Developing Ergonomic Interventions to Reduce Musculoskeletal Disorders in Grocery Distribution Centers

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The purpose of this work was to explore intervention concepts aimed at addressing the workers' needs in grocery distribution centers. Worker interviews indicated that many of the items that they handle are heavy, including cases of meat (up to 80 lbs), juice, water, and detergent. Management and safety personnel who participated in a brainstorming focus group session indicated key ergonomic issues include the weight of the meat cases, extended reaching, and even more specifically, overhead reaching. Intervention ideas discussed during the brainstorming indicated a need for mechanisms that reduce reach distances by keeping product close to the order picking aisle and mechanisms that relieve the physical burden of handling heavy product from their storage slots onto the order-picker's pallet jack.

INTRODUCTION

Statistics. Bureau of Labor Statistics (BLS) reports show that Warehousing & Storage (W&S), as an industry sector, has an overall incidence rate of lost time non-fatal injuries that was comparable to Construction, and higher than private industry as a whole or that of the Manufacturing sector. Rates for every type of injury listed are higher for W&S than for private industry as a whole. When injury and illness data are examined by type of exposure, incidence rates are also higher for W&S, compared with private industry as a whole. Sprain and strain injuries constituted 49% of the non-fatal lost time injuries in W&S in 2006 (BLS, Table R1), a percentage similar to that found in a large prospective study of risk factors associated with repetitive material handling work (Craig *et al.* 2003).

Risk factors. There is a limited amount of research that has been published specifically addressing ergonomics in warehousing/DC operations. NIOSH investigators performed a hazard analysis of a grocery warehouse wherein the rate of back injuries was 16 per 100 workers. They found lift loads exceeding recommended limits and rates, locations from or to which items were picked or placed to be too low, too high, or too deep, and work periods exceeding 8 hours to be points of concern (Putz-Anderson *et al.* 1993). In an earlier study of wholesale grocery order selectors, (Garg 1986) found excessive reaching postures imposed by the design of the storage systems, which, based on biomechanical modeling, he predicted would cause half of male workers and 90% of the females to overexert themselves on the job. More recently, (Lavender *et al.* 2006) studied the low back disorder risk values of 53 jobs in 7 automobile parts DCs. They found the probability of low back disorder risk ranged from about 25-75%, however about half of the jobs studied had risk estimates at or above the 60% value which signifies high risk (Marras *et al.* 2000). In a study of problematic work factors for stockers in a warehouse superstore, (St.-Vincent *et al.* 2005) identified factors in several aspects of the work system that made the stocker job less efficient and more risky. These included product and packaging characteristics (weight, lack of handles, flimsy packaging materials that did not support the weight of the product), facilities/display layout (requirements to stack product very high, deep storage bins, congestion), equipment (mismatches between pallets and pallet jacks, poor maintenance), and work organization (poor planning by management).

As in many industries, some DC operations are seeing their workforce age. Reports and research studies that provide information for engineers and others on how to design work to compensate for decrements that occur in various capacities as workers age are becoming increasingly important and relevant (Shin *et al.* 2006, Haight and Belwal 2006). In a younger sample of workers, a number of personal factors were shown to be associated with injury risk in material handling operations, and therefore, provide additional opportunities for injury risk reduction (Craig *et al.* 2006).

Interventions. There are a few published reports specific to interventions in warehouse

operations. One describes countermeasures taken by a hardware retail DC (Washington State Department of Labor and Industries 2001), that include modifications that are limited in scope (self-imposed weight limits on totes and smaller wheels on carts) and modifications that are wider in scope, including changes to their inbound receiving procedures and containerizing outbound shipments. The report specifically discusses the decrease in trailer utilization that occurred as a result, but there were also decreases in the amount of material handling performed by the loader and the driver and decreases in "product damage, fewer misdeliveries, and increased equipment utilization and labor efficiencies". This exemplifies the need to take a systems approach to the intervention process. Ulin and Keyserling (2004) presented case studies of three interventions in automobile parts DCs. Their paper demonstrates how the intervention process involves multiple steps and may require iterations to "get it right". They also provide examples of objective means by which pre- and post-intervention conditions can be evaluated. Recently a large scale study of DC workers found only limited effects of state-of-the-art lift training on back injury prevention; results indicated that prevention efforts in DCs should focus on work and process design issues rather than relying on training lifting techniques (Lavender *et al.* 2007).

In a lab-based study that simulated box handling conditions in grocery DCs, (Marras *et al.* 1999) studied effects of box size and weight, box-handle coupling, and location on pallet on spine compression and shear forces. They found box weight and location of the box on the pallet affected compression, as well as anterior-posterior and lateral shear forces. Box size affected A-P shear and the presence of handles affected A-P shear and compression. The bottom location on the pallet was particularly problematic with regards to spine compression and A-P shear (consistent with some field studies mentioned previously). The effect of including handles was equivalent to reducing the weight of the box by about 4.5 kg.

This paper describes an ergonomics process initiated to address the issues encountered in grocery distribution centers. The overall goal of this process is to identify and evaluate interventions (methods, tools, processes, etc.) that will allow grocery distribution workers to work more efficiently and safely through established participatory ergonomics research methods.

METHODS

The Process. In pursuit of goal of the project, we have initiated the five stage process shown in figure 1. We begin by working with our industry stakeholders, comprised of management and safety personnel, to identify common concerns they share about DC operations and to provide an opportunity for intervention ideation and discussion. This is accomplished by convening focus groups comprised of representatives from a number of DCs, in this case they were from the eastern and central portions of the US. After the focus group, the research team does further work on the ideas, by researching existing solutions, contacting vendors to discuss new ideas for which solutions do not currently exist, and we also develop prototypes in our facility. These initial solution concepts are then evaluated by the focus group participants and prioritized. The concepts that hold the most promise are then evaluated using biomechanical measures to validate that the biomechanical loads on the DC workers would be reduced if the solution was adopted. Usability studies are used to identify potential barriers to the adoption of the intervention concepts, at the organizational &/or individual levels. Intervention concepts that have passed all these tests are then evaluated in field implementation testing to confirm their effectiveness under real world conditions. The remainder of this paper describes the result from the first stage of this process.

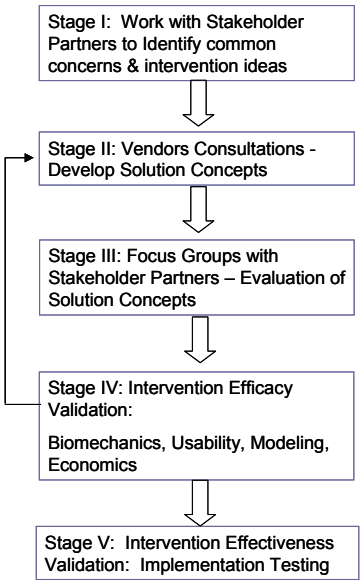

Figure 1. Stages in the research methodology.

Participants. Eleven individuals representing management and safety functions from five large grocery distribution organizations participated in a single 3-hour focus group session. All signed informed consent documents. Experience with distribution centers ranged from 7 to 34 years (average = 18 years).

Focus Group Preparation. Prior to the focus group session these individuals were provided with workbooks to sensitize them to the issues that would be discussed. In addition to learning about their experience level in grocery distribution, the workbook asked the participants to (1) reflect on what their organizations have done to address ergonomics concerns in the past, (2) interview two employees to obtain their views of the what represented the most physically challenging components of their jobs, and (3) photograph the tasks that were physically challenging. These workbooks were sent to the investigators in advance of the meeting.

Focus Group Process. The investigators moderated a focus group meeting comprised of three components. First, the moderator initiated a discussion of the issues identified in the participant's workbooks and the photographs submitted. As photographs were displayed the submitter(s) described the issue they were trying to highlight in their pictures. As issues were verbalized by the narrator or other participants they were recorded on 4 by 6 inch cards. At the completion of the issues discussion the issue cards were taped to the wall in clusters which indicated that the cards in a given cluster addressed a similar topic (theme or category of concern).

Second, there was a consensus building process regarding the issues discussed. This was done by handing each participant a set of sticky dots. The participants were asked to indicate which issues were most important by placing one or more of their sticky dots on an issue. The dots were tallied to determine which issues were the most important to the group.

Third, a brainstorming component was used to elicit ideas regarding potential ergonomic interventions which would address the issues. We used a sketch and pass method in which the participants were placed at small tables in groups of 3 to 5 people. They were provided with large sheets of paper and markers and asked to sketch intervention concepts that they believe would address one or more of the priority issues. After approximately 10 minutes each participant passed his/her sketch to the participant on his/her left. At this point participants were encouraged to explain their artwork to the recipient who was, in turn, asked to augment the sketch, or if the idea triggered a new idea, sketch an additional concept on the page. After 5 to 10 minutes, the pages were passed again to the left and process repeated until the sketches completed one full cycle around the table. Once the process was completed, the sketches were placed on the wall and each one, in turn, was presented by its originator and then discussed by the entire group. The discussion focused on the purpose of the concept, it expected implementation, and potential usability issues.

RESULTS

Prior to the meeting, individual focus group participants interviewed a total of 20 DC employees ranging in experience from 0.25 to 24 years. Collectively, the employees who were interviewed indicated the following items were most difficult to handle: meat, juice, canned food, potatoes and onions, bleach and detergents, bottled water, bags of dog food, and soft drinks. On average, just over 10 percent of the items they handled were considered by them to be "too heavy". The interviewed employees estimated 31 percent of the items they handle are picked-up or placed above shoulder height and about 30 percent of the items are handled below knee height.

The discussion of issues at the beginning of the focus group meeting exposed many of the important common challenges to target for improvement. Figure 2 shows the most important issues were "overhead reaching", "far reaches", and "meat cases"

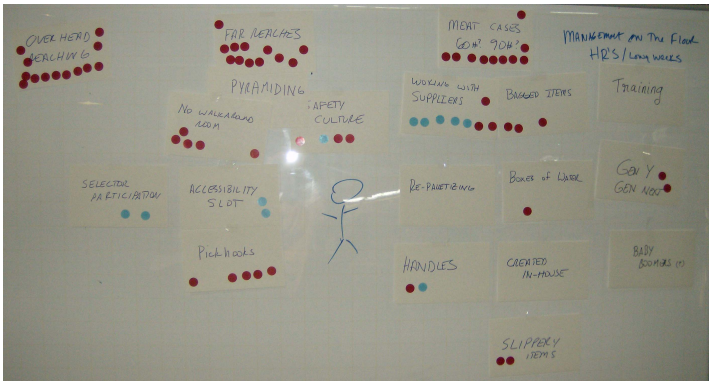

Figure 2. The ergonomics issues brought up in the discussion. The number of dots indicates each issue's priority as assigned by participants.

In the brainstorming component the participants proposed solutions addressing these issues. Figure 3 shows several of the sketches created in the session. Sketches a – e focused on ways to reduce the reach distance and overhead reaching by bringing the products closer to the selector by either using turntables (Figure 3 a, b, d), by presenting products on pallets in flow-racks that could be broken down into

smaller units as product is removed (Figure 3c), or by changing the organization of the warehouse so that each slot could be picked from two sides (Figure 3e). The concept of raising items in the slots by means of lift-tables or some other similar device was sketched in Figure 3f. Others focused on ways to reduce the manual lifting of heavy cases by proposing the use of automated or semi-automated case selection equipment (Figures 3g and 3i). The concept of incorporating a lift assist into a pallet jack was developed in Figure 3h. The height of the pallet jack was addressed in Figure 3j by having a pallet jack rise far enough off the floor that the bending would be eliminated when placing items on the pallet.

DISCUSSION

The issues discussion and the figures emphasize the need to develop means for bringing items closer to aisle, thereby reducing the reaching required. The second phase of this project will be looking for ways to achieve this in a cost effective manner. Likewise, we are working with lift assist manufactures to develop equipment that can address the need for lift assists in the more physically demanding areas such as the handling of meat cases and cartons of juice. As these solution concepts are identified we will be taking them back to the brainstorming participants to obtain their feedback. We will be probing on usability concerns that might interfere with the adoption of what on the surface may be promising intervention concepts.

In summary, this work has initiated a process where in the physical ergonomics challenges in the grocery distribution industry can be addressed. Most of the participants reported that their prior "ergonomic" efforts have focused on training which has been shown to be minimally effective (Lavender et al., 2007). However, by engaging management and safety personnel engaged in distribution processes, we are confident that the this process will yield successful interventions in what has remained an ergonomically challenged industry.

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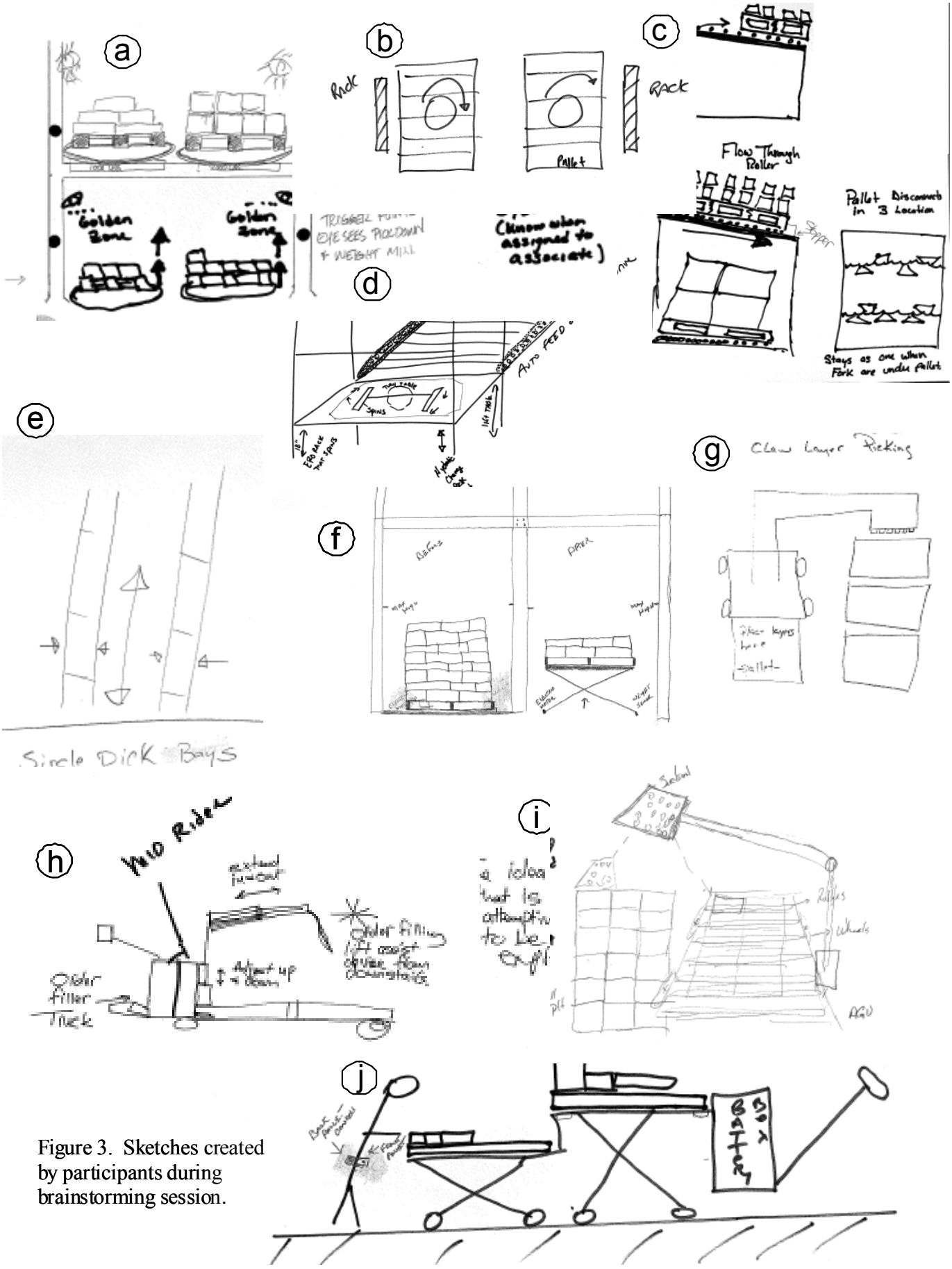

Figure 3. Sketches created by participants during brainstorming session.