



# ERGONOMICS IN MANUFACTURING

## Workplace Ergonomics

### Abstract

This article focuses on the need of humans in modern day manufacturing, identifies the key issues concerning ergonomics in the workplace, and provides solutions for improving ergonomics and reducing potential injuries.

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# SOS SAFETY SOLUTIONS ERGONOMICS IN MANUFACTURING

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## OVERVIEW

### 1. Introduction:

#### **i** *Ergonomics in the Workplace*

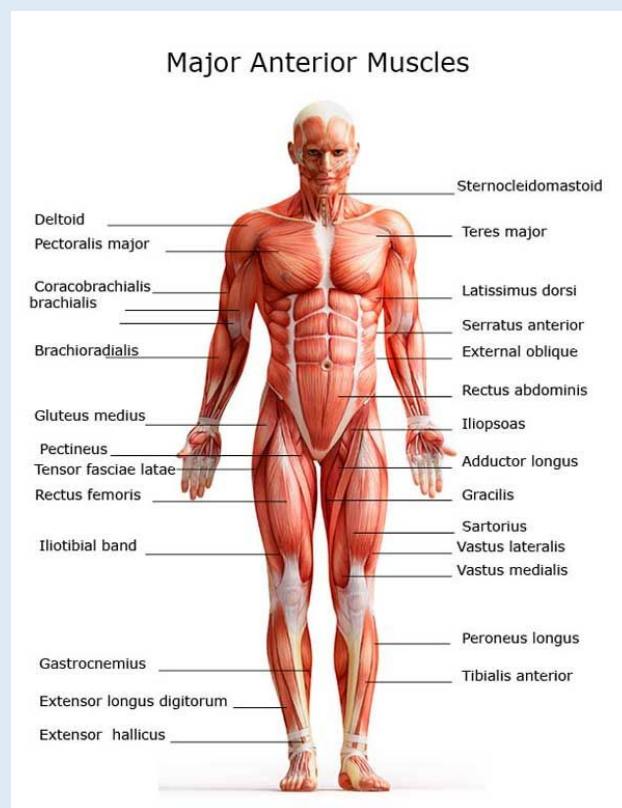
Ergonomics in a simpler form is the idea or process of fitting a task or job to an individual. This can affect anyone from in-home office settings to manufacturing and industrial operations. Ensuring a task is properly fit helps to reduce work-related incidents and injuries that ultimately lead to increased business costs, added workplace stress, and other potential physical limitations in the future that may burden the individual. It is important not only for employers to ensure that they are doing their due diligence, but it is also important for each individual to understand how to properly identify and mitigate ergonomic hazards throughout their day.

Throughout the manufacturing industry, we encounter ergonomic-related issues on a daily basis. Whether it is a workstation design or layout, heavy and/or repetitive lifting of items, or even storing and accessing stored items, all involve ergonomics. Some common injuries related to ergonomics include muscle strains, muscle sprains, and repetitive motion injuries such as carpal tunnel, tendinitis, and so on. To better understand these injuries, their occurrences, and ergonomics as a whole, people need to understand how muscles function and support the human body.

When discussing ergonomics or muscles, it almost always pertains to the musculoskeletal system of the human body. This system is made up of bones, muscles, ligaments, tendons, and so much more. This is the system that gives our body shape and support. If someone were to remove the bones, tendons, muscles, and everything else, the body would be a pile of mess on the ground with no movement or ability. Therefore, it is important that people take care of their bodies, especially the musculoskeletal system.

A-1

Muscles are made up of a bunch of stretchy fibers that are bundled into different groups called fascicle. These bundles can contract or relax and expand as needed to give our body movement through muscles called extensors and flexors. All the muscles in our body have a particular grain, much like a grain pattern found on wood, and they tend to run in a similar direction. Looking at diagram A-1, specifically in the chest or leg region, it should be fairly easy to identify the bundles along with their direction or grain of travel.



Understanding muscles can lead to a better understanding of how strains and sprains occur. When people partake in resistance weight training, they are knowingly putting the muscles under stress creating little tears across the muscle fibers. These tears, also referred to as micro tears given how miniscule they are, do not pose a risk to individuals. The body naturally heals these micro tears, which in turn grows the muscle. When dealing with a strain or sprain, which is another way of saying tear, it is usually on a larger scale than what people may encounter while resistance training. Harvard Medical School defines a muscle strain as, “the stretching or tearing of muscle fibers”. This is followed up with “Most muscle strains happen for one of two reasons: either the muscle has been stretched beyond its limits or it has been forced to contract too strongly”.

It is vital to understand why ergonomics is important and how to properly identify and avoid ergonomic issues. Start with the big question: Why? Then look at the most valuable part of a company: You! Everyone enjoys being present and living in the here and now, but what about the future? If you do not take care of your body, you may have limited movement as you get older, and you may not be able to participate in things you wish you could. It could mean the difference between whether or not you can play with kids or grandkids, walk someone down the aisle at their wedding, or even go on vacation. All these things rely on being healthy and taking care of your body inside and outside of work.

## 2. Chapter One:

### **i** *Why the Human Body is Great*

The better question is, “Why isn’t the human body great?” That list would not take as long. Perhaps it is because it is susceptible to compromise, or that every body has an expiration. Nevertheless, when individuals actually take a second to look at everything it does, that is when the body can truly be appreciated. The human body allows us to communicate. One of the most basic building blocks of any civilization is communication. Without that, individuals cannot communicate their intent. That leads to the mind or nervous system. Human intelligence far surpasses almost all things. The brain is able to assist in the development of thoughts and ideas. From there, the brain is able to interact and speak to the rest of the body, controlling organs and processing various items—all the way to commanding the muscles to move the bones. Ergonomics is all about protecting your most valuable asset. Your body.

## 3. Chapter Two:

### **i** *Understanding Manufacturing and Ergonomics*

Manufacturing is the conversion of raw materials into finished products by using machinery, making humans the essential part as the operation of manufacturing systems. A number of activities are involved in the process such as manual material handling, hand tool use, and awkward postures. That being said, many injuries result from manufacturing, and most of those are musculoskeletal disorders (MSDs) caused

by cumulative trauma. Cumulative trauma is defined as “the excessive wear and tear of tendons, muscles, and sensitive nerve tissue caused by continuous use over an extended period of time”. In order to reduce the risk of developing MSDs and eliminate these injury types, workplace ergonomics should be implemented while following the Hierarchy of Controls.

Workplace ergonomics is known as the science of designing the workplace to remove risk factors and avert injuries while improving human performance and productivity. Therefore, by focusing on ergonomics in the workplace, risk will be reduced and manufacturing will be improved through productivity, quality, and by reducing costs all at the same time.

#### 4. Chapter Three:

##### **i Injury Types and Short- and Long-Term Consequences**

In an article by John Triano, DC, PhD, called “Work Ergonomics: Minimize Back Injuries,” he states that prolonged static posture is the enemy and that a healthy body can only tolerate staying in one position for about 20 minutes. This explains why standing on a concrete floor at an assembly line for an extended time leads to pain in the body, most often being back pain. In his article, Triano explains that if the body is held at the same position, it will slowly diminish elasticity in the soft tissues such as the muscles, ligaments, and tendons in the back. Stress will then build up and cause

discomfort in the back and/or the legs. Poor ergonomics in the workplace can lead to multiple injuries with short- or long-term consequences.

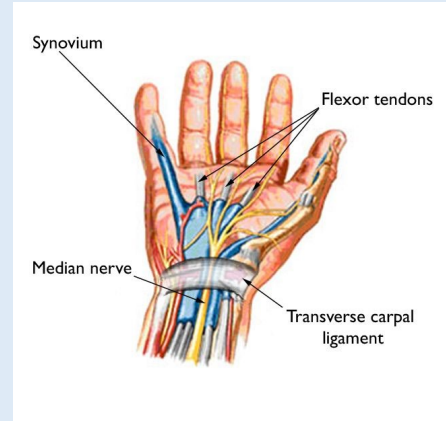
The most common types of short-term consequences are sprains, strains, and back pain from prolonged static postures. As explained above in the introductory section, a sprain is an injury to a ligament, which is thick, tough fibrous tissue that connects two bones together. Sprain injuries involve a stretching or a tearing of this tissue.

Additionally, a strain is an injury to either a muscle or a tendon – the tissue that connects muscles to bones. Strains may be a simple overstretch of the muscle or tendon, or it can result in a partial tear. Sprains and strains can develop suddenly or they may develop over a course of days, weeks, or even months. Some ergonomic risk factors that may cause strains and sprains are excessive force, excessive repetition, awkward postures, and other environmental factors such as slip, trip, and fall hazards. On the other hand, back pain can result from an ample range of movements, including twisting the waist while lifting items and lifting items from below the knees or over the shoulder. The key to preventing this type of injury is frequently changing positions and posture, stretching, and being cautious when handling or lifting materials. It is vital to avoid these risk factors and to implement corrective actions to prevent these injuries from becoming long-term.

Avoiding or refusing to acknowledge ergonomic risks and to implement corrective actions can lead to long-term musculoskeletal disorders. Carpal tunnel is one of



those long-term consequences and one of the most common MSDs. It affects employees of all ages, and it is leading the way for increased cost to industry. If we breakdown injury types into severity and look at the total cost of work-related incidents, ergonomic-related injuries consistently rank among the highest costing and most frequently occurring. According to the Bureau of Labor Statistics, 888,220 non-fatal work injuries occurred in 2019. Ergonomic factors were related to over 250,000 of those incidents.



Carpal tunnel is one of the top MSDs injuries to consistently plague industries around the globe. Carpal tunnel syndrome (CTS) occurs when the tendons that run from your hand through the forearm along the median nerve begin to become restricted under the transverse carpal ligament. The pressure on the nerve is what causes the individual to feel pain, making movement of the wrist and hand uncomfortable. Typically, CTS is a result of repetitive motion. This could be repeat tasks that require the use of one's hands. There are also tasks that have an impact on the body even though the individual may not be doing anything. A good example of this would be vibration. These repetitive motions or sensations lead to tendon or ligament swelling, predominantly around the joints. This is when pressure begins being applied to the median nerve as previously mentioned, causing discomfort, swelling, and other uncommon sensations. According to one article published in U.S. National Library of Medicine and National Institutes of Health, "It is estimated that one million adults

(annually) have a form of CTS that requires medical intervention” (Carpal Tunnel Syndrome, 2008). According to the same publication, “In 1995, Palmer et al estimated that between 400,000 and 500,000 cases of CTS require operative treatment annually in the States, with an economic cost in excess of \$2 billion per year” (Carpal Tunnel Syndrome, 2008). The data continually shows that industries can and need to continue focusing on MSDs such as CTS.

Another common long-term consequence that results from poor ergonomics is arthritis. Merriam-Webster defines arthritis as “inflammation of joints due to infectious, metabolic, or constitutional cause”. Merriam-Webster puts the first use of the word “arthritis” in the sense mentioned above to 1543. According to the CDC, “23% of all adults, or roughly 54 million, in the U.S, have arthritis.” Of those 54 million, the CDC reports that 8 million claim their arthritis hinders their work performance. When it comes to the workplace, it is important to understand what can lead to arthritis.

A number of factors that are a result of arthritis can stem from personal life choices. The CDC and many other leading institutions list maintaining a healthy weight as one of the top factors to limit arthritis. When people put on weight, they are adding to the compression felt within their joints. This is especially evident in the knees and hips, which tend to do most of the weight support for the human body. The added stress can cause the body’s joints to become inflamed, making movement restricted or uncomfortable. A proper diet can also ensure that joints are prepped internally to handle the daily stressors we face and maintain durability.

Even though a lot of what comes with arthritis can be mitigated through personal choices, it is important to focus on the work environment. Repetitive stressors or motions in the workplace can just as easily lead to arthritis down the road. A good example of this would be a full-time forklift operator. The repetitive vibrations that an employee is exposed to during forklift operations could lead to a multitude of conditions including arthritis. Another form of arthritis, according to a Reuters Health study in 2017, being rheumatoid arthritis, is more likely to affect males in the manufacturing industry than most other industries. Rheumatoid arthritis is when your body attacks your own joints causing extra wear and tear compared to other forms of arthritis. The study goes on to state how air pollutant factors are continuously being studied to see how changes in lung function or air quality can bring about this serious form of arthritis.

When it comes to functions and jobs throughout manufacturing, it is important to identify the key factors that can lead to the development of this impactful disease. Factors such as repetitive motion, repetitive heavy lifting, and even air quality factors can all play a role in the formation of arthritis. So, if those factors can be identified early and put through the Hierarchy of Controls to limit employee exposure, this long lingering disease may just become a thing of the past one day.

One of the top concerns, when it comes to long-term health of employees, is the ever-increasing cases of lower back pain. As previously mentioned, back pain can be short-term; however, if ergonomic issues are not corrected in due time, it will become long-term. Similar to arthritis, lower back pain can stem from many factors that

plague the manufacturing industry as a whole and can affect every individual in the company. Lower back pain is generally a result of a gradual buildup of damage to either the musculoskeletal system or the nervous system. According to one study, back pain in general had a direct cost of \$25 billion in healthcare costs to employers with the indirect costs surpassing \$100 billion dollars each year (AL-Otaibi, 2015).

Similar to the aforementioned disorders, companies who perform routine job hazard analysis of various jobs and tasks are able to be proactive, especially with disorders that form over a longer period of time.

It is crucial that employees are aware of proper lifting techniques to avoid putting stress on the lower back. It is important for employees to be aware of any available lifting aids and how to use them properly. This could be anything from dolly carts to hoists and cranes. However, employees should be aware that although a lifting aid may reduce certain risks, it could present new ones as well. A perfect example would be a hoist. The hoist reduces the chance of an ergonomic-related injury occurring; however, it introduces a struck-by hazard for employees if the hoist were to fail.

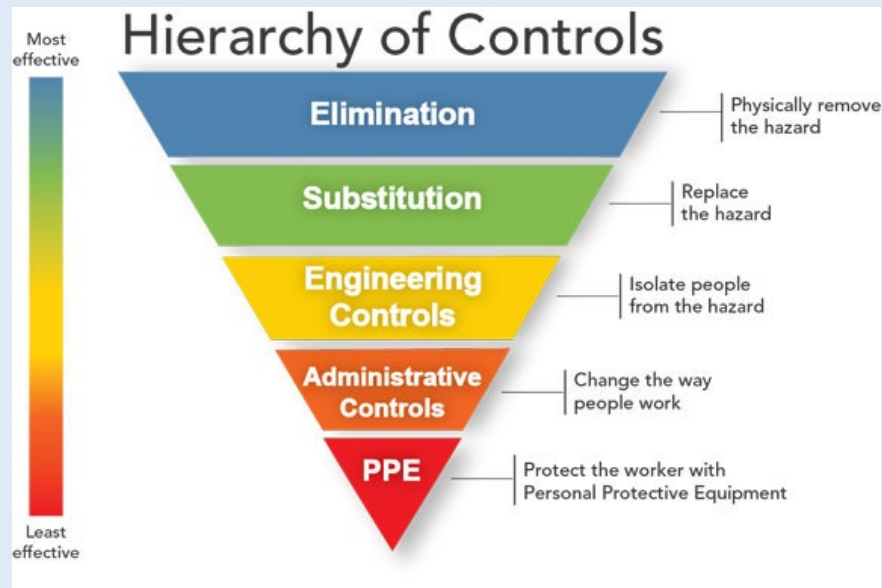
Lower back pain is so prevalent because many variables could be the root cause. Vertebral discs could be applying unwanted pressure onto nerves. Perhaps there is a lower lumbar strain of the muscles in the lower back. Some causes of lower back pain may be due to personal choices. Nevertheless, it is important for employers to recognize and identify present tasks that could issues down the road, along with ensuring that employees are properly trained on present hazards and proper mitigation techniques.

## 5. Chapter Four:

### **i** How to Prevent Ergonomic Injuries

According to the CDC and NIOSH, in their article “Hierarchy of Controls”, they state, Controlling exposures to occupational hazards is the fundamental method of protecting workers. Implementing this control into the workplace and controlling exposures to occupational hazards, including chemical, biological, psychosocial, and physical hazards, are essential. This can be used to determine how to implement feasible and effective control solutions. The Hierarchy of Controls is represented as an upside down triangle with the most effective and protective control at the top being Elimination, followed by Substitution, Engineering Controls, Administrative Controls, and lastly Personal Protective Equipment (PPE) being the least effective (Diagram A-2). Following this hierarchy can lead to the implementation of safer systems, where the risk or injury can be significantly reduced.

A-2



## Elimination and Substitution

Elimination and substitution are processes of physically removing or replacing the hazard. Although they are known to be the most effective at reducing hazards, they are the most difficult to implement in an existing process. However, if the process is still being designed or developed, elimination and substitution may be inexpensive and easily implemented. For a process that already exists, major equipment changes and new procedures may be required to eliminate or substitute for a hazard.

## Engineering Controls

Engineering controls are designed to isolate people from hazards. Engineering controls are often favored over administrative and personal protective equipment because they are designed to remove the hazard at the source before it comes in contact with a worker. This can include adding material handling equipment to

eliminate manual lifting, changing workstations, or adding ramps or steps to facilitate movement – all highly effective controls. Initial cost of engineering controls can be higher than administrative controls or PPE, but in the long run, they can be cheaper.

### **Administrative Controls**

Administrative controls change the way people work. Trainings and techniques to mitigate hazards are ways to improve existing processes. Finding solutions, such as training employees on ergonomic risk factors and implementing pre-shift stretching routines, can act as administrative controls.

### **Personal Protective Equipment**

Providing employees with the necessary personal protective equipment (PPE) will help protect them from minor to severe hazards. It is important to follow the company's policy to ensure that all employees wear their PPE daily and that they be held accountable if otherwise.

("Hierarchy of Controls" pg. 1-2)

### **Ergonomic Process**

To implement a good ergonomic process the Hierarchy of Controls should be followed. It is important to determine how the hazard can be removed, whether through elimination/substitution, engineering controls, administrative controls, or personal protective equipment. While establishing an ergonomic process, important

elements must be followed to make the process effective. It is vital to provide management's support, involve the workers, provide training, identify problems, and encourage early reporting of MSD symptoms. There are tools that can be used to evaluate the whole body postural MSD and risks associated with job tasks. Utilizing these tools can help identify ergonomic risks in order to work on eliminating them. One of those tools is known as a Rapid Entire Body Assessment, also known as REBA.

A Rapid Entire Body Assessment can be completed to identify risks associated with a job task. This single page worksheet evaluates body postures, forceful exertions, type of movement or action, repetition, and coupling (Diagram A-3). This worksheet

was designed for easy use – all that is needed is a pen and the worksheet itself. The way this works is by the evaluator assigning a score for body regions such as the wrists, forearms, elbows, shoulders, neck, trunk, back, legs, and knees. The score will then determine the level of MSD Risk and if action and change is required (Diagram A-4).



**REBA Employee Assessment Worksheet**

Task Name: \_\_\_\_\_ Date: \_\_\_\_\_

**A. Neck, Trunk and Leg Analysis**

**Step 1: Locate Neck Position**

Neck Score: \_\_\_\_\_

Step 1a: Adjust...  
If neck is twisted: +1  
If neck is side bending: +1

**Step 2: Locate Trunk Position**

Trunk Score: \_\_\_\_\_

Step 2a: Adjust...  
If trunk is twisted: +1  
If trunk is side bending: +1

**Step 3: Legs**

Leg Score: \_\_\_\_\_

Step 3a: Adjust...  
If leg is twisted: +1  
If leg is side bending: +1

**Step 4: Look-up Posture Score in Table A**  
Using values from steps 1-3 above, Locate score in Table A

**Step 5: Add Force/Load Score**  
If load < 11 lbs.: +0  
If load 11 to 22 lbs.: +1  
If load > 22 lbs.: +2  
Adjust: If shock or rapid build up of force: add +1

Force / Load Score: \_\_\_\_\_

**Step 6: Score A, Find Row in Table C**  
Add values from steps 4 & 5 to obtain Score A. Find Row in Table C.

**Scoring**  
1 = Negligible Risk  
2-3 = Low Risk. Change may be needed.  
4-7 = Medium Risk. Further Investigate. Change Soon.  
8-10 = High Risk. Investigate and Implement Change  
11+ = Very High Risk. Implement Change

**B. Arm and Wrist Analysis**

**Step 7: Locate Upper Arm Position:**

Upper Arm Score: \_\_\_\_\_

Step 7a: Adjust...  
If shoulder is raised: +1  
If upper arm is abducted: +1  
If arm is supported or person is leaning: -1

**Step 8: Locate Lower Arm Position:**

Lower Arm Score: \_\_\_\_\_

**Step 9: Locate Wrist Position:**

Wrist Score: \_\_\_\_\_

Step 9a: Adjust...  
If wrist is bent from midline or twisted: Add +1

**Step 10: Look-up Posture Score in Table B**  
Using values from steps 7-9 above, locate score in Table B

**Step 11: Add Coupling Score**  
Well fitting Handle and mid range power grip. **good: +0**  
Acceptable but not ideal hand hold or coupling acceptable with another body part. **fair: +1**  
Hand hold not acceptable but possible. **poor: +2**  
No handles, awkward, unsafe with any body part. **Unacceptable: +3**

Coupling Score: \_\_\_\_\_

**Step 12: Score B, Find Column in Table C**  
Add values from steps 10 & 11 to obtain Score B. Find column in Table C and match with Score A in row from step 6 to obtain Table C Score.

**Step 13: Activity Score**  
+1 1 or more body parts are held for longer than 1 minute (static)  
+1 Repeated small range actions (more than 4x per minute)  
+1 Action causes rapid large range changes in postures or unstable base

Activity Score: \_\_\_\_\_

**Table A: Neck**

	Neck		
	1	2	3
Legs	1	2	3
Trunk	1	2	3
Posture	1	2	3
Score	1	2	3

**Table B: Lower Arm**

	Lower Arm		
	1	2	3
Wrist	1	2	3
Upper Arm	1	2	3
Score	1	2	3

**Table C: Score A vs Score B**

Score A	Score B											
	1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	7	7	8	8
3	2	3	3	4	5	5	6	7	7	8	8	8
4	3	4	4	5	6	6	7	8	8	9	9	9
5	4	5	5	6	7	7	8	9	9	10	10	10
6	5	6	6	7	8	8	9	10	10	11	11	11
7	6	7	7	8	9	9	10	11	11	12	12	12
8	7	8	8	9	10	10	11	12	12	13	13	13
9	8	9	9	10	11	11	12	13	13	14	14	14
10	9	10	10	11	12	12	13	14	14	15	15	15
11	10	11	11	12	13	13	14	15	15	16	16	16
12	11	12	12	13	14	14	15	16	16	17	17	17

Table C Score: \_\_\_\_\_ Activity Score: \_\_\_\_\_ REBA Score: \_\_\_\_\_

Original Worksheet Developed by Dr. Alan Hedge. Based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205

Score	Level of MSD Risk
1	negligible risk, no action required
2-3	low risk, change may be needed
4-7	medium risk, further investigation, change soon
8-10	high risk, investigate and implement change
11+	very high risk, implement change

A score for body regions below '7' may need a change. However, a score of '8+' requires that a change to be implemented. Using tools such as this will aid in eliminating long- and short-term injuries.

In addition to external tools that employers implement to reduce workplace ergonomic risks, a lot of ergonomics comes down to the individual moving properly. Technique and form are just as important as control methods, especially if we cannot eliminate or engineer out the hazard. We need to make sure that our posture is correct to eliminate the possibility of incurring an MSD. Imagine holding a broomstick with a bowling ball on one end. If the stick was held straight up and down with the ball on top and you then tilt it forward, depending on your hand position, it may be more difficult or perhaps easier. The closer the hand is to the bowling ball the easier it would be. As the distance between your hand and the bowling ball grows, it becomes more difficult.



A-5



A-6

Imagine the broomstick as the spine, the hand as the lower back, and the ball as the load being lifted. When it comes to a safe lift, eliminating that forward tilt and keeping the load close to the body will eliminate a lot of stress put on the lower back. In example A-5 above, notice the individual has a rounded back and bends at the waist to lift the box. This is an example of an improper proper lift that would put much unneeded stress on your lower back, which could cause an injury or long-term damage from repetitive poor lifts. In example A-6 above, examine the individual keeping their back straight and bending at the knees to lift the package. When performing a proper lift in the workplace, employees should have one foot slightly in front of the other to ensure good balance. As the lift begins, it is important to keep the back straight and chest pointed to the front. Finally, employees can transport the item to its destination, and, if necessary, repeat the previous steps to ensure a safe drop off.

## 6. Conclusion:

### **i** *Additional Information and Resources*

Ergonomic change to improve the health and safety of workers will not develop overnight. It is vital that everyone—employer and employee—takes the time to educate themselves on ergonomics in their work environment. They should also be aware of the consequences if no changes are implemented. The goal is to avoid short- and long-term consequences by using all the knowledge and tools available.

Below are additional resources to learn more about ergonomic risks and to begin a culture shift toward improved safety.

#### **National Safety Council**

**Nonprofit, public service organization promoting health and safety.**

**<https://www.nsc.org/>**

**800.621.7619**

#### **Occupational Safety and Health Administration**

**Provides training, outreach, education, and assistance.**

**<https://www.osha.gov>**

**800-321-6742 (OSHA)**

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