Case Study in Ergonomics Problem Solving Process at a Beer Distribution Company

Kelsie Daigle[1(✉)], Colleen Brents[2], Molly Hischke[2], Rebecca Brossoit[1], Kelly Cave[1], Shalyn Stevens[1], and John C. Rosecrance[2]

[1] Department of Psychology, Colorado State University, Fort Collins, CO 80521, USA
kdaigle@rams.colostate.edu
[2] Department of Environmental and Radiological Health Sciences, Colorado State University, Fort Collins, CO 80521, USA

Abstract. The ergonomic problem-solving process is a uniformly consistent approach to address challenges presented in various environments. Steps include: (1) identification, (2) analysis, (3) brainstorm of possible solutions, (4) implementation (prototypes), and (5) evaluation. This process was conducted at a distribution company that delivered beer to commercial establishments. Less than 200 employees worked at the company. The first three steps of the ergonomic problem-solving process were carried out with warehouse and delivery workers. A safety climate survey was administered. Following data collection (delivery and warehouse tasks observations and a safety climate survey), employees participated in a workshop. The first session introduced work design principles (including product quality, customer service, efficiency, decrease risk of injury, and improve quality of work life) and how they aligned with the company's goals. Concepts were communicated in an interactive setting. During the second session, two separate groups discussed challenges specific to warehouse or delivery workers. Videos gathered during data collection were shared with workers. Researchers facilitated brainstorm sessions to address challenges presented in those videos. Identified challenges included errors in building orders at the warehouse to delivering keg up stairs and around tight spaces. One suggestion included shifting emphasis from individual pick-rates to team accuracy to stress accuracy over speed. Another solution from brainstorming involved standardizing communication policies with clients. This project covered the first three stages of the ergonomics solution development process (identification, analysis, and brainstorming possible solutions). Further collaboration with the company will incorporate the prototype, implementation and evaluation steps.

Keywords: Participatory ergonomics · Beverage distribution
Musculoskeletal disorders · Manual materials handling

S. Bagnara et al. (Eds.): IEA 2018, AISC 819, pp. 105–118, 2019.
https://doi.org/10.1007/978-3-319-96089-0_11

1 Background

1.1 Introduction

The wholesale beer distribution industry, classified as North American Industry Classification System (NAICS) 424810 beer and ale merchant wholesalers, employs approximately 40,000 workers in 1,300 organizations across the United States (North American Industry Classification System 2018). The number of workers might actually be higher, with an estimated 93,000 people in the U.S., averaging about 37 people per organization (McGrath 2003). The NAICS states that "this industry comprises establishments primarily engaged in the merchant wholesale distribution of beer, ale, porter, and other fermented malt beverages" (North American Industry Classification System 2018). The U.S. brewing industry has more than doubled in the last ten years, with over 6,000 breweries in 2016 (Brewers Association 2017). Increases in beer distribution jobs coincide with the brewing industry growth. Job tasks associated with beer distribution include lifting kegs and cases of beer, loading and unloading delivery trucks, carrying kegs and cases up and down staircases, among others.

The job design of beer distribution requires manual materials handling of kegs and cases of beer. Risk factors for musculoskeletal disorders have been associated with manual materials handling tasks (Hagberg et al. 1995; Marras 2000). Work design in warehouses and delivery routes require frequent lifts and repetitive motions that may put the worker at an increased risk of developing low back or upper extremity work-related musculoskeletal disorders (MSDs). There may also be psychophysical risks for MSDs at play in this industry, such as time pressure due to deadlines. The risk for MSDs and costs of such disorders should be of concern to the industry, practitioners, and researchers alike. Established in previous research, MSDs can increase compensation claims, health care costs, and prevent employees from rejoining the workforce due to injury or disability (Hagberg et al. 1995; Institute of Medicine 2001). Low back disorders are considered to be the most common MSD (Marras 2000). Musculoskeletal disorders are the most common work-related illness in the U.S., Japan, and Nordic countries (Putz-Anderson et al. 1997; Institute of Medicine 2001; Pope et al. 1991; Sjøgaard et al. 1993; Punnett and Wegman 2004). In 2011, MSDs accounted for one third of all lost work time (Bureau of Labor Statistics 2011). Importantly, rates of MSDs resulting is lost work time were higher in wholesale and retail trade compared to other industries (Bureau of Labor Statistics 2011). Previous studies have investigated low back motion during pallet loading and unloading (Jorgensen et al. 2005; Marras et al. 1997; Plamondon et al. 2017) While these studies are relevant to distribution industries overall, only a handful of studies are specific to MSD and the beer industry (Abaraogu et al. 2015; Jones et al. 2005; Ramsey et al. 2014).

An interdisciplinary team, consisting of occupational ergonomics and safety and occupational health psychology, applied the participatory ergonomic process at a beverage distribution company. The purpose was to assess the physical and psychosocial risk associated with possible MSDs of the upper extremities and low back with warehouse and delivery workers. This participatory approach utilizes the traditional ergonomic five-step process of (1) identification, (2) analysis, (3) brainstorm possible solutions, (4) implementation (prototypes), and (5) evaluation in conjunction

with input directly from the employees. Specifically, this action research process "combines intervention and research components into a systematic and integrated process that contribute to improving the systems performance and expanding general scientific knowledge" (Rosecrance and Cook 2000; Schurman 1996).

1.2 Project Overview

The beverage distribution company serves over 2,000 accounts in Colorado. Kegs and cases may be delivered to a variety of clients, such as restaurants, bars, liquor stores, and grocery stores. The employee base consists of 43.8% sales, 24.8% delivery, 19% warehouse, and 12.4% administration. Overall, the company is 81.9% male, with the majority of females working outside of the warehouse and delivery sectors. About 38.1% of the workforce are supervisors. This company's principles and mission demonstrate their commitment to prioritizing employee safety and well-being. However, the nature of the beverage distribution work presents challenges to this mission. Workers are at an increased risk for developing musculoskeletal disorders throughout the beverage distribution process (Pramitasari et al. 2015). Most manual materials handling tasks occur in either the warehouse filling orders or on delivery routes (shown in Figs. 1 and 2).

Fig. 1. A delivery worker loads a keg onto a dolly to transport it from the delivery truck to the customer's facility. Additional cases and kegs are shown in the truck bays.

The interdisciplinary research team accomplished the first three steps of the ergonomics process during August 2017 through January 2018. Initial meeting with the client help clarify the project goals and introduce the research team's expertise. The primary objectives were to assess the risks associated with beverage handling, conduct

Fig. 2. Warehouse workers build pallets of custom orders by transfer specific beers from large stacks onto a new pallet (shown in the bottom left corner).

an ergonomic assessment of the physical and psychosocial risks, conduct participatory workshops, and collaborate with current employees to develop recommendations to help improve work conditions. The purpose was presenting findings, risks, and possible solutions to the company's top leadership. The primary objectives of the beverage distribution company were to uphold their value of safety in the organization, recognize weaknesses, and identify possible interventions.

The research team observed work tasks, took photographs and videos, applied lift measurement tools, conducted a safety climate survey and unstructured interviews. Based on this data, the team identified risks for MSDs, as well as the safety-related strengths of the company. Employees were invited to participate in workshops where researchers discussed the goals of ergonomics and identifying risk factors in job tasks. Employees were invited to provide input in the solution development process and were encouraged to play an active role in overall company safety. Findings from the observations and safety climate survey were shared with top leadership.

2 Study Design

A participatory action research approach was applied to this study. "Action research is frequently used in applied behavioral sciences when investigating and implementing organizational change" (Rosecrance and Cook 2000). Using this process, investigators hoped to foster collaboration and participation between the research team and

employees (Israel et al. 1992; Schurman 1996; Rosecrance and Cook 2000). The research team took this approach for multiple reasons: to provide richer data (about the company, job design, tasks, and safety) and to empower employees to take ownership of the participatory ergonomic process. Chances of a successful ergonomic process are greater with increased employee ownership and participation (Imada 1991; Rosecrance and Cook 2000). Further, using the interdependence between the research team and employees, employee can provide their own insight and ideas, increasing the likelihood of behavior change and buy-in with the process (Elden 1986; Rosecrance and Cook 2000).

3 Ergonomic Process

3.1 Problem Identification

Risks associated with manual materials handling and possible MSDs were identified from four information sources: (1) observation and lifting measurements, (2) unstructured employee interviews, (3) workshops with employees, and (4) safety climate survey. An initial meeting between the safety director of the company and the research team initiated the problem identification process. During this meeting the safety director discussed what he considers to be their safety weaknesses and general safety principles of the organization.

Four site visits to the company's warehouse were conducted to observe job design and conduct lifting measurements. Researchers also photographed and filmed employees performing their assigned tasks. Risk associated with lifting tasks was assessed using the National Institute for Occupational Safety and Health Lifting Equation (NIOSH) lifting equation (Waters et al. 1993).

Researchers rode along with delivery employees on five occasions. During these 'ride-alongs', job tasks were observed to assess manual materials handling risks and to collect lift measurements. The NIOSH lifting equation was used to assess and rank lifting risks during delivery tasks. Details of delivery job tasks and the complex delivery environments were captured using photos and videos.

During these observations both in the warehouse and out on delivery, informal and unstructured interviews were held with employees to gauge their perceptions of specific tasks and possible risk factors. Working tasks were observed to determine where the most obvious risk factors (high forces, high repetition rates, and awkward postures) were present. Once the primary risks were identified, researchers utilized videos, photos, and measurement data to prioritize identified risks.

Safety climate measurements can serve as a leading indicator for safety behaviors and outcomes (e.g., predicting accidents and injuries) in a workforce (Beu et al. 2010; Neal and Griffin 2006). Safety climate, a psychosocial metric, is a measure of the overall perceptions workers may have about the value of safety within their workplace at a given point in time. Safety climate can be considered a 'snapshot' of the broader safety culture. Measuring shared perceptions of safety climate among all employees can help shed light on organizational safety related weaknesses and strengths that may not be visible during observation periods. If one area of safety climate was low, it could

indicate an area of safety that may contribute to a higher risk of MSDs. The safety climate survey included items from a widely-used, validated measure of safety climate (Neal and Griffin 2006). All safety climate items were rated on a scale of 1 (strongly disagree) to 7 (strongly agree). Higher scores reflected stronger agreement with the item. The safety climate measure comprised of eight dimensions, which assessed (1) management values, (2) safety communication, (3) training, (4) physical work environment, (5) safety systems, (6) safety knowledge, (7) safety motivation, and (8) safety behavior. The research team created and distributed this online safety climate survey, which was distributed via email to all employees and locations in November of 2017. Two versions of the survey were developed, one for supervisors and one for subordinates (those without a supervisory role). Employees were emailed using the Qualtrics online survey platform. All employees were informed that their participation was voluntary and responses would remain confidential. They were encouraged to complete the survey by management and by members of the research team. Three $50 raffle prizes were randomly awarded as further incentive for employees to complete the survey. Of 155 employees, 105 completed the survey (68% response rate).

3.2 Problem Analysis

The primary goal of the problem analysis step was to better understand job and task requirements and to determine specific circumstances responsible for the identified problem. Researchers focused on the specifics of the work tasks, equipment used, perceptions of safety, and methods of doing work. Videos, photos, observations, safety climate survey, and lifting measurements were used to analyze the problems identified. The team utilized quantitative measures of safety climate, the height of stacking or lifting, size of materials handled, distance traveled with load, reaching distances, and weight of cases or kegs. The team also asked employees and the safety director about the purpose or method of specific tasks and if they have tried other solutions or ways of doing things in the past.

Employees were invited to participate in workshops to discuss challenges in their industry. Due to the scope of risks associated with warehouse and delivery work, two separate workshops were facilitated. The first workshop introduced workers (in both warehouse and delivery areas) to the principles of good work design (efficiency, customer service, quality, and safety). Employees were also briefed on what factors can increase risk in a lifting task or job demand. Videos and photographs from the observational phase were used to demonstrate examples of risk in the beverage distribution industry tasks (such as lifts or job movements). Employees were asked to participate in this discussion. Rather than being directly told what risks were present in the examples, workers were asked to identify what they thought might constitute a risk to their safety. Near the end of these workshops, researchers discussed how employees can play an active role to influence production and safety culture within their own workplace.

After these workshops, the research team combined the qualitative data collected from employee-discussions with quantitative data to reanalyze the challenges to ensure accuracy. One-way quantitative data was analyzed using the NIOSH lifting equation (a tool developed based on biomechanical, physiological, and psychophysical factors to

compute a weight limit for manual lifting) (Waters et al. 1993). The computed recommended weight limit represents the maximum weight of an object that should be lifted under the given lifting conditions (e.g., height, distance traveled, twisting, reach, and the type of object being lifted). The lifting index, or measure of how much risk is associated with the lift, is calculated from dividing recommended weight limit by the actual weight of the object. A lifting index less than one indicates low risk, and greater than one indicates higher risk of developing MSDs. Ideally, a task has a lifting index less than one. Therefore, tasks with a lifting index greater than one were considered especially risky. This formula was applied to all the lift measurements the team conducted.

3.3 Solution Development Through Brainstorming

After the initial workshop, employees participated in a subsequent workshop broken into two groups (warehouse and delivery). The purpose of this workshop was to brainstorm possible solutions to challenges identified in the previous workshop. Employees were encouraged to speak freely about their solution ideas, acting as if they had unlimited resources to remedy challenges. The research team also proposed some solutions to further facilitate discussion and employee feedback. During this workshop, the team talked about possible prototypes, potential implementation, and evaluation methods. However, the full exploration of prototypes, implementation, and evaluation was not conducted during the extent of this project due to time and resource constraints.

4 Results

4.1 Observations, Lifting Equations and Discussions with Employees

Warehouse. General areas of improvement focused on MSDs risks and the three goals of ergonomics (quality, efficiency, and safety). The first common warehouse task discussed handling cases of beer. The average case of beer weighs 20 lbs. (9 kg). Warehouse workers move a high volume of cases daily. Due to the high volume, there opportunity for human error when compiling orders. Quality is a concern here because once those orders are compiled, they are loaded on trucks for delivery. Incorrect orders and extra case handling can occur if pallets are incorrectly built. Considering efficiency, after orders are completed on a pallet, they are loaded on a delivery truck. This pallet is weighed to identify filling errors. However, sometimes the weight differs even when orders are correctly picked. This results in pickers and supervisors recounting orders multiple times and handling cases of beer unnecessarily. There were multiple safety concerns regarding case handling in the warehouse. The cases differ in packaging, and therefore degrees of coupling vary between brand packaging. Some cases are challenging to lift and carry because they lack handles. Cases with handles seem to make lifting easier, but they encourage employees to stack them and carry multiples at a time, increasing their risk of developing MSDs. Cases can be stored anywhere between 4.0 in. (10.2 cm) off the ground when stored on a pallet to above the average

employees head (approximately 233.8 cm or 8.0 ft. tall). The cases on the ground require the employee to bend down to pick them up. The cases stacked overhead can require employees to climb on other cases of beer to reach them.
An updated order picking software (i.e., Pick Management Software) was one intervention ideas generated by the warehouse employees. Newer software could better tolerate error thresholds of weight per order. Currently, there can be a difference of 16 lbs. (7.25 kg) above or below the expected load weight. Additionally, if the pallet weight does indicate an incorrect amount, that employee must manually recount the order, locate a supervisor to approve the recount, and make appropriate changes to the order.

Another solution was to encourage accuracy over speed by removing picking speed from the order management system. While the company claims to prefer accuracy over speed, employees still feel pressure to work quickly. Employees also suggested hiring additional workers. They suggested this because errors usually occur with larger orders, especially during the busy season around holidays.

Investigators discussed the solution of purchasing a Rotating Load Leveler to ensure products are always at waist-level to endorse safer lifting. Additionally, the research team proposed having adjustable shelves with rollers so that cases were more easily accessible.

The second main task of warehouse workers involves keg handling. Full kegs weigh approximately 160 lbs. (72.6 kg). Warehouse workers pick keg orders based on their label. These labels are 'checked' with a mark to indicate what is inside. If they are labeled incorrectly they can cause a delivery error. The warehouse workers are responsible for loading and organizing pallets of orders for the delivery trucks. Often, kegs were loaded and stacked in ways that delivery drivers would have to reorganize their trucks to get to the kegs they needed first. This is a major efficiency concern. Additionally, kegs exceed the NIOSH recommended weight of 51 lbs. (23 kg.). Further, workers are moving quickly and using forklifts, which can cause potential for accidents and injuries.

Intervention ideas generated by the employees included using pallets to handle kegs. Consistently placing on a pallet guarantees that employees can use forklifts (instead of manually reaching) to transport kegs. However, the employee would also have to stack and organize kegs on the pallet in such a way it was balanced for the forklift. Regarding keg picking errors, employees suggested hiring additional workers to decrease the sense of being rushed. They also suggested rolling kegs off pallets onto the forklift when the pallet and forklift are at the same height. While this solution may decrease risk, it may also decrease efficiency. Further, they suggested kegs are purposefully organized at a safer lifting height for workers building upcoming orders. The research team suggested implementing a lifting partners system so employees would conduct team lifts to handle full kegs.

Delivery. General areas of improvement focused on MSDs risks and the three goals of ergonomics (quality, efficiency, safety). There were more areas for improvement for delivery than warehouse workers. Challenges surrounding maneuvering kegs on client staircases were one major area of potential improvement. Oftentimes, workers deliver to venues that lack elevators. Efficiency is a compromised because transporting kegs up

and down stairs in variable conditions is challenging and time consuming. Additionally, keg quality or cases of beer quality can be damaged if the product falls off the dolly. There is a safety concern because there is a high risk for back injury when handling kegs and cases of beer up or down. The company invested in a mechanized stair-climbing-dolly. Employees did not use this tool based on anecdotal evidence that the mechanized stair climber hurts their back more than the traditional dolly. Sometimes employees will carry two kegs stacked up stairs, or a keg with cases of beer on top, increasing the overall weight of the lift. Inclement weather makes this task more dangerous as well.

Intervention ideas generated by employees centered on revisiting the stair climbing dolly (including retraining and re-testing to make sure it is properly calibrated). Workers also suggested retraining on how to squat lift properly up the stairs. Frustration was expressed at the fact that the stairs or delivery site could not be structurally modified. They mentioned that even clients with elevators might not have the elevator functioning or maintained. The research team suggested designing a pulley system to help move kegs up and down stairs, or purchasing a new mechanized stair truck. During discussions between the researchers and employees, investigators learned that some deliveries sites can be mandated as two-man stops. This approach could help reduce the lifting load of the keg by distributing it across two people.

The environment in which workers were delivering the product presented another challenge. Coolers vary in size, organization, and cleanliness. Some employees were forced to reorganize and restack kegs from other companies simply to create space to deliver their own products, sacrificing efficiency. Multiple delivery coolers and storage spaces indicated a NIOSH lifting index greater than three. Lifting full kegs, 160 lbs. (72.6 kg), above the waist greatly increases the risk of developing a low back injury. Lifting cases in tight spaces often requires awkward postures and twisting. Tight delivery spaces can also increase the likelihood of damage to the product, decreasing quality. These tight spaces also have major implications for efficiency. Delivery workers may have to reorganize stacks of beer, which can reach 10 ft. (3.05 m) tall, simply to be able to maneuver their order. Narrow and tight spaces also decrease speed because the worker must cautiously and slowly maneuver the dolly around other beer products. Oftentimes, the walkway is just wide enough to fit the dolly though. Other debris and obstacles may litter the aisle ways, including uneven floors, spilled liquid on the floor, and broken glass, to name a few. Furthermore, these tight spaces limit how and where delivery workers can put their product. Frequently they have to stack cases of beer 10 ft. (3.05 m) or higher. To stack this high, workers craft makeshift stairs with other cases of beer. This strategy requires time and risks compromising product quality if they fall or step on cases of beer at awkward angles.

Solutions from both employees and the research team centered on communicating with clients on characteristics for a safe and efficient delivery space. This included defining a stacking height limit with the client, having a formal policy and procedure for debris (glass, spills, and uneven floors). Specifically, clients notorious for having have multiple obstacles and poor housekeeping practices (that increase the risk of injury to delivery drivers as well as damaged products) could be identified. Then the distribution company could work with these clients to develop a strategy of addressing these housekeeping concerns. New clients could be briefed on what constitutes good,

clean housekeeping practices as well. Additionally, the research team suggested that managers remind employees to avoid awkward postures and twisting while lifting.

4.2 Safety Climate

The average age of participants that completed the survey was 35 years old. Regarding gender, 81.9% of participants were male, 14.3% were female, 2.9% identified as "other", and 1% of employees chose to not identify their gender. For supervisor status, 38.1% of participants were in a supervisory role and 61.9% were not in a supervisory role. Next, 77.1% of participants worked at one worksite (where observations and workshops too place) and 22.9% worked at the other location. Finally, 19.0% of participants worked warehouse, 24.8% delivery, 43.8% sales, and 12.4% in administration.

Scale scores were created by calculating the average score of the items within a dimension (e.g., all items pertaining to safety behavior were averaged to create an overall measure of safety behavior). For individual items, percent agree is the percentage of participants who responded with somewhat agree, or strongly agree (i.e., responded with at least a 5 out of 7 for the item). For overall measures, percent agree is the percentage of participants who responded on average with somewhat agree, agree, or strongly agree (i.e., responded with at least an average of 5 out of 7 for all the items in a dimension). Wherever 'employees' are described regarding safety climate, this indicates any worker at the company who does not have a supervisory role. Wherever 'supervisors' are described, this indicates any worker who does have a supervisory role.

Overall, supervisors and employees both perceive very high levels of safety climate (m = 5.92, 96.2% agree). Similar levels of overall safety climate were found regardless of a worker's role (i.e., supervisor status), worksite, and department. Of note is that for all participants, safety motivation was the highest rated dimension; all participants agreed with each of the items related to safety motivation (m = 6.51, 100% agree for employees; m = 6.52, 100% agree for employees). However, the physical work environment dimension was rated the lowest of all dimensions for both employees and supervisors (m = 4.38, 21.5% agree for employees; m = 4.37, 38.5% agree). For example, over half of all participants believed that there were significant dangers inherent in the workplace.

Given that the physical work environment dimension was rated the lowest, further analyses were conducted to determine if this differed based on job title. Participants that work in the delivery department rated the physical work environment lower than participants that work in warehouse, sales, or administration departments. The mean rating of the overall physical work environment (i.e., the average of the items related to physical work environment) for delivery workers was 3.50 out of 7, with 5.6% reporting that they work in a safe environment. The mean rating of the overall physical work environment for delivery supervisors was 3.75 out of 7, with 12.5% reporting that they work in a safe environment. This is not surprising given the dynamic environment that delivery drivers work in. They are required to enter liquor stores, grocery stores, etc. that are not always maintained safely, or have cleared pathways.

4.3 Future Steps

Given the findings, the next steps in the process of ergonomic participatory process would be to specify prototypes and implement the recommended solutions. To do this, buy-in is required from top leadership, supervisors, and employees. Following the implementation of solutions, they should be evaluated. Evaluation should consider if the risks and problems were reduced, and how the solutions influenced the goals of ergonomics (efficiency, customer service, quality, and safety). Additionally, the solutions should be evaluated overtime to explore any longitudinal changes.

The distribution company in the present study wishes to achieve a specific health and safety certification status with the Occupational Safety and Health Administration (OSHA). Starting with findings from the present study and continued collaboration with the interdisciplinary team, the company is working towards becoming part of the Safety and Health Achievement Recognition Program (SHARP) Certified through OSHA.

While the present study covered the first three steps of the participatory ergonomics process, future collaboration to address the final steps (prototype implementation and evaluation) are hopeful for the future. Both the university and distribution company plan to continue interdisciplinary collaboration in the following academic year.

5 Discussion

Both employees and the workplace benefited from worker participation in problem identification, problem analysis, and solution development through participatory action research. Gathering employee perceptions of job tasks and risks helps ensure the researchers target their investigation in relevant and meaningful directions. Second, it helps gain employee buy-in for the implementation of solutions and future organizational changes.

We found multiple inherent risks in the beverage distribution company. One particular example was how employees regularly lift full kegs (160 lbs. or 72.6 kg.), which increases their risk for developing low back MSDs. In addition to the load exceeding NIOSH recommended values, the origin and destination heights are less than ideal.

Overall, the safety climate survey generated desirable results for the company, and highlighted their areas for improvement. These findings suggest that employees place a high value on workplace safety but still perceive aspects of the physical work environment to be dangerous. Workplace safety efforts should emphasize improving the safety of the physical work environment that employees are exposed to. These efforts could be particularly helpful for delivery workers' physical work environment(s), who had the lowest perceptions of safety in their physical work environment. Other target areas to improve workplace safety at this company could include emphasizing safety trainings, clarifying safety systems to prevent workplace safety incidents, and increasing communication about safety-related issues, as these dimensions of safety climate were also rated slightly lower compared to other dimensions (though were generally still highly rated).

6 Limitations

During this project, the first three steps of the ergonomic process were completed. Future collaboration between the interdisciplinary group and beer distribution company hopes to complete the final steps of the participatory ergonomics approach.

During the observational period, investigators were unable to communicate with all employees. Further, not every employee attended the workshops. Scheduling and time conflicts restricted interactions and participation. Therefore, findings may not be generalizable to all employees at the company and may not represent the most accurate picture of the MSDs risks in the organization.

The NIOSH lifting equation was applied to estimate risk associated with different lifting tasks. However the model has limitations and does not apply to one handed lifts, lifting tasks exceeding eight hours, seated or kneeling positions, restricted workspace, unstable objects, unreasonable floor coupling, high speed motion, extreme environments, and unexpected loading (Waters et al. 1993). Furthermore, the NIOSH lifting equation does not apply to combined motions such as lifting and carrying or wheelbarrow or shoveling movements (Waters et al. 1993).

Safety climate perceptions were very high, however, there were still evident risks of MSDs in the company. Additionally, the survey was a one-time cross-sectional measure of safety climate. Safety climate could change day to day, or fluctuate during busier seasons of production. This variation means that current survey findings might not reflect accurate safety culture.

7 Closing Comments

An interdisciplinary group of occupational ergonomics students and occupational health psychology students conducted a participatory ergonomics problem solving process with a beer distribution company in Northern Colorado. The first three steps of the process (1. Identification, 2. Analysis, 3. Brainstorm possible solutions) were completed over the course of an academic semester. Challenges for warehouse and delivery workers were identified and discussed. The interdisciplinary group facilitated workshops to educate employees on basic concepts of identifying risk factors in job environments. Employees were encouraged to contribute and share their perspectives on their own work experience during these workshops. Manual materials handling challenges around transporting cases of beer and full kegs were some situations addressed in the workshops. A safety climate survey was administered to supervisors and employees to gauge perceptions of safety support across the company. While overall high levels of satisfaction and safety support were measured, both supervisors and workers identified environmental challenges to safe distribution practices. The next two phases of the participatory ergonomics approach (4. Prototype and implementation, 5. Evaluation) will be continued during future collaboration between the interdisciplinary group and beverage distribution company.

Acknowledgments. The authors declare no conflict of interest. This study and publication was supported in part by the Grant T42OH009229 (Mountain and Plains Education Research Center),

funded by the Centers for Disease Control and Prevention (CDC). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the CDC or the Department of Health and Human Services. Additional funding for this project was from the CDC through the National Institute for Occupational Safety and Health (NIOSH) and the High Plains Intermountain Center for Agricultural Health and Safety, grant number U54 OH008085. The content is the responsibility of the authors and does not necessarily represent the official views of the CDC or NIOSH.

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