Evaluating Physical Demand of Palletizing - Depalletizing Tasks: An Application in a Soft Drink Company

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Abstract

The aim of this study is to evaluate the physical demands of the manual materials handling method that is currently used in a soft drink beverages company for palletizing and depalletizing soft drink beverage boxes, to assess the potential risk of injury and to recommend injury prevention strategies. The study utilizes three methods of evaluation namely, biomechanical, physiological and psychophysical. The results of this study revealed that both palletizing and depalletizing tasks pose significant risk on the lower back with depalletizing tasks involve more physiological and psychophysical workload than palletizing tasks. A set of intervention strategies have been developed and evaluated by the revised lifting equation of the National Institute for Occupational Safety and Health (NIOSH) of the USA. Implementation of these intervention strategies could reduce the severity of the investigated tasks.

Keywords
Palletizing and depalletizing manual tasks, intervention strategies, biomechanical, physiological and psychophysical methods of evaluation.

1. Introduction

Manual material handling is still unavoidable in many workplaces because of various reasons (e.g., economic considerations, practical situations, or social consideration). The industrial productivity is affected by the operator capability and well being. Preventing back injuries and other trauma to employees while handling materials manually is a major concern for companies involved in manual materials handling (MMH) activities today. How a company evaluates the job risks can affect the bottom line of a company. Misidentified risks such as under-rated job risk may increase the cost of workers’ compensation due to the injuries that could occur. In contrast, over-rated job risk may have the company spend money on job modifications that are not required. Control methods can be made to the physical work environment, equipment, tools, work processes, and employees’ behavior to reduce the number or level of the risk factors involved. Control methods, or sometimes called ergonomic intervention methods, can be thought of as solutions that eliminate or at least reduce employees’ exposure to risk factors. Risk factors are those job or task characteristics that increase the chance of sustained an injury. The more risk factors are present in a job, the greater the risk of employees’ injury.

As mentioned earlier, MMH evaluations are conducted in a variety of ways. Biomechanical, physiological, and psychophysical approaches have been used for many years to evaluate the manual materials handling stresses imposed on workers. However, since NIOSH published its Work Practices Guide for Manual Lifting (1981) and its revision (Watters 1993), those two documents have been widely used to assess manual materials handling activities. Many studies have been conducted to evaluate the work load involved in manual materials handling tasks and to assess the potential risk of musculoskeletal injuries in these tasks. Jones, T., et al. (2005) engaged in the analysis of the tasks related to three occupations-bartender, waitress, cook – within the pub environment. The aims of the study were to determine the biomechanical loads of job tasks identified as physically demanding for the three occupations analyzed; to assess the potential risk of musculoskeletal injury in these job tasks, and to recommend injury prevention measures. Risk of musculoskeletal injury was assessed with four validated methods. Tasks commonly and frequently performed were observed to pose some risk to the working populations and require investigation and changes soon as indicated by the upper extremity and low-back assessment procedures used. Mean combined
Compression at the lumbrosacral disc in common tasks have been demonstrated to exceed the action limit described by NIOSH. Ligament strain was observed to reach as high as 18% at the lumbosacral joint.

Wright and Haslam (1999) conducted an investigation into manual handling risks and controls within a soft drinks distribution centre. Methods used included semi-structured interviews, document analysis, analysis of training, working postural analysis system (OWAS) and use of the NIOSH lifting equation. Warehouse operators and delivery drivers were studied, and two methods of work compared involving pallets and cages. Significant differences were found between the two work methods with respect to harmful postures. Manual handling risks were found in both warehouse and delivery areas, some being classed as “excessive” using the NIOSH equation. Chung et al. (2005) investigated the effects of weight and stairway transport to evaluate the physiological workload involved in backpack-mode carrying of soft drink beverage boxes. They measure heart rate and oxygen uptake while carrying on the back. The results showed that stairways involved an increased physiological burden, and that a load of 60 kg entailed a significantly higher physiological cost than carrying a load of 40 kg. Thus, the worker should be advised to carry a load of less than 40 kg to avoid a high physiological load, and to make more trips with a light load rather than fewer trips with a heavier load per trip. Jorgensen, et. al., (2005) assessed the effects of pallet distance with regard to a constant lift origin on the torso kinematics and as a measure of low back disorder risk. Fifteen male participants transferred 11.3 Kg boxes from a constant distance origin to six different regions on a pallet. Two pallet distances with regard to the lift origin were investigated. The results indicated that increasing the pallet distance resulted in increases in torso kinematics as well as a measure of the risk of low back disorders. Taking a step during palletizing task does not appear to be an effective intervention strategy to reduce the risk of low back disorder.

In a study undertaken by Pradhan, et. al., (2007) to evaluate the workers of rice mills and food grain depots with respect to their nutritional status, workload, energy expenditure and musculoskeletal pain or discomfort resulting of work practice. Average peak heart rate of the workers suggested the workload as moderate to very heavy. Their average energy expenditure values also indicated the workload as moderate to heavy. Subjective assessment of the workers showed the workload as heavy for 60.7% of depot workers and 23.1% of rice mill workers. Besides the weight, awkward postures like bending and twisting of trunk adopted frequently causes musculoskeletal pain in knee and lower back of workers. Scott, and Renz, (2006) contended that it is the responsibility of modern ergonomists to take the results of scientific findings from the laboratory and apply the theoretical solutions in the field, for without application within a working situation, ergonomics loses much of its value. The aim of the current study is to evaluate the physical demand of the palletizing and depalletizing of boxes that are currently used in the Benghazi soft drink beverage company, to assess the potential risk of injury, and to recommend injury prevention strategies.

2. Experimental Method

2.1 Description of tasks
In the returnable glass bottles production line at Benghazi beverage company; the manual materials handling method was used to palletize and depalletize soft drink boxes from and to the production line conveyor. There are four workers alternating one by one or two by two to handle empty boxes from the pallets to the production line conveyor (palletizing) as shown in Figure 1. At the conveyor placed at the end of the production line there are four workers, at least three of them are to lift the full boxes from the conveyor and stack the boxes on the pallets (palletizing), as shown in Figure 2. The production line output rate fluctuates from zero to about 35 boxes/min. The soft drink box dimensions are (46 cm long x 30 cm wide x 23.5 cm high). It weighs 10.5 kg with empty glasses and 16.8 kg full. The pallet dimensions are (185 cm long x 76 cm wide x 15 cm high). Each pallet is loaded with 50 boxes distributed on five layers; ten boxes for each layer.
2.2 Identification of Ergonomic Risk Conditions
The following risk factors were identified in this workplace:
- Force: workers have to handle full boxes which weigh 16.8 kg each, and empty boxes which weigh 10.5 kg each.
- Repetition: frequency of depalletizing the empty boxes exceeds 16 boxes / min, and the frequency of palletizing full boxes is up to 12 boxes / min.
- Posture: the worker stands between the conveyor and the pallet, and he has to twist while handling the boxes, and must bend forward to reach the lower layers on the pallet.

When these tasks were evaluated by revised NIOSH lifting equation; the results of the Lifting Index was 5.8 in the palletizing task and 3.6 in the depalletizing task. The resulting values of Lifting Index indicated that these tasks would be hazardous for a majority of healthy industrial workers.

2.3 Subjects
Twenty male subjects free of cardiovascular disorders and musculoskeletal injuries volunteered for this study. They are currently engaged in manual materials handling jobs or jobs of similar nature that involve heavy use of muscular work. Subjects’ age ranged from 19 to 38 years. The average and standard deviation (SD) of weight, stature and age of the subjects were 75.5 kg (11.73), 176.1 cm (6.03) and 24.9 yrs. (5.66), respectively.

2.4 Experimental Design and Measurement
Prior to the experimentation phase, pilot studies were conducted to examine and refine the simulated task conditions and laboratory setup.

In the pilot study which was conducted to analyze the biomechanical loads, the subject postures were recorded by a digital camera and the WATBAK software was utilized to calculate the biomechanical loads (the peak compression and shear forces at the L4/L5 joint) on the lower back for each posture. The highest biomechanical loads were found when the subject stack the full boxes in the back of each layer of the pallet, These five postures were considered the postures to be analyzed to evaluate the biomechanical workload.

For the purpose of measuring heart rate; a heart rate meter was fitted around the subject’s chest with a receiver worn as a wristwatch displaying the instantaneous heart rate. The researcher observed the wristwatch and recorded the heart rate readings at fifteen second intervals. Heart rate measured once when the subject is at rest before the experimental tasks begins, and then during the last ten minutes of the second and third sessions.

In order to evaluate the workload psychophysically; the modified Borg CR10 scale was used, which is a category ratio scale with values from 0 nothing at all to 10 extremely strong. Subjects were required to give their ratings of perceived exertion to the following body parts: head and neck, shoulders, upper back, lower back, arms and hands, and legs.

The laboratory setup was based on actual workplace settings. The subject was required to perform the experimental tasks in a manner similar to the real tasks. In the case of palletizing, the subject put the pallet parallel to the table and stood between the table and the pallet and handle a full box from the table to the pallet and stack it on the pallet in the same pattern that is in the real task, with a frequency of 12 boxes per minute. The assistant returned the full box from the pallet to the table and adapted each layer by empty boxes as shown in Figure 3.
In the depalletizing case the pallet was put laterally to the table. The subject handles the empty boxes from the pallet to the table with a frequency of 16 boxes per minute as the actual frequency reaches to more than 16 boxes per minute, however, from the conducted pilot study frequencies more than 16 boxes per minute were found too hard and intolerable by the subjects as well as difficult to be controlled. The assistant returned the empty boxes from the table to the pallet stacking them in the same pattern used in the real task as shown in Figure 4.

2.5 Experimental Procedure
Experimentation in the laboratory included three sessions; the first session is a training session to allow the subject to familiarize himself with the meter he wears and the tasks he would be required to perform. This session lasts for twenty minutes; ten minutes palletizing full box with a frequency of twelve boxes per minute, and ten minutes depalletizing empty boxes with a frequency of sixteen boxes per minute. After finishing this session the subject was allowed to rest for at least 40 minutes before starting the next session. This 40 minutes rest was allowed to the subject between the second and third sessions as well. One of the second or third session is a palletizing session and the other is a depalletizing session, the sequence of them were alternatively assigned in order to minimize the influence of fatigue on the experimental results.

In the second and third sessions the researcher controlled the task frequencies at twelve boxes per minute when the subject palletized full boxes and at sixteen boxes per minute when the subject depalletized empty boxes. Ten minutes after the session began the researcher started taking heart rate readings every fifteen seconds and recorded them for the last ten minutes.

Immediately after finishing each of the second and third sessions the subject was asked to give his ratings of perceived exertion for head and neck, shoulders, upper back, lower back, arms and hands, and legs, and to record the ratings in a recording sheet. For the purpose of the biomechanical analysis, and at the conclusion of all experimental sessions; the subject was asked to perform the palletizing task and to stop at the postures when he places the box in the back of each layer in order to record these five postures by the digital camera.

3. Results and Discussion
The following is presentation of the results obtained. The results are classified according to the method of analysis namely, biomechanical, physiological and psychophysical.
3.1 Biomechanical results
The mean value and standard deviation of peak compression and shear forces for the five selected conditions (when the subject stack the full boxes in the back of each layer in the palletizing task) are shown in Table 1 and figures 5 and 6. It is clear that the mean compression force for all five layers are greater than NIOSH standard of 3400 N, and the mean values of peak shear force for the first, second and third layers (528, 559 and 533 N) exceeded the action limit of 500 N as suggested by McGill, et al.,(1998) which is a clear indication of the risk involved in performing this task.

Table 1: Mean values and standard deviation for peak compression and shear forces in palletizing task

<table>
<thead>
<tr>
<th>Layer no</th>
<th>Compression force (N)</th>
<th>Shear force (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>1</td>
<td>4648</td>
<td>663</td>
</tr>
<tr>
<td>2</td>
<td>5139</td>
<td>750</td>
</tr>
<tr>
<td>3</td>
<td>5305</td>
<td>629</td>
</tr>
<tr>
<td>4</td>
<td>5241</td>
<td>711</td>
</tr>
<tr>
<td>5</td>
<td>4943</td>
<td>619</td>
</tr>
</tbody>
</table>

Results of the analysis of variance, which evaluates the effect of layer height on peak compression force for a randomized complete block design, with blocking on subjects indicated that; the effect of layer height on peak compression force is highly significant (P-value < 0.0001). The results of Fisher Least Significant Difference (LSD) method showed that; first layer is significantly different from the other four layers and has the lowest mean value of compression force. The fifth layer is significantly different from the other four layers and has a mean value of compression force higher than the first layer and lower than the second, third and fourth layers. There is no significant differences between the second, third and fourth layers, and they have the highest mean value of compression force.

Figure 5: Mean values of peak compression force at each layer

Figure 6: Mean values of peak shear force at each layer
From Table 1 and Figure 5 the highest mean value of compression force of 5305 N was found at the third layer, 62 cm above the floor, and the lowest mean value of compression force of 4648 N was found at the first layer (bottom layer) 15 cm above the floor. The increase in compression force between lowest and highest mean value was 657 N representing a 14% increase of compression force. The results of the analysis of variance, which evaluates the effect of layer height on peak shear force indicated that the effect of layer height on peak shear force is highly significant (P-value < 0.0001). The results of LSD showed that the fifth layer is significantly different from the other four layers and has the lowest mean value of shear force. The fourth layer is significantly different from the other four layers and has a mean value of shear force higher than the fifth layer and lower than the other three layers. There is no significant difference between the first and third layers, and they are significantly different from the other three layers. The first and third layers have a mean values of shear force higher than the fifth and forth layers and lower than the second layer. The second layer is significantly different from the other four layers and has the highest mean value of shear force. From Table 1 and Figure 6 the highest mean value of shear force 559 N was found at the second layer, 38 cm above the floor, and the lowest mean value of shear force 334 N was found at the fifth layer, 109 cm above the floor (top layer). The increase in shear force between lowest and highest mean value was 225 N representing a 67% increase of shear force. Except for the first layer (bottom layer), shear force increases as the layer height decreases, this is can be explained, in part, by the increase of the trunk forward flexion which increases the shear force acting on the spine. However the first layer's shear force was different because there are no boxes on the pallet at that time and the subject bends his knees and advances forward which decreases the forward flexion of the trunk compared with the second layer.

3.2 Physiological results
The mean, maximum, minimum, and standard deviation of heart rate mean value at resting and for palletizing and depalletizing tasks are shown in Table 3. Figure 7 shows the heart rate mean value at resting and for the palletizing and depalletizing tasks.

<table>
<thead>
<tr>
<th>Task</th>
<th>Max</th>
<th>Min</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting heart rate</td>
<td>88</td>
<td>62</td>
<td>73.5</td>
<td>7.3</td>
</tr>
<tr>
<td>Palletizing heart rate</td>
<td>138.2</td>
<td>98.1</td>
<td>121.2</td>
<td>10.9</td>
</tr>
<tr>
<td>Depalletizing heart rate</td>
<td>159.6</td>
<td>104.3</td>
<td>139.5</td>
<td>12.97</td>
</tr>
</tbody>
</table>

Figure 7: Heart rate mean values at resting and for palletizing and depalletizing tasks

The mean value of heart rate for palletizing was 121.2 beats per minute, this workload could be categorized as moderate according to Sanders and McCormick (1993) and Kroemer and Grandjean (1997) classifications. In this study 7 of 20 subjects (35%) had their average heart rates exceeding 125 beats per minute thus indicating heavy work. Only 1 of 20 subjects (5%) was of an average heart rate under 100 beats per minute, indicating light work.
The mean value of heart rate for depalletizing was 139.5 beats per minute, this workload could be categorized as heavy work according to the aforementioned classifications. In this study 5 of 20 subjects (25%) had their average heart rates exceeding 150 beats per minute indicating very heavy work. Only 2 out of 20 subjects (10%) were of average heart rates under 125 beats per minute indicating moderate work.

The results of the analysis of variance, which evaluates the effect of work condition on heart rate indicated that the effect of work condition on heart rate is highly significant (P-value < 0.0001). The results of LSD test showed that; the three work conditions differ significantly from each other. Depalletizing mean heart rate is higher than palletizing mean heart rate, this is due to the increase in frequency from twelve to sixteen lifts per minute and the increase in horizontal distance between lift origin and destination in the depalletizing task. Which indicated that; depalletizing task involve more physiological workload than palletizing task.

3.3 Psychophysical Results

Mean values of rating of perceived exertion (RPE) of the six body parts for each task are shown in Figure 8. Mean values of rating of perceived exertion for the selected six body parts showed that; the neck and head perceived exertion in both tasks classified as very weak. Shoulders and upper back show similar mean values of perceived exertion in both tasks classified between weak and moderate. Hands and arms perceived exertion in both tasks which is classified as moderate. Legs perceived exertion in palletizing classified between weak and moderate, and in depalletizing classified as moderate. Therefore in the palletizing and depalletizing tasks investigated in this study a moderate perceived exertions found in the last four body parts. Low back showed the highest mean values of RPE, classified between moderate and heavy in the palletizing case, and as heavy in the depalletizing case with 30 % of the subjects perceived very heavy exertions. It is clear that the current method of manual material handling where the worker has to twist and bend his trunk repetitively in these tasks, put excessive demands on the worker in terms of heavy exertions on the low back. Results of the analysis of variance, which tests the effect of body parts on rating of perceived exertion indicated that the effect of body part on rating of perceived exertion for palletizing and depalletizing tasks is highly significant (P-value < 0.0001).

![Figure 8: RPE of the six body parts mean values for each task](image)

The results of LSD test showed similar results for palletizing and depalletizing tasks, where head and neck part is significantly differs from the other five parts and has the lowest mean value of RPE. Lower back is significantly differs from the other five parts and has the highest mean value of RPE. There is no significant differences between shoulders, upper back, arms and hands, and legs means. They differ from the other two parts and their means of RPE higher than head and neck mean and lower than lower back mean.

A paired t-test was conducted to test the differences between palletizing and depalletizing means of RPE for each body part. The results of the test show that; there is no significant differences between palletizing and depalletizing
tasks RPE mean values for head and neck, shoulders, upper back and arms and hands. However lower back and legs have a significant differences between palletizing and depalletizing tasks mean RPE. Where depalletizing task has a mean value of RPE for lower back and legs higher than palletizing task.

4. Discussion

4.1 Biomechanics
In this study the results of compression and shear forces at lumbar spine were used to evaluate the biomechanical workload involved in the current manual materials handling method to assess the potential risk of injury

4.1.1 Compression force
Comparing the mean peak compression force for the five layers (4648, 5139, 5305, 5241 and 4943 N) to the mentioned criterion (action limit 3400 N and maximum permissible limit 6400 N) that was set by NIOSH (1981), and comparing the mean peak shear force mean values for the five layers (528, 559, 533, 442 and 334 N) to the mentioned criterion (action limit 500 N and maximum permissible limit 1000 N) that was suggested by McGill, et al. (1998), it is clear that the current method of manual material handling where the worker has to bend his trunk while handling the load farther from the body puts great stress on the worker in terms of the substantially high compression and shear loads on the low back.

The difference between the lowest and the highest mean value of compression force was smaller than expected; the lowest mean value of compression force 4648 N at the first layer and the highest mean value of compression force 5305 N at the third, an increase by 14% (657 N). The effect of layer height from the floor on the compression force also was unexpected specially for the first layer (bottom layer) which is only 15 cm above the floor.

Marras et al. (2007) and Marras et al., (2007) have found the lowest mean value of compression force at the top layer and the highest mean value of compression force at the bottom layer, by an increase of more than 100 %.

The second, third, and fourth layers have higher compression force mean values, since their heights require from the subject to bend his trunk forward which increases the horizontal distance of the load from the spine. The trunk forward flexion increases the mechanical moment arm of the upper body weight which increases the compression force acting on the L4/L5 joint.

The effect of the horizontal distance of the load from the spine on the compression stress applied to the spine in the results of this study were consistent with the results reported by others. Waters et al. (1993) mentioned that biomechanical and psychophysical studies indicate that the increase in the horizontal distance of the load from the spine increases the predicted disc compression force.

Results of previous studies of palletizing and depalletizing tasks (Marras et al. 2007) have revealed that spine loadings increase as the layer height on the pallet decrease, lower layers represent the greatest loading on the spine. The previous results are not consistent with the results of this study, where the first layer (bottom layer) has the lowest mean value of compression force and a mean values of shear force lower than the second layer. This may be explained by that; subjects bend their knees and advance forward at the first layer since there is no boxes on the pallet at the first layer which enable the subject to advance forward minimizing the horizontal distance of the load from the spine and the trunk forward flexion. This result may give an indication regarding the effect of lifting technique on spine loadings when lifting from low layers of a pallet.

4.1.2 Shear force
The highest mean value of shear force occurred at the second layer where the trunk has its biggest forward flexion. And the lowest mean value of shear force occurred at the fifth layer (top layer) where the subject can stand with a slight forward flexion of the trunk. In except of the first layer (bottom layer), shear force increases as the layer height decreases, this is consistent with the results of previous studies of palletizing and depalletizing tasks (Marras et al. 2007). This is can be explained, in part, by the fact that the increase in the trunk forward flexion increases the shear force component (resulting from upper body weight and load forces) that act on L4/L5 joint.

4.2 Work physiology
Analysis of the physiological response indicated that excessive strain on the cardiovascular system was due to the
great demands placed on the working muscles by these repetitive tasks. The frequencies of twelve and sixteen boxes
per minute were found to be physiologically stressful for the subjects. This is consistent with the findings of
previous studies. Renz (2004) mentioned that researchers had found frequencies more than six handleings per minute
had a significant fatiguing effect. and Waters et al. (1993) considered frequencies above six lifts per minute to be of
high frequency.

4.3 Psychophysics
The psychophysical results are consistent with the physiological results; where the physiological workload in
palletizing was classified in the upper range of the moderate category and in depalletizing was classified in the
middle range of the heavy category. Lower back showed high RPE classified as heavy and very heavy for some
subjects; this is due to the strenuous nature of the investigated tasks where the subject perform a repetitive twisting
which causes a muscular fatigue of the lower back and increases the lumbar stresses. This is consistent with the
finding of a previous study by Elfeituri and Buseif (2006), for subjects who were bending the upper body while
lifting and twisting. He found that the highest level of physical exertion perceived by the subjects was that of the
back.

The results of this study revealed that depalletizing task involve more physiological and psychophysical workload
than palletizing task even though the empty box weight in the depalletizing task is 10.5 kg which is less than the full
box weight in the palletizing task of 16.8 kg. This is because that; depalletizing task is more repetitive than
palletizing task, and the distance between lift origin and destination in the depalletizing task is more than that in the
palletizing task which required from the subject to lift and carry the box when he lifts a box from the farthest area of
the pallet. This is consistent with the findings of Renz (2004) who mentioned that results of his study and previous
studies showed that frequency to be the main contributor to fatigue, particularly with combined manual materials
handling tasks.

5. Recommended Intervention
The recommended intervention strategies for the investigated tasks was developed by the application of revised
NIOSH lifting equation and the general rules of ergonomics for manual materials handling tasks. The goal of the
recommended intervention strategies is to reduce the physical demands by reducing the exposure to the risky
working conditions and stressful body movements.
The recommended intervention strategies are as follows:

- Rearrangement of the pallets with respect to the production line conveyor to be laterally arranged on one or
  both sides of the conveyor for both tasks as shown in Figure 9. Two workers are to be assigned for each
  pallet; one worker at each side.
- Increasing work force size to decrease the lifting frequency for each worker to be limited to five lifts per
  minute per worker.
- Training the workers how to lift without twisting.
- Reducing the weight of the full boxes by minimizing the box size, and / or reducing the weight of the
  empty glass bottle which weighs about 0.4 kg each, or by replacing the glass bottles by plastic ones.
Figure 9: Recommended workplace rearrangement for both tasks

The revised NIOSH lifting equation was used to evaluate the effect of implementing the above mentioned intervention strategies on the investigated tasks. The results showed that the composite lifting index for both tasks would be reduced to (CLI < 1), indicating that both tasks would be safe.

6. Conclusion
Evaluating the physical demands of the method currently used by the workers in the soft drink beverages company for palletizing and depalletizing soft drink beverage boxes has revealed that this method puts a great biomechanical stress on the worker in terms of high compression and shear forces on the low back. In terms of physiological response, these repetitive tasks are found to be physiologically stressful and can be classified as heavy work and very heavy work for some subjects. Psychophysical responses showed that rating of perceived exertion of the lower back can be classified as heavy and very heavy for some subjects. Therefore, the three criteria that were utilized to assess the current method confirmed that the method currently used in the soft drink beverages company for palletizing and depalletizing soft drink beverage boxes is potentially hazardous for most workers and in need for ergonomic intervention. Implementation of the developed recommended intervention strategies stated above could reduce the severity of the investigated tasks.

References