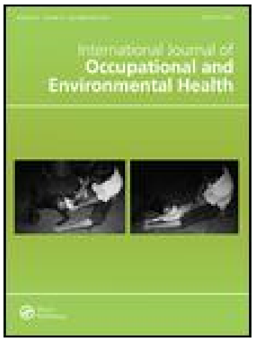

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Ergonomic Exposure Assessment: An Application of the PATH Systematic Observation Method to Retail Workers

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This study examined biomechanical stressor variables (physical work exposures) in relation to job title, gender, and back-belt status in 134 retail store workers. The principal concerns were to quantitatively describe physical work exposures and to determine the degrees to which these quantitative variables correlated with job title and with the use of back belts. An additional objective was to assess the inter-rater reliability of the observation method. The systematic observation method employed was based on a modification of the PATH (Postures, Activities, Tools, and Handling) measurement method. Chi-square analysis indicated that the frequencies of bent or twisted postures followed the pattern of unloaders > stockers > department managers. For weight handled per lift, lower, or carry, the pattern was unloaders > department managers > stockers. The mean lifting frequencies per hour were 35.9 for department managers, 48.8 for stockers, and 137.4 for unloaders. Back-belt–wearing percentages were higher for unloaders (63%) compared with stockers (48%) and department managers (25%). Back-belt–wearing workers had higher levels of biomechanical stressor variables, including arm position, twisting, weight handled, and number of lifts per hour. Kappa statistics ranged from 0.5 to 0.63, a level of adequate or good reliability beyond chance. The method employed in this study is applicable in studies that require only fairly crude distinctions among biomechanical stressor variables. Nevertheless, this level of distinction may be sufficient when implementing intervention studies and control strategies for many material-handling–intensive jobs. *Key words:* ergonomics; exposure assessment; retail workers; work sampling; work-related musculoskeletal disorders; back injuries.

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Assessment of work exposure is important in epidemiologic studies of the prevention and control of back injuries. Many studies of work-related risk factors for injuries have used administrative data such as job titles to determine physical work load. Not only are surrogates such as job title only crude measures of physical work exposures, but the misclassification inherent in surrogates can bias estimates of an individual's true work exposure.[1,2] For this reason, we sought a more quantitative assessment of work exposure feasible to employ in a large epidemiologic study of back belts.[3]

Quantitative assessment in a field setting of physical work exposures of material-handling workers has been very limited to date. On the other hand, laboratory studies of biomechanical, physiologic, and psychophysical factors related to back injury have been numerous, but these have provided no guidance as to practical methods of collecting reliable data on work exposures outside the laboratory. This lack of detailed and objective exposure measurement has impeded validating claims that back injuries are preventable. For example, physiologic measures such as heart rate and oxygen consumption not only lack consistent correlations with workload, they are also significantly affected by psychological and environmental factors.[4] Video analyses using biomechanical models to simulate actual manual material-handling tasks must consider many limitations, such as the estimation of joint angles and force vectors.[5] Which methods of assessing physical exposures are the most reliable and objective has not been determined. Systematic direct observations may offer a compromise between the low validity and reproducibility of responses to questionnaires and the high cost and great technical hurdles of direct quantitative recordings.[6,7]

We report here the results of a survey of 134 retail merchandise store workers using systematic observations to assess back-injury risk factors. The method used is a modification of the Postures, Activities, Tools, and

Handling (PATH) measurement method.[8] The modification eliminated postures of the lower extremities and neck and did not consider tools separately from material handling. The PATH method was based on an earlier method, the Ovako Working Postures Analyzing System (OWAS), which estimated the proportions of time spent in working postures.[9] The scientific basis of the PATH and OWAS methods derives from work sampling, an industrial engineering technique used to investigate the proportions of total time devoted to the various activities that comprise a job or work situation.[10] Work sampling by systematic observation has been used to estimate and assess cumulative exposures to specific risk factors.[8,11–14] The PATH method, described by Buchholz,[8] is task oriented: ergonomic exposures are assumed to be a function of the tasks performed, so that an exposure profile for an individual is based on the distribution of exposures within a task and the proportion of time the individual spends performing the task. This orientation has important implications for epidemiologic studies.

The current study's timed-interval work sampling was arranged to sample tasks of significant biomechanical exposure across the maximum number of individuals in a work shift. This sampling orientation was needed to characterize job titles and tasks rather than exposures of individuals. This sampling orientation was somewhat different from traditional work observation (also known as time study), which typically requires observation of individuals over long periods in order to calculate the frequency or fraction of time per day in a particular activity.[15] Traditional time studies are concerned with sampling to ensure representative times for repetitive activities; the PATH method, by contrast, is better suited to nonrepetitive work with long work cycles.

The objectives of this study were: 1) to examine differences in biomechanical risk factors among individuals in three retail merchandise job titles (unloaders, stockers, and department managers); 2) to examine the same biomechanical risk factors according to whether the workers were wearing back belts; and 3) to assess the interrater reliability of the PATH observation method. This information will be used in the development and validation of methods to be employed in an intervention study of the use of back belts in the same worker population.

METHOD

Subjects

One hundred and thirty-four retail workers (21 stockers, 41 unloaders, and 72 department managers) were observed at a chain of four retail stores in northern West Virginia. The order of observation of subjects was not prearranged. Subjects were selected from a list of all workers in the three job titles, and observed according to their availability on the day the observations were made. Fifty-four subjects were observed wearing nylon stretchable back belts and 80 were observed not wearing back belts. Back belts were supplied by the company. Although the company's stated policy required workers who handled freight to wear back belts, individual managers had wide latitude in the enforcement of the policy.

Tasks

The workers in this study represented three job titles: department manager, stocker, and unloader (i.e., receiver). Of all the job titles of workers in the retail chain, these three have the most consistent requirements for handling freight. Workers in these job titles are full-time employees working the morning and late night shifts. They comprise about a third of the total number of employees in each store; most of the remainder of the employees are part-time, and have less consistent requirements for handling freight. Each job's activities were divided into several major tasks. During each observation of a given job title, one, two, or at most three of the tasks were performed. The tasks for the three job titles are listed in Appendix A.

Systematic Observation Measures

The biomechanical stresses of posture, force, and repetition inherent in material handling represent risk factors for back injury and back pain. The mechanical forces exerted during material handling are supposed to relate causally to both instantaneous back injuries and gradual-onset back pain. Biologically relevant internal exposures to these risk factors are expressed in the more biologically relevant "primary" dimensions of force level, repetitiveness, and duration.[2] How to best operationalize these primary dimensions in particular instruments in epidemiologic studies is the subject of considerable debate among engineers, epidemiologists, and physiologists. The three main methods that have been used to operationalize physical risk factors for back injury are self-reports, direct instrumentation methods, and systematic observation methods.

In the current study, systematic observations were conducted in four field settings (retail stores) within the same retail chain, by two observers. Observations were made of manual material-handling activities and tasks that involved biomechanical stresses, especially those tasks that involved repetition, weight and force loading, and arm and trunk postures. A predetermined fixed sampling interval of 45 seconds was used, which was considered optimal for recording the greatest number of observations with the greatest accuracy. Therefore, at each 45-second sampling point, the observers instantaneously recorded subjects' arm and trunk postures, the type of material handling (described below), and the estimated weight of the object being moved. Approximately 15–20 observations were made for each subject, taking a total of 11–15 minutes. All the variables were recorded at each 45-second cyclical point except frequency of lifts and manual material-handling activities, which were recorded continuously during the entire 11–15-minute period.

Manual material-handling (MMH) categories. Manual material handling was differentiated into seven categories: lift, lower, carry/hold, move/place/operate, push/pull/drag (heavy), push/pull/drag (light), and not handling/idle. Heavy or light push/pull/drag was subjectively determined by observing the force required for handling activities. For example, a "heavy" push/pull/drag was defined as the initial starting/operating/moving of a pallet and a "light" push/pull/drag was defined as the subsequent push/pull/drag of a pallet to the predetermined destination. In contrast, a move/place/operate was recorded only for handling small freight, not for a pallet. All of the manual tasks (up to a maximum of three) of each worker observed were recorded within each sampling interval.

Risk factors. Risk factors investigated fell into three categories:

1. Awkward postures can result in transient fatigue and discomfort. Prolonged exposures can lead to potential injuries to musculoskeletal tissues and peripheral nerves.[8,9,16] Several epidemiologic studies have shown that non-neutral postures are significantly related to injuries.[17–19] In this study, trunk and arm postures were collected to classify potential exposures associated with awkward postures.

2. Forceful exertions during material-handling tasks can result in chronic or acute musculoskeletal injuries.[14] In this study, estimates of the weights of the materials being handled indicated potential exposures to forceful exertions. The estimates of weight/force were made in very broad categories, which were necessary because of the short time interval (precluding weighing each item) and the very large number of different items in the store inventory.

3. Repetitive motions can accumulate minor exposure doses and cause the same damage to musculoskeletal systems as forceful exertions or awkward postures.[14] Frequency of lifts was the measure used to determine potential exposures to repetitive-motion patterns in this study.

Study Design

Observations were conducted during day shifts (6 AM to 2 PM) and night shifts (11 PM to 7 AM). During the day shift, sampling was conducted from 6:30 AM to 1 PM (the peak-exposure period) for each of the three job titles, consecutively for 15 to 20 observations for each subject, with sampling intervals of 30 or 45 seconds. A standardized 45-second interval was fixed and used after preliminary 30-second-interval trials, which were used for the first several subjects of the first store, and which were determined to be impractical. Sampling of the night shift was conducted from 11 PM to 3:30 AM for unloaders and night stockers, with the same observation procedure. Observations at each field setting were conducted on two consecutive days and nights.

TABLE 1 Categories of Postures, Forces and Activities

Classification	Variable
T1	Trunk: neutral or straight
T2	Trunk: bent forward 20° to 45°
T3	Trunk: bent forward > 45°
T4	Trunk: laterally bent or straight but twisted > 20°
A1	Arm: 1 elbow higher than shoulder level
A2	Arm: 2 elbows higher than shoulder level
A3	Arm: 2 elbows > 20° behind trunk
A4	Arm: everything else (not A1, A2, A3)
F1	Force/weight: < 1 lb
F2	Force/weight: 1 to 25 lb
F3	Force/weight: 26 to 50 lb
F4	Force/weight: > 50 lb
Lift	Number of lifts during the period (i.e., frequency) of observation
M1	Material handling: lift
M2	Material handling: lower
M3	Material handling: carry and hold
M4	Material handling: move/place/operate
M5	Material handling: push/pull/drag—heavy
M6	Material handling: push/pull/drag—light
M7	Material handling: not handling

Inter-observer Reliability

Prior to collecting data from the four stores, simultaneous data collection by two observers was undertaken during observations of ten subjects in a fifth store that was part of the same chain. These preliminary data were used to assess reliability, i.e., agreement between the two raters.

Data Analyses

Table 1 presents the biomechanical stressor variables and their respective categories, as used in the analysis. Appendix B is a copy of the form used to record the observations. Category values (T1, T2, F1, F2, etc.) were recorded directly on the data-collection form.

The percentage of time a subject was observed in each category of the variables was calculated. For example, if a subject was observed 20 times (the rows in Appendix B) and was observed 5, 10, 3, and 2 times in trunk positions T1, T2, T3, and T4, respectively, the percentages of times for T1, T2, T3, and T4 would be 25%, 50%, 15%, and 10%, respectively. The use of percentages allowed for the inclusion of some subjects who were observed fewer than 20 times.

The distributions of these percentages were examined to form categorical variables. First, the distributions of percentages of A1, A2, A3, and A4 were calculated. Because less than 3% of the workers were ever scored as A3, the category of "bending elbows behind trunk" was combined with all other into "never raised above shoulder height." Workers were categorized into the following levels for arm position:

1. Never raised elbows above shoulder height (n = 56, 41.8%)
2. Raised only one elbow during some observations (n = 41, 30.6%)
3. Raised two elbows during some observations (n = 37, 27.6%)

The distributions of percentages for T1, T2, T3, and T4 were calculated next. Variables for trunk bending and trunk twisting were created based on these distributions. Workers were categorized into the following levels for trunk position:

Trunk bending
1. Never bent trunk forward (n = 41, 30.6%)
2. Bent trunk forward in less than 25% of the observations (n = 53, 39.6%)
3. Bent trunk forward in more than 25% of the observations (n = 40, 29.9%)

Trunk twisting
1. Never twisted trunk (n = 86, 64.2%)
2. Twisted trunk at some time (n = 48, 35.8%)

Weight handled (or force exerted) was categorized for each worker based on the distribution of weight handled (F1, F2, F3, and F4). Individuals handling either no weight or less than 1 pound more than 75% of the time were classified as "light weight." The remainder of the workers were classified as "moderate weight" unless they were observed handling more than 25 pounds at least 10% of the time, in which case they were classified as "heavy weight."

Weight handled
1. Light weight (n = 72, 53.7%)
2. Moderate weight (n = 49, 36.6%)
3. Heavy weight (n = 13, 9.7%)

A worker was placed in a particular material-handling category based on the activity he or she performed most frequently. The results are given below:

Manual material-handling classification
1. Move, place, or operate (n = 82, 61.2%)
2. Push, pull, or drag (n = 18, 13.4%)
3. Carry or hold (n = 22, 16.4%)
4. Lift or lower (n = 12, 9.0%)

The frequency of lifting was assessed by calculating the number of lifts per hour for each worker using the following equation:

$$\textbf{Lifts per hour} = \{[\text{lifts observed}]/[\text{minutes observed}]\} \times 60 \text{ minutes/hour}$$

The number of lifts per hour was then categorized into the following groups:

Frequency of lifts
1. No lift observed (n = 41, 30.6%)
2. 1–30 lifts/hour observed (n = 21, 15.7%)
3. 31–60 lifts/hour observed (n = 27, 20.2%)
4. More than 60 lifts/hour observed (n = 45, 33.6%)

Statistical Methods

Kappa statistics[20] were calculated to measure reliability. The kappa statistic (κ) measures interrater reliability beyond chance. Chi-square tests were used to test the associations between job titles and the selected risk factors and between back belt use and the selected risk factors. Fisher's exact tests were used to investigate these associations when the expected counts in any of the cells did not exceed five.

RESULTS

The kappa statistics for arm position, trunk bending, and estimated average weight of the object handled were all equal to 0.5. The kappa statistics for trunk twisting and manual material-handling classifications were slightly higher (0.6 and 0.63, respectively). Reliability data were not collected for frequency of lifts. For each of the measures taken, $0.5 < \kappa < 0.63$, which implies good reliability beyond chance (see Table 2).

The results of the chi-square tests (Table 3) showed significant associations between job title and the following risk factors: arm position, trunk bending, trunk twisting, frequency of lifts, estimated average weight of object(s) handled, and manual material-handling classifications (all $p < 0.04$). More than half of the department managers (70.8%) and stockers (57.1%) were female, but almost all unloaders (95.1%) were male. Table 3 also gives the percentages of subjects in the individual job titles by arm position, trunk bending, trunk twisting, average weight handled, number of lifts, and material-handling classification. Nearly 43% of the stockers and 37% of the unloaders had to raise both arms to perform tasks. The department managers were more often in the lowest risk group for arm position than were the stockers and unloaders; more than 50% of the department managers did not raise their arms while working. For the trunk-bending exposures, the unloaders were in bent postures more frequently than were the stockers and department managers, with 63.4% of them in the category of bending in more than 25% of observations. A similar trend was found for trunk twisting. The unloaders demonstrated the highest frequency of trunk twisting, followed by the stockers and the department managers. The percentages of workers in the "trunk twisted some time" category were 87.8%, 42.9%, and 4.2% for unloaders, stockers, and department managers, respectively.

For the stockers, the most common weight handled was in the category of "light," with 81% of the workers handling no weight or less than 1 pound 75% of the time. No stocker in the sample handled weights classified as heavy (Table 3). The unloaders' weight handling was distributed rather evenly throughout the three categories (39%, 34%, 27%) reflecting the wide range of weights of products unloaded. The department managers fell somewhere between the stockers and the unloaders in the distribution of weights handled, with more handling in the light range than unloaders (54%), a similar amount of handling in the moderate range (43%), but far less handling in the heavy range (3%). The reason for the difference in the distributions of weights handled by the stockers compared with the department managers is that stockers are assigned more frequently to departments with higher inventory turnover; these departments tend, on average, to involve lighter-weight merchandise.

The mean lifting frequencies for the department managers, stockers, and unloaders were 35.9, 48.8, and 137.4 lifts per hour, respectively. About 63% of the un-

TABLE 2 Kappa Statistics for Reliability between Two Observers

Variable	Kappa
Arm position	0.50
Bending of trunk	0.50
Twisting of trunk	0.60
Weight handled	0.51
Material-handling classification	0.63

TABLE 3 Study Population Characteristics by Job Title

	Stocker No. (%)*	Unloader No. (%)*	Department Manager No. (%)*	No. (%)*
Gender				
Female	12 (57.1)	2 (4.9)	51 (70.8)	
Male	9 (42.9)	39 (95.1)	21 (29.2)	< 0.001
Arm position				
Never raised	5 (23.8)	13 (31.7)	38 (52.8)	
1 arm raised	7 (33.3)	13 (31.7)	21 (29.2)	
2 arms raised	9 (42.9)	15 (36.6)	13 (18.1)	0.038
Bending of truck				
Never bent	7 (33.3)	3 (7.3)	31 (43.1)	
Bent < 25% of observations	5 (23.8)	12 (29.3)	36 (50.0)	
Bent > 25% of observations	9 (42.9)	26 (63.4)	5 (6.9)	< 0.001
Twisting of trunk				
Trunk never twisted	12 (57.1)	5 (12.2)	69 (95.8)	
Trunk twisted some time	9 (42.9)	36 (87.8)	3 (4.2)	< 0.001
Weight handled				
Light	17 (80.9)	16 (39.0)	39 (54.2)	
Moderate	4 (19.1)	14 (34.2)	31 (43.1)	
Heavy	0 (0.0)	11 (26.8)	2 (2.8)	< 0.001
Number of lifts/hour				
None	7 (33.3)	5 (12.2)	29 (40.3)	
1–30 lifts/hour	4 (19.1)	3 (7.3)	14 (19.4)	
31–60 lifts/hour	5 (23.8)	7 (17.1)	15 (20.8)	
Over 60 lifts/hour	5 (23.8)	26 (63.4)	14 (19.4)	< 0.001
Material-handling classification				
Move, place, or operate	17 (81.0)	12 (29.3)	53 (73.6)	
Push, pull, or drag	2 (9.5)	14 (34.2)	2 (2.8)	
Carry or hold	0 (0.0)	5 (12.2)	17 (23.6)	
Lift or lower	2 (9.5)	10 (24.4)	0 (0.0)	< 0.001†

*Percentage of category by column.
†Exact *p*-value.

TABLE 4 Breakdown of Workers Wearing and Not Wearing Back Belts by Job Title and Gender

	Belt No. (%)	No Belt No. (%)	p*
Job title			
Department manager	18 (25.0)	54 (75.0)	
Stocker	10 (47.6)	11 (52.4)	
Unloader	26 (63.4)	15 (36.6)	< 0.001
Gender			
Female	15 (23.1)	50 (76.9)	
Male	39 (56.5)	30 (43.5)	< 0.001

*From chi-square analysis.

loaders performed lifting tasks more than 60 times per hour, while 33.3% of the stockers and 40.3% of the department managers did not lift any object during our observations (Table 3). Table 3 shows the classification of job titles by various types of material handling. The majority of the stockers (81%) and department managers (73.6%) were in the category of "move/place/operate." The unloaders were spread more evenly across all four categories, with the highest (34.2%) and lowest (12.2%) percentages of unloaders falling into the "push/pull/drag" and "carry/hold" categories, respectively.

Since 54 of the 134 subjects were observed wearing back belts, similar analyses were performed to determine whether there were associations of belt wearing with gender, job titles, and the six biomechanical risk factors. Tables 4 and 5 present the belt-wearing percentages by job title, gender, and biomechanical stressor. There were significant associations between belt wearing and all of the above-mentioned factors (all $p < 0.02$). About 63% of the unloaders and 47% of the stockers wore back belts while performing their tasks, but only 25% of the department managers wore back belts (Table 4). More than half of the male workers (56.5%) wore belts, while only 23.1% of the women wore belts during the observations (Table 4). Belt wearing also increased in frequency with increased biomechanical stress. Workers who fit into the following categories tended to have higher frequencies of belt wearing: had two arms raised, were bent over at the trunk for more than 25% of observations, were twisted at the trunk, handled heavier weights, and performed more than 60 lifts per hour (Table 5). Workers in the "lift/lower" material-handling category wore belts with the greatest frequency. They were followed by workers in the "carry/hold," "move/place/operate," and "push/pull/drag" groups.

DISCUSSION

This exposure-assessment investigation was a preliminary step for the NIOSH intervention study of the effect of back belts on back injuries in material-handling

TABLE 5 Breakdown of Workers Wearing and Not Wearing Back Belts by Biomechanical Stressor Variables

	Belt No. (%)	No Belt No. (%)	p
Arm position			
Never raised	14 (25.0)	42 (75.0)	
1 arm raised	17 (41.5)	24 (58.5)	
2 arms raised	23 (62.2)	14 (37.8)	< 0.002
Bending of trunk			
Never bent	10 (24.4)	31 (75.6)	
Bent < 25% of observations	21 (39.6)	32 (60.4)	
Bent > 25% of observations	23 (57.5)	17 (42.5)	< 0.010
Twisting of trunk			
Trunk never twisted	25 (29.1)	61 (70.9)	
Trunk twisted some time	29 (60.4)	19 (39.6)	< 0.001
Weight handled			
Light	20 (27.8)	52 (72.2)	
Moderate	23 (46.9)	26 (53.1)	
Heavy	11 (84.6)	2 (2.5)	< 0.001
Number of lifts			
None	7 (17.1)	34 (82.9)	
1–30 lifts/hour	5 (23.8)	16 (76.2)	
31–60 lifts/hour	12 (44.4)	15 (55.6)	
Over 60 lifts/hour	30 (66.7)	15 (33.3)	< 0.001
Material-handling classification			
Move, place, or operate	30 (36.6)	52 (63.4)	
Push, pull, or drag	5 (27.8)	13 (72.2)	
Carry or hold	9 (40.9)	13 (59.1)	
Lift or lower	10 (83.3)	2 (16.7)	< 0.012

workers.[3] The selection of workers in this investigation, i.e., those whose duties involved significant material handling, was intended to reflect the worker population enrolled in the back-belt study. This study represents one of the first attempts to evaluate physical-work–exposure factors in workers employed in a retail setting through systematic observations using work-sampling methods. The chi-square tests indicate there was significant heterogeneity in the distribution of biomechanical stresses among the three job titles. While the three job titles appeared to follow a pattern of increased bending and twisting: unloaders > stockers > department managers, they did not follow the same pattern with respect to weight handled or number of lifts per hour. These differences indicate the difficulty of using a simple qualitative approach such as job title to characterize physical-work exposures in these workers.

Interobserver agreement on these observations was estimated as good (kappas of 0.5 to 0.63) but not excellent. This assessment of interobserver agreement should be taken as a lower limit of what is achievable with this method. In the development of the PATH method, it was determined that about 30 hours of training would be needed to achieve 80% agreement on individual observations of construction laborers.[8] The joint observations on ten workers that formed the basis of the interobserver agreement in these data were carried out with essentially no training. During practice coding sessions that have been carried out in additional stores subsequent to this study, observers using this method have routinely achieved 80% agreement.

Based on the results of this study, unlaoders appeared to have highest levels of exposure to trunk bending and twisting postures, followed by stockers and department managers. The unloaders also handled heavier objects and lifted objects much more often than did workers with the other two job titles. The stockers were nearly identical to the department managers in terms of weights lifted per hour, but they handled more lightweight items than the managers. The department managers were in the lowest risk group for arm position, trunk bending, and trunk twisting. In a separate analysis of worker's compensation data in 260 stores of the same chain, the back-injury incidence rate per 200,000 hours for unloaders and stockers combined was higher than that for department managers.[21]

The results we observed concerning back belts—higher frequencies of lifting and lifting heavier weights, as well as more twisting associated with the use of back belts—do not imply that the belts caused these differences. Higher exposures associated with belt wearing is confounded by company policy, which encourages workers to wear belts to reduce injuries during unloading or handling of freight. Male workers were involved in freight unloading and stocking activities more frequently than female workers; thus, male workers were more likely to be observed wearing belts. In a field study where belt wearing and the associated tasks are primarily self-determined by the worker, inferences about the effect of belts on biomechanical stressors is not possible. Inferences about these biomechanical variables can more safely be made in a controlled laboratory setting where tasks are rigidly standardized and belt wearing is randomly or systematically allocated in order to eliminate biases. Back belts may or may not be causally associated with reduced trunk motions,[22–24] but we do not conclude from these data that because the workers who wore belts in this study lifted and twisted more frequently, belts are a cause of increased lifting and twisting.

The findings from this study should be viewed with caution, due to several limitations. For instance, the broad categorization of lifted weights (<1, 1–25, 26–50, 50+ pounds) reduced the precision with which differences in lifting weights could be observed. It was not practical to make finer and more detailed distinctions among the weight/force categories handled without recording the exact weight of each item handled. These stores receive two or three truckloads of merchandise per night. On one night in July 1995, the workers in one of the four stores in the study unloaded two trucks containing 1,219 separate cases of merchandise. The weights of the cases were not recorded (on computers or elsewhere), nor were they marked on the cartons. Therefore, the estimation of the weights handled during unloading required the exercise of judgment of the observers. In addition, this study did not measure risk factors such as velocity, momentum, and position, which are also relevant to material-handling activities.[25–27] To eliminate observer bias in selection of subjects to be observed, the subjects to be observed should be selected from a predetermined randomly ordered list of workers, similar to the method employed by Buchholz.[8]

The PATH method was intended to apply to a wide variety of industrial applications; the method the authors used should be applicable to a wide variety of material-handling jobs where tools are not considered separately from material handling. It will be employed as one measure of physical-work exposures in the NIOSH back-belt study. The actual dose of back-stressing exertion delivered to the tissues also depends on the individual's physical work capacity.[28] Therefore, in addition, the back-belt study will include a subjective assessment of perceived exertion to supplement the systematic observations.[29]

Additional observer training beyond the amount we allotted is likely to significantly increase interrater reliability. Further research is needed to determine whether this assessment method can be modified to take into account velocity, momentum, and position of load. Implementation of the current observational method is sufficient when only fairly crude distinctions among biomechanical stressor levels are needed; finer distinctions within biomechanical stressor levels would require collection of additional variables and more detail in weight/force levels. However, for many intervention studies and control strategies for material-handling–intensive jobs, this level of distinction may be adequate.

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APPENDIX A

Tasks

Department manager

1. Unloading pallets and shelving freight alone (one worker).
2. Unloading pallets and shelving freight with help from other workers (i.e., two or more workers unloading the same pallet).
3. Building displays; assembling merchandise or shelves; and unwrapping, tagging, or putting out freight.
4. Helping customers: locate, retrieve merchandise, discuss customer needs.
5. Other (e.g., cleaning up or checking inventory in the department).

Unloader

1. Unloading freight inside large truck to conveyer by hand.
2. Unloading freight from conveyor line to pallet (palletizing freight).
3. Unloading freight off small trucks without conveyor.
4. Pulling pallets using pallet carts (empty or full load) to floor only (no stocking).
5. Stocking freight alone in the different departments.
6. Stocking freight with help from other workers in the different departments (i.e., two or more workers stocking same freight).
7. Other (e.g., cleaning up in back room or different departments).

Stocker

1. Pulling pallets or carts (empty or full load) from back room to floor without stocking.
2. Pulling pallets or carts (empty or full load) and stocking.
3. Building displays and assembling sample merchandise.
4. Stocking freight alone in the department.
5. Stocking freight with help from other workers in the department (i.e., two or more workers stocking same freight).
6. Helping customers, operating department cash register.
7. Other (e.g., cleaning up in back room or different departments).

APPENDIX B

Work Observation Data Collection Form

Date: ______________ Name: ______________

Store: ______________ Sex: _____

Time: ________ to ______ Investigator: ____________

Job Title: ______________ Department: ____________

	TRUNK	ARMS	MMH	WEIGHT	TASK
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					