Manual Materials Handling

Training Managers for a Safer Workplace

Giving managers tools to better protect their workers

By Jessie F. Godbey, Greg Murphy and Robert E. Thomas

TRAINING IS AN EFFECTIVE WAY to develop new skills and knowledge, including the application of ergonomic principles. Benefits of safety training for workers are clearly understood. Such training is essential for creating a safe work environment (Colligan); workers must be informed of hazards and instructed on how to protect themselves from these hazards. In addition, OSHA has identified safety training as a key element of an effective safety program. New ideas regarding safety training are emerging; among them are participatory training, where workers help develop, present and provide feedback on training (Nash). An individual's application of the newly acquired knowledge—the transition from "knowing" to "doing"—is a critical element of training (Gebrewold and Sigwart 25+).

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Safety training for management is important as well. However, managers are often required (and even rewarded) for making decisions quickly; as a result, they often rely on common sense when making decisions. The attempted application of ergonomic principles to manual materials handling situations is an example of the use of intuition. Often, managers must make several decisions in situations where knowledgeable application of ergonomic design practices would likely be beneficial. These situations may range from relatively simple to complex. Is it possible that managers who complete job-specific ergonomics training will make superior decisions regarding application of ergonomic principles to those tasks? In the authors' experience, many managers neither have the time nor the inclination to apply "academic" methods acquired through training to everyday work situations, and instead rely on intuition to guide decisions regarding the tasks at hand.

For example, in manual materials handling situations, managers know (intuitively) that workers must keep their backs straight and lift with their legs. Yet, back injuries and other strain/sprain injuries are leading work-related injuries (NSC). Statistics show that many occupational injuries occur each year because of the failure to properly apply ergonomic task analysis and design principles; these injuries cost American industry millions of dollars annually (NSC). How is it that ergonomic-related injuries are so costly and so numerous if preventing them is intuitive? Perhaps ergonomics involves more than the mere application of common sense (Thomas and Smith). If managers are trained in manual materials handling, will they retain the knowledge imparted and actually apply it in practice? Will the resulting task analyses and design solutions be superior to those developed on the basis of intuition and common sense? Will the investment in such training lead to a safer workplace?

Methodology

To answer these questions, an applied experiment was conducted at a large apparel manufacturing facility. Functions include fabric production, cutting, sewing, dyeing and distribution. In this experiment, managers trained in manual materials handling principles and "untrained" managers were asked to determine the amount of weight a worker could safely lift during two different simulated lifting tasks. The 1991 National Institute for Occupational Safety and Health (NIOSH) Lifting Equation was used to determine the "benchmark" for both situations. Developed by an ad hoc committee of experts who reviewed the current literature on lifting, this equation defines the recommended weight limit (RWL) that would be acceptable to nearly all healthy American workers, male or female, accustomed to physical labor. The committee determined that the RWL is consistent with or lower than the safe lifting capacities reported in the literature (Waters, et al 749+). Table 1 provides a summary of the NIOSH equation. (The *Applications Manual for the Revised NIOSH Lifting Equation* provides further details on the use and application of the RWL.)

It should be noted that this study used RWL as a benchmark to examine the effectiveness of manual materials handling training for managers; it made no attempt to validate RWL as a measure. It should also be noted that RWL is only one of the tools available for analyzing and improving workplace safety. In this limited study, the decisions of the "untrained" managers significantly increased the risk of an unsafe lift in both simulated lifting tasks. Results also show that trained managers recognized the need to apply skills developed in training and applied these skills properly.

The first simulated lifting task involved a relatively simple lift: picking up a carton and placing it on a worktable directly in front of the worker; it required no twisting (Figure 1). The carton's initial position was eight inches above the floor, and the worktable was 28.5 in. above the floor. The carton had handhold cutouts 15 in. above its bottom. After a carton was lifted onto the table, its contents were sorted. This sorting process, the second part of the task, took five to 10 minutes. Once items were sorted, another carton was delivered, and the process started anew—lift then sort. Cartons arrived at a rate of nine per hour for an entire eight-hour shift with normal breaks.

The second lifting task was more complex (Figure 2). Again, the carton was positioned eight inches above the floor and its handholds were in the same location; however, now it was at a right angle to the placement surface, requiring a 67-degree twist during the lift. The carton had to be placed on a work surface 59 in. above the floor, with no follow-on sorting of contents. Cartons arrived at a rate of one per minute for an entire eight-hour shift with normal breaks.

Several trials of each task were conducted to determine the benchmark RWL for each scenario. The equation begins with a load constant of 51 lbs. Six different physical layout and task characteristic modifiers may then reduce this constant, resulting in the final RWL. The benchmark for the simple lifting task was determined to be 20.72 lbs. while the benchmark for the complex lifting task was 11.01 lbs. These values were used to evaluate the weights established by both trained and untrained study participants.

Table 1

1991 NIOSH Lifting Equation

The purpose of the 1991 NIOSH Lifting Equation is to calculate the recommended weight limit (RWL). This calculation involves six modifiers that are used to adjust the load constant (51 lbs. or 23 kg.) to an acceptable level for most healthy American workers. The value of each modifier is determined from a mathematical formula or from a table. This RWL is valid for a limited set of lifting tasks. RWL is calculated using the following equation:

RWL = LC * HM * VM * DM * AM * FM * CM

Modifiers	Definition	Calculation (U.S. Customary)
LC	Load Constant	51 lbs.
HM	Horizontal	10/H
VM	Vertical	$1 - (0.0075 \lvert V-30 \rvert)$
DM	Distance	0.82 + (1.8/D)
AM	Asymmetric	1 - (0.0032 * A)
FM	Frequency	*table value
CM	Coupling	*table value

Where:
H is the horizontal distance of the hands away from the midpoint between the ankles, in inches;
V is the vertical distance of the hands above the floor, in inches;
D is the distance of the lift from origin to destination, in inches;
A is the angle of twist measured in degrees.

**See DHHS Publication No. 94-110 for table values.*

Decisions of Untrained Managers

Over a two-day period, six male and six female untrained individuals from the apparel manufacturing facility were asked to determine the amount of weight that a worker could safely lift over an eight-hour shift in both lifting tasks. The average chronological age of these participants was 38.3 years and the average length of employment at the facility was 12.8 years. These 12 individuals represented a cross section of department managers, supervisors and lead workers with no known ergonomics training. Each was individually brought to the simulated workstation, presented with the tasks and asked to determine how much weight a worker could lift safely. Complete task descriptions were provided to each participant, along with an empty carton and a set of five-lb. and two-lb. weights. In addition, a NIOSH lifting equation worksheet was provided should the untrained managers know how to use it.

Each task was demonstrated without the weights in the carton. Each participant used a trial-and-error method—placing and removing weights until s/he determined a safe lifting weight. None of the 12 untrained managers indicated knowledge of any other way to determine the safe lifting weight. After analyzing the simple lifting task, participants moved to the complex task.

The mean safe weight determined by the group for the simple task was 32 lbs. compared to the NIOSH RWL of 20.72 lbs.—54 percent more weight than considered safe according to the NIOSH equation. The mean safe lifting weight determined by untrained male managers was 31.67 lbs., which exceeded the NIOSH RWL by 53 percent; the mean safe lifting weight determined by their female counterparts was

Figure 1

Simple Task Factors

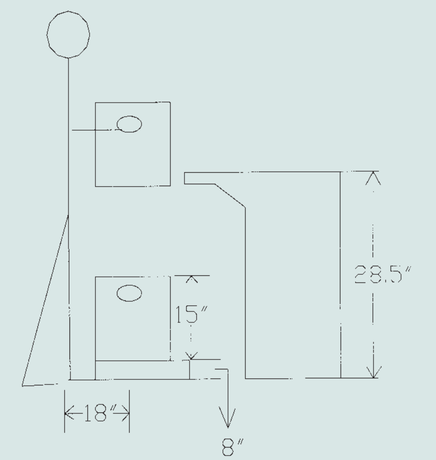
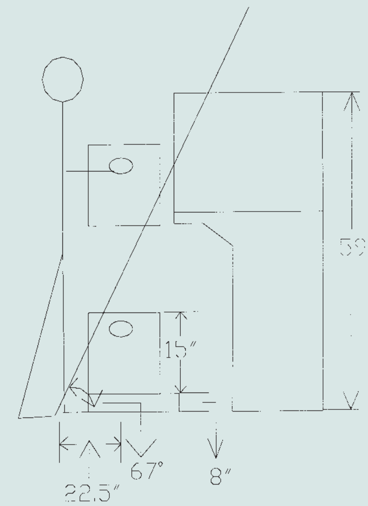


Figure 2

Complex Task Factors



If managers are trained in manual materials handling, will they retain the knowledge imparted and apply it in practice?

32.33 lbs.—56 percent above the benchmark-RWL. Only one of the 12 determined a weight that was equal to or less than the RWL; the remaining 11 managers overestimated the simple lifting task by 25 to 50 lbs.

Results from the complex lifting task demonstrated an even-more-dramatic deviation from the benchmark-RWL. The mean safe weight determined by the untrained managers for this task was 25.75 lbs. compared to the NIOSH RWL of 11.01 lbs.—34 percent more weight than the recommended safe weight. The mean safe-lifting weight determined by males in this group was 28.33 lbs., while females determined it to be 23.17 lbs. All 12 participants overestimated the task, with estimates ranging from 15 lbs. to 35 lbs.

Results of this study show that decisions based on intuition and common sense significantly overestimated the safe-lifting weight recommended by the NIOSH lifting equation. When analyzing the complex task, intuition triggered a reduction in the amount of weight considered safe, but this reduction was not nearly enough. Such common-sense decision making would lead to an unsafe lift in the simple task and to an even-more-hazardous lift in the complex task.

Decisions of Trained Managers

Approximately one week after the untrained managers completed the experiment, a three-day (12-hour) ergonomic training course was conducted at the facility. Participants included department managers, supervisors and lead workers, including several participants from the first stage of the experiment. Three topics were covered: repetitive motion in a manufacturing environment, manual materials handling—during which the NIOSH lifting equation was introduced—and office ergonomics. Training consisted of classroom instruction and provided participants the opportunity to demonstrate their skill at using the lifting equation through hands-on exercises.

Four months after this course, 12 class participants—none of whom had participated in the first stage of the experiment—were presented with the same two lifting tasks as the untrained managers had been. Again, six males and six females participated, representing a cross section of department managers, supervisors and lead workers. The average chronological age of the trained group was 43.9 years and the average length of employment at the facility was 8.6 years. As during the first stage, trained managers were individually brought to the simulated workstation and given the same task descriptions and demonstrations that had been provided to the untrained group, as well as the same empty carton and weight sets. A copy of the NIOSH lifting equation worksheet used during the ergonomic training was available upon request.

Most members of this group immediately recognized that both situations involved the application of ergonomic principles covered in training. Several started with a trial-and-error method but soon realized that the task required application of the lifting equation. To use the equation, each manager was required to take his/her own workstation measurements; as a result of individual variation in measurement, not one of the trained managers' final RWL calculations was identical. The mean safe weight determined by the trained managers for the simple task was 18.64 lbs., compared to the benchmark-RWL of 20.72 lbs., a 2.08-lb. variance. The mean safe lifting weight determined by trained male managers was 17.75 lbs., while their female counterparts determined it to be 19.53 lbs. Three calculations exceeded the benchmark-RWL—by an average of 1.80 lbs.—while the other nine were below the benchmark value.

This group exhibited similar skill in applying ergonomic principles to the complex task. The mean safe weight determined for this task was 10.81 lbs. compared to the benchmark-RWL of 11.01 lbs., only a 0.2-lb. variance. The mean safe lifting weight determined by the trained male managers was 10.86 lbs., while the trained female managers determined it to be 10.76 lbs. Calculations by six participants were less than the benchmark-RWL. In this study, managers trained in "academic" methods of manual materials handling task analyses and design did not necessarily take the easier (and quicker) route for decision making. These managers recognized the need to apply skills acquired in training; moreover, they applied this knowledge properly four months later.

Further Analysis

Table 2 presents a summary of the calculated means for the two groups as well as the benchmark-

RWL values. An analysis of variance (ANOVA) was conducted on the data to measure the statistical significance of the ergonomics training. This analysis examined the statistical significance involving several factors including:

•Group (G)=Trained vs. Untrained (Fixed Variable)

•Lifting Task (T)=Simple vs. Complex (Fixed Variable)

•Gender (S)=Male vs. Female (Fixed Variable)

The analysis considered the absolute difference between the benchmark-RWL and the managers' determined weights as well as the raw differences between the benchmark-RWL and the managers' determined weights (weight above the benchmark was shown as a negative number). Table 3 provides a summary of the statistical effects.

The group factor is the specific factor of interest to determine whether the decisions of trained managers versus untrained managers differ. Decisions made by the trained group were substantially closer (p=0.01) to the benchmark-RWL than those made by the untrained group. Task interaction was strong as well (p=0.01). Specifically, the untrained group was markedly farther from the benchmark as task complexity increased. While the added complexity of the second task (twisting, increased frequency, higher lift distance) was apparent to untrained managers, they failed to accurately comprehend the magnitude of the appropriate weight reduction. In contrast, trained managers, using the NIOSH equation, again determined an appropriate weight for workers to lift safely.

The difference in gender is less marked. In the untrained group, both males and females determined a weight more than double the benchmark-RWL. Moreover, data indicated that for the complex lifting task, untrained males were substantially farther from the benchmark than their female counterparts, which, in the authors' opinion, may imply the introduction of a "macho" factor.

Table 2

Comparison of Results

Category	Simple Lifting Task (lbs.)	Complex Lifting Task (lbs.)
Benchmark RWL	20.72	11.01
Untrained Group	32.00	25.75
Untrained Male	31.67	28.33
Untrained Female	32.33	23.17
Trained Group	18.64	10.81
Trained Male	17.75	10.86
Trained Female	19.53	10.76

Table 3

Comparison of ANOVA Results Showing Level of Significance

FACTORS	Absolute Difference Analysis	Raw Difference Analysis
Group	0.01	0.01
Lifting Task		0.01
Group/Task	0.01	
Gender/Task	0.10	0.05
Group/Gender/Task	0.10	

Conclusion

If the application of ergonomic principles is truly intuitive (so-called common sense), no significant differences should exist in the results produced by the two groups in this limited study. Analysis of the results refutes this contention, however. Using the NIOSH lifting equation, trained managers made significantly superior decisions at each task level regarding the amount of weight a worker may lift safely. Untrained managers, applying intuition and trial-and-error tests, decided on a weight that significantly exceeded the benchmark-RWL for both lifting tasks. Intuition resulted in decisions in the right direction (lower weight) for the complex task, but not nearly sufficient for it to be safe.

Accordingly, the more complex the lifting task, the more critical training becomes in reducing the potential for serious injury. In the setting studied, failure to train managers to apply a research-based decision-making tool such as the NIOSH lifting guide may be a significant decrement to the organization's safety program, resulting in real hazards for workers. Managers often encounter decisions that affect complicated lifting tasks. Results of this study suggest that management decision making regarding manual materials handling tasks was positively affected by job-specific ergonomics training. Perhaps more importantly, the results indicate that managers will take the time to use research-based skills and knowledge acquired during training. Consequently, this "academic" training is not a waste of resources and can produce a safer workplace. ■

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