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# Ergonomic Evaluation Pilot Study Between A Traditional and Reach™ Workstation Using Motion Analysis and Electromyography

Reach Workstation

Traditional Workstation

# Introduction

Ergonomic design has recently become increasingly important in the workplace. There has been a marked increase in the number of musculoskeletal injuries, which can be caused by various occupational hazards. Companies have asked for more ergonomically designed products, and manufacturers have responded. Much emphasis has been placed on the seated posture, and while that remains of vital importance to the reduction of occupational injuries, ergonomics is also important for systems furniture and workstations.

### Workstation Design Considerations

Many factors are taken into consideration when designing a workstation. Business and Institutional Furniture Manufacturer's Association International (BIFMA), provides guidelines and standards for furniture manufacturers to follow. Many users are unaware of potential hazards that face them in the workplace. There has been an increase in the number of reported musculoskeletal disorders (MSDs), and while efforts have been made to reduce them, much is still unknown about their cause. According to the Bureau of Labor and Statistics, musculoskeletal disorders account for approximately two-thirds of all occupational illnesses and injuries. These problems have led to over $20 billion in worker compensation claims and other indirect costs (Balance Systems, 2005).

Ergonomic features in a workstation can help reduce risks of MSDs and discomfort. Some of those features include:

- Ideally, a workstation allows people to perform tasks in both a sitting and standing posture.
- Adequate leg clearance below the worksurface is necessary to ensure the user does not get injured or obstructed by any equipment or furniture that might be placed below the worksurface.
- Filing cabinets should allow a user to open and close the drawers with minimal effort. The handles should be easy to grasp and operate.

- Overhead storage bins should be attached at a reasonable height so the user will not have to reach too high, yet be out of the way from taking up desk space.
- Users will move around in their environment to file papers, answer a phone, or to get up and move around. Chairs and other devices in the workspace should allow the user to easily get up and move around without having to move armrests, adjust other chair settings, or put undue stress on the body.

### Problems With Workstations and Systems

Despite the ergonomic features that exist in a workstation system, there are some underlying issues that should be addressed with design.

First, many companies are trying to fit more people into a smaller space. This means that the footprint of an individual's office cubicle is shrinking (Parkinson, 2003). There is a challenge to design a workstation that provides adequate storage, yet appears spacious and uncluttered.

Secondly, items in a workstation are spread out—the storage pedestals and filing cabinets are far away from the user's "home" position. ("Home" position is where the individual sits and works the majority of the time.) Other desks have too much on the worksurface or underneath, and the mouse and keyboard are placed in positions that cause discomfort for the user. Additionally, users may have little legroom because the storage is placed under the desk.

Thirdly, in many systems, overhead storage is used above the worksurface to locate books, binders, and other materials off of the work surface. When a user is seated, these overheads are usually reachable, but depending on the user in the system, they may be beyond their natural reach.

**People’s Ranges of Motion**

Ultimately, the workplace should be comfortable for users and mold to their needs as much as possible. Better-designed workplaces can lead to higher worker productivity and lower risk of injury and illness. The human body has a natural range of motion (ROM). Movement within the proper ROM promotes blood circulation and flexibility. Despite the need to promote motion, users should avoid repetitive movements and certain extremes in their ROM over long periods of time.

Figure 1 shows the ROM for different joints in the human body and illustrates four different zones: 0, 1, 2, and 3. Zone 0 includes smaller joint movements, while Zones 2 and 3 represent more extreme positions. Zones 2 and 3 should be avoided when ever possible, especially for repetitive and heavy tasks.

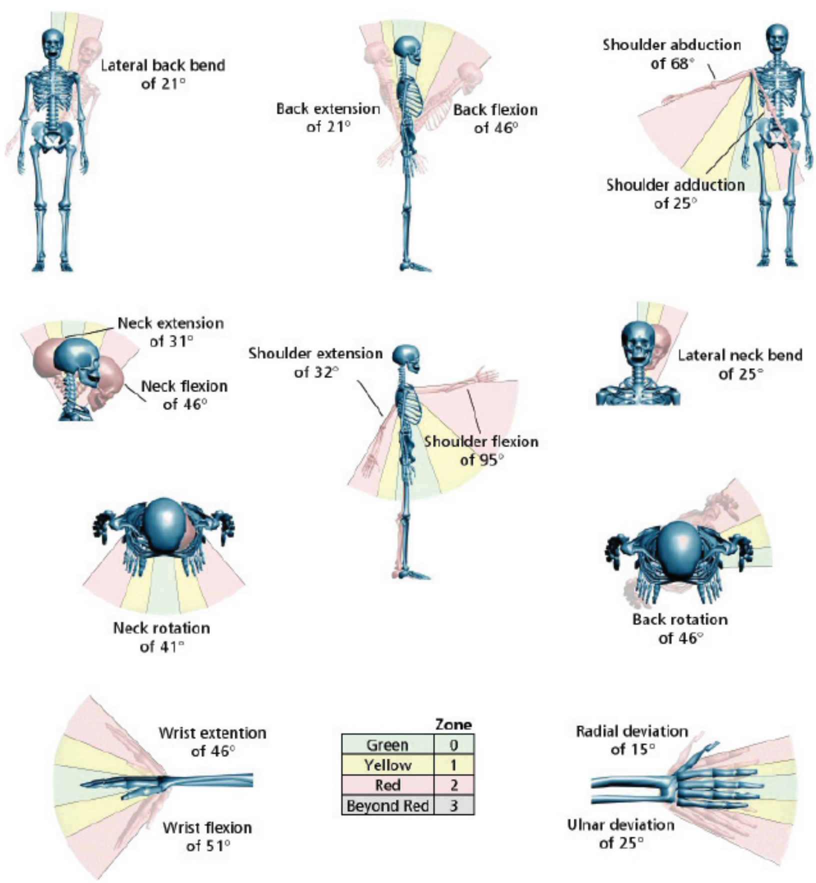


Figure 1. Reaching zones and range of motion

While sitting or standing, an individual will usually have to reach. Ideally, the workstation, and storage within the workstation, such as overhead bins and pedestals, should allow the user's body joints to move within Zones 0 and 1. Occasionally it will be necessary and is permissible to have the user move in Zones 2 and 3.

Zones 0 and 1 are preferred for most movements. Zones 2 and 3 should be avoided whenever possible, especially for repetitive and heavy tasks. Motion in these ranges puts more strain on muscles and tendons and places the individual at much higher risk for developing a MSD.

In order to protect the health of a workstation user it is very important to be aware of how far, how often, and in what posture a person is reaching for an object. Repetitive motions are often encountered answering a phone, bending over to file, and so forth. Repetitive tasks can cause discomfort, pain, and even MSDs. If repetitive tasks are necessary, minimizing the number of continuous movements can help reduce risk of injuries. There is no magic number for minimum repetitions. The factors affecting repetitive tasks include user's muscle strength, amount of force required, type of instrument used, and type of task. Additionally, decreasing the amount of force required to perform a task, such as using a hole punch or stapler, will also lower the risk of pain and MSDs.

**Measuring ROM and Muscle Activity**

Motion analysis systems can be used to accurately evaluate reaching zones. These systems collect kinematic data from reflective markers and infrared cameras, allowing researchers to view the 2D or 3D movement of a person or objects in space. These systems are usually used to analyze gait for rehabilitation patients, but they have even been used to produce graphics and animation for movies. There is a definite application for this technology in the office environment.

Motion analysis, along with muscle activity (electromyography or EMG), is used to evaluate products and serve as predictors in simulated models of human motion within an office space. Muscle activity is acquired using electrodes that measure the amount of electrical activity that occurs when a muscle is contracted or relaxed. Through proper design of ergonomic studies, EMG can be a useful tool in evaluating work performance. For example, if the design of a workplace is thought to be causing muscle pain and fatigue, EMG can evaluate this claim (Marras, 1992).

A combination of EMG and motion analysis can determine the levels of tension in muscles (Lamb, Hobart, 1992) to help understand MSDs. These technologies can also be used to determine fatigue in the muscles (Kroemer, 2001) and joint torques and forces (Redfern, 1992). A better understanding of muscle mechanics and postural dynamics through the use of EMG and motion analysis can help manufacturers in the design of healthier workstations for users, hopefully eliminating many instances of MSDs.

## Testing and Validation

A pilot study using motion analysis and EMG was conducted with Des Moines University's Human Performance Laboratory in Des Moines, Iowa, and the Ergonomics Lab Group at Allsteel Inc. The objective of the study was to compare and evaluate the biomechanics and ergonomics of a traditional workstation and Allsteel's new Reach workstation. An 8-camera motion analysis system (Motion Analysis Corporation, 2004), and a 16-channel electromyography (EMG) system (Motion Lab Systems, 2004) were used to capture movement data of three different subjects.

### Setup

The two workstations had similar L-shaped configurations (Figure 2 and 3). The footprint of the traditional system was approximately 72” x 66” while the footprint of the Reach workspace was 68” x 66”. Six different objects were placed in each workstation for the subjects to interact with:

- Laptop
- Phone
- Stapler
- Cup
- Book
- Box
- Binder

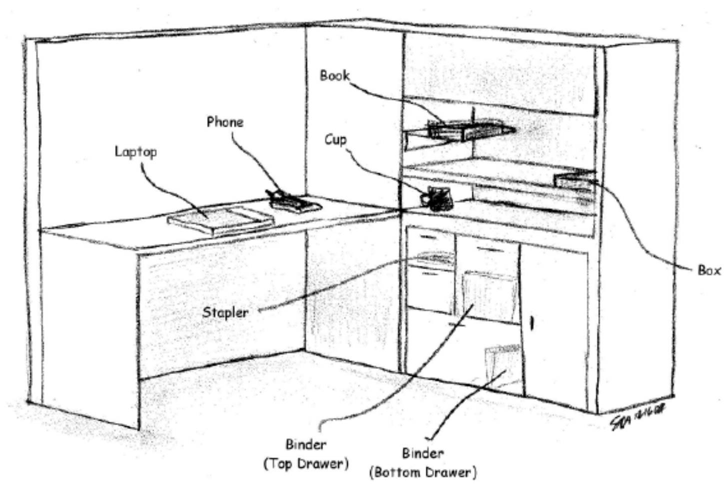


Figure 2. Reach office with objects in workstation.

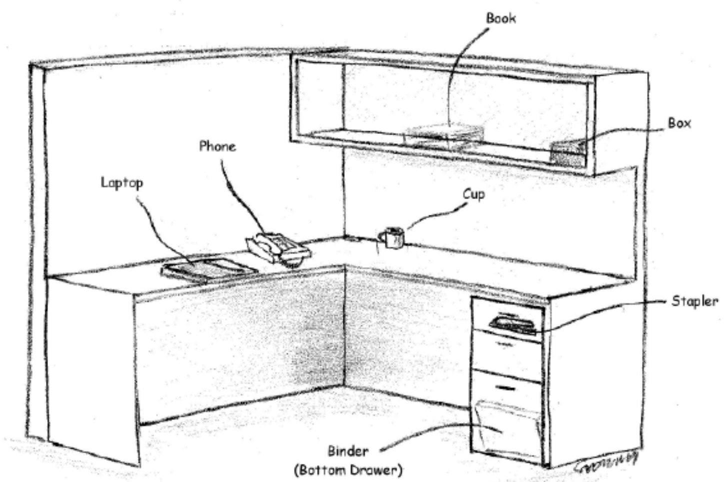

Figure 3. Traditional office with objects in workstation.

A total of 24 reflective markers for the motion analysis system were placed on each subject (Figure 4). These markers allowed the infrared cameras from the motion analysis system to capture a subject's movement while performing tasks. The markers were placed over joints and prominent locations of the body to provide a basic outline of the subject's shape and identify locations of interest in studying ROM.

In addition to the reflective markers, 9 EMG electrodes were placed on the subject's body (Figure 4) over the following muscles:

- Right anterior deltoid
- Right medial deltoid
- Right posterior deltoid
- Right upper trapezius
- Left upper trapezius
- Right lower trapezius
- Left lower trapezius
- Right erector spinae
- Left erector spinae

These muscle groups were chosen because they gave the best indication when a task was being performed. Reaching with the right arm was detected by recording the right deltoid muscles. The back muscles chosen (trapezius and erector spinae) showed activation of muscles during movement.

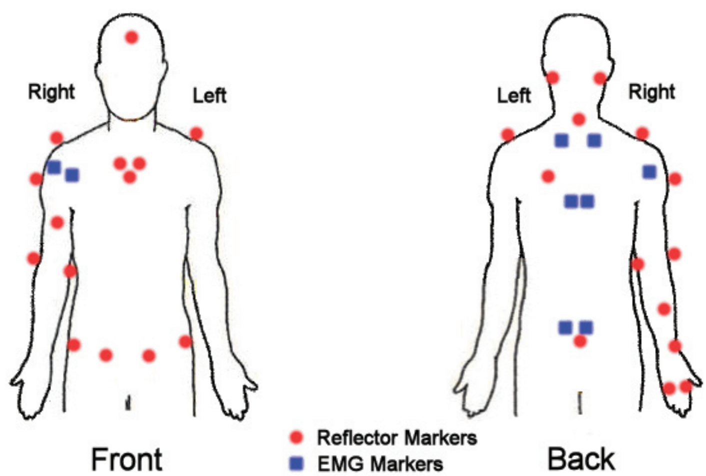


Figure 4. Markers were placed on each subject for motion analysis and EMG.

Reflective markers were also placed in the workstations and on each of the six objects to provide points of reference to the motion analysis system. Figure 5 shows the reflective markers that were placed in each of the workstations.

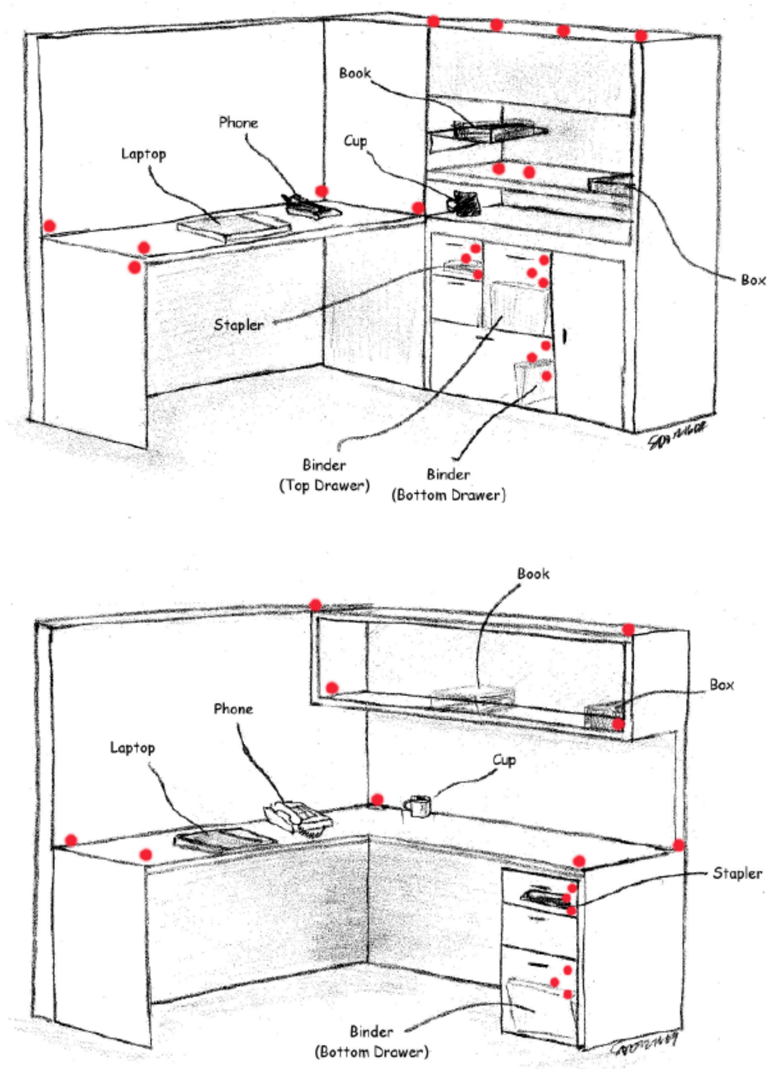


Figure 5. Reflective markers in the workstations gave the cameras a frame of reference.

### Procedure

For the study, subjects sat on a chair at the workstation with their hands on the laptop. The researcher would then instruct the subject to grab marked objects in the work area. The motion analysis software recorded both the subject's movement and EMG activity. After picking up an object, the subject would return the object to its original location, and then place their hands back on the laptop to repeat the process until all objects had been retrieved. Three trials were done for each object.

## Results and Discussion

The distances between the laptop and each object were comparable in both workstations, but they were always shorter for the Reach office. Since the footprint of Reach is inherently smaller, an individual sitting in this workstation would have to move less than when sitting in a traditional system. Additionally, the objects are in the smaller zones of a person's range of motion and individuals would not need to reach as far in this system.

The objects that the individual had to reach for were at a lower height and shallower depth than the traditional system. For example, the overhead shelf for the traditional system sat higher than the Reach workspace. This allowed for less movement into Zones 2 and 3 with the Reach office.

The traditional workstation required more translation of the subject's pelvic region than the Reach office. This pelvic movement was a result of having to move the whole body while seated on the chair or moving off of the chair to reach for an object. Not having to move very far to reach for an object can decrease the amount of time spent performing tasks, and therefore translates to an increase in productivity for the worker sitting in the Reach workstation.

The angle of the subjects' torso (trunk) was measured to estimate the amount of effort needed to perform a task. When the torso angle was vertical, there was less force produced by the trunk postural control muscles, resulting in a decrease of shear and compressive forces in the spine. Subjects in the Reach office had a more vertical alignment of the trunk when they completed their tasks, implying a better ergonomic design.

## Conclusion

Designing a workstation that is ergonomic can help reduce musculoskeletal disorders and discomfort. Keeping objects within a closer range of motion where the user's joints do not have to deviate far from neutral posture is one way to improve ergonomics.

Reach's arrangement of worksurfaces and filing and storage areas allows a user to design their work area in a manner that the most frequently used items are placed at a comfortable reaching height and distance.

The design of Reach allows the user to place repetitively used objects in easily accessible locations in the work area, so as not to inhibit movement within the workspace. The majority of the work that would be performed in a Reach workspace allows the user to restrict most of their movements to Zones 0 and 1.

Additionally, since objects are primarily within arm's reach and seldom above shoulder and below waist, this will allow the user to put less strain on their shoulder muscles and joints.

The study using motion analysis and EMG demonstrated that there is an ergonomic advantage in having storage closer to the user and at a more manageable height.

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