CONCLUSIONS

NIOSH researchers conclude that the ergonomic interventions used in this study reduce musculoskeletal stress and morbidity among driver-salesworkers. Modifications to the beverage delivery truck, hand trucks, and beverage packages and contents, used in combination with improved work practices, will significantly reduce fatigue, the amount of beverage handled per day, and awkward postures during beverage handling, and will improve work efficiency.

Recommendations in this report should be applied in order to meet the goals of the company, while not exceeding the metabolic and biomechanical abilities of driver-salesworkers. Favorable reports from the driver-salesworkers in the study about the effectiveness of these controls helped convince management that all new trucks should have these controls installed. Many of the lessons learned from this study and recommendations herein may be applied to other beverage delivery companies to control and prevent musculoskeletal disorders among driver-salesworkers. The following summarizes the major findings of this study.

The participants in this study who have suffered a musculoskeletal injury while delivering beverages had done this job, on average, for 20 years and were considered a "survivor" population with highly developed skills in beverage material handling. These workers may not be typical of the average beverage driver-salesworkers in this industry because of their considerable experience.

- Musculoskeletal hazards and metabolic demands were evaluated through the use of the Discomfort Assessment Survey, heart rate monitoring, biomechanical models, and observation of work practices. Based on this information, a computer analysis of psychophysical discomfort assessment surveys, the SDS data, and workers' compensation data, it is theorized that the beverage delivery person has a high probability of suffering a job-related musculoskeletal injury. According to BLS data the probability of such musculoskeletal injuries, in terms of days lost, is twice as high as for those in general manufacturing jobs.

- The Discomfort Assessment Survey (DAS) showed the key areas where workers experienced discomfort. In decreasing order these are:

  a. the lower back,
  b. back right shoulder,
  c. knees,
  d. left elbow, and
  e. neck.

  The assessment of physical demands of removing beverages from the truck supported an association between these activities and the location of reported musculoskeletal discomfort.

- The NIOSH lifting criteria showed that most of the beverage lifting tasks exceeded the recommended weight limit (RWL). This was based on a combination of beverage package weight and worker posture during beverage handling. Exposures, which were over 3 times the NIOSH RWL or lifting index (LI) exceeding 3.0, were common when beverage cases exceeding 40 lb were handled, especially when the cases were being removed from the truck.

- Beverage handling tasks were divided into high (beverage cases exceeding 51 lb), medium (above 38 lb to 51 lb), and low (38 lb and less) handling risks. Most tasks performed were high and medium risk for low-back injuries. The highest risk occurred when handling 16-oz glass returnable, 20-oz glass nonreturnable, 8-pack 2-L bottles, pre- and postmix tanks, and 5-gal bag-in-the-box. Handling individual cases of 12-oz cans produced the least amount of risk.

- Based on heart rate measurements, the beverage delivery person's job is classified as physically demanding. This indirect measurement of metabolism showed that the energy demands may exceed normal metabolic demands for an 8-hour day during peak delivery periods, especially during the summer and just before holidays. Work exceeding the normal demands, (i.e., average heart rate of approximately 120 bpm) translates to moderate or heavy work for most healthy workers.

- Ergonomic evaluations showed that the depth in the truck bays exceeded the normal reach limit of the workers (average reach 30 in., truck bay depth 40 in.). Extended reaches for heavy beverage cases may significantly increase the risk for musculoskeletal injuries. A good work practice is to move the beverage cases forward to the edge of the bay openings before lifting to reduce some of the risk.

- Avoidance of injury depends on several factors: (1) good work practices, such as parking trucks close to the entry area and not overloading the hand trucks; (2) pre-planning to minimize handling; (3) using and maintaining material handling equipment, such as hand trucks, conveyors, and hoists; and (4) providing and using ergonomic controls on the beverage trucks such as pullout steps, step holes, external handles, and slip-resistant surfaces.

- The ergonomic interventions applied during this study were successful in reducing metabolic and biomechanical demands during beverage delivery. Feedback from the driver-salesworkers about ergonomic controls was relayed to plant management and labor. In a one-year follow-up evaluation of the ergonomic interventions at this plant, it was observed that these improvements were made to the new trucks. If these ergonomic interventions were to be applied to the entire beverage delivery driver work force, a decrease in injury and illness incidence and in severity should occur.

RECOMMENDATIONS

Based on the findings of this study, the widespread implementation of the following recommendations should benefit most of the driver-salesworkers in the soft drink industry.

Engineering Controls

A. Drop-down shelves should be used when possible to separate beverages and reduce multiple handling. Additional shelving spaced at least 3 ft above and below the adjustable drop shelves should be used as needed, especially when new products are introduced to the market (see Figure 27). Careful shelving placement will reduce multiple handling of beverages.

B. Tank and bag-in-the-box (BIB) delivery should be considered when applying engineering controls. Tank cages should be kept in good repair with working latches that are lightly lubricated. Full pre- and post-mix tanks should be stored on the bottom of the bays; empty tanks and boxes for cups and lids should be stored in upper level bays. Tank and BIB driver-salesworkers should encourage customers to purchase 3-gal BIBs because they are easier to handle for all concerned.

C. Increasing the fleet of "low boy" tractor-trailers with 14 bays should help reduce injuries. Approximately 20–25 additional products and packages are introduced to the plant each year. Larger trucks with adjustable height shelving can help accommodate this variety of products and packages and reduce multiple handling of beverages. Ergonomic features that will facilitate beverage handling and reduce musculoskeletal stress include the following:

   1. External grab handles should be installed between all bay doors to improve biomechanical leverage when handling beverages in the truck.

   2. Anti-slip grit should be painted on all bay rails, foot wells, platforms, and steps

(including those for the tractor cab). Anti-slip grit should be reapplied when worn or when needed by the driver-salesworker.

3. Multiple-height drop shelves should be installed for all bays. An inventory of such shelves should be available and installed as needed for the delivery person. Shelves should be straight and well maintained. Shelf lock pins should be lubricated for easy installation and removal. Drop shelves should be properly aligned from front to back, and from left to right when installed in bays. Beverage loading operators should check shelves for proper alignment before loading beverage on the truck. If the delivery person determines that shelves are not properly aligned or that product is wedged between shelves, then shelves should be realigned before the truck leaves the plant.

4. Additional foot wells or pullout step bars with hooks to secure the step bar should be installed around tire wells for easier access to beverages stored above the wheels.

5. Pullout steps (stand-on platforms) should be considered on a case by case basis. Workers who request the pullout step should be given the opportunity to try them out, especially when heavy packages are stored in the upper levels of bays. The prototype pullout step used in this study should be modified with larger hand-hold openings to allow for foot clearance (4 in. × 6 in). The pullout step should be portable so that it can be moved to any bay of the delivery person's choosing. Rather than welding the step in place, lock pins similar to the drop-down shelves could be used.

6. A dual hand truck holder with high back should be installed. One 2-wheel and one 4-wheel hand truck should be offered to each delivery person so that they have more beverage transportation options with the hand trucks. Slot openings on the hand truck holders should be wide enough for the hand truck foot plate to easily slide in and out during storage and use.

7. Bay doors should be well maintained and repaired immediately if damaged. Bay door rollers should be replaced when needed and lubricated at least 4 times per year or more often as directed by the delivery person.

8. Bay door straps should be maintained and replaced when worn.

9. Adjustable-height, air-cushioned seats with lumbar support should be installed to reduce whole body vibration from the road.

10. The current computerized beverage billing and printing system on the trucks should be replaced. The driver-salesworkers indicated that the current method is slow, inefficient, and stressful. The printer is bulky and is located at the back of the cab; this requires the worker to assume a twisted position to download information from the hand-held computer unit. The printer also drains the truck battery overnight when it is cold since the printer draws current to keep the printing mechanism warm. A light-weight, rugged, portable, hand-held computer unit which meets the needs of the delivery person and company should be considered. Printers should be smaller, self-contained, and easy to access when printing receipts. The location of the printer and hand-held downloading device should be accessible on either side of the truck. Possible locations to consider are in the left and right front bays, or in the cab adjacent to and below driver and passenger seats. The present system of climbing in and out of the truck cab for each transaction is inefficient and may cause problems to the worker's knees due to repetitive climbing. Hand-held field units with telecommunications capability should be considered so that information can be transmitted directly to the plant. This would facilitate preparation of inventory for the next delivery.

Safety Features

A. Five-inch spot mirrors on the right and left door, a five-inch spot mirror mounted on the right side of the hood, and heated and motorized external rear-view mirrors would improve visibility for the delivery person, especially in the city deliveries where other motor vehicles can pass the truck on either side.

B. The 3-point seat belt is generally used for driving longer distances, but driver-salesworkers seldom used them in the city because they do not "buckle up" for just a few blocks. Driver education and input is recommended so that seat belt systems are used more frequently and do not encumber the delivery person.

C. The motion back-up alarm system used during this study was faulty. The driver-salesworkers did not receive training on how the device worked. When the alarm was activated, it was not clear to either the delivery person or the NIOSH personnel riding along when the truck was in reverse. A wide-angle camera mounted on the top rear of the truck, or an audible bell located at the rear of the truck to warn others that the truck is backing up may be a better system. Driver-salesworkers should be consulted for ideas to improve back-up safety systems.

D. Because delivery may take place early in the morning and may continue into the evening and because these beverage trucks make frequent stops in congested areas, the raised tail light package, wide-turn signal, and reflective safety tape around the trailer may make the truck more obvious to other motorists and pedestrians and may reduce the potential for accidents.

E. All safety enhancements to the truck must be in accordance with Department of Transportation and state motor vehicle regulations.

Hand Trucks

Two hand trucks should be available for each delivery person: one 2-wheel hand truck and one 4-wheel hand truck. If rough terrain is encountered or in snow, the 4-wheel hand truck can be used in the upright position as a 2-wheel hand truck. Balloon tires should be kept in good repair and properly inflated. Tire pressure should be checked on a quarterly basis or more often if needed. A pressure gauge and conveniently located air compressor and pressure hose (located next to the delivery person's hand truck storage area) should be available for these workers to use. L-shaped tire stems should be avoided; straight stems are easier to access when inflating tires. All moving parts on the hand trucks should be lubricated as needed. Replacement hand trucks should be available for driver-salesworkers to use when their own hand truck is being repaired. An ergonomically designed 2-wheel hand truck was not used enough for its performance to be judged. It did show promise in reducing biomechanical stress for the one worker who used it during beverage delivery. If such hand trucks are purchased, operators need training and practice before using them on a full-time basis. Feedback from the driver-salesworkers about performance is important because slight modifications may make the units more acceptable. One concern about the Equalizer™ was that it required more "foot" clearance (from the counterbalancing mechanism) and was less maneuverable in tight spaces.

Beverage Packages

The recommended weight limit under ideal lifting conditions (i.e., standing knuckle-height with the load next to the body) should not exceed 51 lb. Beverage handling should be analyzed using the revised NIOSH lifting equation to identify highly stressful tasks and to determine alternatives and optimum weight material handling options. Such options include repackaging beverages in smaller units, such as the 5-gal bag-in-the-box to the 3-gal bag-in-the-box; elimination of some beverage packages, such as the 16-oz glass returnable bottles; replacing glass containers with plastic containers, such as the 20-oz beverages; and use of material assist devices, such as gravity conveyors, hoists, fork lift trucks, and pallet jacks.

A. Beverage packages that are handled and are in excess of the NIOSH Lifting Index (LI) of 3.0 should be a priority for material handling limitations through engineering controls. Task analysis should be done first where posture (no twisting or excess forward bending) and location of the load (small horizontal distance between the load and body and at knuckle height) are optimized. Based on task analysis, heavy loads should be stored in the trailer bays that capitalize on the best posture and location for retrieval of these loads. During material handling, if the LI still exceeds 3.0, then engineering controls such as hoists, fork lift trucks, and gravity conveyors are encouraged. This approach should be used for all beverage packages stored in the bays to reduce biomechanical stress to the driver-salesworkers. Package weight reduction and better package design for easier handling, may be the most cost/effective improvements toward reducing musculoskeletal disorders among driver-salesworkers.

B. Plastic shells, such as the 2-L 8-pack, should be redesigned to a lighter 6-pack package or designed to better contain the 2-L beverages and make handling easier. The bottom of the 8-pack plastic shells should be redesigned so that the delivery person does not have to lift and pull the package forward when removing it from the truck. The redesigned 8-pack plastic shell observed during the follow-up survey appears to be an improvement over the shells evaluated during this study.

C. Lighter weight plastic pallets should be considered instead of heavy wooden pallets.

Work Practices

A. Ergonomic principles should be applied when loading the beverage truck; heavier beverage packages should be accessible from knee to mid-chest height. Examples include cases of 20-oz nonreturnable, 2-L, 16-oz returnable, pre- and post-mix tanks, and bag-in-the-box. Packages that are lighter in weight, such as cases of 12-oz cans and 16-oz sport drink (plastic containers), can be stored above shoulder level, but should not be more than 60-in. high from the base of the bay. This height will enable most driver-salesworkers the leverage to manually handle the cases of beverage. For safety reasons, glass containers should ***not*** be stored above shoulder level. Such packages are best kept at waist level or below to avoid head and eye injuries from falling bottles and broken glass.

B. Driver-salesworkers should park the truck as close to the delivery point as possible to reduce manual transportation distance.

C. Driver-salesworkers should take the time to turn the truck around if large orders are removed from both sides of the truck.

D. Driver-salesworkers should preplan the most efficient way for unloading the truck to minimize trips to and from the truck, without overloading the hand truck.

E. Beverage loads should not be double-stacked (i.e., side by side) on 2-wheel hand trucks nor should beverages be stacked above the hand truck support bar. This is of special concern when loads are transported up or down hills, ramps, or stairs.

F. Hand trucks and tractor trailers must be in good repair. When inspecting the truck for beverage inventory in the morning, driver-salesworkers should also perform a walk-around of the truck and look for problems, such as missing grab bars, shelving and shelving alignment, dented bay doors, etc. They should inspect the hand trucks, as well as ensure the tires are properly pressurized and in good repair. Problems should be fixed before the truck leaves the plant. Hand trucks that are not working properly in the field should be given to maintenance when drivers return to the plant. Another hand truck should be issued to the delivery person until the hand truck is repaired.

G. Seasonal trends should be kept in mind for self-pacing to avoid heat-related illnesses such as heat cramps and heat exhaustion. In the summer workers should drink plenty of water, take rest breaks when needed, and use air conditioning in the cab when available. They should have air conditioning in the cab if heat stress is a recurrent problem. When possible, drivers should adjust routes to reduce the work load on hot days.

H. Appropriate personal protective equipment can make the job safer and easier to perform. Such equipment includes gloves, safety shoes (light weight), and knee pads (for kneeling on floors to load vending machines or individual merchandising units).

I. Other items to consider include a retractable utility knife to cut shrink wrap and tape from palletized beverage packages; door wedges to keep doors open when bringing beverages into store or storage areas; and a light-weight, high-strength portable ramp when 4-wheel hand trucks are used to transport large orders over door thresholds.

Work Organization

A. Coordination between employees who load beverages on the delivery trucks and driver-salesworkers should be done on a weekly basis. Problems with loads, shortage of product, and suggested modifications to trucks for improved beverage handling for both groups should be documented. Strategies to minimize beverage handling for both groups of workers should be incorporated.

B. Light-duty jobs should be made available for injured workers. The jobs should be designed to facilitate their returning to work and to gradually integrate them back to full-time work. This can be done by having a second person in the truck to help service the route, or by assigning lighter loads to be delivered individually and heavier loads with a helper. Return-to-work policies following an injury should be medically managed by a qualified physician and physical therapist team who are experienced in occupational medicine and musculoskeletal injury prevention.

C. Consideration should be given to standardizing loads to reduce excess beverage handling by the warehouse loaders and driver-salesworkers. A standardized load may vary between driver-salesworkers, the type of route they have, seasonal demands, and new products offered. Analysis of the load sheets over time should suggest minimum choices for the core load (what is taken to the customers on a consistent basis) which could be modified as required.

D. Development of career progression jobs should be considered for the delivery person. Currently there are few jobs available, other than management, that are attractive to the delivery person. The independence, interaction with the public, outside work, and incentive salary make this job very appealing. On the other hand, the physical demands of the job are among the highest in private industry. The day-to-day manually handling 25,000 to 50,000 lb of beverages, driving a truck, maintaining a professional and pleasant disposition under all circumstances, and dealing with many other annoyances take their toll. As the delivery person ages, the job demands remain. The nature of this business is that the more successful the delivery person is, the more beverage is sold. One suggestion is to create a pre-sale position as the next career level move. The pre-sale position would be available to experienced driver-salesworkers who have established rapport with customers and know how to sell their product. The experienced driver-salesworkers could phase out of these jobs by training new employees on the delivery business and phasing the new employees in over time.

E. Loading the beverage trucks with a product that does not sell should be avoided. On average, 25% of the product loaded on the truck during this study was not sold on a daily basis. The end of day reports should be used to determine what is not moving and to avoid unnecessary loading of these products. This will reduce multiple handling by both the warehouse loaders and driver-salesworkers (and also save on fuel costs). If a customer is in need of extra beverage product(s), another delivery person can perform this service.

F. As more beverage packages are introduced to the market, there may come a time when it would be cost effective to split beverage routes, for example, one for carbonated beverages and one for others, such as juices, teas, etc. Experimenting with routes may be beneficial and may offer another career option for the experienced delivery person.

G. When an ergonomic or safety control is installed on a beverage vehicle, hand truck, or at a customer's establishment, the advantages and disadvantages to the driver-salesworkers and company should be evaluated; if found to be beneficial, the control should become standard operating procedure. For example, the external grab handles, adjustable height shelves, and slip-resistant grit paint for the trailer bays should be entered into the master book of standards by company fleet managers. This will ensure controls will be available for all trucks in the company fleet.

ROBBERIES

Suggestions for Decreasing the Chances of Being Robbed

1. Form a task force of experienced driver-salesworkers, safety specialists, immediate supervisors, labor, and management to discuss methods to avoid robbery and bodily harm of driver-salesworkers. Contacting local law enforcement agencies for suggestions may also help.

2. Develop an outline of the best strategies for decreasing opportunities for robbery and avoiding bodily harm. From this, develop an emergency preparedness and action plan. Successful strategies should be shared with all in the beverage delivery industry. Dissemination of this information can be done in the form of a newsletter and shared with route driver-salesworkers during periodic safety and/or sales meetings. The types of interventions which could be included for discussion or publication during the strategy sessions include:

    a. Scheduling deliveries during the daylight hours whenever possible;

    b. Installing directional spot lights on the front, side, and rear of trucks to "light up" the delivery area. This may be helpful during winter months when days are short;

    c. Training on conflict resolution and nonviolent response to robbery attempts;

    d. Working with the delivery stops to implement various types of engineering and administrative controls to reduce the risk of robbery. Examples of controls include improved lighting, work areas openly visible to the public, and increased staffing.

3. Work more closely with accounts to develop a reliable system of payment other than cash such as credit cards, business checks, and/or money orders. Because some businesses do not have established credit histories, development of a tracking system to encourage and establish a credit history is suggested.

4. When possible, coordinate route schedules so that deliveries are conducted when other driver-salesworkers are at the same account. For example, if a route stop looks unsafe, and there are no other delivery trucks at this account, then stop at another account and backtrack. If this is not convenient, then delivery on another day, at another time, or when a prearranged time is suggested.

5. Before entering high crime areas where some accounts are located, schedule a stop at an account with a good credit history and exchange cash for a business check. Banks and loan institutions are an alternative but exchange must be done with care. Employees have been followed by an assailant to these institutions and subsequently robbed. Vary times and routes for delivery to avoid a predictable, set schedule.

6. Other suggestions which may benefit the beverage delivery person include:

    a. Installation of safes on all trucks

    b. A credit-only transaction system

    c. Refusal of delivery to accounts where driver-salesworkers have been robbed

    d. Refusal of delivery where threat of bodily harm has occurred, or could occur.

Since a single solution may not fully address these safety concerns, the implementation of multiple interventions is recommended.

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APPENDIX A

Revised NIOSH Lifting Equation

This equation was used for selected manual materials handling tasks. The calculation for the recommended weight limit is as follows: RWL = Load Constant (LC) * Horizontal Multiplier (HM) * Vertical Multiplier (VM) * Distance Multiplier (DM) * Asymmetric Multiplier (AM) * Frequency Multiplier (FM) * Coupling Multiplier (CM) (* indicates multiplication). The multipliers in this equation are described in Tables A1, A2, and A3.

Table A1

Revised NIOSH Equation for the Design and Evaluation of Manual Lifting Tasks

COMPONENT	METRIC	U.S. CUSTOMARY
LC = Load Constant	23 kg	51 lb
HM = Horizontal Multiplier	(25/H)	(10/H)
VM = Vertical Multiplier	(1-(.003 V-75))	(1-(.0075 V-30))
DM = Distant Multiplier	(.82+(4.5/D))	(.82+(1.8/D))
AM = Asymetric Multiplier	(1-(.0032A))	(1-(.0032A))
FM = Frequency Multiplier	(see Table A2)	(see Table A2)
CM = Coupling Multiplier	(see Table A3)	(see Table A3)

Where:

H = Horizontal location of hands from midpoint between the ankles. Measure at the origin and the destination of the lift (cm or in.).

V = Vertical location of the hands from the floor. Measure at the origin and destination of the lift (cm or in.).

D = Vertical travel distance between the origin and the destination of the lift (cm or in.).

A = Angle of asymmetry—angular displacement of the load from the sagittal plane. Measure at the origin and destination of the lift (degrees).

F = Average frequency rate of lifting measured in lifts/min. Duration is defined to be: ≤ 1 hour; ≤ 2 hours; or ≤ 8 hours assuming appropriate recovery allowances (see Table A2).

Table A2

Frequency Multiplier

Frequency lifts/min	Work Duration ≤ 1 Hour		≤ 2 Hours		≤ 8 Hours	
0.2	1.00	1.00	.95	.95	.85	.85
0.5	.97	.97	.92	.92	.81	.81
1	.94	.94	.88	.88	.75	.75
2	.91	.91	.84	.84	.65	.65
3	.88	.88	.79	.79	.55	.55
4	.84	.84	.72	.72	.45	.45
5	.80	.80	.60	.60	.35	.35
6	.75	.75	.50	.50	.27	.27
7	.70	.70	.42	.42	.22	.22
8	.60	.60	.35	.35	.18	.18
9	.52	.52	.30	.30	.00	.15
10	.45	.45	.26	.26	.00	.13
11	.41	.41	.00	.23	.00	.00
12	.37	.37	.00	.21	.00	.00
13	.00	.34	.00	.00	.00	.00
14	.00	.31	.00	.00	.00	.00
15	.00	.28	.00	.00	.00	.00
>15	.00	.00	.00	.00	.00	.00

Table A3

Coupling Multiplier

Couplings	V < 75 cm (30 in.)	V ≥ 75 cm (30 in.)
	Coupling Multipliers	
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

APPENDIX B*

Information Relevant to the Design of Ergonomic Controls in the Beverage Industry Including Container Packaging, Container Handles, Push versus Pull, and Whole Body Vibration

Back Injuries

Eighty percent of all Americans will suffer low back pain sometime during their lifetime.[1,2,3,4] Over 30 million Americans currently experience low back pain;[5] 13 million of those cases have resulted in reduced ability to function.[6] Over ten million cases of back impairment have been reported among U.S. employees between the ages of 18 and 64.[6] Each year, seven million people will be added to the total number of Americans who have suffered back injuries.[7] Lost time from work has increased significantly over the past 30 years, while the incidence of low back pain has stayed the same.[8] Estimated total costs for low back pain exceeds 16 billion dollars annually (compensable and noncompensable) in the United States.[5] Low back injuries account for one-third of total workers' compensation claims paid by the Federal Government according to the U.S. Department of Labor Office of Workers' Compensation Programs.[9] The National Council on Compensation Insurance reported low back injuries make up 25% of the claims for indemnity benefits, claims made by workers who have lost time from work because of job-related injuries. A 1983 Massachusetts study by the Massachusetts Health Data Consortium found that back problems and back and neck surgery accounted for approximately one out of every three hospital stays paid for through workers' compensation, with nearly 30% of the total workers' compensation payments being spent on back cases.[9] Current estimates for low back compensation costs are approximately 6,807 dollars as the average or mean costs, and 390 dollars for the median.[10] The large difference between the mean and median shows that costs for low back pain are not evenly distributed; instead, a few cases account for most of the costs.[10] The higher cost for the few cases is attributed to more hospitalization, surgery, litigation, psychological impairment, and extended loss of time from work. Age, gender, and occupation are personal risk factors for the occurrence and severity of low back injuries. Older workers are more likely than younger workers to have severe back disorders.[11] More women than men are likely to have restricted-activity, bed disability, and lost work days.[12]

Hildebrandt[13] performed a comprehensive review of epidemiological studies on risk factors of low back pain. Risk indicators of low back pain include ***general***—heavy physical work and work postures in general; ***static work load***—static work postures in general, prolonged sitting, standing or stooping, reaching and no variation in work posture; ***dynamic work load***—heavy manual handling, lifting (heavy or frequent, unexpected heavy, infrequent torque), carrying, forward flexion of trunk, rotation of trunk, pushing/pulling; ***work environment***—vibration, jolt, slipping/falling; and ***work content***—monotony, repetitive work, work dissatisfaction.

*Special thanks to Tracy M. Bernard for her assistance in assembling the material in Appendix B.

Individual risk factors found by Hildebrandt include age, gender, weight, back muscle strength (absolute and relative), fitness, back mobility, genetic factors, back complaints in the past, depression, anxiety, family problems, personality, dissatisfaction with work or social status of work, tenseness and fatigue after work, high degree of responsibility and mental concentration, degree of physical activity, smoking, alcohol, coughing, and work experience.

Container Packaging and Container Handles

Container packaging and their handles are very important to the delivery person in making it easy to grasp, lift, carry, and position soft drink packages. Unfortunately, many of the packages are designed with poor material handling specifications, such as narrow handle clearance, pre-formed grips, and sharp edges. As a result, beverage material handling is less than optimal. The following is a summary of what is known about container packaging and handles.

Soft drink beverage products are sold in steel and aluminum cans (52%), plastic bottles (30.1%), and glass containers (17.9%) accounting for 53.3, 32.0, and 20.5 billion containers, respectively.[14] Beverage containers are sold in paperboard or plastic packages, or loose. In 1990, 36.5% of cans were packaged in paperboard, 56.7% in plastic, and 6.8% were loose. PET (plastic bottles) were packaged as 6% paperboard, 84% plastic, and 10% loose. Returnable glass containers were 95% paperboard packaging and 5% loose.[15]

Improving the operator/container coupling by providing handles has been recommended consistently. Handles can increase the maximum force exerted on the container and reduce task energy expenditure.[16] Drury, Law, and Pawenski studied more than 2,000 different box-handling tasks including beer and soft drink distribution, paper products manufacturing, and food distribution. Despite the evidence in favor of handle usage, only 2.6% of the containers have handles.[17]

Box handling is a task consisting of seven steps: pregrasp, grab, pickup, move/carry, put down, adjust, and release. Factors, such as handle position and handle angle, have a large effect on body angles (i.e., posture), physiological measures, and psychological measures.[18] In studying 2,000 industrial tasks, the most commonly used hand positions were one hand at the upper front corner of the box and the other hand at the lower rear corner. One of the many task factors that has been linked to back injuries is the amount of twisting of the upper torso relative to the hips. Drury, Law, and Pawenski also cataloged the amount of twisting which occurred during the 2,000 box handling tasks.[17] The observed pattern shows a considerable amount of twisting being performed, usually to the right, at the start of the task; almost no twisting during the task; and considerable twisting favoring the left at the end of the task.[17] Fewer than 20% of lifts are free from twisting at the start of the task.

Drury and Deeb studied two-handed dynamic lifting tasks to determine the best handle positions and handle angles.[18] There were nine possible hand positions defined on each side of the container. Positions 1 to 3 were at the top of the box, 4 to 6 were at the middle of the box, and 7 to 9 were at the bottom of the box. Positions 1, 4, and 7 were closest to the worker's body. Normally, the hand accommodates to handle angles both by deviating the wrist and by allowing slippage between the hand and handle.[16] However, Drury and Deeb allowed the handles to pivot in order to find the best handle angle which caused the wrist to maintain a neutral angle. Handle positions at the front of the box required optimum angles that were nearly vertical, while positions along the bottom required more horizontal angles. The height at which the box was held above the floor had a large effect on handle angle, so that no single angle was optimum at all heights.[18] In static holding tasks, angles of 70 degrees to the horizontal are recommended.[19] However, in the dynamic lifting task, a biomechanical analysis of the lifting resulted in the following recommendation: place handles in positions 6 and 8 with angles of 60 and 50 degrees, respectively, to the horizontal.[18]

The most common placement of handles in industry is in the 2/2 position (i.e., located near the top of the box at the center). With handles in this position, Drury and Deeb recommended that the optimum angle, which would give neutral wrist and slippage angles averaged over all stages of the lift, is 83 degrees.[18] Subjects' heart rates, rated perceived exertion (RPE), and body-part discomfort were also measured to determine whether the biomechanical recommendations were supported by the physiological and psychophysical responses. In a floor to waist lifting task, the symmetrical handle position 2/2 showed minimum discomfort. An angle of 70 degrees showed much less discomfort severity for all body regions as compared to 35 degrees.[20] The shape of a cutout handle (cutouts were 25 mm [1 in.] wide and 100 mm [4 in.] long with 25 mm [1 in.] diameter rounded ends) in a cardboard box was varied; a straight handle accommodated the hand shape better and a curved handle showed no significant differences when compared to a straight handle.

Push Versus Pull

Cart or hand truck pushing and pulling are common dynamic tasks in the beverage delivery process. In these tasks, a worker must exert enough force to push or pull the cart, but must also be ready to regain balance in case the cart moves unexpectedly. The potential instability of a moving cart often causes the worker to adopt awkward postures, resulting in over-exertion injuries.[21]

Chaffin et al. [1983] tested for maximal isometric position in one-handed and two-handed push and pull tasks at three different handle heights.[22] Previously, Ayoub and McDaniel found that optimal handle heights for pushing and pulling tasks should be between 91 (35.4 in.) and 114 cm (44.5 in.) above the floor;[23] Martin and Chaffin recommended maximum push/pull handle heights of between 50 (19.5 in.) and 90 cm (35.1 in.).[24] In the Chaffin et al. [1983] study, the maximum push/pull strengths were set to the strength level which the subjects themselves considered they exerted greatest push/pull strengths. The results showed that mean push strength (372 N) was significantly greater than mean pull strength (267 N).[22] When pushing, the subjects would incline the torso more than when pulling, thus using the body weight more effectively to assist in counteracting the push force on the hands.[25] Also demonsting that using two hands as opposed to one hand to perform the task significantly increased both push and pull strengths. Two-handed push strength was 42 percent greater than one-handed, while pull strength was 25% greater.[22] The height of the handle also significantly affected push/pull strengths when heights of the handle from the floor were 68 (26.5 in.), 109 (42.5 in.), and 184 cm (71.8 in.). A similar trend developed in both pushing and pulling strengths. The greatest strengths occurred at the lowest handle height, followed by the medium height, then the highest height. Strengths at the lowest handle height were significantly greater than at the highest handle height. However, through a biomechanical analysis, Chaffin et al. determined that the body posture required by the lower handle created the largest mean L5/S1 spinal compression (3600 N) which is greater than the NIOSH Action Limit (AL) for spinal compression.[22]

Lee et al. [1991] investigated the effects of dynamic hand truck pushing/pulling tasks on lower back stress resulting from both personal and task factors, including pushing and pulling force, cart moving speeds, and subject body weight.[21] Results indicated that at all handle heights, pulling resulted in a significantly greater compressive force on the L5/S1 disc than pushing for all subjects. Handle heights of 109.0 cm (42.5 in.) and 152.0 cm (59.3 in.) reduced lower back loading for pushing and pulling, respectively. Results also showed that the compressive force on the L5/S1 disc increased with increasing cart speed (1.8 km/h (1.1 mile/hour) vs. 3.6 km/h (2.2 mile/hour)).[21] Finally, peak compressive forces were most affected by subject weight and height.[21]

Whole-body Vibration

Beverage driver-salesworkers are subject to whole-body vibration from the delivery truck. Beverage delivery routes can vary from 40 km (25 miles) to over 124 km (200 miles). Often the truck cabs are not well insulated from the road, but the seats are insulated to absorb road shock. As a result, much of this vibration is transmitted to the driver. The following is a brief overview of whole-body vibration.

Whole-body vibration is harmful to the spinal system with the most frequently reported effects being low back pain, early degeneration of the lumbar spine, and herniated lumbar disc.[26] Gruber[27] tested the hypothesis that certain physical disorders develop with undue frequency among interstate truck drivers and that some of this excess morbidity is due in part to the whole-body vibration factor of their job. Vibration resonances occurring in the 1 to 20 Hertz (Hz) frequency region is transmitted to the whole body, mainly in the vertical direction, through its supporting surface as a result of direct contact with a vibrating structure. Maximum biodynamic strain is associated with trunk resonances occurring at about 5 Hz. A typical worker may be exposed to over 40,000 hours of occupational vibration over a 30-year period.[28] Biodynamic strain, microtrauma, and intraluminal/intra-abdominal pressure fluctuations that are known to be produced by truck vibrations have been postulated as being at least partially responsible for the development of certain musculoskeletal, digestive, and circulatory disorders among interstate truck drivers with more than 15 years of service. The combined effects of forced body posture, cargo handling, and improper eating habits, along with whole-body vibration, are considered contributory factors for such truck driver disorders as spine deformities, sprains and strains, appendicitis, stomach troubles, and hemorrhoids.[27]

The effects of whole-body vibration have been studied in several jobs, including crane operators,[29] personal motor vehicles,[30] and forklift operators.[31]

The incidence of permanent work disabilities due to back disorders in crane operators exposed to vibration was compared with a control group by Bongers et al. [1988]. This study concluded that crane operators with more than five years of exposure have almost three times the risk of incurring a disability due to intervertebral disc as a control group, and the risk increases to five in crane operators with ten years of experience.[29]

A case control study of the epidemiology of acute herniated lumbar invertebral disc in the New Haven, Connecticut area was conducted.[30] This study compared the characteristics of persons who had acute herniated lumbar intervertebral disc with characteristics of two control groups of persons who were not known to have herniated lumbar disc. It was found that the driving of motor vehicles was associated with an increased risk for developing the disease. It was estimated that men who spend half or more of their on-job time driving a motor vehicle are about three times as likely to develop an acute herniated lumbar disc as those who do not hold such jobs.

Brendstrup and Biering-Sorensen studied the effect of forklift truck driving on low back trouble.[31] The occupation of forklift truck driving submits workers to five conditions which can be assumed to increase the risk for contracting low back trouble, including assuming a static, sedentary position while driving; twisting the trunk in relation to the pelvis; stooping; bending the trunk in deep sideways positions; and vibrating the whole-body. Brendstrup and Biering-Sorensen used the responses to a questionnaire concerning low back trouble of 240 male forklift truck drivers who drove at least four hours daily as compared to two reference groups: skilled workers and unskilled workers. Forklift truck drivers had a statistically higher occurrence of low back trouble (65%) as compared to the control group of skilled working men (47%); however, no statistical difference occurred when compared to unskilled workers (52%). The forklift truck drivers had a significantly higher rate (22%) of absence from work due to low back trouble than both control groups (7% and 9%). It was concluded that forklift driving can be a contributing cause of low back trouble.

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APPENDIX C

Questionnaire Used in NIOSH Study to Determine Past Work Experience and Medical History

Data Sheet—Employee Job Description

The National Institute for Occupational Safety and Health Study at this facility

SUBJECT ID NUMBER. ______

LAST NAME ______ **FIRST NAME** ______ **SOCIAL SECURITY NUMBER** ______

AGE ______ **HEIGHT** ______ **FORWARD REACH** ______ **WEIGHT** ______

MAXIMUM HAND GRIP STRENGTH: LEFT HAND ___ ___ ___ **RIGHT HAND** ___ ___ ___

WORK HISTORY

When did you begin working with the company? ______ ______
MONTH **YEAR**

When did you begin delivering beverages for this company? ______ ______
MONTH **YEAR**

Since working for this company has this been your only job? ____ (yes) ____ (no)

Have you been continuously performing this job since you started (any other jobs)? ____ (yes) ____ (no)

Did you deliver beverages for any other company or at another facility? ____ (yes) ____ (no)

List any other previous work experience you have done in the last five years.

______
COMPANY NAME

______
COMPANY LOCATION

WORK ACTIVITIES

WHEN STARTED ______ ______
MONTH **YEAR**

HOW LONG AT JOB ______ ______
MONTHS **YEARS**

COMPANY NAME

COMPANY LOCATION

WORK ACTIVITIES

WHEN STARTED ____________ ____________
MONTH YEAR

HOW LONG AT JOB ____________ ____________
MONTHS YEARS

COMPANY NAME

COMPANY LOCATION

WORK ACTIVITIES

WHEN STARTED ____________ ____________
MONTH YEAR

HOW LONG AT JOB ____________ ____________
MONTHS YEARS

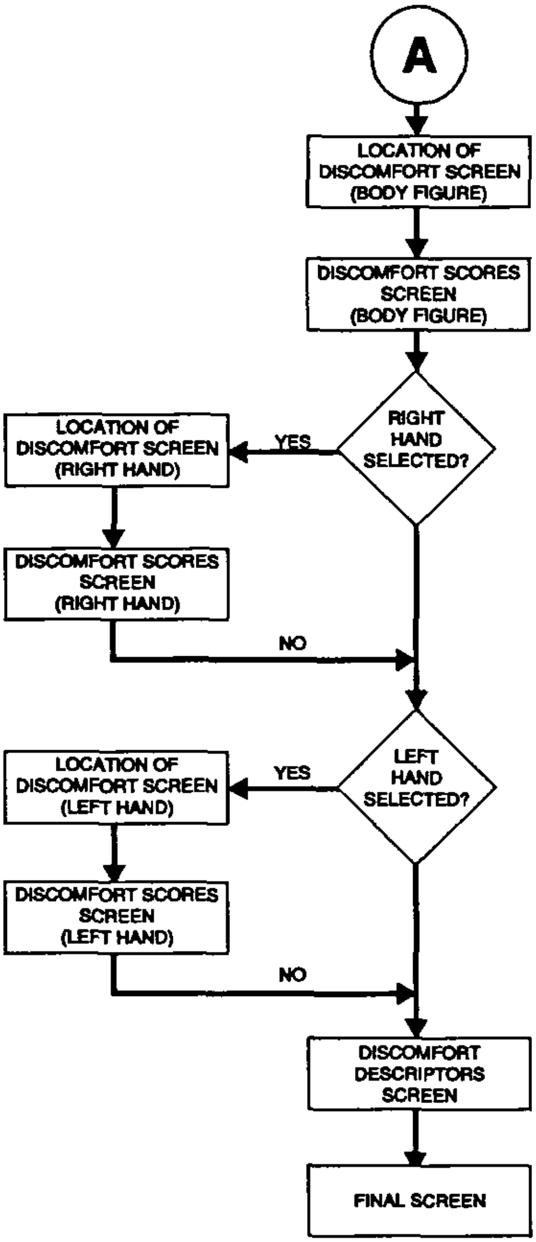
Do you have, or did you ever have, any musculoskeletal disorders while performing your job?
If yes, please explain.

Did you ever have time off as a result of a musculoskeletal injury? If yes, how long?

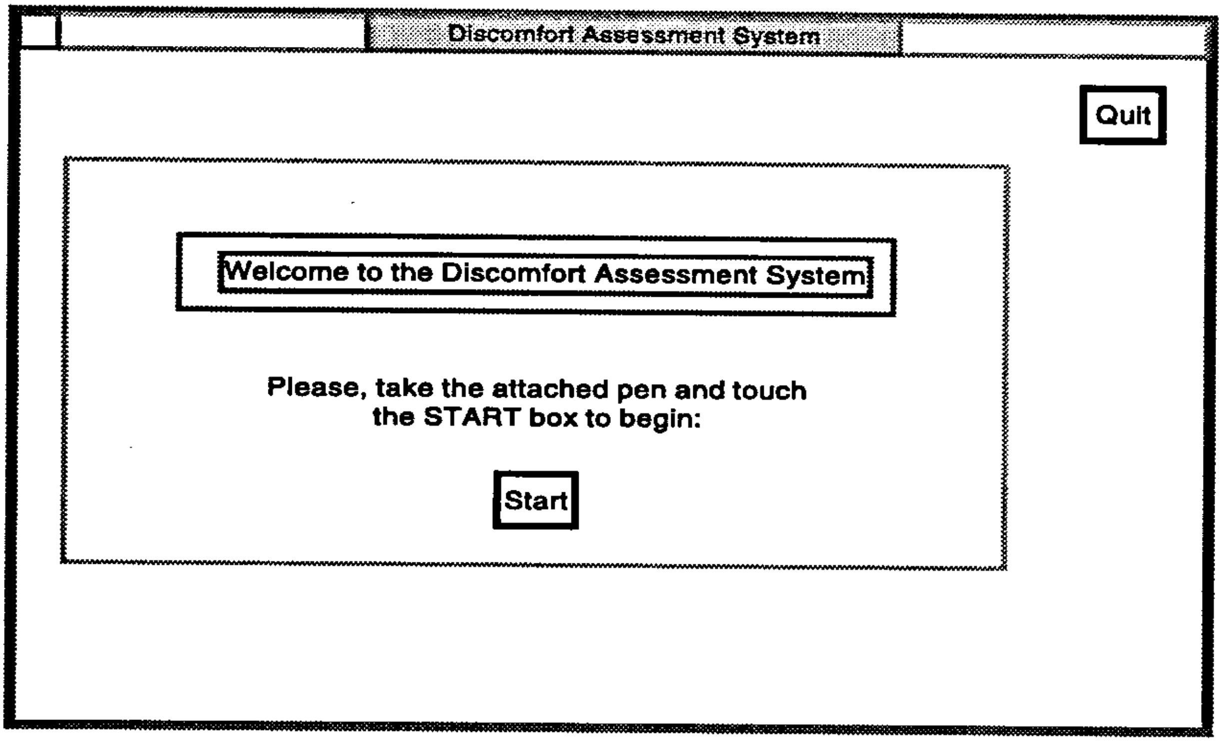
APPENDIX D

Figures Showing the Different DAS Screens Shown on the Computer

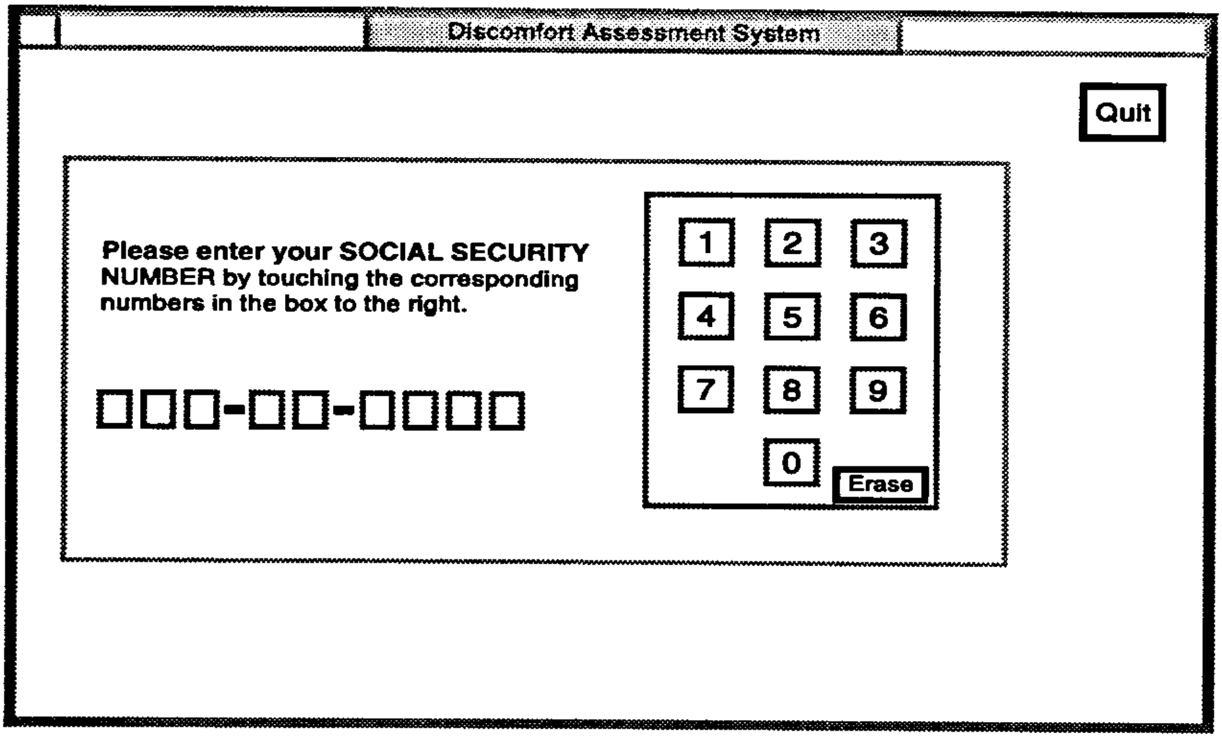
[Software program developed by Norka Saldana, Ph.D. in Partial Fulfillment of Dissertation University of Michigan, Center for Ergonomics, Ann Arbor, Michigan]



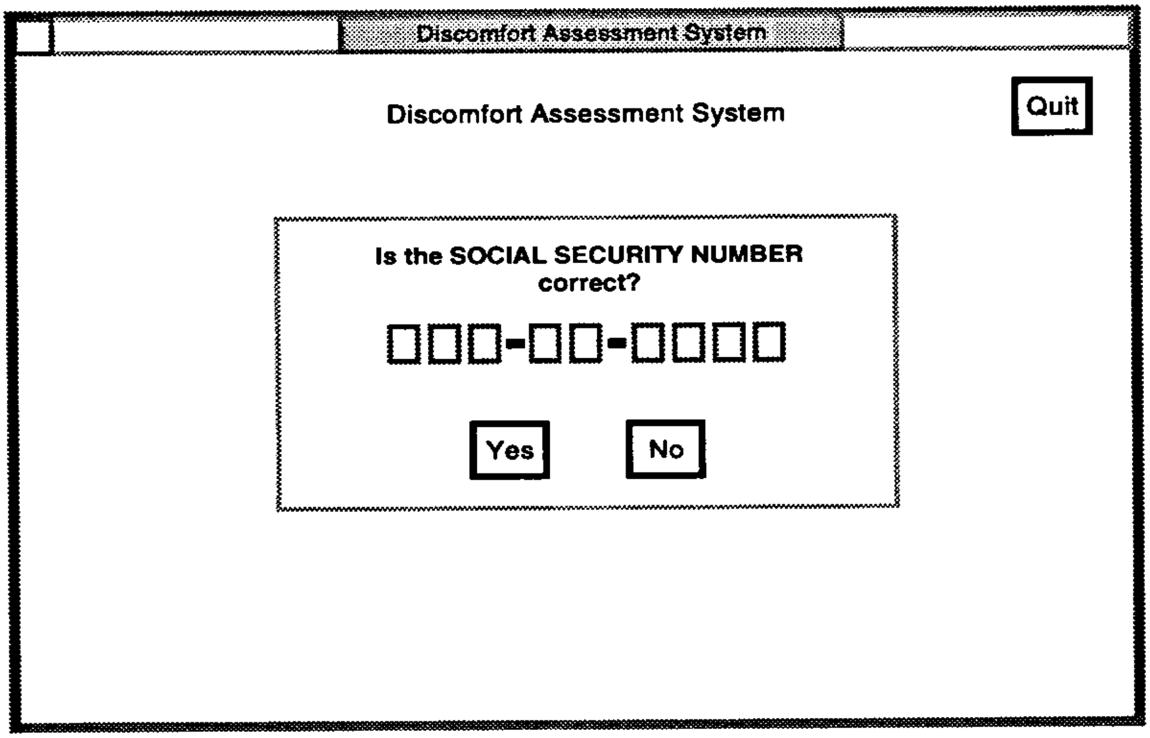
Architecture of Software Program



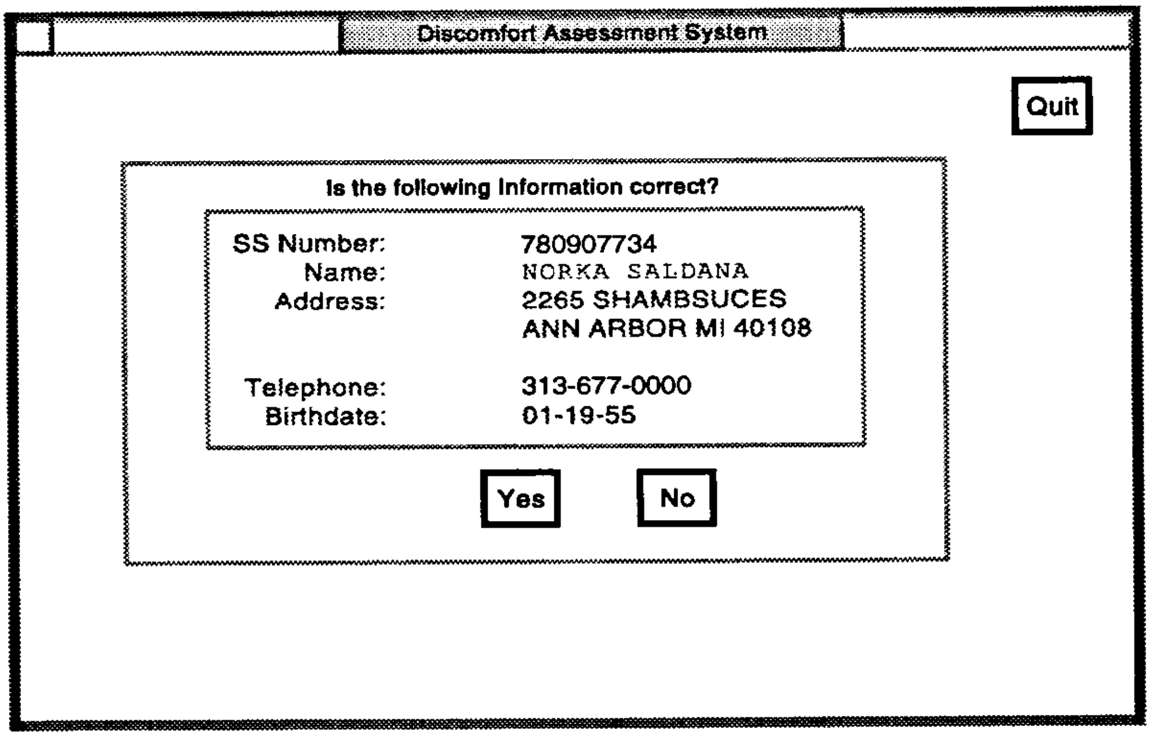
Welcome Screen



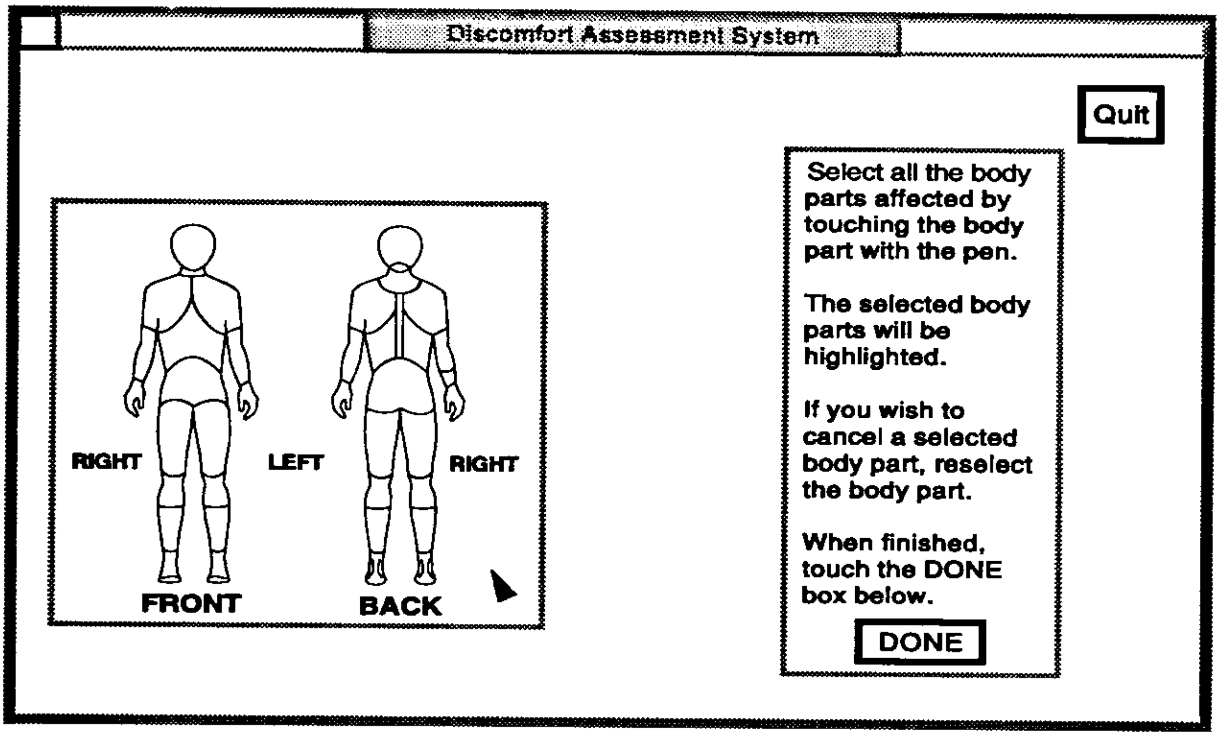
Social Security Number Screen



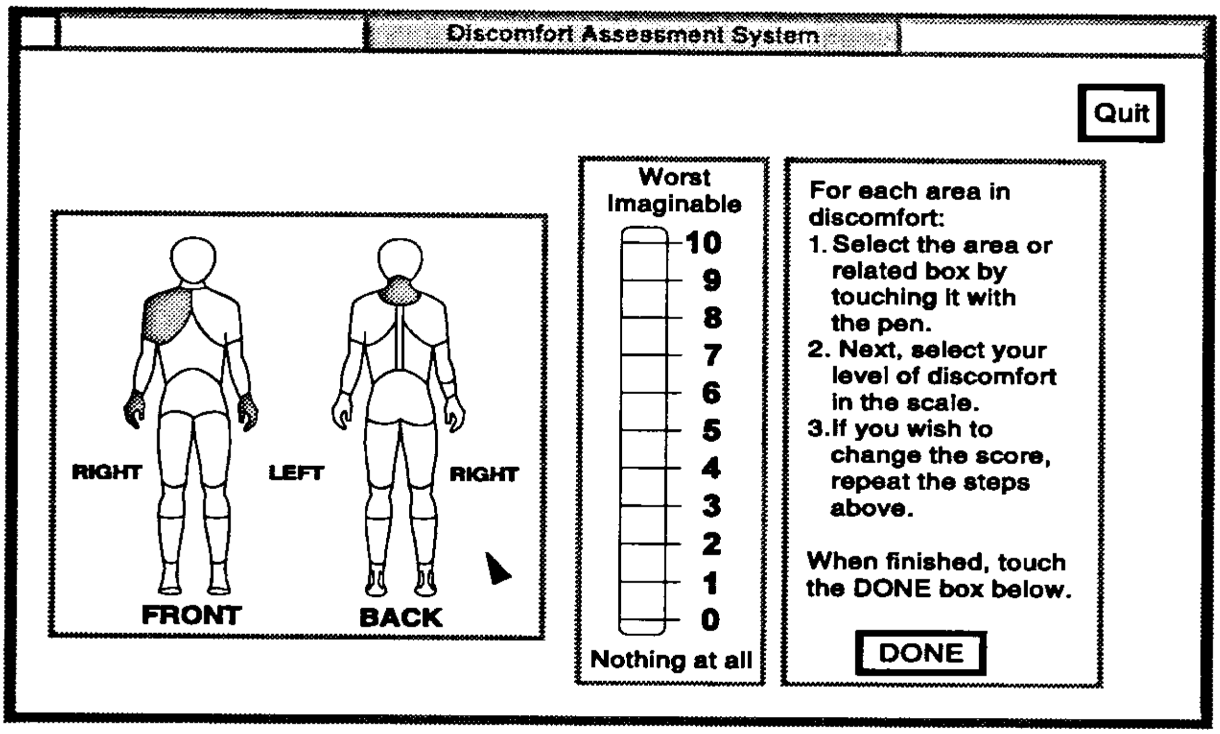
Social Security Number Confirmation Screen



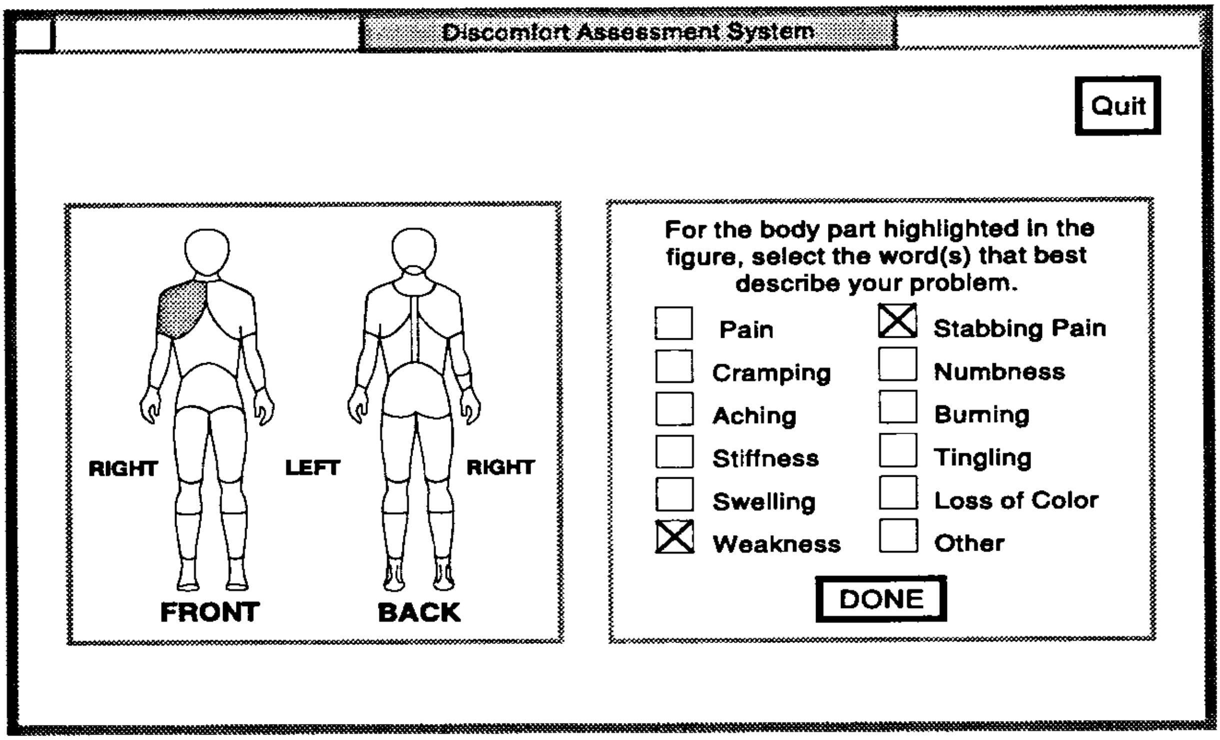
User Information Confirmation Screen



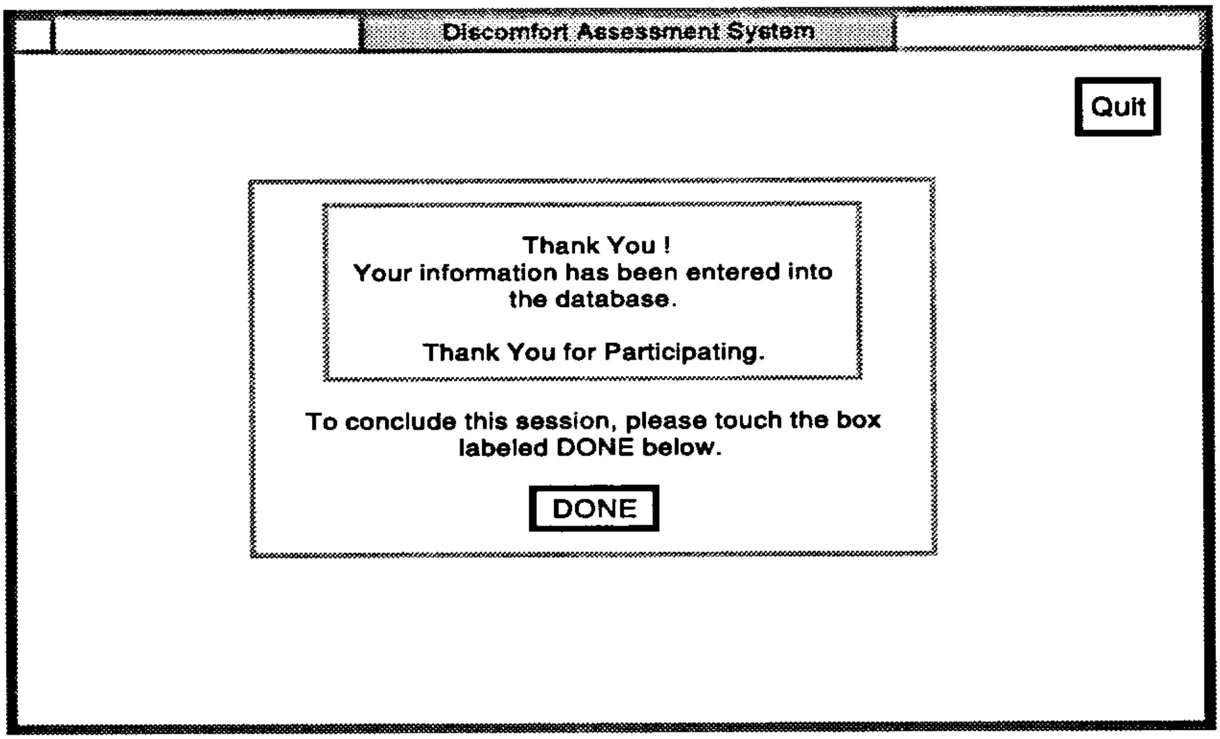
Location of Discomfort Screen (Body Figures)



Discomfort Scores Screen (Body Figures)



Discomfort Descriptors Screen



Final Screen

APPENDIX E

Selected Pictures of Activities and Associated Risk Factors for Musculoskeletal Injuries

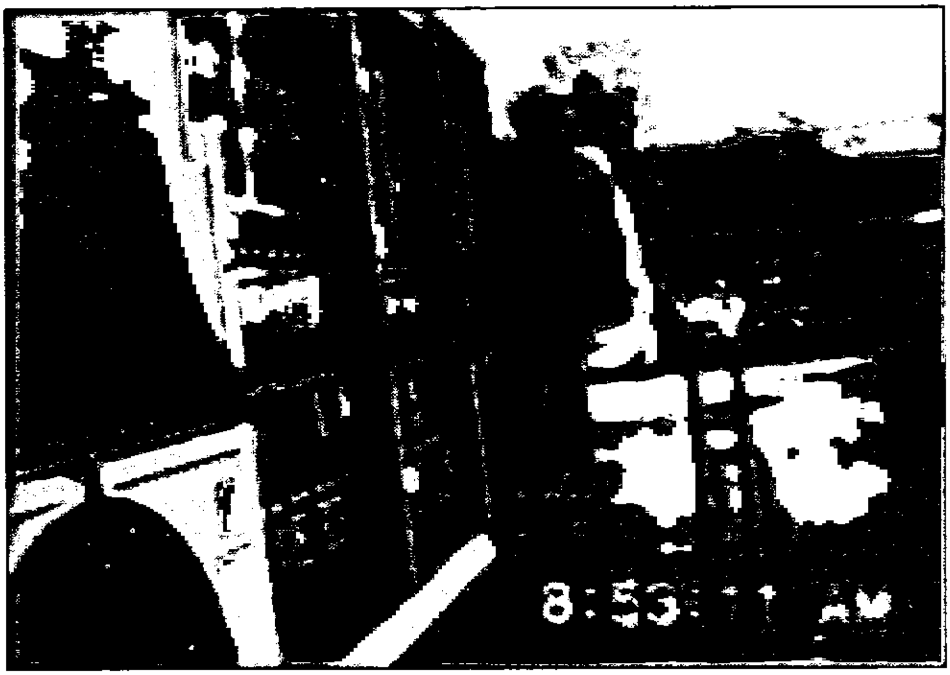


Figure E1. *Driver-salesworker lifting 24-bottle case of 20-oz glass soft drink beverages from truck while standing on platform.* **[Comment: Excessive reach was reduced by standing on platform. This reduces biomechanical stress on shoulders.]**

Figure E2. *Driver-salesworker placing 24-bottle case of 20-oz glass soft drink beverages on platform.* **[Comment: Driver-salesworker does not have to step off truck to place beverage case on ground.]**

Figure E3. *Driver-salesworker lifting 24-bottle case of 20-oz glass soft drink beverages from truck platform.* **[Comment: Excessive reach was reduced; lowered biomechanical stress on shoulders.]**

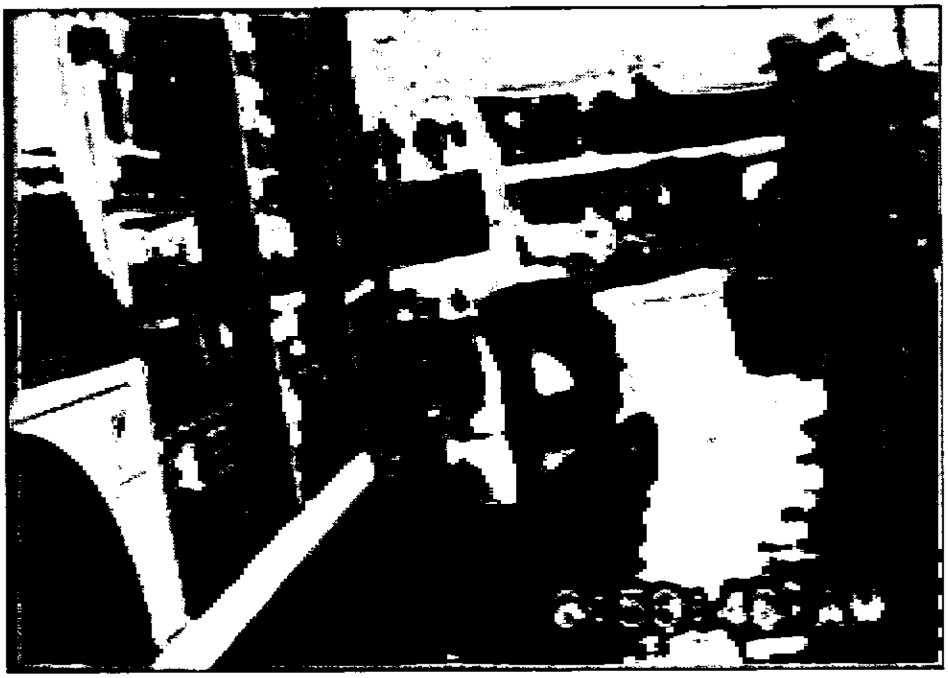


Figure E4. *Driver-salesworker placing 24-bottle case of 20-oz glass soft drink beverages from truck platform on hand truck.* **[Comment: Figures E1 through E4 show that beverage cases are handled twice by using truck platform. However, metabolic costs are less than biomechanical costs when beverage cases are handled once.]**

Figure E5. *Driver-salesworker lifting 8-pack case of 2-L beverages from truck not using truck platform.* **[Comment: Extended reach to access 8-pack 2-L beverage case. Driver-salesworker initially does not use platform, but later remembered to use platform (see Figure E6).]**

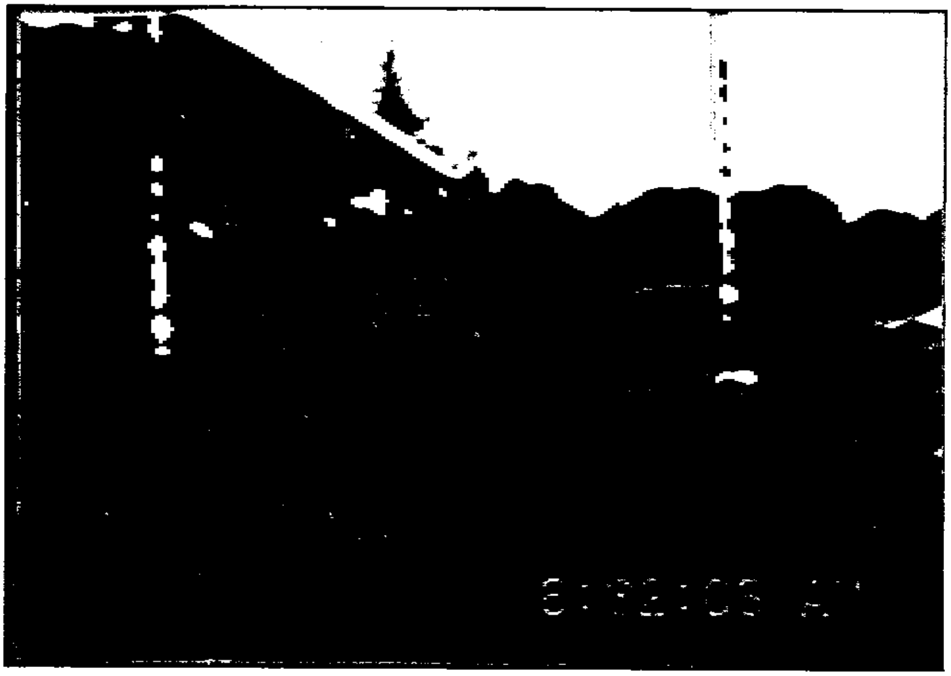


Figure E6. *Driver-salesworker using truck handhold to stand on platform to access 8-pack, 2-L beverage cases.* **[Comment: Driver-salesworker uses truck handholds to step on platform for easier access to beverages.]**

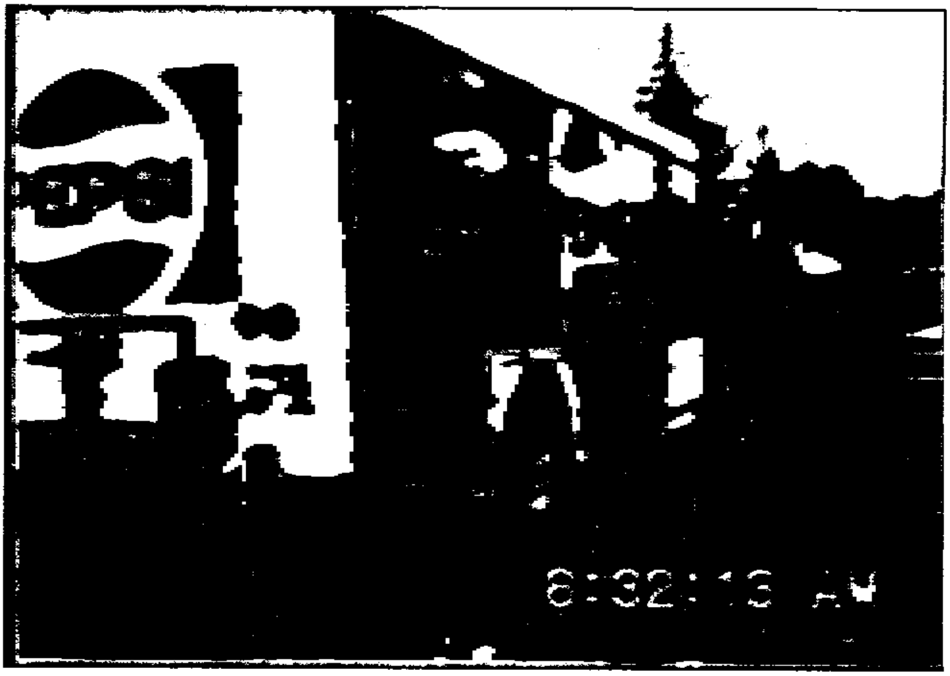


Figure E7. *Driver-salesworker lifting 8-pack, 2-L case from truck using truck platform.* **[Comment: Driver-salesworker uses platform to unload beverages from truck.]**

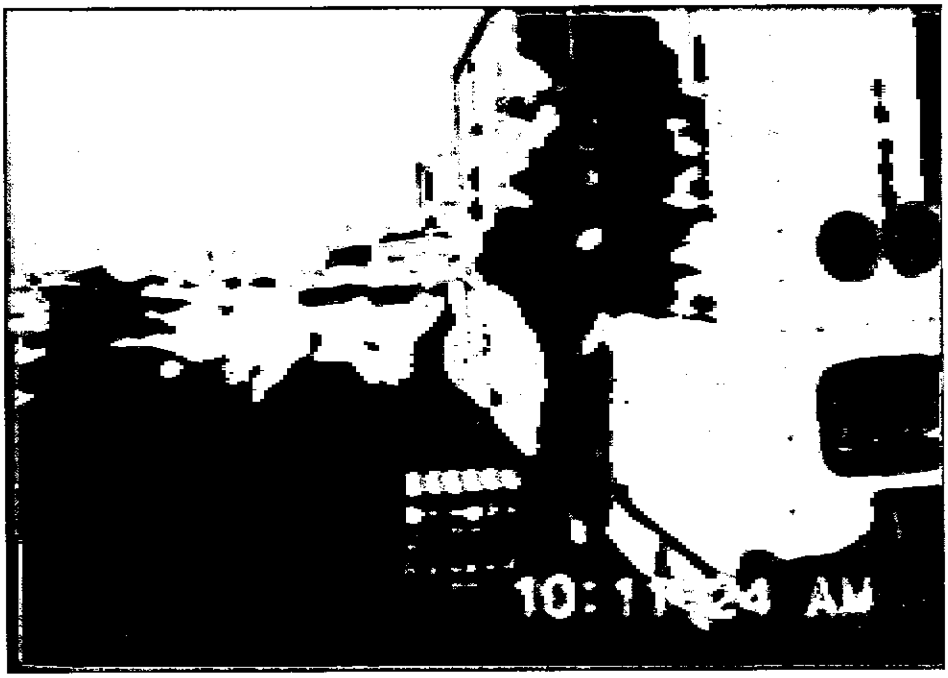


Figure E8. *Driver-salesworker using truck wheel bar and using handhold to improve leverage for lifting 24-pack case of 20-oz soft drink beverages from truck.* **[Comment: Driver-salesworker uses truck handles for leverage while getting 24-pack case of 20-oz beverage crates from truck.]**

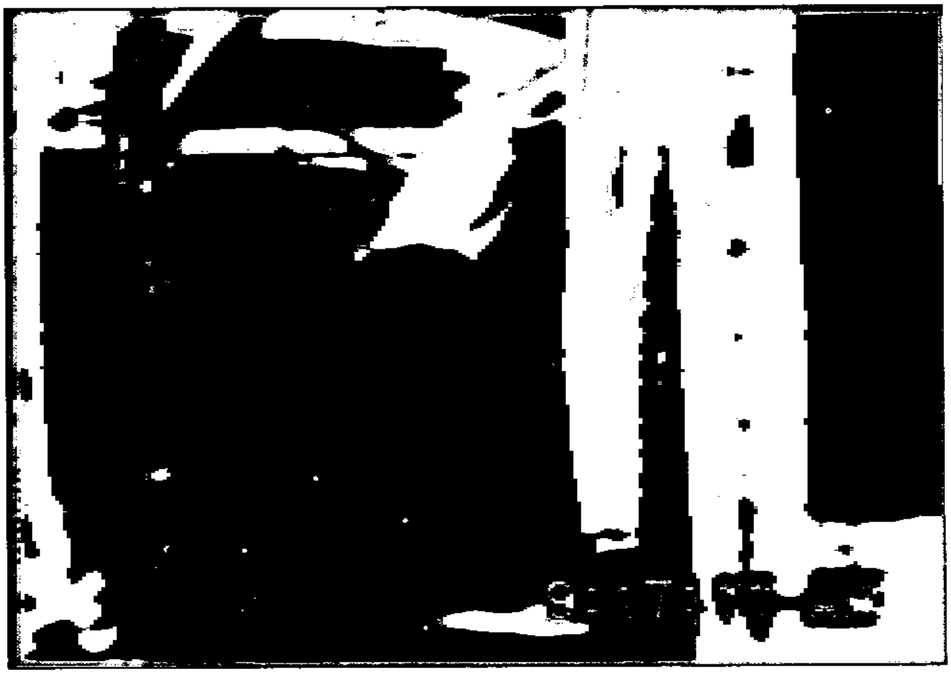


Figure E9. *Driver-salesworker getting printed receipt from printer located in the middle, back wall of truck cab.* **[Comment: Driver-salesworker is in an awkward posture to access the printer to get receipt. This may increase stress to the back. Excessive twisting was also observed when the driver operated the printer from the driver's seat.]**

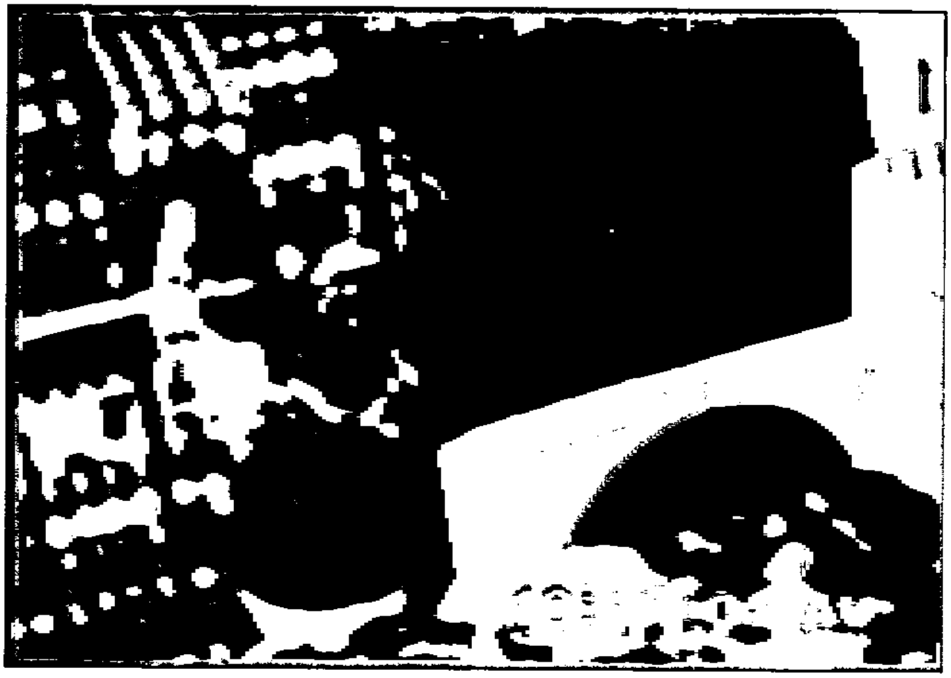


Figure E10. *Driver-salesworker unloading 24-pack case of 20-oz soft drink beverages from truck during snow storm.* **[Comment: Poor weather conditions add stress to job. Snow and ice may increase chances for beverages to slip out of hands and fall on driver-salesworkers.]**

Figure E11. *Driver-salesworker loading 8-pack, 2-L soft drink beverages on hand truck on high dock during snow storm.* **[Comment: Beverages are loaded on high dock on 4-wheel hand truck during poor weather conditions. The combination of extended reach, ice, snow, and cold increases stress to the arms and shoulders and may increase slip and fall injuries. Covered docks may help reduce slippery conditions and reduce some stress.]**

Figure E12. *Driver-salesworker lifting loaded hand truck (350 lb—includes weight of hand truck) up steps to store.* **[Comment: The combination of a heavy load, control of load, posture, and effort to pull load up steps create significant biomechanical loads on the back.]**

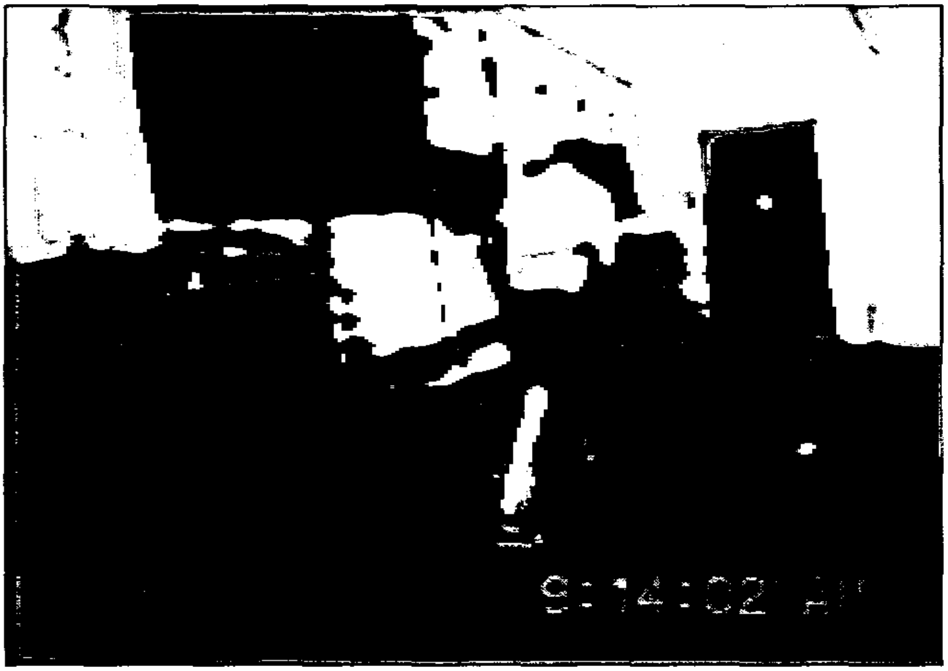


Figure E13. *Driver-salesworker pushing loaded 4-wheel hand truck (approximately 680 lb—includes weight of hand truck) up low grade hill to store service entrance.* **[Comment: Pushing or pulling loads up hill cause significant stress to the back and increase chances for slip and fall injuries if the foot and ground contact is not good.]**

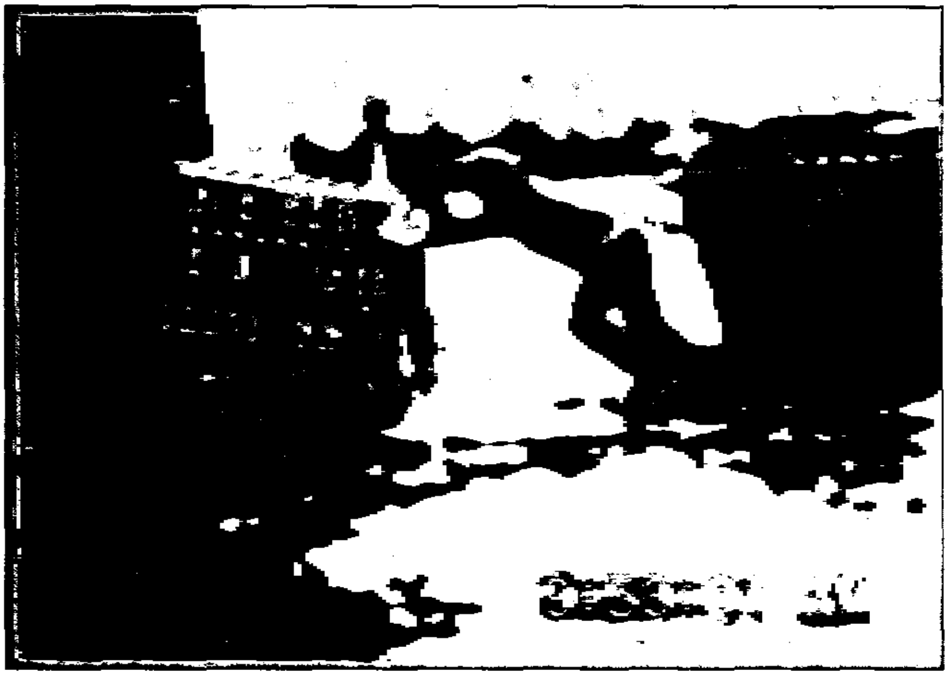


Figure E14. *Driver-salesworker pushing loaded 4-wheel hand truck (approximately 680 lb—includes weight of hand truck) up 6 degree ramp to store service entrance.* **[Comment: Pushing or pulling loads up ramps cause significant stress to the back and increase chances for slip and fall injuries if the foot and ground contact is not good. Longer, lower grades are recommended over short, steep grades.]**

Figure E15. *Driver-salesworker stooped over while loading beverage cooler with individual servings of 20-oz soft drink.* **[Comment: Stooped over posture increases stress to the back even though materials handled are low in weight. It is recommended that driver-salesworkers kneel on one knee and keep back more erect to perform this task.]**

Figure E16. *Driver-salesworker stocking shelves with 24-can cases of 12-oz soft drink.* **[Comment: Stooped over static postures with heavy loads significantly increases stress to the back. It is recommended that driver-salesworkers kneel on one knee, handle one case at a time, and keep back more erect to perform this task.]**

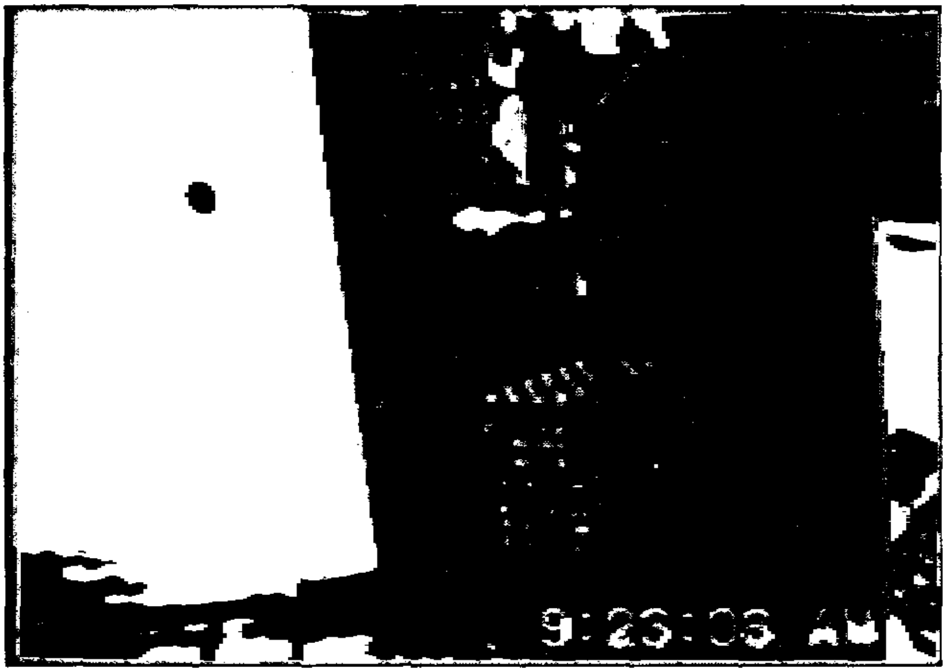


Figure E17. *Driver-salesworker loading beverage cooler with individual servings of 20-oz soft drink.* **[Comment: Driver-salesworker loads beverages in cooler while kneeling. This work practice reduces stress to back. However, knee pads may help reduce stress to knees.]**

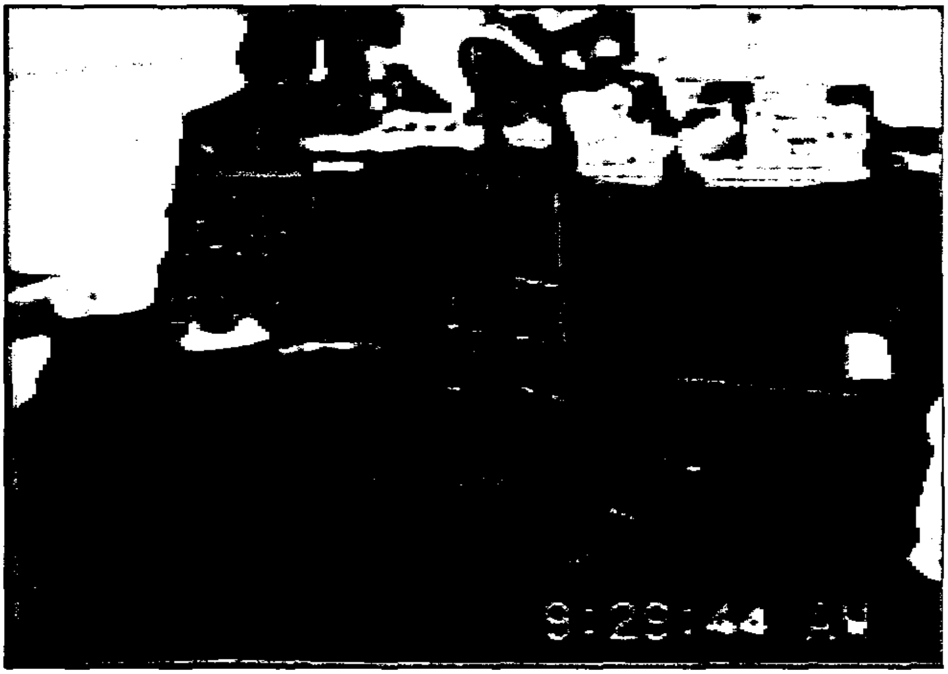


Figure E18. *Driver-salesworker loading 53-lb bag-in-the-box (BIB) under the counter.* **[Comment: Driver-salesworker has to get into awkward posture to position the BIB under the counter. This causes stresses to back and knees. The BIBs can be loaded on a small cart with wheels and moved in and out of this space.]**

Figure E19. *Driver-salesworker lifting 8-pack of 2-L beverages from truck.* **[Comment: Slip and fall hazard exists from standing on narrow ledge while removing beverages. Pullout platform may reduce slip and fall hazards.]**

Figure E20. *Driver-salesworker stepping off truck with 8-pack of 2-L beverage load.* **[Comment: Driver-salesworker steps off truck with load. Load is unstable and 2-L containers may fall from the 8-pack shell causing injury to the deliveryperson. Also, unloading the beverage cases in this manner causes significant strain on the back and legs when cases contact the ground. Pullout platform should help reduce strain to back and legs.]**

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