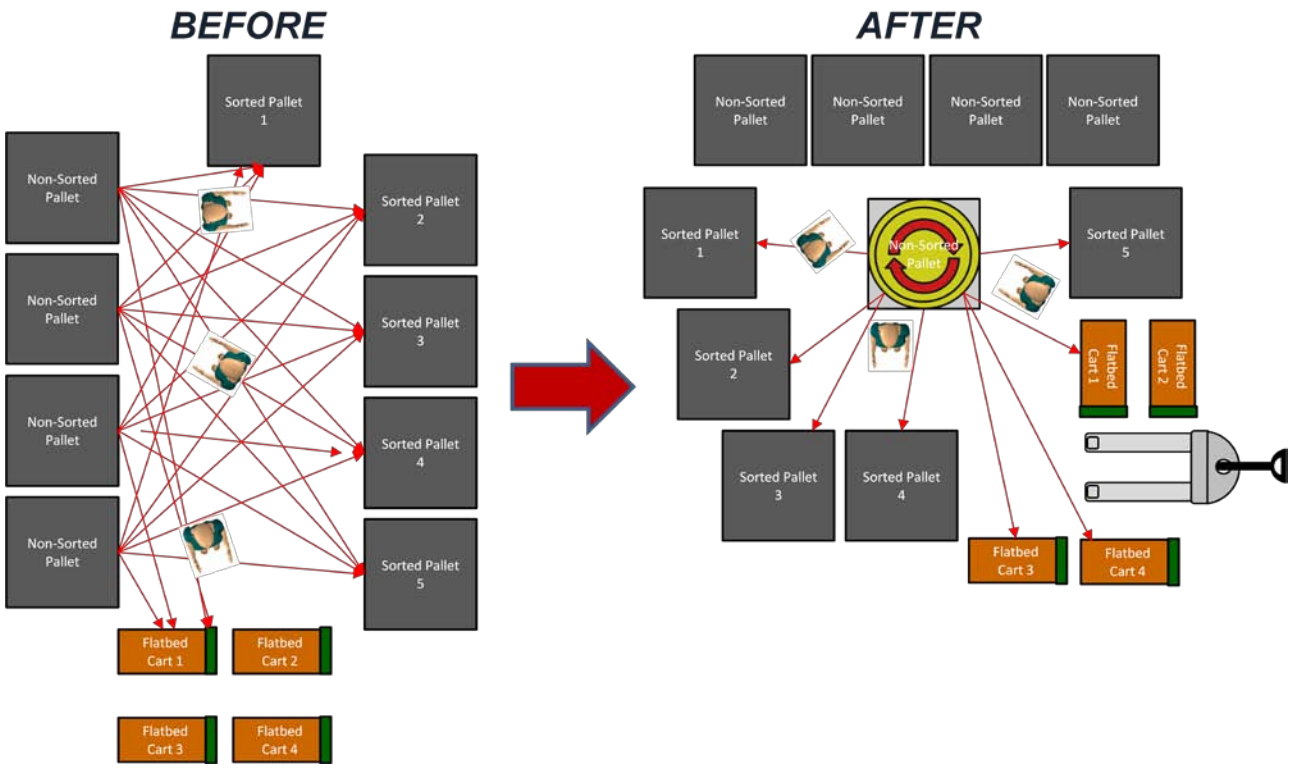


Figure 4.1. Pre- vs. Post-Intervention Illustration of Back Room Pallet Breakdown and Sorting Strategy. The layout on the left depicts the pre-intervention strategy and the layout on the right depicts the use of the pallet disc turntable and sorting-U pallet layout strategy in which stock clerks downstack from the same pallet.

Table 4.3: PRE- vs. POST-Intervention Ergonomic Risk Results (Pallet Disc + Sorting-U)

Job Task	Analysis Tool Used	PRE-Intervention Results	POST-Intervention Results
Manual lift of cartons / boxes from non-sorted pallets to carry height (Back Room)	NIOSH LE[8,9] (Back)	**HIGH risk** Composite Lift Index = **4.59** (max lift wt. = 60 lb) **HIGH risk** Composite Lift Index = **3.24** (avg. lift wt. = 20 lb)	**HIGH risk** Composite Lift Index = **3.63** (max lift wt. = 60 lb) **Moderate risk** Composite Lift Index = **2.61** (avg. lift wt. = 20 lb)
	3DSSPP[6] (Back)	**HIGH risk** Low back compressive force = **1,729 lb** Back strength % capable = **3%** (max lift wt. = 60 lb)	**Moderate risk** Low back compressive force = **911 lb** Back strength % capable = **74%** (max lift wt. = 60 lb)
	3DSSPP[6] (Back)	**HIGH risk** Low back compressive force = **1,235 lb** Back strength % capable = **38%** (avg. lift wt. = 20 lb)	**Moderate risk** (borderline) Low back compressive force = **783 lb** Back strength % capable = **86%** (avg. lift wt. = 20 lb)
	3DSSPP[6] (Knees)	**HIGH risk** Knee strength % capable = **0%** (avg. weight = 20 lb)	**Low risk** Knee strength % capable = **98%** (max weight = 60 lb)

Ergonomic risk differences were due to reduced horizontal reach distance when lifting cartons from the centralized non-sorted pallet on the disc turntable. However, since the sorting-U strategy encouraged Stock Clerks to downstack from a different side of the same pallet, rotating the pallet on the disc turntable was often not necessary. Therefore, the ergonomic benefits were due primarily to the sorting-U strategy as associates rarely rotated pallets on pallet disc when working in sorting-U pallet layout.

4.3.2 Body Discomfort Results

As shown in Figure 4.2 below, reported Upper Back, Middle Back, Lower Back, and Knee discomfort decreased by 50%, 44%, 51%, and 39%, respectively. No other body parts reported ratings greater than 1.0. 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.

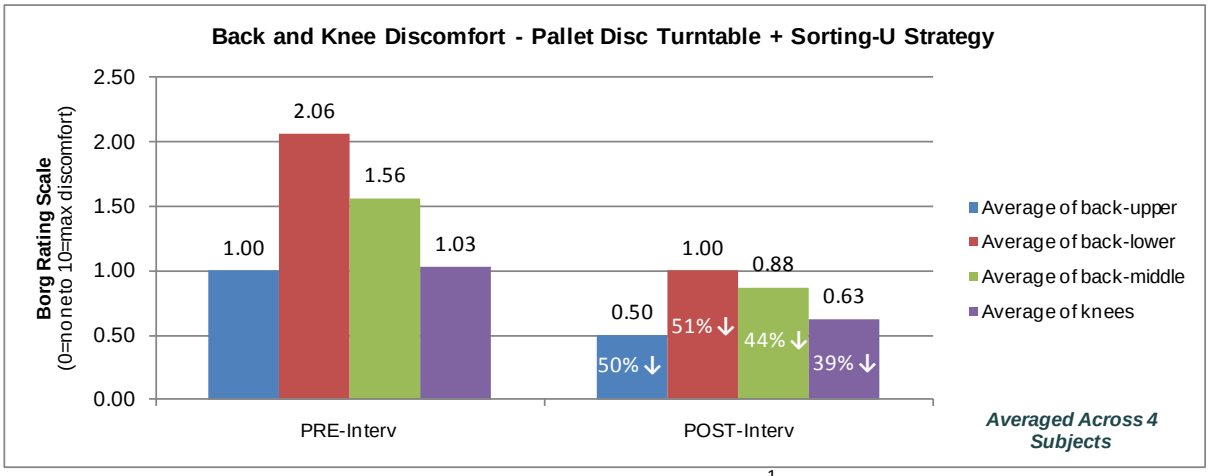


Figure 4.2. PRE- vs. POST-Intervention Discomfort Results[1]. Using the pallet disc turntable + sorting-U pallet layout strategy in the back room for pallet breakdown.

4.3.3 Usability Feedback Results

On-site observations and supervisor follow-ups noted that the pallet disc turntable was only used twice during pallet breakdown and sorting activities in the back room over the course of the 6-week trial period. However, the sorting-U pallet layout strategy was routinely followed. As shown in Figure 4.3 and Table 4.4 below, there were mixed and some negative usability feedback on the pallet disc turntable. Positive responses were geared towards the sorting-U strategy and neutral or negative responses concerning potential safety issues of the pallet disc turntable were reported.

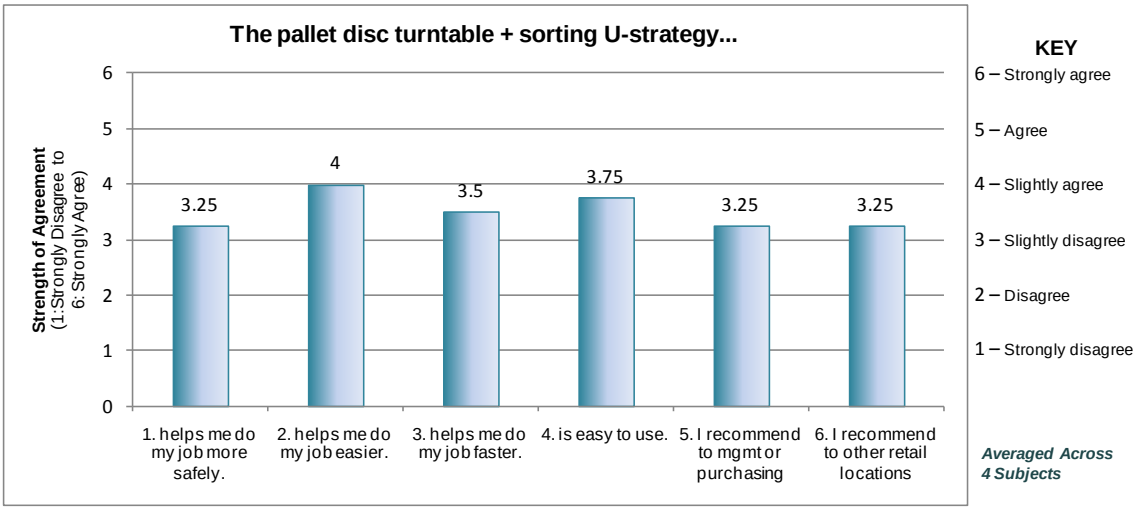


Figure 4.3. Usability feedback on pallet disc turntable + sorting-U pallet layout strategy (4 participants).

Table 4.4: Employee comments concerning pallet disc turntable + sorting-U strategy

Subject ID	Comment / Feedback
S01	Works pretty good. Seems to make things a little faster
	Three stockers working on one pallet didn't run into each other [as expected]
	Allowed us to get closer to the boxes [a.k.a. load lifted]
	May need more room in back room to be able to use U-strategy w/ disc
	May be even better if it were height adjustable (if flush w/ floor & easy to raise/lower)
	Heavy to slide to move into position for sorting U
	It increases chance of tipping a pallet when pulling pallet over top of the disc
S02	Thought it was beneficial, liked turntable. Thought it reduced reach when lifting
	Felt it eliminated walk time. Felt it was faster, quicker to break down
	Worried about spinning pallets & stability. Needs to be fixed to floor to prevent sliding of disc
S03	Equipment is nice and usable. I've always been a fan of sorting U-strategy
	Backroom needs to be larger to be able to use sorting U-strategy. Disc storage may be a problem
	Not sure you need the pallet turntable if you pull out single pallet & use sorting U-strategy
	It is hard to move disc around [into position] & it moves when electric jack moves over top of it
S04	Potential safety hazard, trip hazard, pallets may get caught on it
	It moves when taking pallets over top of it. If built into floor to begin with, it may be better

4.3.4 Productivity Results

Time study data from downstacking and sorting pallets in the back room and transporting to grocery pallets to the sales floor showed a productivity improvement with the use of the sorting-U pallet layout strategy and pallet disc turntable. On average, there was a **12.5%** improvement (i.e. 6.7 min. time savings) to sort and transport pallets to the floor. Since three Stock Clerks were dedicated to pallet breakdown in the back room, the total labor time savings was **20.1 min. total savings** per stocking shift. Such an improvement resulted primarily from a reduction in walk time between sorted and non-sorted with the sorting-U layout strategy. The added time to use the powered pallet jack to move the next non-sorted pallet onto the disc turntable was factored into this time savings.

4.4 Height Adjustable Pallet Jack (Battery Powered) Results

A summary of results from introducing the height adjustable pallet jack is highlighted in Table 4.5 below.

Table 4.5: 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 cutting cartons open and lifting cartons from pallets during stocking activities on the sales floor.
Application / Observations	• Used in conjunction with the "Stock and Roll" Cart to assist in stocking higher volume, non-bulk cartons (4-35 lb) in the canned goods and sauces aisles. • However, the height adjustable pallet jack (by itself) was also used on occasion to stock bulk products (up to 60 lb)
Ergonomics Risk	• Ergo risk ↓ from **Moderate** to **Low** (Back)[6] for cutting cartons open on pallet • Ergo risk ↓ from **Moderate** to **Low** (Back)[2-4,6]; **HIGH** to **Low** (Knees)[6] for lifts from pallet (heaviest wts. in canned goods/sauces aisles) o Compressive force on spine ↓ **62%** from 1,388 lb to 526 lb if 35 lb wt. lifted[6] • Ergo risk ↓ from **HIGH** to **Low** (Back)[2-4,6]; **HIGH** to **Low** (Knees)[6] for lifts from pallet (heaviest wts. in bulk goods aisles) o Compressive force on spine ↓ **55%** from 1,561 lb to 630 lb if 56 lb wt. lifted[6]
Body Discomfort	• Reported Back, Shoulder, Upper & Lower Extremity discomfort ↓ **by ≥ 75%**, and Whole-Body discomfort ↓ **45%** (3 associates)
Usability Feedback	• Strong positive usability feedback and highly recommended (3 associates)
Productivity	• Productivity ↑ **0.52%** (stock time) = **5.4 min. savings/day** (total across 3 associates)

4.4.1 Ergonomics Risk Results

A height adjustable pallet jack (battery-powered) was implemented to minimize back flexion when cutting open and lifting from cartons on pallets during stocking activities. Store personnel used this device in conjunction with the "Stock and Roll" cart to assist in stocking primarily higher volume, non-bulk cartons weighing between 4 and 35 lb. More specifically, the stocking of canned goods and sauces cartons was the primary application observed and evaluated for the height adjustable pallet jack. However, it should also be noted that the height adjustable pallet jack (by itself) was used on occasion to stock bulk products (up to 60 lb). Ergonomic risk results are summarized for the height adjustable pallet jack in Table 4.6 below.

Table 4.6: 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 bottom of pallet to carry height or to "Stock and Roll" cart (Stocking on Sales Floor: canned goods/sauces aisles)	LMM / LBD Risk Model[2-4] (Back)	**Moderate risk** Probability of High Risk Group Membership for LBDs = **47.8%** (max weight = 35 lb)	**Low risk** Probability of High Risk Group Membership for LBDs = **22.4%** (max weight = 35 lb)
	3DSSPP[6] (Back)	**Moderate risk** Low back compressive force = **1,388 lb** Back strength % capable = **69%** (max weight = 35 lb)	**Low risk** Low back compressive force = **526 lb** Back strength % capable = **93%** (max weight = 35 lb)
	3DSSPP[6] (Knees)	**HIGH risk** Knee strength % capable = **35%** (max weight = 35 lb)	**Low risk** Knee strength % capable = **99%** (max weight = 35 lb)
Manual lift from bottom of pallet to carry height (Stocking on Sales Floor: bulk aisles)	LMM / LBD Risk Model[2-4] (Back)	**HIGH risk** Probability of High Risk Group Membership for LBDs = **60.2%** (max weight = 56 lb)	**Moderate risk** Probability of High Risk Group Membership for LBDs = **35.3%** (max weight = 56 lb)
	3DSSPP[6] (Back)	**Moderate risk** Low back compressive force = **1,561 lb** Back strength % capable = **64%** (max weight = 56 lb)	**Low risk** Low back compressive force = **630 lb** Back strength % capable = **95%** (max weight = 56 lb)
	3DSSPP[6] (Knees)	**HIGH risk** Knee strength % capable = **15%** (max weight = 56 lb)	**Low risk** Knee strength % capable = **99%** (max weight = 56 lb)

As shown in Figures 4.4 – 4.7 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, slight reductions in average twist velocity and maximum lateral velocity also contributed to lowering overall low-back risk.

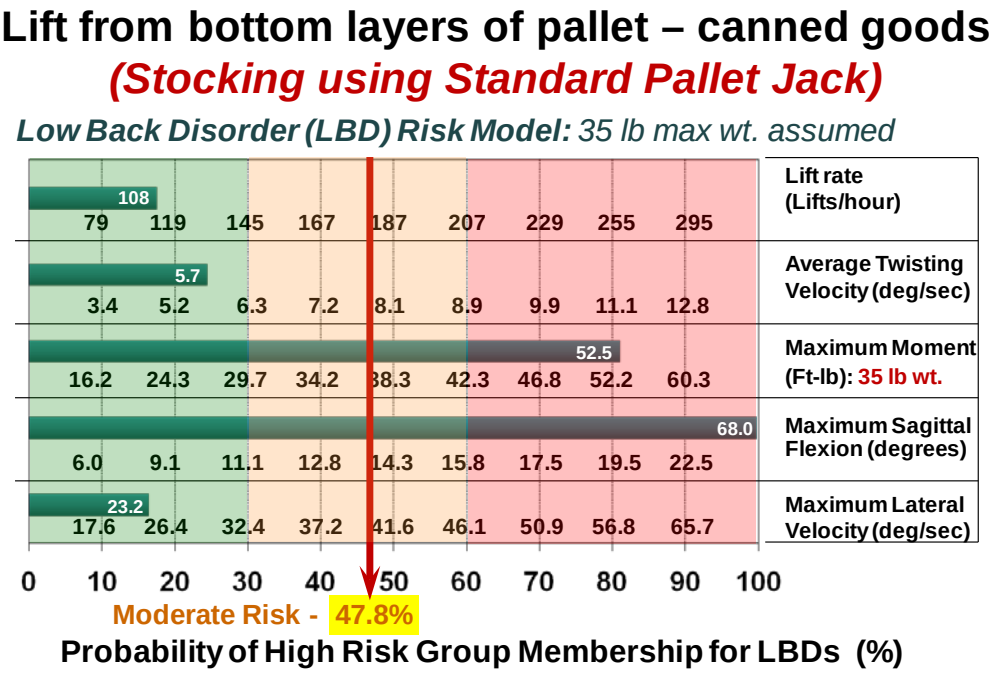


Figure 4.4: PRE-Intervention LBD Risk Model Results[2-4]**.** Stocking on sales floor (canned goods aisles): Lift carton (35 lb) from bottom layer of pallet on floor to carry height.

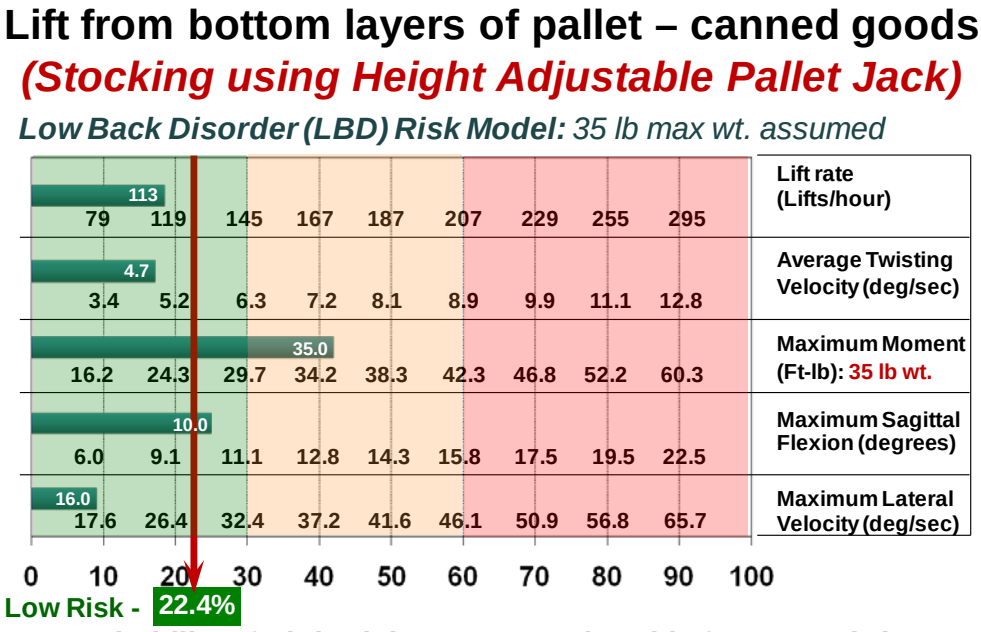


Figure 4.5: POST-Intervention LBD Risk Model Results[2-4]**.** Stocking on sales floor (canned goods aisles): Lift carton (35 lb) from bottom layer of an elevated pallet on a height adjustable pallet jack to Stock and Roll Cart.

Lift from bottom layers of pallet – bulk aisles
(Stocking using Standard Pallet Jack)

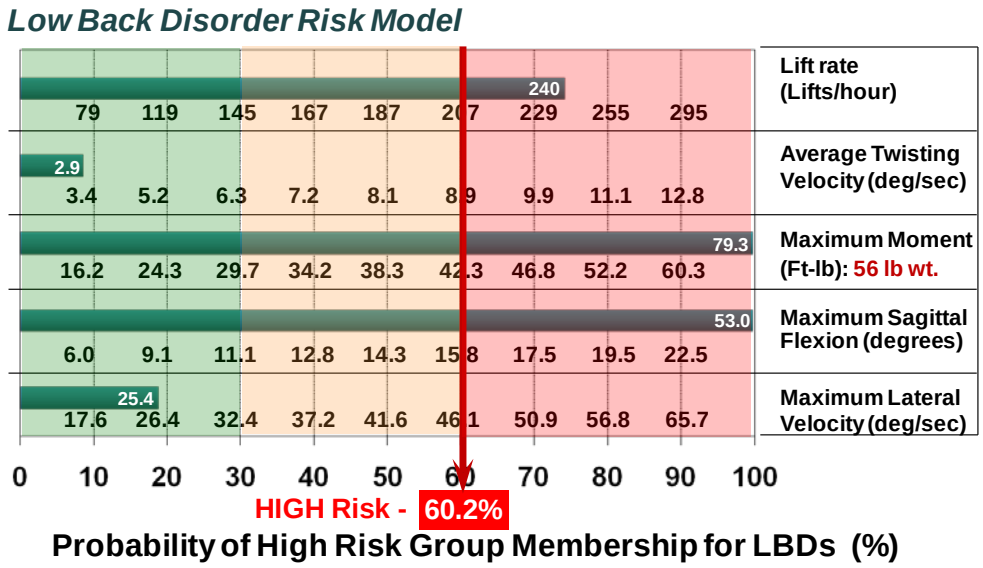


Figure 4.6: PRE-Intervention LBD Risk Model Results[2-4]**.** Stocking on sales floor (bulk goods): Lift item (56 lb) from bottom layer of pallet on floor to carry height.

Lift from bottom layers of pallet – bulk aisles
(Stocking using Height Adjustable Pallet Jack)

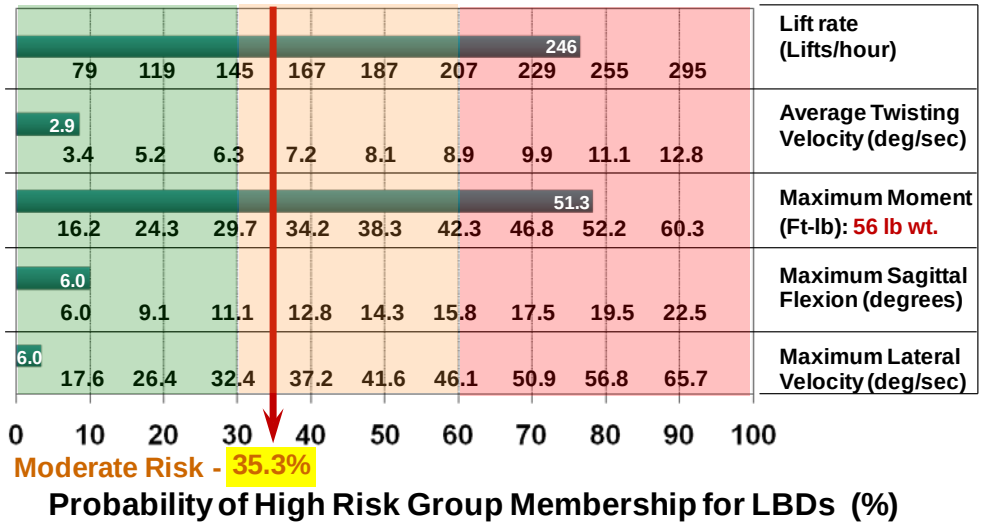


Figure 4.7: POST-Intervention LBD Risk Model Results[2-4]**.** Stocking on sales floor (bulk goods): Lift item (56 lb) from bottom layer of an elevated pallet on height adjustable pallet jack to carry height.

4.4.2 Body Discomfort Results

As shown in Figure 4.8, reported Whole Body and Shoulder discomfort decreased by 45% and 82%, respectively. Reported Upper Back, Middle Back, and Lower Back discomfort decreased by 80%, 81%, and 84%, respectively (Figure 4.9). Reported discomfort to the Upper Extremities (Elbows, Forearms, Hands/Wrists) decreased by ≥ 75%. Lastly, reported Hip, Upper Leg, Lower Leg, Knee, and Foot discomfort decreased by 60% or more (Figure 4.10). No other body parts reported ratings greater than 1.0. 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.

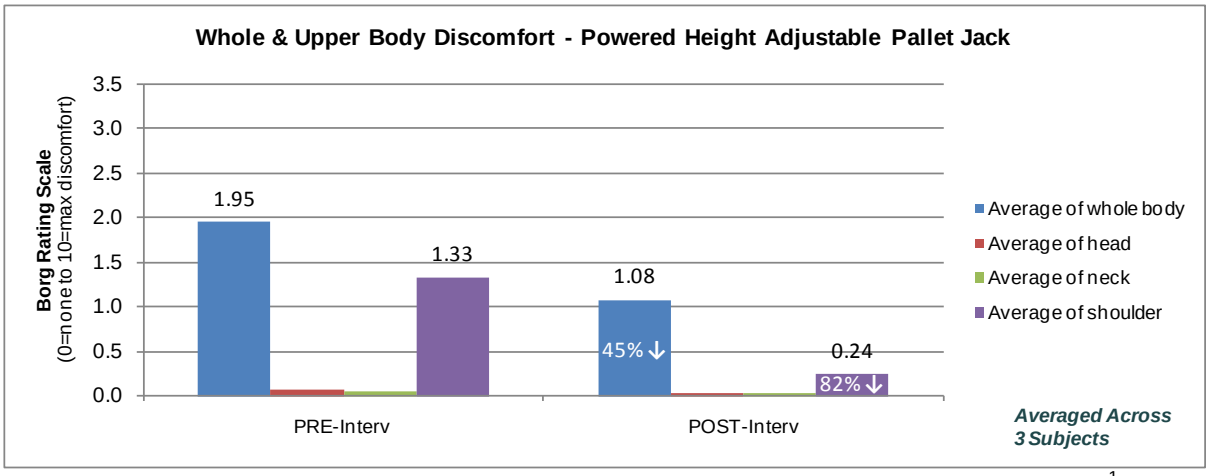


Figure 4.8: PRE- vs. POST-Intervention Whole and Upper Body Discomfort Results[1].
Using the height adjustable pallet jack to assist in stocking on sales floor.

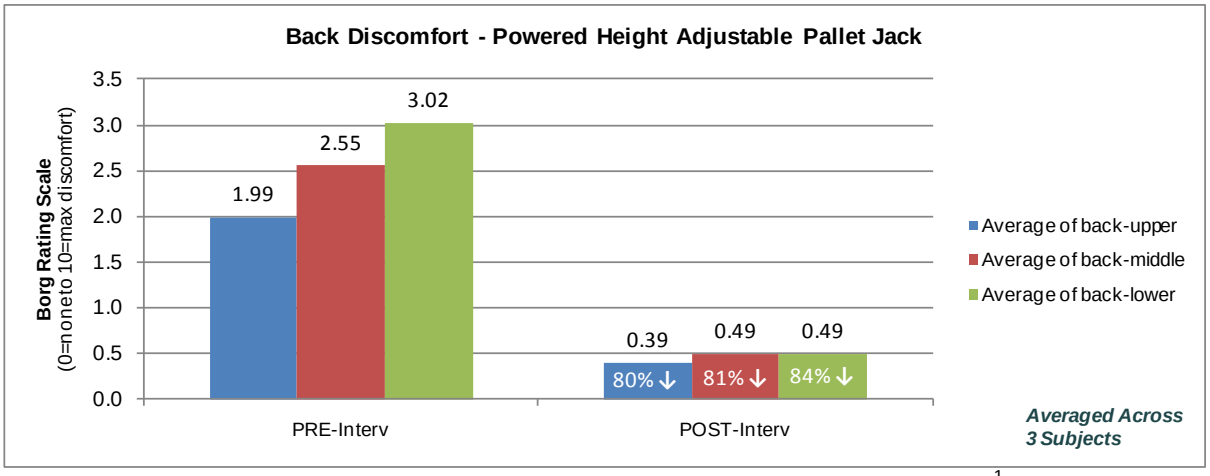


Figure 4.9: PRE- vs. POST-Intervention Back Discomfort Results[1].
Using the height adjustable pallet jack to assist in stocking on sales floor.

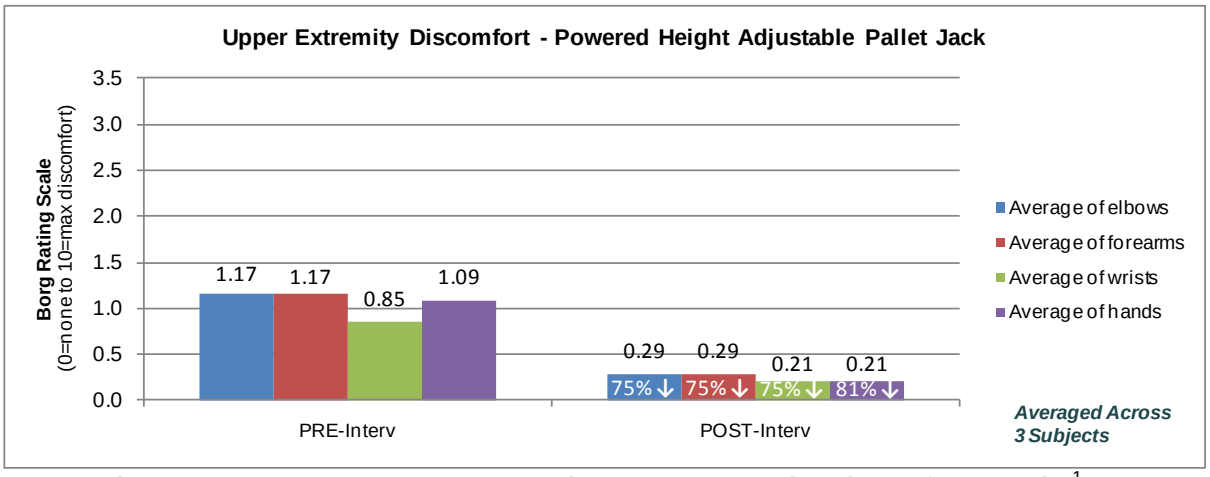


Figure 4.10: PRE- vs. POST-Intervention Upper Extremity Discomfort Results[1].
Using the height adjustable pallet jack to assist in stocking on sales floor.

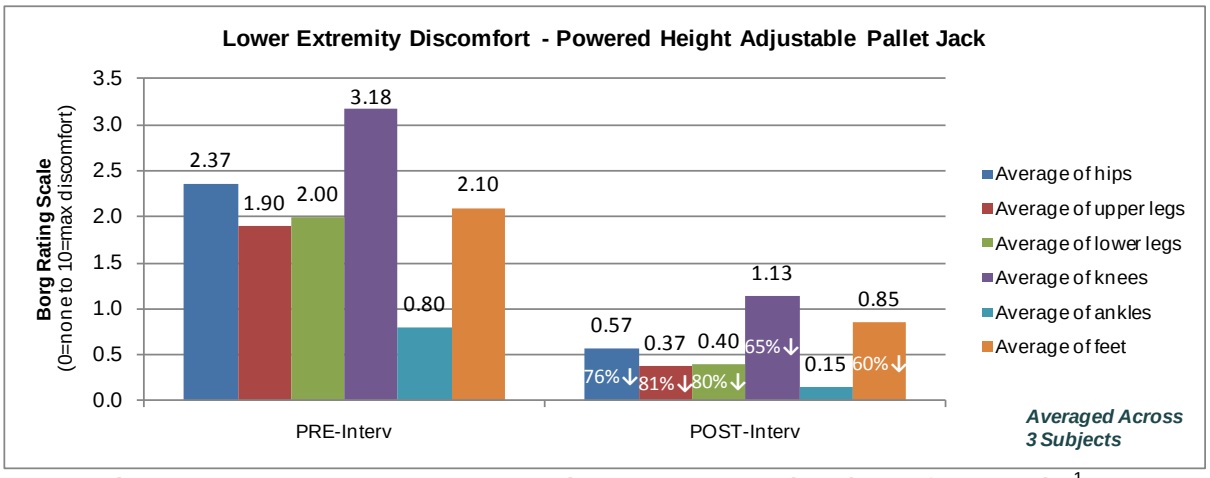


Figure 4.11: PRE- vs. POST-Intervention Lower Extremity Discomfort Results[1].
Using the height adjustable pallet jack to assist in stocking on sales floor.

4.4.3 Usability Feedback Results

On-site observations and supervisor follow-ups noted that the height adjustable pallet jack was routinely used on the stock floor. Store personnel used this device in conjunction with the "Stock and Roll" cart to assist in stocking primarily higher volume, non-bulk cartons weighing between 4 and 35 lb. More specifically, the stocking of canned goods and sauces cartons was the primary application observed and evaluated for the height adjustable pallet jack. However, it should also be noted that the height adjustable pallet jack (by itself) was used on occasion to stock bulk products (up to 60 lb). As shown in Figure 4.12 and Table 4.7 below, three Stock Clerks reported strong positive usability feedback and highly recommended the height adjustable pallet jack.

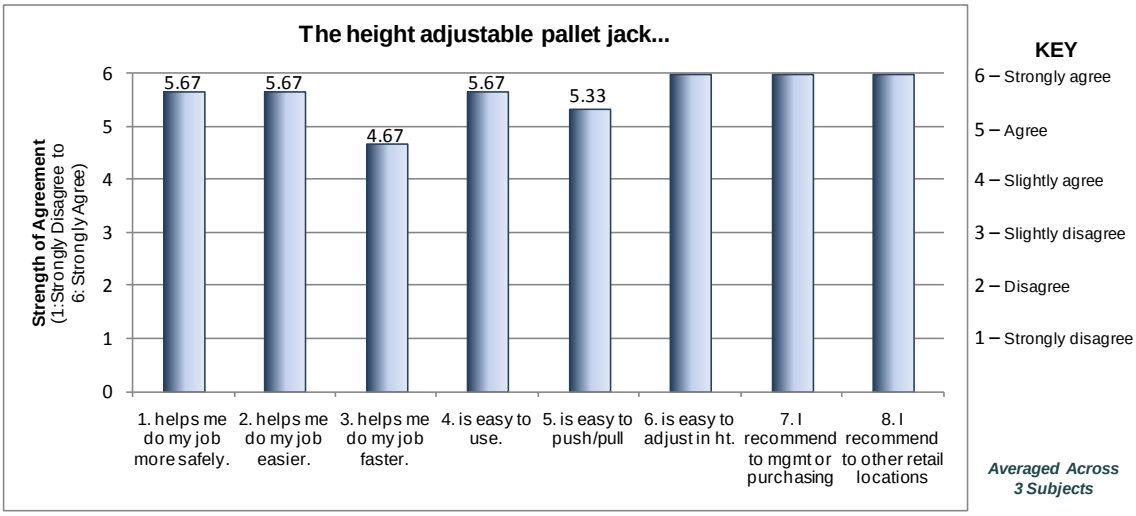


Figure 4.12. Usability feedback on height adjustable pallet jack (3 participants).

Table 4.7: Employee comments concerning height adjustable pallet jack

Subject ID	Comment / Feedback
S01	It helps my back because I don't have to bend all the way down to the floor when lifting [off pallet]
	Once the safety lock is off, it's very easy to adjust the height of the forks
	Rolls easily when forks are lowered
S03	You're my hero for getting me this height adjustable pallet jack
	This seems to cut down on the amount of bending I have to do by about half
	Charging station needs to be mounted better
	Forks don't fit as easily under some pallet loads
	Balance bars sometimes mark floor when push/pull if not raised to proper level
S05	I really liked the height adjustable pallet jack
	For a person with partial limitations in physical ability, I think it made the job a lot easier and safer
	I'm not sure how much faster it made it but I believe it was faster, definitely easier & safer though

4.4.4 Productivity Results

Time study and work sampling data showed that the height adjustable pallet jack (by itself) showed a slight productivity improvement in stocking activities, but was very close to being productivity neutral. On average, there was a **0.52%** improvement (i.e. 1.8 min. time savings per Stock Clerk) to stock cartons while using the height adjustable pallet jack. Therefore, if all three Stock Clerks were given a height adjustable pallet jack, the total labor time savings would be minimal (**5.4 min. total savings** per stocking shift). This slight improvement resulted from reduced bending to cut open and lift from the bottom two to three layers of cartons on a pallet. The added time to raise and lower the pallet jack was factored into this time savings.

4.5 Stock and Roll Carts (with Adjustable Height Platform) Results

A summary of results from introducing the "Stock and Roll" carts with the adjustable height platform is highlighted in Table 4.8 below.

Table 4.8: Summary of Results for Stock and Roll Cart (with Adjustable Height Platform)

 **Stock and Roll Cart (Adjust. Platform)**	 **PRE-Intervention** **POST-Intervention**
Intervention Description	• Three height adjustable "Stock and Roll" carts were introduced to load and transfer multiple cartons from pallets to aisle locations, and supported cartons at variable heights while items were stocked in an attempt to eliminate manual carries up/down aisles, minimize walk time, and eliminate static holds of cartons with one-hand while stocking with the other hand.
Application / Observations	• Used in conjunction with the height adjustable pallet jack to assist in stocking primarily higher volume, non-bulk cartons (4-35 lb). More specifically, the stocking of canned goods and sauces cartons was the primary application observed and evaluated for the "Stock and Roll" cart.
Ergonomics Risk	• Ergo risk ↓ from **HIGH** to **Low** (Whole Body) for carrying cartons (>31 lb) to shelf[7] • Ergo risk ↓ from **HIGH** to **Moderate** (Shoulder, Arm/Elbow, Hand/Wrist)[5] for static holds of cartons and stocking shelves • Ergo risk remained **Low** (Back)[8-9] for stocking shelves with Stock & Roll cart (middle & high shelves in canned goods aisles; associates don't stock from cart for bottom two shelves)
Body Discomfort	• Reported Back and Shoulder discomfort ↓ **by ≥ 81%**, Lower Extremity ↓ **61%**, and Whole-Body discomfort ↓ **54%** (4 associates)
Usability Feedback	• Strong positive usability feedback and highly recommended (4 associates)
Productivity	• Productivity ↑ **30.8%** (stock time) = **2.61 hrs. savings/day** (total across 3 associates stocking non-bulk cartons)

4.5.1 Ergonomics Risk Results

Three height adjustable "Stock and Roll" carts were implemented to allow Stock Clerks to load and transfer *multiple cartons* (instead of one at a time) from pallets staged in aisle centers to aisle shelving locations, and supported cartons at variable heights while items were stocked. Introducing such devices was an attempt to eliminate manual carries up/down aisles, minimize walk time, and eliminate static holds of cartons with one-hand while stocking with the other hand. Stock Clerks used the "Stock and Roll" carts to stock primarily higher volume, non-bulk cartons weighing between 4 and 35 lb. Although the "Stock and Roll" carts were used across multiple non-bulk aisles, the focus of the ergonomic risk and productivity evaluation was narrowed to the stocking of canned goods and sauces aisles. Ergonomic risk results are summarized for the "Stock and Roll" carts in Table 4.9 below.

Table 4.9: PRE- vs. POST-Intervention Ergonomic Risk Results (Stock and Roll Carts)			
Job Task	**Analysis Tool Used**	**PRE-Intervention Results** (without Stock & Roll cart)	**POST-Intervention Results** (with Stock & Roll cart)
Manual two handed carry from pallet staged in aisle center to shelf location	LM MMH[7] (whole body - carry)	**HIGH risk** Recommended carry weight limit of 31 lb exceeded (lift weight = 35 lb)	**Low risk** Carry eliminated due to cart use
Static manual holds of cartons (L. Arm) and Stocking shelves (R. Arm or Both)	RULA[5] (Shoulders, Arms, Hands/Wrists)	**HIGH risk** Left = **7**; Right = **5** (max and avg. weights) Static holds with L. Hand, Repetitive stocking w/ R. Hand	**Moderate risk** Left = **5**; Right = **5** (max and avg. weights) Static holds eliminated, Repetitive stocking still required
Static manual holds of cartons and Stocking shelves (middle shelves in canned goods)	LMM / LBD Risk Model[2-4] (Back)	**Low risk** Probability of High Risk Group Membership for LBDs = **16.6%** (carton weight = 13 lb)	**Low risk** Probability of High Risk Group Membership for LBDs = **11.1%** (item weight = 2 lb)
Static manual holds of cartons and Stocking shelves (high shelves in canned goods) - step stool used	LMM / LBD Risk Model[2-4] (Back)	**Low risk** Probability of High Risk Group Membership for LBDs = **18.2%** (carton weight = 13 lb)	**Low risk** Probability of High Risk Group Membership for LBDs = **28.3%** (item weight = 2 lb)

Ergonomic risk differences were due to the elimination of manual carrying tasks and static manual holds of cartons when the "Stock and Roll" carts were used. In addition, the carts allowed Stock Clerks to stock shelves with both hands versus one hand, thereby reducing the repetition required by one side of the body (i.e. shoulder, arm/elbow, and hand/wrist). While ergonomic risk was reduced to the upper extremities by introducing the carts, it was hypothesized that risk to the back may increase as twisting or lateral bending to/from the "Stock and Roll" carts to/from the shelves may increase. Hence, the LMM / LBD Risk Model was used to quantify such dynamic parameters of the back. As shown in Figures 4.13 and 4.14, stocking items on middle shelves showed a decrease in risk to the back as sagittal flexion and maximum moment decreased while no substantial increase in twist velocity or lateral velocity was quantified. However, as shown in Figures 4.15 and 4.16, stocking items on high shelves (while standing on a step stool) showed a marked increase in lateral velocity and a small increase in twist velocity and sagittal flexion with the use of the "Stock and Roll" cart. Nonetheless, ergonomics risk to the back still remained **Low**.

Holding box (L-hand) & stocking cans (R-hand)
(without Stock & Roll Cart – middle shelves)

Low Back Disorder Risk Model: *13 lb carton wt. lifted*

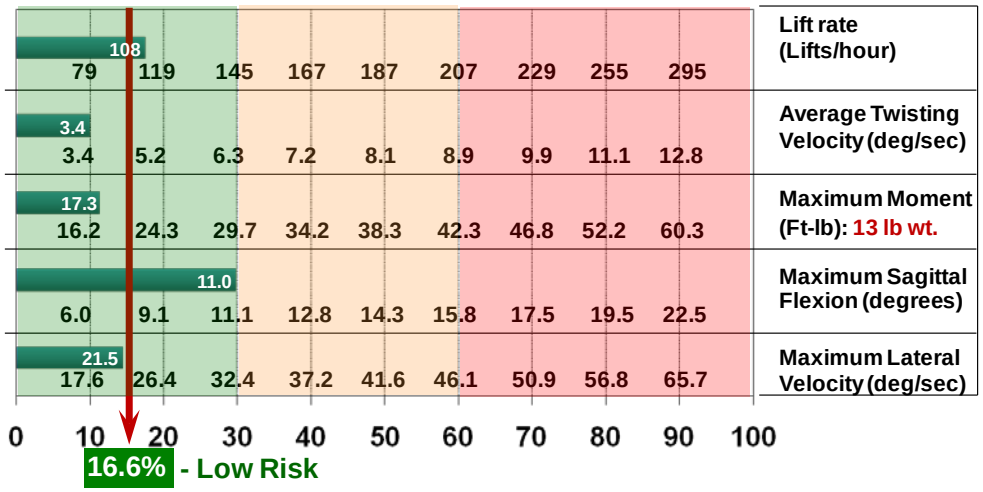


Figure 4.13: PRE-Intervention LBD Risk Model Results[2-4]**.** Stocking on sales floor (canned goods): No "Stock and Roll" cart used - Static hold of carton (13 lb) with left-hand while stocking cans on middle shelves with right-hand.

Stocking canned goods (both hands)
(with Stock & Roll Cart – middle shelves)

Low Back Disorder Risk Model: *2 lb item weight lifted*

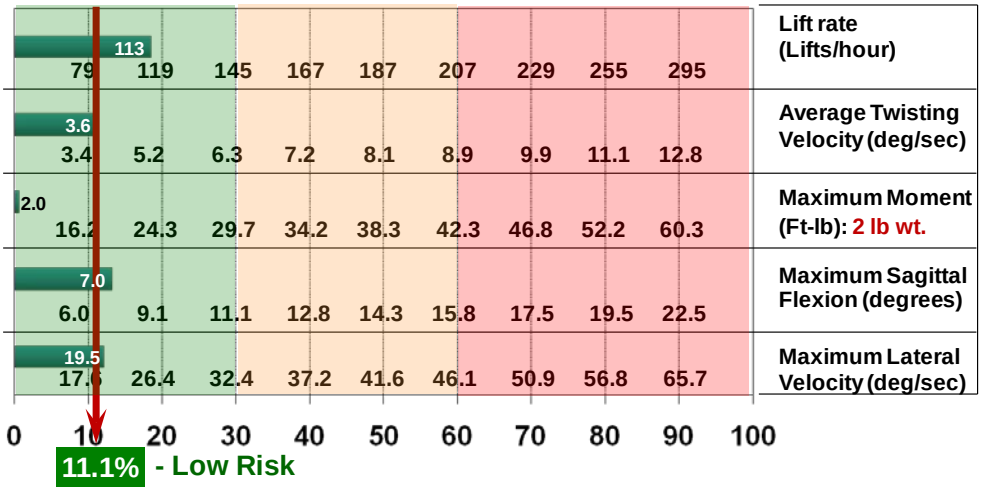


Figure 4.14: POST-Intervention LBD Risk Model Results[2-4]**.** Stocking on sales floor (canned goods): "Stock and Roll" cart used – Stocking items from carton resting on adjustable height platform to middle shelves using both hands to stock.

Holding box (L-hand) & stocking cans (R-hand)
(without Stock & Roll Cart – high shelves on stool)

Low Back Disorder Risk Model: *13 lb carton wt. lifted*

Figure 4.15: PRE-Intervention LBD Risk Model Results[2-4]**.** Stocking on sales floor (canned goods): No "Stock and Roll" cart used - Static hold of carton (13 lb) with left-hand while stocking cans on high shelves with right-hand (while standing on step stool).

Stocking canned goods (both hands)
(with Stock & Roll Cart – high shelves on stool)

Low Back Disorder Risk Model: *2 lb item weight lifted*

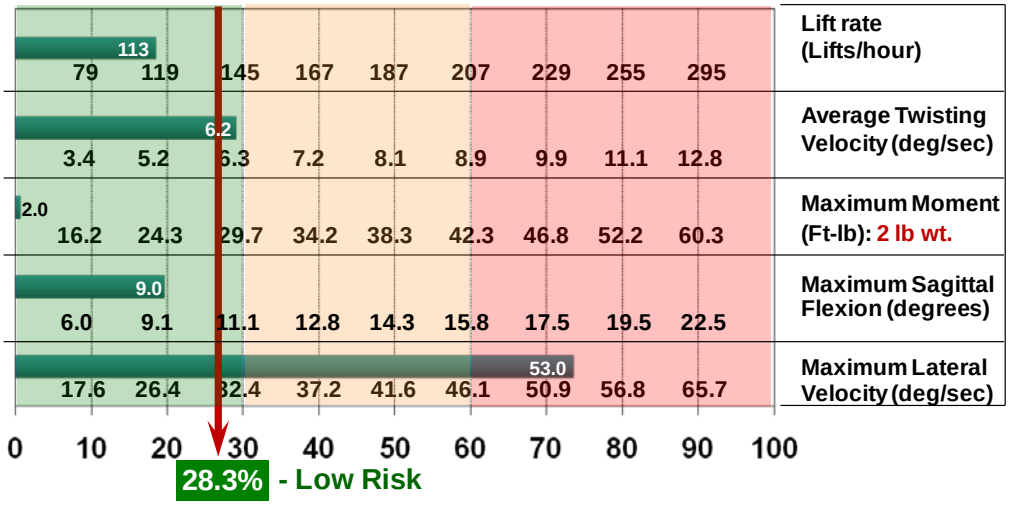


Figure 4.16: POST-Intervention LBD Risk Model Results[2-4]**.** Stocking on sales floor (canned goods): "Stock and Roll" cart used – Stocking items from carton resting on adjustable height platform to high shelves using both hands to stock (while standing on step stool).

4.5.2 Body Discomfort Results

As shown in Figure 4.17, reported Whole Body and Shoulder discomfort decreased by 54% and 86%, respectively. Reported Upper Back, Middle Back, and Lower Back discomfort decreased by 88%, 81%, and 84%, respectively (Figure 4.18). Lastly, reported Hip, Upper Leg, Lower Leg, Knee, and Foot discomfort decreased by 76%, 87%, 80%, 61%, and 71%, respectively (Figure 4.19). No other body parts reported ratings greater than 1.0. 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.

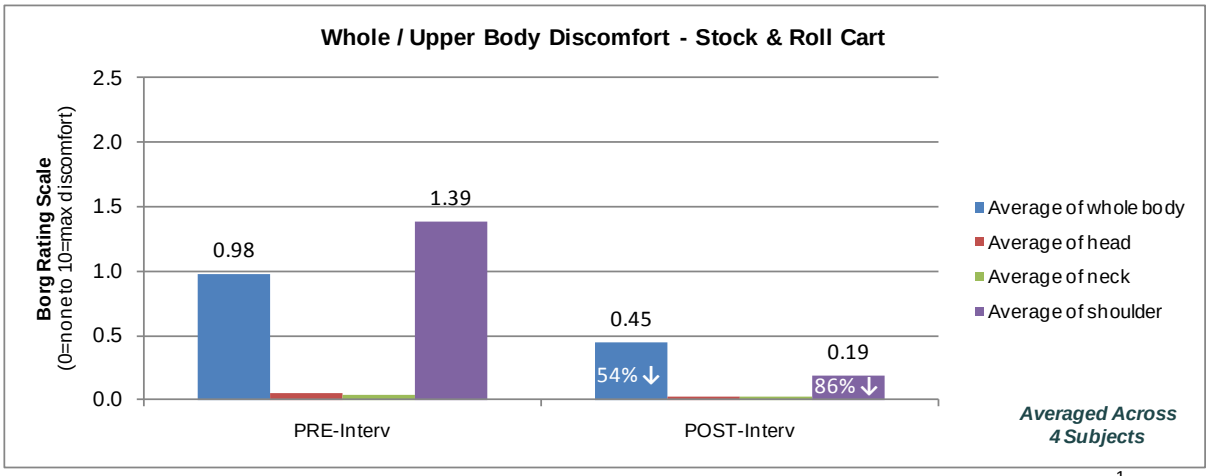


Figure 4.17: PRE- vs. POST-Intervention Whole and Upper Body Discomfort Results[1].
Using the "Stock and Roll" carts (with adjustable height platform) to transport and stock shelves.

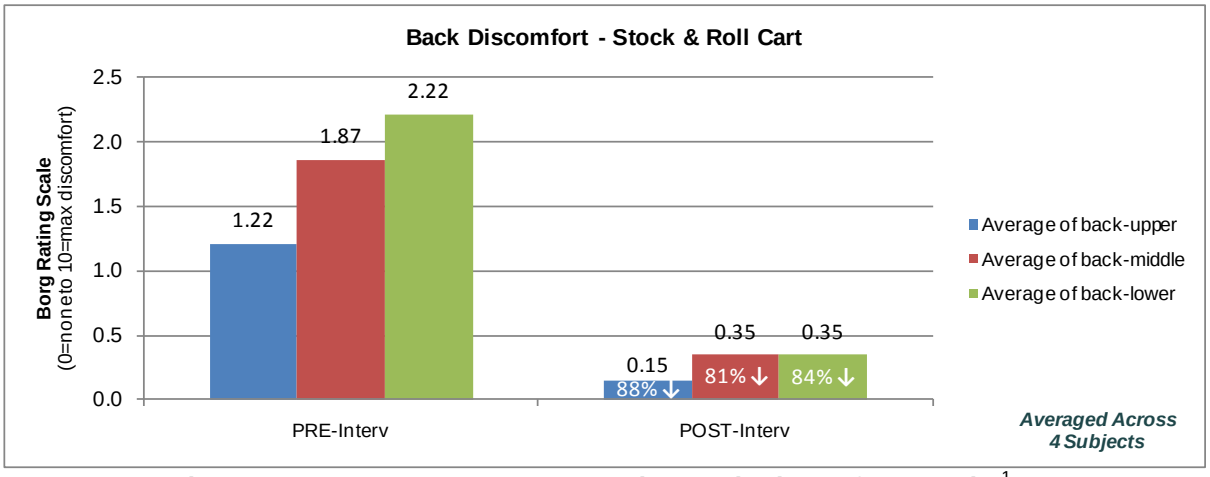


Figure 4.18: PRE- vs. POST-Intervention Back Discomfort Results[1].
Using the "Stock and Roll" carts (with adjustable height platform) to transport and stock shelves.

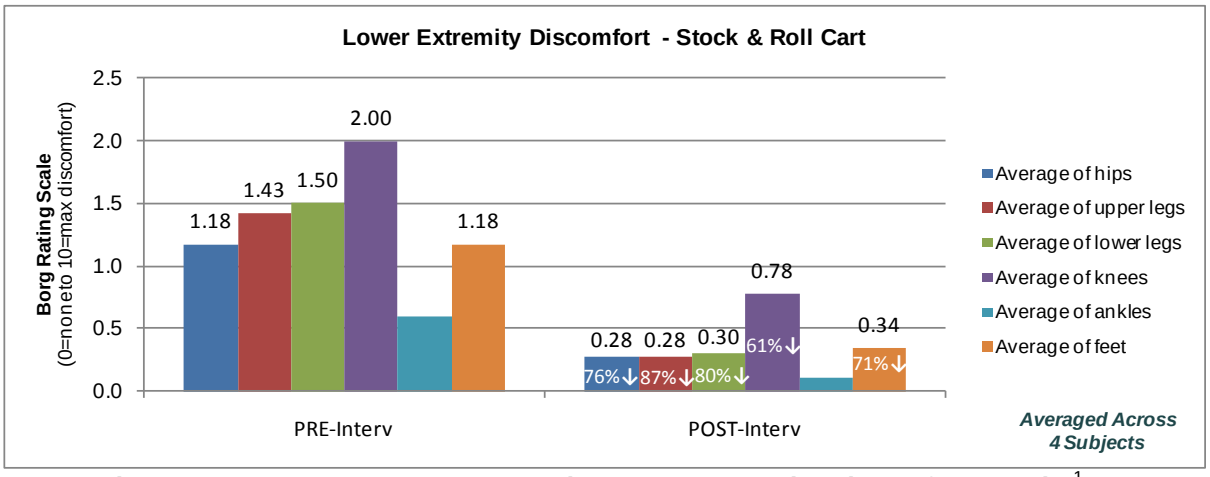


Figure 4.19: PRE- vs. POST-Intervention Lower Extremity Discomfort Results[1].
Using the "Stock and Roll" carts (with adjustable height platform) to transport and stock shelves.

4.5.3 Usability Feedback Results

On-site observations and supervisor follow-ups noted that the "Stock and Roll" carts were routinely used on the stock floor. Store Clerks used these devices to assist in stocking higher volume, non-bulk cartons. As shown in Figure 4.20 and Table 4.10 below, four store employees reported strong positive usability feedback and highly recommended the carts.

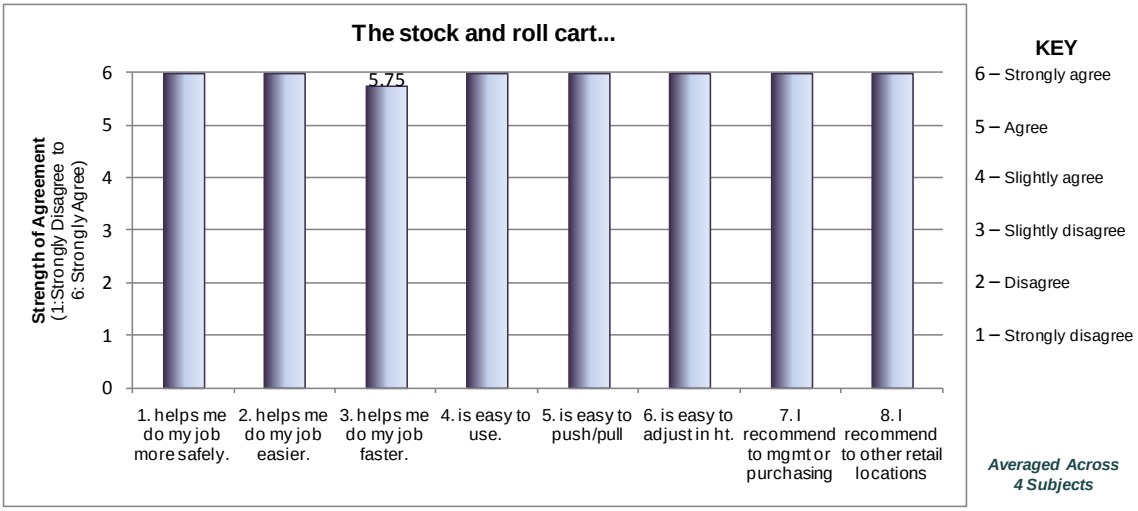


Figure 4.20: Usability feedback on "Stock and Roll" carts (4 participants).

Table 4.10: Employee comments concerning “Stock and Roll” carts

Subject ID	Comment / Feedback
S01	Carts are great! Best device in grocery stocking history!
	Rolls easily, it's nice to have brakes too
	It seems to cut out at least about 20-min. per aisle
	I think every store should get these for their stockers
	The whole idea of working smarter not harder plays into effect with these carts
S02	Carts do make it easier, especially for the top shelf items (espec. glassware, jello, etc.). Glass is also a mess in terms of cases falling apart on us and this helps a lot
	Saves time walking back and forth
S04	Carts are useful, especially for higher shelves
	Good platform size and cart size to be able to maneuver around
	Brackets surrounding blue waste bins on cart bottom could be more durable
S05	I really liked the adjustable stock carts
	For a person with partial limitations in physical ability, I think it made the job a lot easier and safer
	I'm not sure how much faster it made it but I believe it was faster, definitely easier & safer though

4.5.4 Productivity Results

Time study and work sampling data showed that the “Stock and Roll” cart (by itself) showed a substantial productivity improvement in stocking activities. On average, there was a 3**0.8%** improvement (i.e. 52.2 min. time savings per Stock Clerk) to stock canned goods and sauces cartons while using the “Stock and Roll” cart. Therefore, assuming a similar time savings across all three Stock Clerks assigned to stocking non-bulk cartons, the total estimated labor time savings would be **2.61 hrs. total savings** per stocking shift). This substantial productivity improvement resulted from minimizing walk time to/from staged pallet to/from shelf locations since Stock Clerks were able to transport multiple cartons (average of 7 cartons per trip) to the shelf location. Time savings also resulted from Stock Clerks being able to use two-hands to stock goods versus one-hand. The added time to position, raise / lower the platform on the cart, and push the loaded cart to the shelf location was also factored into this time savings.

4.6 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:

- ***Pallet Disc Turntable:***
  - Very heavy to manually move into position for use in back room
  - Pallet disc would move or slide when pallets were pulled over top of disc with powered pallet jack
  - Increased chances of tipping a loaded pallet when pulled over pallet disc turntable
  - May provide more benefits if disc was flush with the floor in the back room and/or had height adjustable capabilities

- ***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

- ***Stock and Roll Carts***
  - Brackets on the bottom to hold a waste bin in place could be more durable
  - Easier storage of carts and/or nesting of multiple carts should be considered

4.7 Return-on-Investment (ROI) Estimates

In an effort to determine if the introduction of such material handling interventions may be economically justifiable, potential return-on-investment (ROI) estimations were calculated. Discussing potential roll-out strategies with corporate stakeholders, it was decided that the two material handling devices that showed positive results (i.e. height adjustable pallet jack and "Stock and Roll" carts) would provide a better ROI if rolled out among stores with higher incidence of strains/sprains related to material handling among Grocery Stocking personnel. Therefore, workers compensation data over 2009-2010 was analyzed to identify "***high priority***" stores that had two or more strain/sprain incidents per year among Grocery Stocking personnel related to material handling. Eight (8) total stores were identified as "***high priority***" among all stores company-wide.

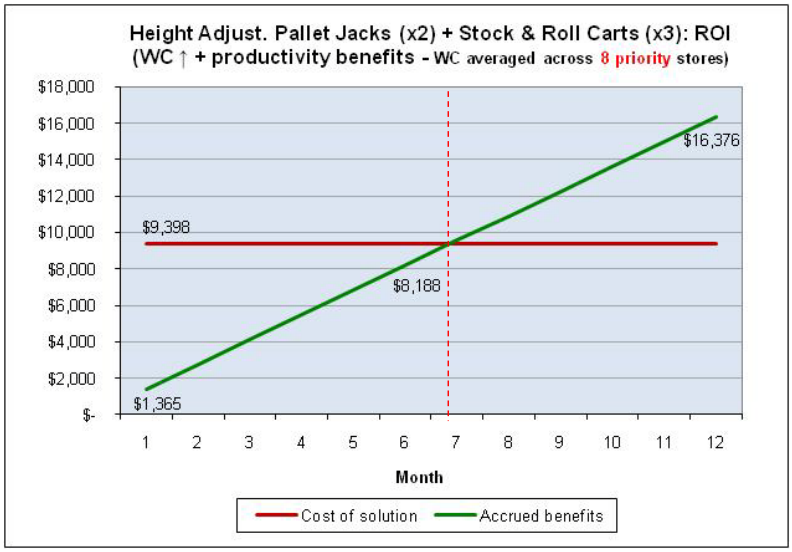
As shown in Figure 4.21, the "Total first-year cost of control" included equipment costs of purchasing two height adjustable pallet jacks and three "Stock and Roll" carts as well as estimated shipping, training and maintenance costs. An annual recurring cost of $100 was also included in this ROI forecasting.

Estimated annual benefits included an estimated **40%** reduction in direct and indirect costs associated with workers compensation claims. The 40% reduction was considered a conservative estimate based on a number of intervention case studies that reduced the level of physical exposure to an ergonomic hazard, such as by introducing load-leveling devices as done in this study (Puget Sound Human Factors Society - http://www.pshfes.org/cba.htm). Direct costs of strain/sprain claims among Grocery Stocking personnel were taken from company workers compensation data and averaged across the 8 "***high priority***" stores to give average direct costs at one store location. Indirect costs were estimated from the OSHA e-tool as a function of direct claims cost as shown below (http://www.osha.gov/SLTC/etools/safetyhealth/images/safpay1.gif):

- Less expensive claims have proportionally higher ***indirect costs***:
  - WC claim ≤ $2,999 = 4.5 x claim cost in indirect costs
  - WC claim $3,000 – $4,999 = 1.6 x claim cost in indirect costs
  - WC claim $5,000 – $9,999 = 1.2 x claim cost in indirect costs
  - WC claim ≥ $10,000 = 1.1 x claim cost

Lastly, productivity improvement was also included as a benefit in the ROI calculation. Total annual time savings for introducing the material handling devices was converted into a potential labor cost savings or time savings that could be spent doing other job functions. An average labor cost of $15/hour was assumed. The estimated annual productivity improvement savings from introducing the height adjustable pallet jacks and "Stock and Roll" carts were **$212** and **$6,131** per store, respectively, for a total savings of **$6,343**.

As shown in Figure 4.21, the estimated payback period after introducing two height adjustable pallet jacks and three "Stock and Roll" carts in a single "**high priority**" store, was **6.8 months**. Estimated net benefits after one year, three years, and 5 years of introduction were **$6,978**, **$39,531**, and **$72,083**, respectively, at a single store.

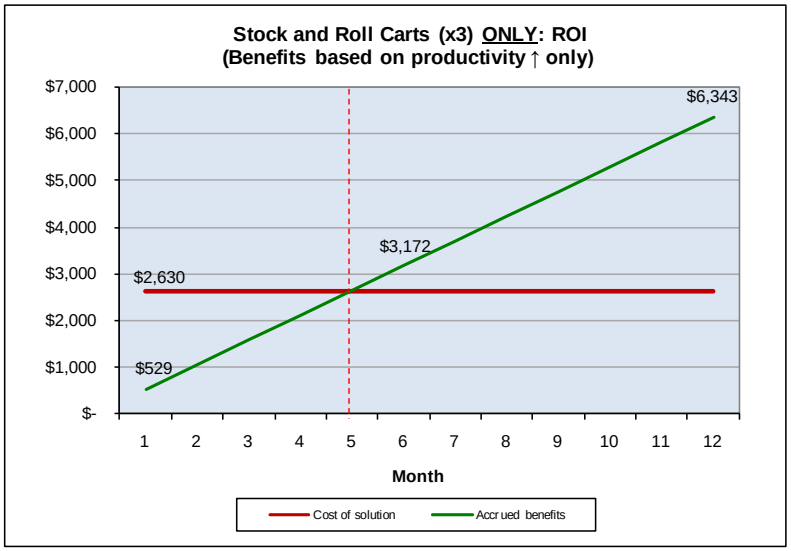


Total first-year cost of control:	$ 9,398.00
Annual recurring costs:	$ 100.00
Estimated annual benefits:	$ 16,376.00
Estimated payback period:	0.57 year (6.8 months)
Estimated net benefits after 1 year:	$ 6,978.00
Estimated net benefits after 3 years:	$ 39,531.00
Estimated net benefits after 5 years:	$ 72,083.00

Ht. Adj. Pallet Jacks + Stock & Rolls	
Reduction in claims:	40%
Reduction in WC costs:	$ 2,701
Reduction in indirect costs:	$ 7,333
Increase in productivity:	$ 6,343

Figure 4.21. Estimated ROI results shown above are for one store location only, in which interventions are introduced. WC data averaged across "**high priority**" stores *(i.e. ≥ 2 sprain/strain Grocery Stocking Dept. incidents per year).* There were 8 total stores between 2009 & 2010 FY.

A second conservative ROI was estimated based solely on productivity savings by implementing the three "Stock and Roll" carts (Figure 4.22). Since these carts had such a substantial impact on productivity, we wanted to determine if the upfront costs to purchase and train employees could be outweighed by the potential productivity improvement only, assuming no change in worker's compensation. Given this conservative scenario, estimated net benefits after one year, three years, and 5 years of introduction were **$3,713**, **$16,199**, and **$28,685**, respectively, at a single store. These estimates certainly support the notion that such interventions may prove to be economically justifiable. However, additional studies are recommended to verify such estimates.



Total first-year cost of control:	$ 2,630.00
Annual recurring costs:	$ 100.00
Estimated annual benefits:	$ 6,343.00
Estimated payback period:	0.41 year (5.0 months)
Estimated net benefits after 1 year:	$ 3,713.00
Estimated net benefits after 3 years:	$ 16,199.00
Estimated net benefits after 5 years:	$ 28,685.00

Stock & Rolls ONLY		
Reduction in claims:		0%
Reduction in WC costs:	$	0
Reduction in indirect costs:	$	0
Increase in productivity:	$	6,343

Figure 4.22. Estimated ROI results shown above are for one store location only, in which three "Stock and Roll" carts are introduced. Payback period was based on estimated productivity improvement only (assuming no reduction in WC costs).

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 grocery stores.

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. Two of the three interventions trialed in this demonstration project 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.

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APPENDIX A: Usability and Discomfort Survey

Usability Questionnaire

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

Subject ID:
Date:

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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_____

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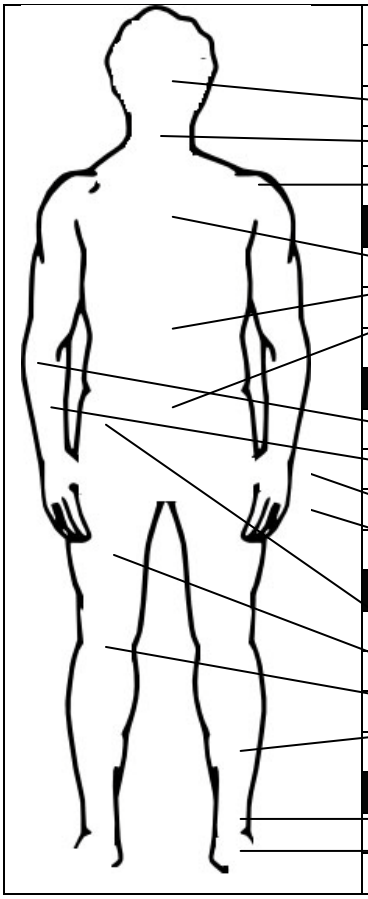
_____

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					