Proactive Ergonomics

Stopping Injuries Before They Occur

By Catherine M. White

Ergonomics has historically gained visibility because of its advertised injury reduction value. Often, ergonomic evaluations involve the assessment of an existing work area, with the intent of reducing risk factors that have been prompted by reports of pain or discomfort. The facility may be limited in the amount of financial resources available, resulting in evaluator recommendations for administrative controls such as increasing breaks between activities or modifying work techniques in an effort to keep body parts in a neutral posture. These interventions are challenging to manage and sustain over time, and can lead to a negative perception of what ergonomics is meant to deliver (Marras & Karwowski, 2006).

The good news is that it is unnecessary to wait for a problem before it is addressed. Practicing a proactive approach to workplace ergonomics allows problems to be solved before an injury occurs. Musculoskeletal disorders (MSDs) are typically treatable and less expensive in the early stages, but are often irreversible and expensive later. Workers' compensation claims for one back injury case can cost or even exceed $40,000 (MacLeod, 2006). It is estimated that the indirect costs associated with MSDs are about 4 to 10 times higher than the direct costs (MacLeod, 2006). From a cost avoidance perspective, proactivity makes very good business sense.

Beyond cost avoidance from the perspective of injury prevention, ergonomics has many other benefits that are often unrecognized. It is common for ergonomic improvements to increase productivity by 10% to 15% (MacLeod, 2006). By designing for a job to allow for neutral body postures, less force exertions and fewer motions, the work area becomes more efficient. Workers are also more comfortable in these positions and less prone to fatigue, which can increase overall job satisfaction and reduce turnover.

Research has also recognized that quality can improve with solid ergonomic design. One study in an assembly environment found that quality deficiencies were three times as common for poorly designed ergonomics tasks compared to other tasks (Eklund, 1995). Another interesting finding in this study was a link between job satisfaction and product quality. To be happy in their jobs, workers ranked producing good quality products as very important. Not only is product quality good for the bottom line, it results in happier, more productive employees.

Given the positive attributes associated with good ergonomics, imagine the benefits that ergonomics can achieve when applied in the design phase as intended. Most issues related to ergonomics are based around the workstation design. Ultimately, proactive ergonomics recognizes and eliminates risk factors in the design stages of new processes and products to not only reduce the risk of injury, but also to achieve benefits in areas such as production, quality and lean manufacturing. This can be achieved in the design phase at a minimal cost where more resources are available and there is a high ability to influence the final setup of the work configuration (Figure 1).

Given all of the benefits of proactive ergonomic design, why is it so difficult for leadership to recognize and invest implementing engineering solutions?

IN BRIEF

- **The main goal of an ergonomics program should be to design the human-machine interface to maximize an operation's productivity, efficiency, quality and comfort. Reactive ergonomics consists of acting in response to an issue that has already become a problem, while proactive ergonomics is about discovering potential problems before they take place.**
- **Eliminating risk and engineering out a potential physical stressor are two effective methods to a successful ergonomics program. It is ideal to apply these control methods at the design phase, when there is a high potential for impact at a minimal cost.**

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Why do facilities so often rely on administrative controls to manage risk? It seems that OSH professionals have the challenge of advertising and documenting the financial benefits that good ergonomics can provide (Hendrick, 1996). Up to this point, the traditional focus on ergonomics has been based on reacting to injuries after they occur. Many solutions have focused on administrative and work practice controls because the cost is seemingly low, coupled with a fast implementation timeline.

Businesses believe that engineering projects are costly, and require considerable time and resources to implement. As a result, ergonomics is not recognized as a tool that can be used in the design process to optimize efficiency as well as comfort. Fortunately, safety professionals can take several or various steps to demonstrate the value that ergonomics provides to ensure that appropriate considerations are made early on in the design process.

Figure 1
Proactive vs. Reactive

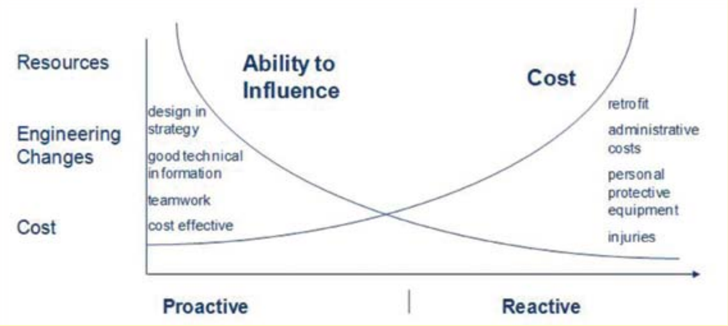
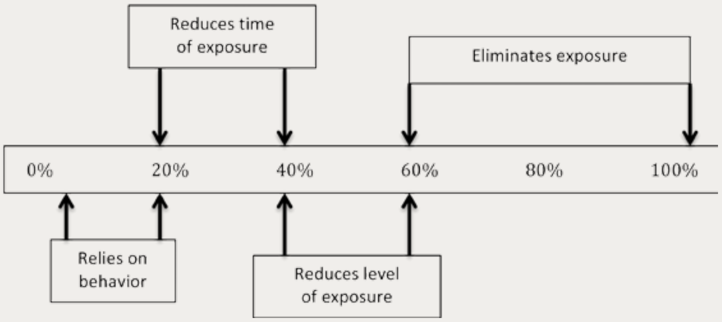


Figure 1: Proactive ergonomics allows for ergonomic considerations to be taken into account at a stage in the design process when there is a great ability to influence design at a minimal cost. Reactive ergonomics does not allow as much flexibility and introduces significant cost to retrofit existing equipment or apply administrative controls.

Figure 2: A proposed relationship of the effectiveness of safety interventions shows that controls that eliminate exposure are most impactful (Goggins, Spielholz & Nothstein, 2007).

Figure 2
Relationship of Safety Intervention Effectiveness



Advertise That Engineering Controls Are the Most Effective Ergonomic Controls

Practitioners understand that ergonomic programs provide value, but it is challenging to convince others of that value. Leadership must understand that engineering controls have the greatest effectiveness to reduce exposure to MSD risk factors and, therefore, are essential to implement. In a literature review that explored the effectiveness of ergonomic programs and the control measures implemented, behavior-based controls have only a range of 5% to 20% effectiveness at reducing MSDs, while controls that focus on engineering or elimination practices have an effectiveness rating of 60% to 100% in workplace injury reduction (Goggins, Spielholz & Nothstein, 2008).

It is essential to communicate that engineering solutions to ergonomic issues will have the greatest effect compared to controls (Figure 2). Administrative controls such as additional rest breaks or job rotation may reduce the duration and frequency of exposure to the risk condition, but they do not eliminate the hazard. Administrative controls can also require resources to sustain and manage. For example, oversight may be required to ensure that workers are taking the required rest breaks or following the established job rotation sequence.

Ultimately, the solution should meet the objective of improving the task's design to eliminate or reduce MSD risk factors. Therefore, OSH professionals must be able to sell ergonomics to management based on cost-effectiveness arguments (Cushman & Rosenberg, 1991). Leadership buy-in will help prioritize ergonomics in the design process where there may be constraints in time and cost that can hinder taking ergonomics into account (Wulff, Westgaard & Rasmussen, 1999).

Show How Ergonomics Saves Money

A common misconception is that ergonomics is costly. In engineering projects, cost and time constraints are factors that can hinder businesses from considering ergonomics (Wulff, et al., 1999). This is why it is essential to effectively market the value of ergonomics to leadership using cost justification as a tool (Cushman & Rosenberg, 1991). The cost to engineer a solution can outweigh the cost of an injury and equipment retrofitting. It can be easy to prove that ergonomic interventions can recoup the initial investment in a matter of months if return on investment is calculated.

Creating a library of ergonomic interventions that have lowered injury risk and generated a cost savings is an effective way to build support for engineering controls. Using cases of ergonomic solutions that have been developed internally is an effective way to market the value of ergonomics within the company. Many examples in industry illustrate simple and inexpensive ergonomic solutions resulting in increased efficiency and productivity. These examples demonstrate that companies can protect their employees from injury, while remain cost competitive in the market.

OSHA's website (**www.osha.gov**) contains examples of cost-effective ergonomics programs and interventions. One success story is related to a manual tool fixture that required an average pull force of 133 lb and resulted in four injuries over a 12-month period. A spring-loaded tool fixture was fabricated at an estimated cost of $200 (Photos 1 and 2). The force requirement was decreased to 2.2 lb and no injuries have been reported since implementation. In addition, this improvement resulted in a 10% reduction in cycle time and a 96% reduction in scrap. This resulted in a cost savings of approximately $1 million. This example is one of many in which the business easily achieved a return on initial investment.

Photos 1 & 2: New spring-loaded fixture is smaller and easier to use, with cost savings from quality, cycle time and injury avoidance.

Photo 1 (top): A large amount of force is necessary to remove the jammed tool fixture.

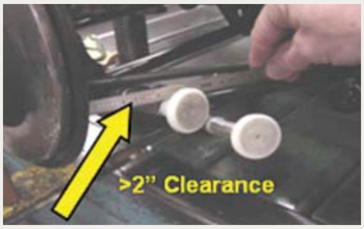


Photo 2 (bottom): The new fixture releases away from the part and does not create a clearance issue.

***Note.** Photos from OSHA Success Stories website. Retrieved from www.osha.gov/SLTC/ergonomics/success_stories.html.*

Build the Ergonomics Knowledge of Engineers

Many engineering disciplines do not receive any form of ergonomics training in their college curricula and rely on formal or informal training received at the job site (Broberg, 2007). Traditional company training related to ergonomics is based on reactive aspects of risk assessment and control from the perspective of comfort and injury prevention.

It is essential for the engineering community to understand the scientific basis of ergonomics. Ergonomics draws on several scientific disciplines, including physiology, biomechanics, anthropometry, statistics and epidemiology. Research bodies such as NIOSH have concluded that ergonomics has a sound basis in scientific literature. Although professionals have applied the science and profession of ergonomics in the design of processes and products in many industries, much of this level of ergonomic knowledge has not reached the engineering community (Helander, 1999).

By transferring ergonomics knowledge and skills to engineers in a usable manner, ergonomics can be integrated into engineering (Sullivan & McLean, 1997). Consider what type of training, workshops or awareness materials are available to equip engineers with support tools to use in the design and redesign process.

For example, provide an interactive workshop approach to raise awareness and enhance the design group's ergonomic skill set. Rather than focus on transferring knowledge, engage learners in an environment of inquiry, analysis and decision making. Activating participation in discussions and problem-solving exercises will increase learning and retention (Knowles, 1973). It is recognized that adult learning is enhanced by hands-on experience that involves adults in the learning process (Pike, 1989). On-the-job training, small group discussions and case study work can build on the existing knowledge and increase retention of new ergonomics information.

Develop Specific Ergonomic Support Tools

Ergonomics guidelines and standards are seen as another way to transfer knowledge. However, research has found that ergonomic standards are ignored by design engineers when they are formulated in vague and general terms (Wulff, et al., 1999). Designers may not understand general ergonomic recommendations, may not know how to make them concrete in the specific situations or may not consider them important enough if they are in conflict with other design requirements. Therefore, ergonomics design criteria must have specific formulations.

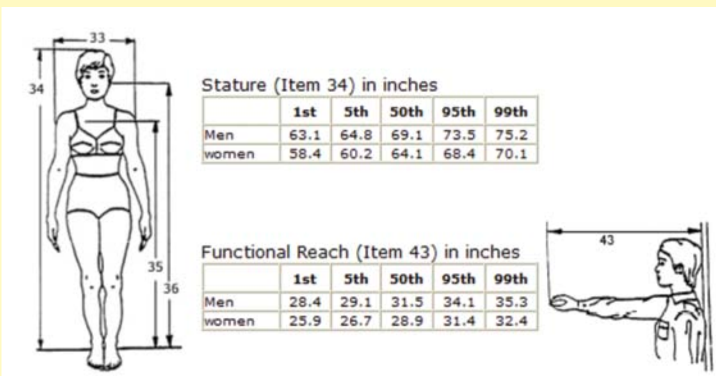
Anthropometry data can be used to establish design criteria. Anthropometry is the study of the dimensions of the different parts of the body. The simplest and most common form of this science is known as *static anthropometry*, where people are measured in unmoving and defined positions. Surveys measure a sample of the population to develop a data set. Anthropometry data are shown by percentiles (Figure 3, p. 72). Once a designer has identified the right anthropometry data and understood the measurement, it must then be determined what percentiles to design for. The typical design strategy is to accommodate extremes in the population to cover a majority of users (Pheasant, 1988). Many businesses will take the information in anthropometry tables to develop and communicate guidelines to the engineering community related to heights, reaches and clearance specifications.

The other branch of anthropometry is known as *functional anthropometry*, which includes dynamic reaches and strength measurement. Computer-generated design tools in this area are evolving for employers who desire to be proactive in addressing ergonomics issues and concerns. These 3-D models can allow the designer to change the size of the individual, the elements of the design and the viewing angles. Images can be changed to simulate motion. This allows for an assessment of the potential impact the design has on ergonomics risk as well as safety, health, quality and productivity. By simulating the impact of a proposed design and making changes prior to implementation, this helps avoid the costs of retrofit, rework and injuries. Items such as reach, access and clearances can be readily assessed using design tools to minimize awkward postures.

If a job task being simulated also requires the operator to manually lift, push or pull an object, a biomechanical strength assessment must be performed. Traditional computer-generated human form images in computer-aided design (CAD) software do not indicate the actual biomechanical stresses required by an individual (Chaffin, 1997). Fortunately, software is available that can be operated alone or in conjunction with software that designers are already using, so that the impact of a given workplace design can be assessed relative to population strengths. Fortunately, software such as University of Michigan's 3-D SSPP is available that can be operated alone or in conjunction with software that designers already use, so that the impact of a given workplace design can be assessed relative to population strengths (Figure 4).

Figure 3

Anthropometric Data



Stature (Item 34) in inches

	1st	5th	50th	95th	99th
Men	63.1	64.8	69.1	73.5	75.2
women	58.4	60.2	64.1	68.4	70.1

Functional Reach (Item 43) in inches

	1st	5th	50th	95th	99th
Men	28.4	29.1	31.5	34.1	35.3
women	25.9	26.7	28.9	31.4	32.4

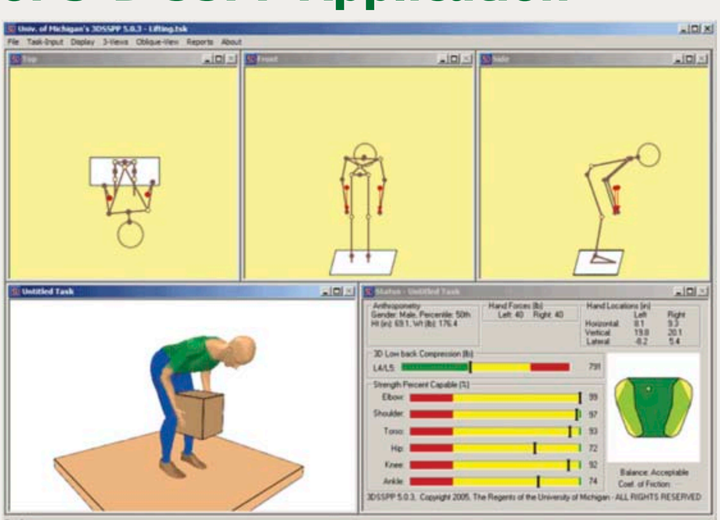
***Note.** Data from* Human Factors Design Guide*, by D. Wagner, M. Birt, M. Snyder, et al., 1996, Atlantic City, NJ: Federal Aviation Administration.*

Figure 3: Dimensions are shown for stature and functional reach, while illustrations demonstrate the measurement taken.

Figure 4: An example of a biomechanical model from the University of Michigan 3-D SSPP application website.

Figure 4

Biomechnical Model of 3-D SSPP Application



***Note.** Copyright 1990 The Regents of the University of Michigan. Retrieved from http://umich.edu/~ioe/3DSSPP/index.html. Reprinted with permission.*

As design solutions are developed, an evaluation of the running system prior to startup is a practice to consider (Pikaar, Koningsveld & Settels, 2007). Constructing a mock-up of the final design gives users an opportunity to provide additional feedback prior to finalization (Photo 3). Although engineers can readily interpret CAD software and newer 3-D modeling applications offer a high clarity level, issues can be identified in a more physical setup by users who are not as familiar with computer modeling tools. This step also allows for additional user participation.

Integrate Ergonomics Design Naturally Into Business

Surveys indicate that engineers find constraints with situations that have many tasks to complete. Lack of time may lead to considering work environment aspects in design as just another task that will impede the deadlines that must be met in the work process. Time constraints may lead to an inadequate design review of ergonomics (Broberg, 2007). The issue is compounded by the perception that management and safety organizations do not explicitly express expectations on the subject (Perrow, 1983). Clearly, it is not only essential that design guidelines or criteria are available to be readily used by the engineering organization, but the expectation to use them must be set by leadership. The business value of ergonomics should help provide safety professionals the case for change if leadership does not currently support the concept of proactive ergonomics.

Examine what existing work processes are in place. Ergonomics is best implemented as part of an existing task, rather than adding another task to a designer's already full plate. For example, if lean manufacturing is considered as part of the design process, ergonomics is a good fit to incorporate, since the goals of both initiatives are similar. Implementation of lean production can lead to optimal work layouts that minimize reaches and waste of material movements, which also lessens the risk of injury. Integrating ergonomics into the lean process begins in the planning stages. To ensure that ergonomics is a key component of the lean process, the team must make ergonomics and safety core values (Kester, 2013). A case study of this concept demonstrates that integration of ergonomics into lean implementation can save money in a redesign of a pail palletizing process (Table 1).

In an engineering design process, many decisions must be made while considering multiple criteria. It can be challenging for any single designer to account for all possible human factors concerns for a given design. If there is a specific role assigned to ergonomics within the business, this role should be part of the design team to ensure proper design throughout the development stages (Moraes, Arezes & Vasconcelos, 2011). This representation can shift the mind-set of the design team to focus on the perspective of the end user by having a facilitator for uncertain areas related to the human-machine interface.

Conclusion

Moving from a reactive mind-set in managing MSDs after they occur to designing workstations to prevent discomfort and injury has numerous benefits. It is a highly cost-effective way to enhance operator performance, promote a healthy workforce and increase employee job satisfaction. The safety professional can play a key role in helping leadership understand the advantages that appropriate ergonomic design and redesign can offer the business. Communication of successes as they are made can help secure continued support and momentum needed to get in front of ergonomic successes. This in turn can help shift the culture of an organization from reactive to proactive. **PS**

Photo 3: Mock-up evaluation of an emergency control center that included a full-scale mock-up of 25 workstations (Pikaar, Koningsveld & Settels, 2007).

Table 1
Lean Redesign With Ergonomic Considerations

	Before	After	Impact
Labor costs—remove one material handler	$60,000	$30,000	($30,000)
Workers' compensation costs (two back injuries per year)	$36,000	$0	($36,000)
Installation of conveyors	$0	$600	$600
Purchase/installation of vacuum hoist	$0	$9,500	$9,500
Employee training on the new equipment	$0	$50	$50
First year totals	$96,000	$40,150	($55,850)

Table 1: Results of a lean redesign with ergonomics considerations that reduced costs by more than $55,000 per year (Kester, 2013).

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