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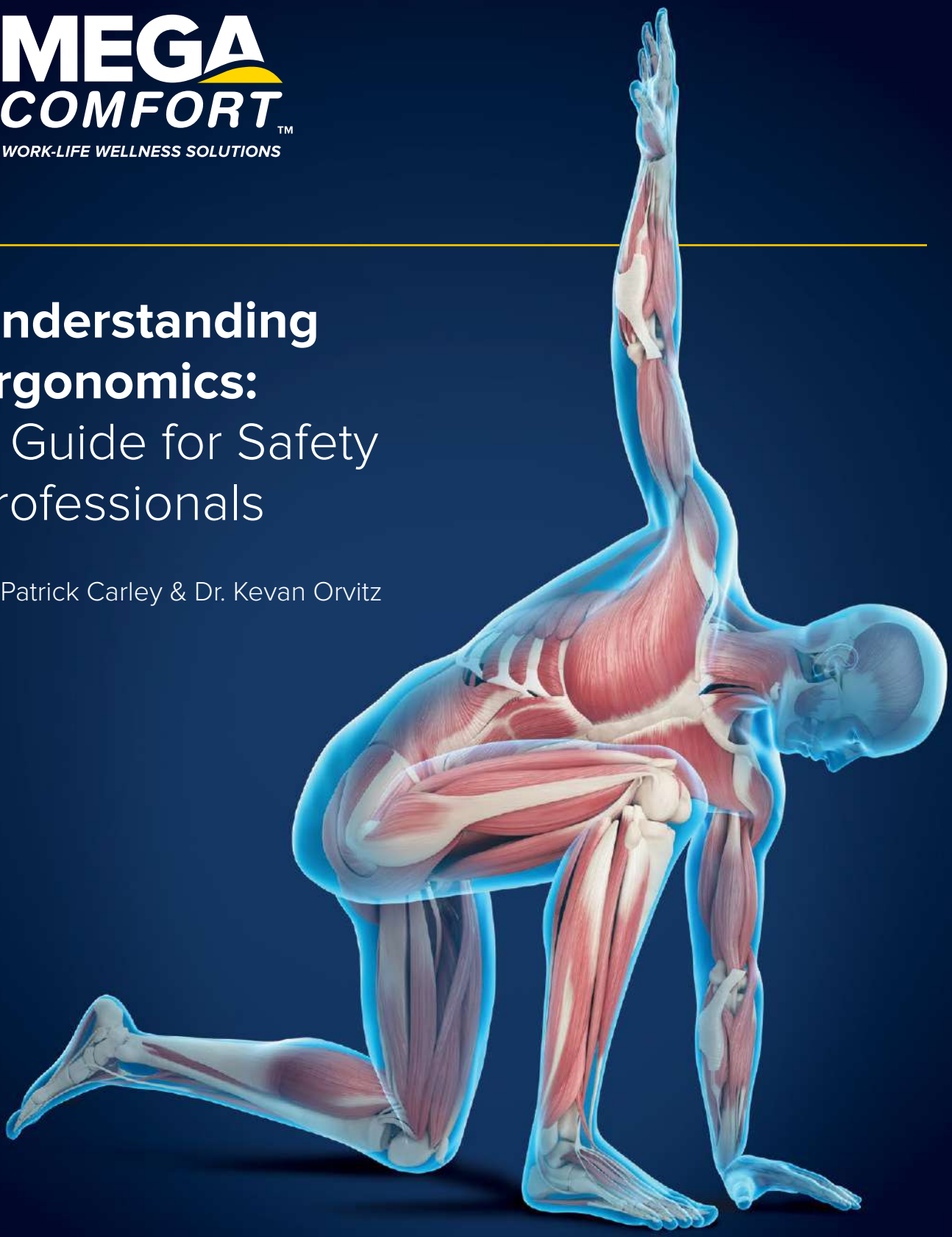
WORK-LIFE WELLNESS SOLUTIONS

Understanding Ergonomics: A Guide for Safety Professionals

Dr. Patrick Carley & Dr. Kevan Orvitz



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Best known for his creation of the Personal Anti-Fatigue Mat (PAM) Insole, Dr. Orvitz and his revolutionary Ergonomic designs have paved the way for employees to experience enhanced comfort, decreased pain and fatigue creating a safer more productive workplace.

With over 20 years of experience in various industries, Dr. Orvitz has studied all aspects of biomechanics and the human body, specifically the lower body and feet. As the costs of absenteeism and injuries skyrockets,Dr. Orvitz has now positioned MEGAComfort as an innovative, leading-edge company that brings new technological health solutions to the workplace to help decrease employee risks and employer medical costs.

Part 1: Introduction to Ergonomics

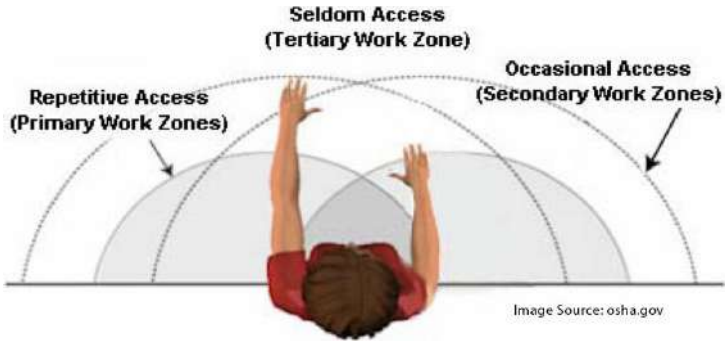
OSHA defines ergonomics as “the science of designing the job to fit the worker, instead of forcing the worker to fit the job”. While that appears like a fairly simple statement, there is much more to the process of understanding ergonomics. The true understanding of ergonomics is changing how we think about how we move and interact in the performance of various work tasks.

There are five basic components of engaging the ergonomic process:

1. DEFINING WORK ZONES

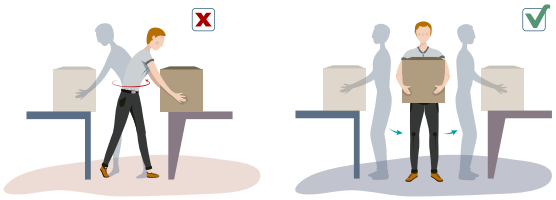
In manufacturing, assembly work, and construction, from the worker’s perspective, the work should be organized using a simple three zone approach. Things that need to be interacted with **frequently**, such as tools, parts, assembly, etc. should be within the elbow to fingertips reach or the **Primary Zone**. Those tasks, parts, tools, etc. that are **less frequently** interacted with should be in reach from the shoulder to the fingertips or the **Secondary Zone**. Lastly, those items that are not often needed in the process of work tasks should be placed in an area where the worker must change their position to obtain, retrieve, or engage in the **Tertiary Zone**.

****All items or articles that are not relevant to the task should be removed or placed in the Secondary or Tertiary Zones, for example, pictures of family, tissue boxes, stuffed animals should all be placed out of the **Primary Zone**.*



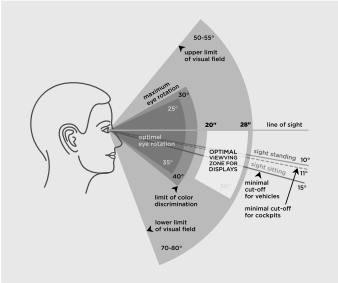
2. KEY MOVEMENTS

Material handling and lifting tasks are common activities in the industrial sector that require change in how objects are approached and manipulated in this setting. Ergonomically, there are three components to be aware of: posture, distance, and load assessment (PDL). Posture when bending should include not only bending the knees but also extending the head upward prior to lifting. This promotes back muscles to engage and **stabilize the spine** in preparation for lifting. The worker should practice getting as close to the object as possible to limit the distance between them and the object. Finally, lifting the object slowly will allow the brain and muscle to create the right amount of muscle tension to handle the load. Reaching creates the opposite conditions and it is consistent risky material handling methods that will ultimately lead to injury of the low back and hips.



3. AWKWARD POSTURES

To understand and recognize awkward postures, it is critical to first define the neutral posture. The neutral posture is assumed when the employee stands upright, with the arms relaxed at their sides, the elbows bent to 90 degrees, and the palms facing inwards, as if to shake hands. When in this neutral posture the body is at its strongest and most stable point, allowing the muscles to work most efficiently. With an understanding of the neutral posture, awkward postures can be defined as any positions that cause significant deviation from the neutral posture. An awkward posture is an ergonomic risk because failure to optimize the body will cause fatigue, unnecessary internal forces, as well as increase the possibility of impingements within the joints. A reasonable solution would be to put cushioned insoles with proper arch support in the worker's footwear. These insoles will prevent fatigue related awkward postures from occurring.



4. EVERYTHING FOLLOWS THE EYES

The body will make postural and positional changes to make sure the eyes can see the elements of work tasks. Some things to keep in mind; if the area of machine operations is too far away, the worker may have difficulty seeing what is needed for the work task. As a result, they will lean forward to accommodate for the eyes. The worker will assume awkward postures for hours to view properly, especially for those wearing reading glasses.

5. ERGONOMICS - A PROCESS

Therefore, one should expect that there will be a need to **re-assess** and adjust newly fitted or modified workstations understanding that there will most likely be a need for further modifications as the worker fine-tunes their adaptations to those changes – **Process not an end goal**

While this is a basic approach to ergonomics, it also reminds us that ergonomics attempts to eliminate excessive motions and awkward postures is a basic way of eliminating barriers to productivity. More importantly, these changes will affect the worker[s] everyday interactions and thus will need to engage the worker in the process, educating them as they will ultimately benefit from those new modifications.

The alternative for **NOT** participating in ergonomics will eventually lead to discomfort, sprains, and strains known as **Musculoskeletal Disorders (MSDs)**. This may lead to possible surgeries, worker's compensation claims, and even disability. As demonstrated by numerous studies, **the corollary to the ergonomic process is a substantial improvement in productivity**. Understanding the basics of ergonomics is just the beginning and once you start thinking about matching the worker with the work tasks, the outcomes are quite amazing.

Part 2: Lower Extremity – Legs, Knees, Ankles and Feet

When someone is asked about the legs in the backdrop of ergonomics, there is typically a look of confusion or that "I never really thought about it before" response. On average, we assume our legs will just do want we want them to do. Consequently, most people do not really think about it much, but legs are really the foundation of how we engage work every day!

From an ergonomic standpoint, our **legs represent only about 25% of our total body weigh**t but that means it holds up, controls, and **supports the other 75% of the body** (head – arms at 25% and trunk at 50% with a total of 75% for the head/arms/trunk referred to at the **HAT**).

With the HAT in mind, our legs will be relied on to help us stand throughout the day, shift our body weight to reach for tools and objects, support the HAT whenever material handling is engaged, and those same legs get us from the car to work, all around work, and then back home again. The legs are truly the unsung heroes involved in just about everything we do at work.

With that concept in mind, now we can build an **ergonomic model** for the legs with one end of the model focused on the **hips and knees**, which provide the strength and power for body movement and stability. So, conceptually, muscle strength and flexibility would be a major concern. Those muscles would be predominately the **quads/hamstrings** for the knees and **Gluteus Maximus and Medius** of the hips

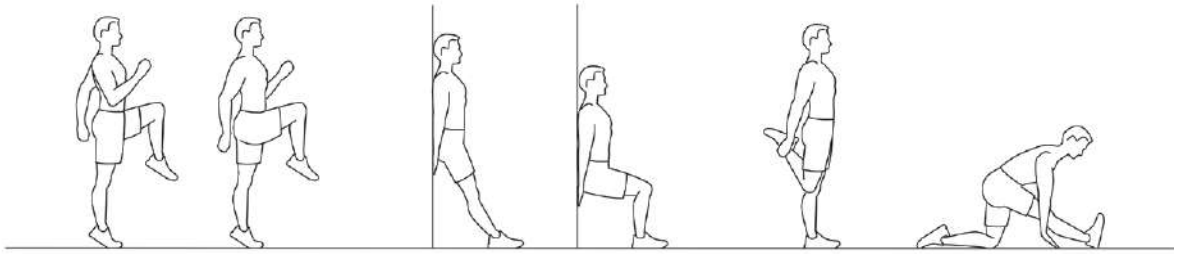
The other end of that model captures the function of the **feet and ankles** interacting with the opposite but equal opposing forces of the ground. The major concern here is **pressure with the ground** (basically what is pushing against us because of gravity which is localized at our foot surface, which is actually the **inside of footwear** and not the ground itself (that is if you are not standing barefoot at your workplace).

Not only do the feet need to deal with a substantial amount of pressure from the opposing ground throughout the workday, the muscles controlling the feet work all day long to continuously **adjust for balance, reaching,** and **weight shifting** from one leg to the other. The most significant muscle responsible for this task is the muscle located just under the **Gastrocnemius (Gastrocs)**. It is rather thick but flat muscle called the **Soleus**, named after its appearance as a flat sandal. The most important thing about this muscle is that it is comprised of **80% slow-twitch muscle fibers**, which makes it extremely fatigue resistant! Perfectly designed for its much-needed functional role in standing and working all day.

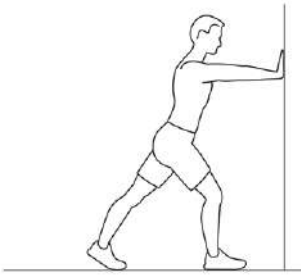
Now that the model is constructed for the legs, a rational ergonomic approach can be formulated to engage problems and improvements for the job the legs are doing all day.

1. **Muscle flexibility** is also a significant concern and to a lesser degree, muscle strength. Realistically, most people will maintain the strength in their legs throughout the functional activities of their daily routine. However, what most people do not do after they work their muscles throughout the day is getting the concept of keeping the muscles flexible.

2. Here are some very important stretches for the **hips and knees** that should be encouraged throughout the day when a machine is down, waiting for the next process, or during their break.



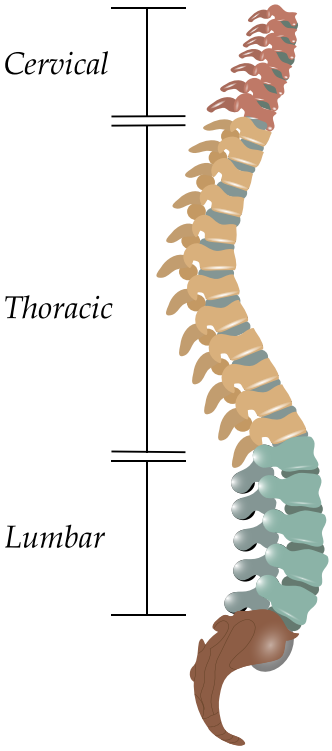
3. When it comes to the **foot and ankle**, there are two very important stretches to do to confirm adequate stretching at the calf to reduce influences on ankle and foot pain. Some of those can be described as **tarsal tunnel syndrome** or **plantar fasciitis**. Make sure to stretch both calf muscles that pull on the largest tendon in the body, which can withstand more than 1,000 pounds of force, according to the American Academy of Orthopedic Surgeons (AAOS).



4. Lastly but most importantly, **reducing the pressure** contact between the feet and ground (inside the footwear) is critical. Studies have shown repeatedly that polyurethane insoles spread out the pressure best thus reducing the forces on the foot surface NOT between the bottom of footwear and the ground. One particular Study, Insole Program in the Manufacturing Setting also demonstrated better muscle control and less muscle force when using **dual layer memory foam insoles** indicating less chance for leg fatigue.

Part 3: Upper Extremity – Structure of Back and Trunk

The etymology of the word "Ergonomics" began in the 1950's but it originates from the core part of the word **"Ergon"** or work. When we complete the word, ergonomics, we are really implying the "pattern or distribution of work". Keeping that in mind, it is not only the pattern of work itself but also the pattern of how things work that interact with ergonomics. The **back and trunk** are not only fundamental to the discussion of ergonomics, but it is also fundamental as to how the human body interacts with work.



Taking a close look at the **structure** of the back truly begins with the basic elements of the spine. It comes in three articulating sections; **cervical, thoracic,** and **lumbar**. The **cervical** vertebrae are smaller and do not have to be large since collectively they are only supporting the weight of the head, which averages 10 to 11 pounds. Since the four major senses (sight, smell, taste, and hearing) are localized within the head, the spine allows for a considerable amount of motion. The facets (joints) of the cervical vertebrae will help guide the motions with the upper part good for controlling rotation and as they go lower, they will begin permitting for more movement in flexion, extension, lateral bending left and right. There is a lot of muscle tissue that adds to more capacity control and moderate those greater degrees of motion.

The **thoracic** portion supports the structures above and the ribs limiting the amount of movement associated with this section. As you can suspect, there is not a lot of muscle tissue in the thoracic spine because of that lack of significant motion. The **lumbar** vertebrae are bigger, wider, and have very prominent spines. They support all the weight above, which now include the organs and contents in the abdomen. The lumbar facets (joints) face inwardly to hug the joints from the lumbar vertebrae above it as if to intentionally control motion. The spines are thicker acting as anchors for thicker muscles to attach assisting to control motion. Another interesting fact is that the spinal muscles have a predominance of Type I – Slow Twitch fibers typically making them not very strong but very fatigue resistant able to adjust and maintain our standing positions all day.

Once the basic concept of the back is constructed, it becomes easier to apply the anatomical model to the biomechanical model, which is essentially how do you want to use the back and trunk during work. This brings in need to discuss one of **Newton's Laws of Motion: for every action there is an opposite and equal reaction.** This is applied to lever or moment arms we all knew about how to play on

the old see-saw. If there was a large child and a small child, they could still have fun but to compensate for the difference, the large child would have to move in closer to the axis of motion to lessen the lever or moment arm effect.

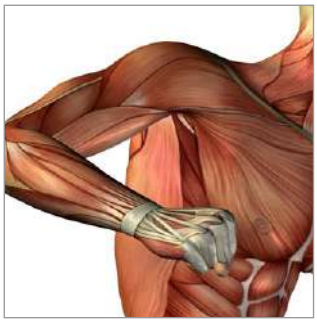
Ergonomically, this is a critical concept since lifting items further away from you causes the back muscle to exert more force because of their proximity to the axis, the spine or vertebra, is so close. We don't have the ability to increase the spinal muscles distance from the spine, so much like the see-saw, we need to constantly **get items as close to us as possible**, thus reducing the amount of force from the spinal or back muscles. Being aware of distance from the material to be handle will **reduce the risk** of back and trunk injuries.

From a physiological perspective, lots can be learned from people who use their back and trunk for recreational or competitive activities of lifting heavy weight. They automatically get as close to the weight as possible, but they do something rather unique and intuitive, but it takes some practice. Before material handling, lifting weights, or even changing the dog's dish, they will lift their heads into extension – **not looking down**. This technique will automatically contract your back muscles preparing the trunk muscles to work and stabilize the spine. Wearing a good pair of **dual layer memory foam insoles** between your feet and footwear will also help in absorbing forces from concrete floors. No need to worry about bending the knees anymore, just remind yourself that lifting your head will better prepare the back and trunk for safe, effective work.

There is a lot of talk about the **"core"** of the trunk much like the core of an apple. Again, it would involve muscles closest to the spine such at the back muscles and the Iliopsoas muscle, which is in the front of the spine. The **abdominal muscles** will help the trunk stabilize during movement, standing balance, and material handling but to a much lesser degree. They tend to be broad, thin muscular structures that are best designed to keep the 25 feet of intestines in place. Just keep in mind, to bring objects as close as possible before lifting, lift slowly at first, and bring your head into extension.

Lastly, vertical loads on the spine and trunk can support up to **1,000** to **1,500 pounds** before suffering any permanent damage. If you use the back and trunk as designed and understood from an ergonomic perspective, the back and trunk are quite strong and durable.

Part 4: Upper Extremity – Arms and Shoulders



In order to truly understand the importance of ergonomics related to the upper extremities, it is vital to appreciate how it is uniquely formed and thus how it is used. The evolution of **arms and shoulders** is just one of the amazing reasons for humans' rise to the top of the food chain. Anthropologist, Susan Larson, at Stony Brook University Center described the change in the shoulder's position beginning some two million years ago as humans left the comfort of trees and began to stand upright. The shoulder's collar bone **(clavicle)** and shoulder blade **(scapula)** transitioned from a more upward and frontal orientation to one that is more horizontal and out to the sides of our bodies. This affords **greater joint flexibility** and **range of motion** to move our arms and hands much further around us. That would include the use of more tools and ability to throw things with more speed and accuracy. An early wooden spear used for hunting found in Europe dates back to 400,000 years. However, early humans were probably throwing rocks and other items for a much longer period.

When considering ergonomics of the modern-day shoulder, there is a need to **balance stability** with all that shoulder **mobility**. Since the evolutionary direction of the shoulder went for extra mobility, the structures of the shoulder are now inherently unstable. This is observed when comparing the shoulder ball and socket design with that of the hip. In the shoulder, the ball is at least three times bigger than the pear-like shallow shape socket unlike the very stable deep socket of the hip joint. The suspended shoulder is now horizontal and out to our sides, the clavicle and scapula need the support of many more muscles to maximize its overall function. There are **14 muscles** surrounding the shoulder and **4 muscles** holding the ball and socket together.

A key component to keep in mind from an ergonomic perspective is that the scapula contains the shoulder socket. In using our arms and shoulders for work, the **shoulder blade constantly changes position** allowing the socket orientation to be moved in up or down and backward or forward motions for added interaction during tasks. For example, lifting one's hand overhead is possible because the scapula now tilts upward resulting in the socket facing upward. The 14 muscles controlling the scapula and the 4 muscles that control surface contact between the ball and socket rely on those muscles to provide critical stability to complete those functional activities. Also, it is quite amazing that 7 of those muscles anchor

off the vertebral spines from the lumbar region and all the way up to the base of the skull.

Since the shoulder and arm extend to our sides, another critical job of those muscles is to hold up the weight of the upper extremity. The body will compensate by overusing the upper and middle trapezius along with the other muscles to support the weight. This causes a **strain in the neck**, most commonly misdiagnosed for a pinched nerve in the neck. This may also lead to impingement syndrome and compression of the four rotator cuff muscles. Ergonomics needs to pay close attention to unsupported arms, particularly in the office setting or where workers will be sitting for long periods, such as piece work and manufacturing areas. If reaching a lot, **consider a good pair of insoles** to reduce the potential balance issues as your center of mass shifts forward.

The **elbow** also has a particularity to its structure referenced as the **"carrying angle"**. Extending one's arm out and looking along the humerus, one will notice a slight bend at the elbow to the outside. The bend is smaller in males but greater in females. It permits the ability to carry objects without hitting your legs, thus the "carrying angle". The greater angles in females have been associated with their smaller shoulders and larger hips than the average male population.

The image on the left shows the many **wrist and finger flexor muscles** used for gripping items that anchor off of the humerus above the inside of the elbow. Continuous grasping and gripping motions will create tighter muscles that need more attention to stretching throughout the workday. Since the muscles attach above the elbow, the fingers and wrist stretching should be performed with the elbows in the extended position.

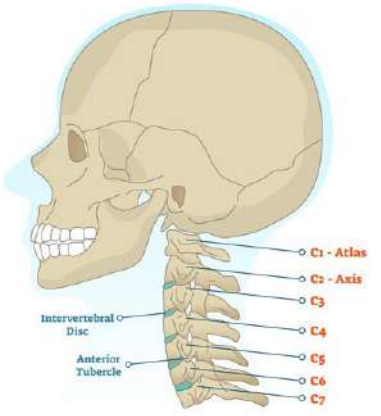
Three ergonomics elements for the upper extremities are:

1. Unload or support the weight of the arms whenever possible
2. Keep work or tasks performed within the primary zone (elbows by your side to finger tips)
3. Consider stretching to the upper extremities throughout the day, breaks and lunch time included.

Part 5: Mechanics of the Head and Neck

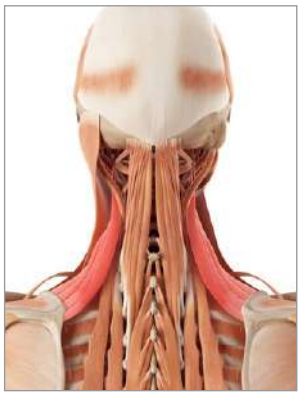
While the ergonomic importance of the head and neck seems apparent to everyone, the coordination of the two are sometimes not obvious. For example, everyone can move their eyes up and down, side to side, but **it is the job of the neck to position the head in three different planes of motion** to maximize one's vision and hearing.

The role of the neck not only repositions the head to maximize our sense and interaction with work, but also will dictate what the back will do. You can confirm that by flexing your neck. As you maximize that flexion motion, you can feel your thorax and lumbar vertebrae all following the direction of the neck. From an ergonomic standpoint, if you wanted more extension of the lower back when lifting or material handling, it would be wise to **extend the neck first**. If you ever watch powerlifters, before they lift heavy weights, they will always maximally extend the neck.



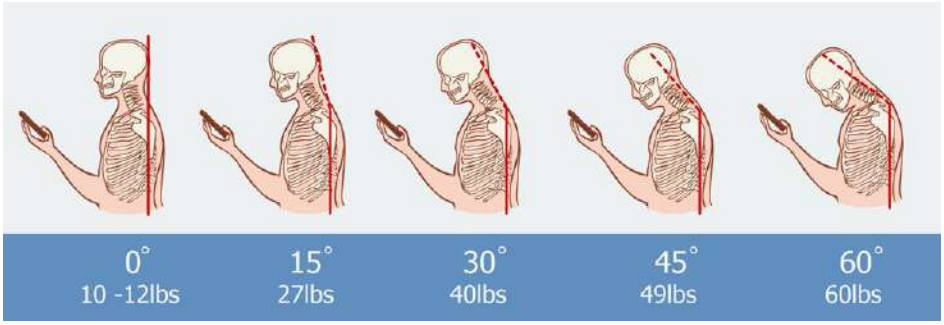
It is important to note that even though there are **seven cervical vertebrae** that make up the neck, the joints and the prominence of the cervical spines progressively change to increase motion. The upper cervical vertebrae are good at allowing rotation for the head. As a result, the name of the first two are called, the **Atlas (C1)** and **Axis (C2)**, mainly responsible for turning your head left and right.

The story goes that **C1** holds up the skull (from Greek mythology describing the "globe of the head" being that Atlas was given the task of holding up the heavens [earth] as punishment from Zeus). The Axis (**C2**) was given its name for two reasons, one because of its structure that has a section of bone (odontoid process) that protrudes upward inside the ring of **C1**. The result is rotation around a pivot point or around the axis of rotation. **C2** also has the greatest motion of all the cervical vertebrae.



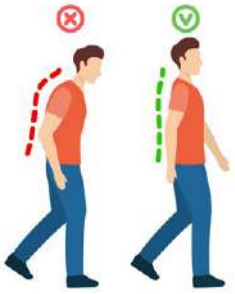
Once the understanding of the cervical structure is known, the synchronized interaction of how we move our head and neck becomes relevant to how we engage various tasks of work and the potential for discomfort can result. Remember, the prominent spinous processes of the neck, those are for **anchoring the muscles of the neck controlling the head movements**. The neck muscles have a unique design that permit well harmonized and controlled movement of the head.

The weaving strap-like design of the neck muscles are effective to achieving the head positions. However, the muscles on the opposite side of the neck need to stretch. When those muscles become excessively tight, it becomes "a pain in the neck" to simply look over your shoulder, especially when driving. So, from an ergonomic perspective, it is vital to encourage people to **include stretching of the neck throughout the day**.



Taste, smell, hearing, and sight are the four senses contained in the head with the neck merely being the articulating intermediary between the head and the rest of the body to maximize our use of those senses. From a work design point of view, if the objects are too high or too far to our right or left, the head will force the neck to make accommodations for our senses to get the right information and interaction. For example, if a smart phone is placed too far away and the eyes have a hard time capturing the information, it will force the neck to **compensate to position the head forward** to better view the work task or the distant screen of the phone.

From an ergonomic standpoint, this simple event **increases the potential for discomfort and awkward chronic postures in the neck and back spinal segments**. Normally, the neck precisely balances the head over the rest of the body. The head accounts for about 8% of bodyweight, so a 150-pound individual has a head weighing 12 pounds, as shown above. However, when the head is forward, the muscles of the neck are effectively trying to control 42-pounds like extending a jug of water or milk away from your body.



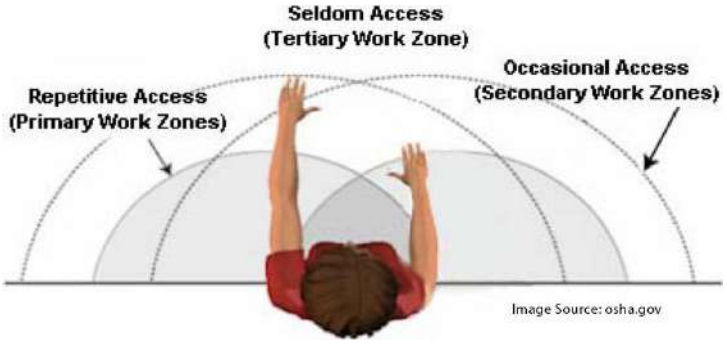
Out of balance positions for the head, an important issue to address at the worksite, can occur in both the sitting and standing positions. **The right insole can help cushion and support the feet helping with standing balance throughout the day**. Work tasks in sitting or standing positions that maintain good posture avoid potential neck strain while also improving productivity, thus bringing work ergonomically back our senses.

Part 6: A Summary of Ergonomic Principles

The following summary gathers the key elements of the other five parts of the ergonomic series. Combining them into **this summary will provide a quick reference for meeting the ergonomic challenges we all face at our worksites**. As we assess and re-assess our interventions, keeping in mind that our efforts are really attempting to maximize the interaction between the work needing to be done and those who are performing the work.

Even though **ergonomics** is often described as a process, however in reality, **it is really a continuum**. The reason for that is that work changes, evolves, and progresses towards new and different work. As a result, we need to think of ergonomics as a sequential method so as work changes so do our approaches to modifying the worksite or work tasks.

In **Part 1**, the concept of **work zones** was discussed with the first zone from the elbow to the fingertips. That **primary zone** is where a lot of work gets done so items and other distractions not related to that task should be moved out to the **second or third zones**. This avoids the chance for awkward postures and the resulting discomfort or injury.



In **Part 2**, our body's interaction with the ground was a key focus. Many occupations require us to stand or walk around throughout the workday. There is a critical need to place adaptive cushioning not between the ground and shoe (standard floor matting) but more importantly **between the ground and the worker** (anti-fatigue insoles), a coherent ergonomically sound intervention.

In **Part 3** of the series, a closer look at the **back** and the role it plays at work. Stability is the back's primary job. Because of that, we can move our arms and legs while we engage our daily work tasks.

Based on the unique structure of the spine, it becomes apparent that the **position of the head plays a key role in controlling how stable the back is during material handling**. The old approach trained people to bend at the knees when lifting heavy objects. However, it only takes one minute to watch people who enjoy lifting very heavy objects for fun to learn that there is another important technique to use during lifting. Powerlifters always extend their neck and back since they realize that this will truly call the back muscles into play.

Part 4 examined the exceptional joint of the **shoulder**. The anatomical design lends itself for a great degree of mobility but that also exposes the joint to instability. Four muscles that make up the rotator cuff are critical in providing that much needed stability. Performing work above the shoulders puts them at risk of injury. **Keeping work lower is more efficient** and lowers the risk of injury.

In **Part 5** of the series, we took stock of the key role of the **head and neck** in how we interact with work. This area controls the lower back and the position of balanced posture equates to much less muscle force during work activities. There was a terrific illustration in this part that showed **when the head is forward and out of balance, the muscle must exert significant force to hold the head's position**. It also contains four of our major senses with vision and hearing being the most critical and protected at the occupational setting.

Balance and posture are one in the same from an ergonomic perspective. It is important for the head and neck but even more important for the many workers that are required to stand and walk throughout the workday. Of all the possible ergonomic interventions, **cushioned dual layer memory foam insoles** between the worker and opposing ground is one of the best cost-effective approach to keep in mind. Insoles are personal and hygienic (not shared) and help with balance, leg muscle efficiency, and it goes wherever the worker needs to be, standing or moving.

In summary, keep in mind that ergonomics is a process. Using this ergonomic series will help you explore and guide your worker engagement. If we constantly remember the "form and function" of the human body described in the early parts of this series, it will always be your guide for an effective intervention.

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