From Pain to Productivity:

Fixing America's Workspaces One Desk at a Time

DAVID BERNARDI, MSBE, CEAS

REVIEWS

"Dave is a great resource for us and his book shows you why. It's a practical guide which explains the process and gives great solutions to sometimes complex cases."

Denise Finch, OTD, OTR/L, CHT
WorkRite Medical Associates

"When I think about how we can give our team the tools they need to do their jobs, I can't think of any area which impacts a person more than their workspace. I believe the work we have done with Dave Bernardi and Summit Ergonomics has had a powerful impact on the overall health and productivity of our team while also providing a professional environment for us to do business in."

Gary Neff, CEO
ParkAssist

"Dave's book, '*From Pain to Productivity*' has an appropriate subtitle, 'Fixing America's Workspaces One Desk at a Time' and content that highlights Dave's unique experience and skills in this area. This publication brings together Dave's foundation in biomechanical engineering and his ability to look at each situation to come to a workable ergonomic solution at the individual level. Professionals who hope to look beyond the nuts and bolts of ergonomics and to provide more holistic solutions will benefit from Dave's sharing of his knowledge, experience, and perspective on solutions for a major problem in American society."

David Hoyle PT, DPT, MA, OCS, MTC, CEAS
National Director of Clinical Quality: Work Strategies
Select Medical

This book explains and makes attainable the difference between a healthy and productive work environment instead of the painful, sedentary life most of us experience. I know firsthand the power of David's knowledge. Stop thinking a few hours of yoga each week will fix 45 hours of poor work habits. Let David and his book be your guru. You're going to be enlightened and energized. You will definitely feel the difference.

Camille Ford, TV Host & Fitness Professional

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David Bernardi MSBE, CEAS

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To all those who have entrusted us to help them and
continue to spread the word about our work.
Thank You!

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Foreword

I am always concerned when individuals and employers describe proper ergonomics as a "luxury" and not what it should be — a priority. In his book From Pain to Productivity, Dave Bernardi makes it clear that people should place greater emphasis on proactive ergonomics by presenting statistics of the financial burdens and waste to employers . These costs are due to workers' compensation claims, medical visits for employees causing an increase in medical insurance premiums, absenteeism and lack of productivity. Imagine what can be accomplished with the monetary savings when these expenses are minimized simply by utilizing sound ergonomic principles in workstation design. Dave uses his experience to explain how to be proactive to achieve these healthy worksites and eliminate unnecessary financial burdens.

It is a great pleasure to have worked with Dave for more than 15 years. His extensive professional background in engineering, rehab & fitness, and spine biomechanics make him well qualified to present effective ergonomic solutions for a variety of problems in many different workplace settings. Dave is creative in evaluating the individual tasks required for a person to perform their job and identifying how a workstation can be adapted to achieve a pain free, productive workspace.

From Pain to Productivity provides good information for all working individuals, whether self-employed or part of a larger organization, managers or staff. It contains essential knowledge to help enable a workforce to prevent pain, be productive, and minimize risk of developing potentially life-changing health issues; be it carpal tunnel, weight gain from prolonged sitting, or blood clots from improper sitting postures in an ill-fitting chair.

Kathi Fairbend MS RPT
Physical Therapist and Ergonomic Consultant

Preface: About the Author

As a kid, I watched a documentary on PBS that focused on the research of Gideon Ariel, PhD. I was fascinated by the motion tracking and computer stick figure system he developed and used to optimize the biomechanics of US Olympic athletes. His work inspired me to learn more about the workings of the human body and the engineering marvel that it is.

When the time came for me to attend college, there were no universities that offered a major in biomechanics. A family friend, who happened to be an engineering professor at UCONN, advised me that "you can teach an engineer to do anything, but you can't teach engineering to just anybody." Since I couldn't focus on biomechanics for a major, I chose to major in the next best thing – mechanical engineering. "Learn the principles of engineering and then apply them to the human body," I remember him saying. I supplemented my undergrad degree with electives in anatomy and physiology, biomechanics as well as research studies in both gait analysis and in head trauma.

However, I was fully aware of the fact that when school ended, I was going to need earn a living, so I worked as an engineer at a local aerospace firm. I was earning that living, but I had also just planted myself in the dreaded "cube farm." This was my first exposure to several of the office worker problems that

I would later strive to solve.

After two years working in a corporate cubicle performing computer analyses and simulations all day, I was ready to pursue my passion. At the time there were only a few universities that offered graduate programs in bioengineering. The one that stood out to me the most was the University of Utah. As a New England native, I'd been conditioned to view Utah as "a state with odd laws where the Mormons lived," but I kept an open mind. My wife and I visited the school in early March and when the avid skiers in us experienced fresh powder skiing under bluebird skies, we knew why Brigham Young famously said "This is the Place!"

I took classes in biomechanics, biomaterials, bioinstrumentation, heart and hemodynamics, ergonomics, and cadaver study while working in an orthopedic lab setting. To me, especially after those two years sitting in a cube, I was in heaven. Eventually I settled on a graduate thesis topic that involved analysis of spinal mechanics and the stabilizing effect of various spinal implant systems.

Winter Sundays were typically spent skiing (when many of Utah's residents were in church) and the rest of the year we spent many a weekend exploring the wealth of national parks that Utah and the West has to offer. Perfecting my fly fishing technique was also a priority for me (talk about good use of biomechanics & ergonomics!). It wasn't long before I was armed with a Master of Science degree and an intimate knowledge of implant design, but seemingly all of the implant firms I thought would be suitable employers were scattered in places that my wife and I didn't care to live and raise a family. Besides, we couldn't bear the thought of leaving Utah, specifically Park City.

Our hearts set on staying in "God's country," I took a job at a local fitness equipment manufacturer. While there, I met some very talented people. We designed exercise machines and

tweaked them according to best practices of biomechanics. This made the equipment optimal for training and eventually for application in physical therapy and rehabilitation. While there I met one of my most influential mentors who later became a business partner.

My experiences with the rehab market led to the start-up of a medical products company that I co-owned with two partners (see above). My role in the company gave me the opportunity to learn about and help create products for functional testing, disability evaluation, impairment rating, work capacity assessments, and job analysis. After several years of success, we sold the company, and at about the same time my wife and I found out we were having twins, so we moved back to the east coast to raise our children closer to family.

Not long after our relocation, I took a job managing a local ergonomics firm that boasted many of the Hartford-based insurance companies as customers. My background made it easy to quickly learn the industry. Thanks to the networking I was able to do and the contacts I made within the insurance world, I eventually got the opportunity to provide solutions for their disability policyholders. Suddenly I found insurers and employers alike seeking my help conceiving viable and reasonable medical accommodations to make it possible for employees to return to work and/or stay at work, thereby saving many entities lots of money. Of greater satisfaction to me, however, was the reward of helping to get folks out of pain so they could move on to become productive again.

I became an expert in the various solutions offered by more than 50 different ergonomic product manufacturers. This knowledge made it possible for me to successfully pick, choose and tailor ideal solutions for those that needed them.

I am now the president of Summit Ergonomics in Manchester, New Hampshire where I am able to coordinate the efforts

of a great staff and I still get to see clients in their workspaces, both in person and remotely. We've been able to leverage past successes into providing large corporations with ergonomic solutions, at the level both of individual employees and staff-wide implementation. Our specialty is working with small- to medium-sized businesses where staff is often their greatest asset.

So, without further ado, enough about me. Let's talk about making your workspace feel as comfortable and conducive to productivity as possible.

Chapter One: Defining the Problem

The American workforce has a problem and, because of it, America's employers have an even bigger problem. The goal of this book is to shed light on that problem, quantify it in terms of incidence and financial impact and then present different strategies that can be implemented utilizing basic anatomical principles to mitigate needless suffering and financial waste.

The short version is that many of America's workers sacrifice their bodies in an effort to get their jobs done, often times ignoring the warning signals as physical ailments progressively worsen and medical intervention is required. America's employers bear the costs of the absenteeism, medical treatments, lost productivity and increasing insurance premiums. This is very much a LOSE-LOSE proposition.

Using the methods published by JP Leigh,[1] it is estimated that there were over 8 million workplace injuries and illnesses in 2016 costing employers approximately $60 billion per year in direct worker's compensation costs. Indirect costs such as loss in productivity, replacement hiring and training and increased premiums are estimated to be anywhere from 2 – 5 times the direct costs[2], making the total cost to American businesses somewhere in the neighborhood of $250 Billion.

According to the U.S. Bureau of Labor Statistics, 17.3% of all non-fatal workplace injuries and illnesses in 2015 that resulted in employees missing days of work were from soreness and pain, tendonitis, or carpal tunnel syndrome (CTS).[3] The average CTS case resulted in 28 days of work missed.[4]

Stewart and colleagues published a 2003 survey of nearly 30,000 members of the workforce in JAMA. 52.7% reported they had some form of headache, arthritic, back or other musculoskeletal pain within 2 weeks prior to the survey. By and large the pain conditions went unreported in the workplace, but they did result in a significant amount of lost productivity. Lost productivity was reported by 13% of the respondents as a result of the pain, exhibited as reduced performance at work rather than absenteeism. Estimates of the cost to business in lost productivity was placed at $61 billion in 2003 dollars.[5]

In 2013, the American Osteopathic Association conducted a similar survey of 1,004 office workers and found that 2 of every 3 experienced musculoskeletal pain within the prior six months. Of those with pain, 63% reported low back discomfort, 53% reported neck pain, 38% reported shoulder pain, and 33% reported wrist pain. Within that group, 70% reported sitting at their desks for 5 or more hours per day.[6]

The prevalence of musculoskeletal disorders (MSDs) among Americans is dramatic. According to The Burden of Musculoskeletal Diseases in the United States (boneandjointburden.org), as of 2014, at least half of the U.S. adult population suffers from one form of MSD or another. Among those 65 and older, that percentage leaps to nearly 75%. Most of the disorders are classified as arthritis and back pain.[7]

In 2012, 25.5 million people lost an average of 11.4 days of work due to back or neck pain. That adds up to 290.8 million lost workdays in 2012 alone.[8]

A similar trend is found in the cost of treating back pain. In

2011, the estimated annual direct costs of treating back pain was $284.4 billion.[9]

In 2012, 1 in 8 persons of prime working age reported lost work days due to a musculoskeletal condition — a total of 216 million days.[10]

In any given year, 12% to 14% of the adult population will visit their physician for back pain.[11]

As you can see the incidence of musculoskeletal pain in the US is astonishing and the costs quite burdensome on corporate America. We will explore the complex inter-relationship of the causative factors and the complicating factors. Once we understand the role these factors play, we'll show how ergonomics can be a critical element to fixing the problem.

Primary Factors

Ill-fitting workspaces

The design of desks has changed little since the 1950s. The default desk height standard was 30 inches[12] as that was deemed the proper height for work directly over the desk, such as writing and drawing. ISO 924, originally named "Ergonomic requirements for office work with visual display terminals (VDTs)" was created in 1998 to establish standards for Human-Computer interaction with section 5 specific to ergonomics. The standard calls for computer desk heights to be 720mm +/- 15mm (essentially 28.5").[13] BIFMA, the Business and Institutional Furniture Manufacturers Association also uses 28.5" as its standard for desk heights.[14]

When we look at anthropometric (the study of human body sizes and volumes as well as its various components) data tables we quickly realize that desks, even at 28.5" are designed for people much taller than US averages.

According to CAESAR (Civilian American and European Surface Anthropometry Resource – recognized as the most representative source of anthropometric data for the US population) an average female is 5'4" tall and the average male is 5'9" tall.[15] Anthropometrics tells us that when seated, elbow height (aka hand height with elbows bent to 90 degrees) will typically be 23" and 27" above the floor respectively. The discrepancy of worker size and desk design creates a mismatch that needs to be addressed.

The rationale for the discrepancy is that it is easier to fit a smaller person to a tall person's workstation than it is to fit a tall person into a small person's desk. An analogy is that of doorway design. Doorway openings aren't cut to work for the average height person, thereby making a taller person have to bend down to use it every time he/she walks thru it. Doorways are designed for the tallest people. Same holds true with desks.

Prolonged Sitting

Estimates vary about how much actual sitting we engage in as a society. Dr. James Levine of the Mayo Clinic suggests 50 – 70% of our awake time is spent sitting[16]. A survey of office workers suggests two-thirds of each workday is spent seated.[17] Some estimates are as high as 15.5 hours per day of sedentary behavior, between office sitting, commuting, meal time, TV watching, online activity, gaming and other seated entertainment.[18] A meta-analysis reviewed multiple published sitting studies and the average sitting time in Western countries was 9 to 11 hours. This study showed a 34% increased mortality risk for those who sit 10 or more hours per day.[19]

Increased computer/smartphone usage both in the office and home

In 1984, 8.2% of all households in the US owned a

computer and by 2013 that figure had increased to 83.8%. Demographically, in the 35 – 44 age group, the percentage rose to 92.5%, while 65% of individuals over age 65 had a computer.[20]

Internet usage has dramatically increased over the last 20 years, from 18 million users in 1995 to 280 million users in 2014.[21] Smart phone users have increased from 62.6 million to 223 million in 2017[22]. The average smart phone user has increased internet usage on their phone from 0.3 hours per day in 2008 to almost 3 hours per day in 2015.[23]

Today, 66% of workers have multiple internet-enabled devices.[24] One study found that 60% of smartphone-using professionals kept tabs on work-related items upwards of 13.5 hours per day, and then spent on average 5 hours juggling work email each weekend, translating to 72 hours a week of job-related contact.[25] Another survey of 1,000 workers found that 68% checked work email before 8 a.m., 50% checked it while in bed, and 38% "routinely" did so at the dinner table.[26] In a survey by the American Psychological Association, 44% of working adults reported that they check work email daily while on vacation.[27]

Longer Hours

The American full-time worker averages 47 hours per week at work, about 8% more than a generation ago.[28] Of all salaried workers, 50% exceed 50 hours per week, with 1 in 4 exceeding 60 hours per week routinely putting time in at home and in the office.[29] A historical review suggests that Americans have typically worked 45 – 55 hours per week,[30] but the nature of the work has changed from physical jobs such as agriculture and manufacturing to more sedentary jobs with emphasis on computer usage.

Complicating Factors

Obesity and Nutrition

Of American adults, 68.8% are considered overweight or obese based on BMI calculations and more than 1 out of 3 American adults (35.7%) are now considered obese with that figure expected to approach 50% by 2030.[31] The Duke Study in 2007 showed that obese workers generally experience more injuries and have more expensive worker's compensation claims than non-obese workers.[32]

Comorbidities associated with obesity provide complicating factors such as diabetes and hypertension, slowing the healing process and delaying return-to-work. In 2011, it was estimated that costs to businesses exceeds $114 billion a year in lost productivity and absenteeism from obesity alone.[33]

Many folks, myself included, believe that the food industry and their powerful lobbying groups have led us astray in terms of defining and providing proper nutrition to the US population. Non-natural sugars, in the form of corn syrup and high fructose corn syrup, and/or poisonous artificial sweeteners have been added to drinks and foods for taste. Sugary foods and empty calories are marketed to our children under the premise of being healthy.

Many of these same foods/ingredients have an inflammatory effect on the body which may be a source of joint pain. Refined sugars and flours, additives, dairy items, oils and trans fats, fried foods, artificial sweeteners, processed meats all have been shown to cause systemic inflammation.[34]

The average American consumed 2,481 calories a day in 2010, about 23% more than in 1970. About 46% of those calories are coming from flour and grains and fats and oils.[35] A 40-year-old man of average height and weight who's moderately active needs about 2,400 daily calories to maintain their metabolism,

a sedentary male perhaps 2,000 calories; a 40-year-old woman with similar characteristics needs 1,850 calories and a sedentary female may only need 1,600 calories per day.[36]

The gut (colon) has a direct neural attachment to the brain thru the ENS (enteric nervous system). Therefore, many of the foods we eat can have a direct effect on the brain and may be a potential cause of mood shifts, anxiety and depression.[37]

Aging Workforce

Nearly 19% of Americans ages 65 and older, or roughly 9 million people, are still in the workforce. This is double the amount from the year 2000.[38] Of these, 64% of them are considered full-time. Age-related physiologic changes such as bone demineralization, intervertebral disc compression, loss in muscle elasticity, decreases in visual acuity, poor circulation and blood flow resulting in less oxygen to tissues, all lead to a greater predisposition to developing a work-related musculoskeletal disorder (WMSD).

Long commutes

There are approximately 139 million workers who commute to work.[39] According to the most recent US Census, the average one-way commute is 26 minutes and 175 of us have commutes that are 45 minutes or longer.[40] At least 2.62% (3.64 million) were commuting longer than 90 minutes.[41] Extended commuting times also contribute to back pain and excessive muscle tightness. Muscles about the hip and pelvis from prolonged sitting as well as shoulders, chest and back from maintaining the traditional hand position on the steering wheel tend to be the most susceptible. The stress from all those crazy drivers doesn't help matters either!

Stress

According to one survey, 80% of workers feel stress on the

job, with 40% suggesting their job is extremely stressful.[42] An estimated 1 million workers call in sick daily due to stress.[43] It is estimated that half the 550 million lost work days per year are a result of stress-induced absenteeism.[44] The effects of stress manifest in the form of physical problems such as back pain, fatigue and headaches. Stress increases cortisol production as part of the fight or flight response, but unless there is activity to consume the cortisol, it may remain at elevated levels in the blood, causing fat storage, increased blood sugar levels, immune system dysfunction, chronic fatigue, and a host of other health issues.

Poor sleep patterns

1 of every 3 American adults is not getting the recommended amount of sleep ($\geq$ 7 hours) on a regular basis.[45] An estimated 50 – 70 million US adults have some form of a sleep or wakefulness disorder.[46] Some of these may be due to work schedules, but many have to do with access and use of technology. Watching television, checking emails, and/or computer use prior to bed all can negatively affect the brain. These LED-based devices emit a blue-light that affects our circadian rhythms and suppresses the production of the hormone melatonin and increases levels of cortisol.[47] Melatonin helps the body fall asleep and reach the REM stages of sleep. REM sleep is when brain "cleaning & restoration" occurs. Increased levels of cortisol inhibit insulin function, which can result in elevated blood sugar levels and fat storage.

Additionally, unsupportive mattresses, improper pillows or disruptive partners may contribute to poor sleep quality. Many of us also adopt postures which exacerbate our musculoskeletal issues by sleeping in a fetal position (shortening hip flexors – see below) or by sleeping on our sides resulting in a rolling/hunching of our shoulders. Full body pillows are recommended by most sleep professionals to provide proper support and good body mechanics for sleeping. Simply placing a standard

pillow between the legs of a side sleeper is an effective means of eliminating back pain for some.

Hobbies/Avocations

Leisure time provides an escape for most Americans where they can focus on something else and get away from the stresses of life. Crafting, playing the guitar, gaming, wood working, car repair are typical weekend pursuits, but I use these specific examples because all create additional stresses on the wrists and forearm musculature. These same muscles may already be taxed all week long with intensive computer work. Watching television, another popular hobby for the overworked, overstressed American worker, may provide a break for the hands and wrists, but unfortunately contributes to the sitting epidemic.

Financial pressures have also led to higher percentages of American's taking second jobs or running side businesses. I recently performed an assessment for a woman who wanted a new mouse and a new chair because of recurring back and wrist pain. As we talked, she casually mentioned she was a dog groomer on weekends. Yikes!

Cause or Effect?

All of the above factors can directly lead to the development of pain and/or disease and therefore pose a potential financial burden in the workplace. Long hours of computer use at a traditional ill-fitting workstation will lead to the user adopting sitting postures for extended periods of time that will ultimately result in muscle tightness, stiffness, and restricted blood flow to the extremities causing pain, stress and fatigue.

Before and after work we hop in the car for more sitting and stressful commuting, and when we get home we may sit down for dinner or shuttle the kids to their activities with

more car sitting. After the responsibilities of the early evening are complete, we may settle into our couch or easy chair for some TV watching while multi-tasking with computer or smartphone in hand, catching up on what we couldn't do during the workday. Sound familiar?

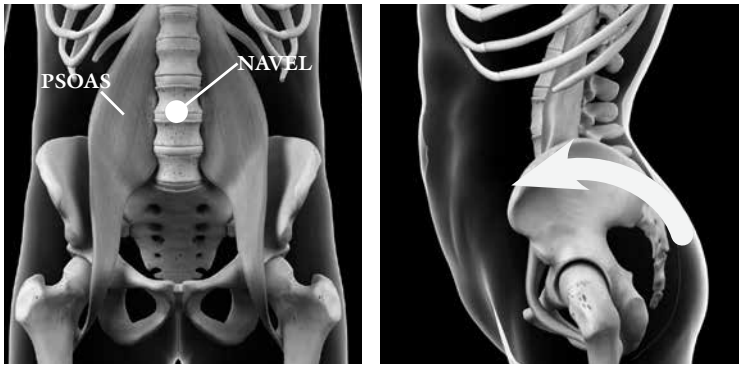
The downside of sitting too long has been well documented. Dr. James Levine of the Mayo Clinic coined the phrase that "Sitting Is The New Smoking'" as sitting has been linked to increased risk of developing various cancers, obesity, diabetes, high blood pressure, cardiovascular disease, deep vein thrombosis, stroke, anxiety and depression, osteoporosis, muscle atrophy amongst others.[48] Combating chronic diseases now consumes 86% of American healthcare spending and clearly sitting and inactivity is a primary cause of these disease states.[49]

Deleterious biochemical effects of inactivity revolve around the enzyme Lipoprotein Lipase (LPL). LPL is found in the capillaries of skeletal muscle (in addition to other tissue types) and facilitates the breakdown of triglycerides (fats) and increases in HDL (good cholesterol). Reduction of LPL due to inactivity therefore can increase fat storage (obesity) and the risk of developing cardiovascular disease.[50]

LPL is released upon contraction of the skeletal muscles. Contraction of slow twitch postural muscles (as during standing and other non-exercise activity) seem to have greater effect on LPL levels, which is why daily exercise training alone may not be enough to combat excessive sitting. LPL activity decreases significantly (90 – 95% in animal models) and HDL levels decrease about 20% after a day of inactivity. LPL levels are restored to normal within 4 hours of intermittent standing and/or slow walking.[51]

One of the biomechanical effects of extended sitting or poor sitting quality is excessively tight hip flexor muscles. The hip flexor complex is made up of the iliacus and the psoas

major muscles; the combination may also be referred to as the ilio-psoas muscle. Tight hip flexors, coupled with tight back muscles from sitting tend to rotate the pelvis anteriorly, potentially causing back pain.



Hip flexor muscle complex and the effect of tight hip flexors tending to rotate the pelvis anteriorly which could potentially cause back pain, especially if back extensors are tight also.

The hip flexor is the only band of muscle connecting the upper body to the lower body and it is considered the primary "fight or flight" muscle.[52] In times of danger, hip flexors are used to either run or assume the protective fetal position. If the hip flexors are constantly tight, they signal the brain that the body is in danger, triggering the overworking of the adrenal glands, resulting in a chronically stressed state of cortisol production which ultimately leads to fat storage (typically belly fat) due to cortisol's effect on insulin suppression.

Elevated levels of cortisol can also affect the body's appetite, causing cravings for high calorie foods. If the glucose doesn't get burned, it gets stored as fat. Chronically elevated levels of cortisol have also been linked to immune system suppression, brain cell death, degenerative arthritis, cardiovascular disease, chronic fatigue, and thyroid disorders. Cortisol is also known as the "death hormone" due to its aging effects when levels

are chronically elevated.[53]

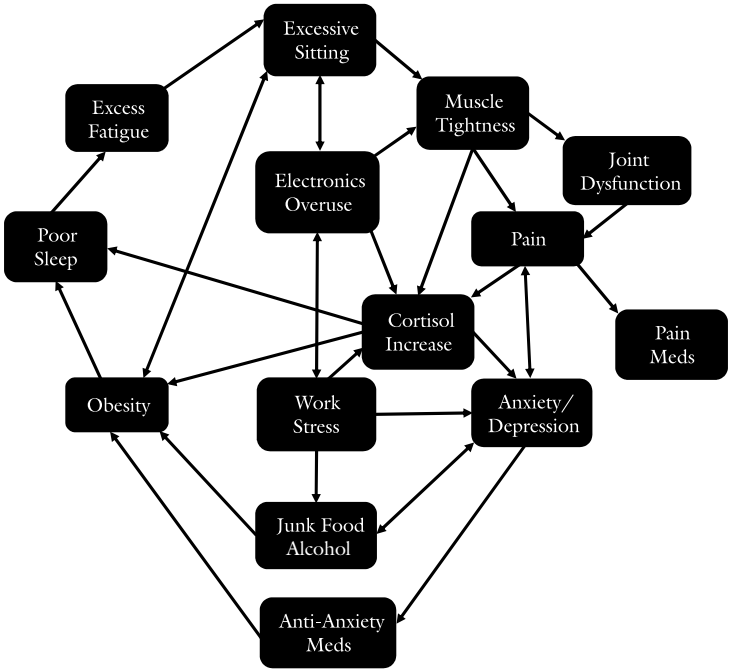
The psoas muscle complex is also attached to the diaphragm, so it contributes to breathing and supporting internal organ structures. Tight hip flexors can result in alterations in breathing patterns. Poor sitting posture results in the diaphragm muscle not being utilized efficiently for proper breathing. Consequently, the muscles of the thoracic region must compensate, resulting in a shallower breath. Breathing with the diaphragm allows for greater transfer of oxygen to the blood as the inhalations go deeper into the lungs where more efficient exchange takes place; typically on the order of 6 – 7 times greater levels of oxygen transport.[54]

Due to our propensity to sit at work, the majority of us engage in a shallower breathing style powered by the rib, shoulder, neck and back muscles, which are traditionally postural muscles, and as we've discussed, already fatigued from supporting poor workplace postures. The overwork of these muscles may cause them to become so tight that patches of the muscles don't receive sufficient blood flow and very painful trigger points may develop.[55] Shallow breathing may also result in a build-up of toxins in the body. 70% of the body's toxins are released through our exhalation in the form of CO_2.[56] Over-breathing, often a symptom of rapid, shallow breathing, also known as hyperventilation, may also be a cause of chronic pain, as improper levels of CO_2 and imbalances in oxygen/carbon dioxide ratios can cause nerve cell irritation and excitability.[57]

Hopefully the discussion in this chapter illustrates that there is a seemingly continuous cycle that can easily form as a result of all of the negative stimuli associated with issues the typical worker experiences in their day to day working life. I've tried to help visualize the cause and effect relationships with the chart below. My feeling is that we can help break that cycle by providing various interventions that I'll outline in the next

chapter. In subsequent chapters we will illustrate the effectiveness of these solutions with client case studies.

With pain negatively affecting the lives of over 100 million Americans, to the tune of $600 billion in healthcare costs and lost productivity,[58] the integration of the solutions offered can make an impact on the lives of many and on the bottom line of businesses throughout the United States.



The ill-health cycle which may result from inactivity and poor ergonomics.

Chapter Two: Ergonomics, Movement and Alternative Solutions

Ergonomics

Ergonomics – pronounced "erga-nah-mix" is the science/art of fitting the workspace to the worker for greater efficiency and comfort. The foremost objective of ergonomics is to minimize the risk of injury to the worker. That being said, ergonomics can also be used to enhance productivity. The physical demands for a particular job obviously differ based on the type of work being done but the goals are the same; minimize repetitive motion, eliminate overexertion, avoid sustained postures — especially awkward ones, remove vibrations, reduce contact forces and maintain a healthy work environment with minimal extremes. Understanding all aspects of an individual's job with observation and written job descriptions when available is key for successful ergonomic intervention.

For the sake of this book, we will focus on office ergonomics where cumulative trauma disorders (CTDs) or Repetitive Strain Injuries (RSI) are the source of the work-related musculoskeletal disorders (WMSDs), as opposed to a one-time overexertion event, or a slip-and-fall type injury. The risk factors

for the development of CTD in the office typically include the repetitive motion of typing/keying, sustained postures such as constant sitting or standing, awkward postures such as mousing with a reach, contact pressures on the edge of desk or chair arm rest, poor lighting conditions such as glare on the monitor, and even temperature effects such as typing in a cold office. The goal of the office ergonomics program is to minimize/eliminate these risk factors with proper ergonomic guidelines and products.

Consider the picture below depicting poor ergonomics; a scenario I am sure we can all relate to personally or something we see every day in our own offices.

The computer monitor by default is positioned on the back of the desk since we need the space to place our keyboard and papers on the worksurface. Vision is our primary sensory input, so in an effort to see the monitor, especially as our eyes fatigue over the course of the day, we lean forward, thoracic spine hunched over with shoulders rolling forward. Significant neck flexion also occurs because our monitor is typically positioned too low. The forearms are pressed against the edge

of the desk and the angle between the upper and lower arm is less than 90 degrees since the desk is too tall for the average height user.

We gradually start to slide forward in our seats, maybe because the discomfort in our back has us seeking an alternate posture. Perhaps the arms of our dated chair are fixed or they adjust but don't go low enough, which prevents the chair from getting any closer to the monitor. We're so focused on the monitor, rapt in our work, vision dictating our posture, we subconsciously adopt this "praying mantis-like" position. Another common struggle we see may be simply that the chair is just too big and the seat pan is too deep, digging into the back of the knees so we slide forward to compensate. To help stabilize ourselves in the chair, we'll typically sway our legs back and put feet on the base of our chair, cutting circulation to the lower extremity. By hunching over in this position, we've increased pressure on the L5 disc, but eliminated any support from the chair back. Yes, maybe our bodies can handle that position for a little while especially if you are younger, but us older folks would need some serious stretching and some ibuprofen after being in that position for 20 – 30 minutes.

Study after study demonstrates the benefits of ergonomics with a strong Return on Investment (ROI) both financially and in productivity. The Washington State Department of Labor and Industries reviewed 250 studies of numerous ergonomic interventions and performed a Cost Benefit Analysis Summary of the study results and arrived at the following:

A 65% average decrease in the incidence of WMSDs, a 58% reduction in absenteeism, a 68% reduction in worker's comp costs due to WMSDs, and a 25% increase in productivity.[59]

When only Office Ergonomics programs were reviewed, the results were consistent, with a 61% decrease in incidence, a

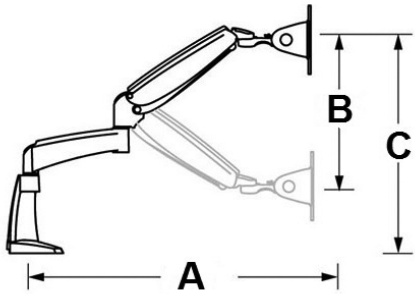
46% reduction in absenteeism, an 81% reduction in worker's comp costs, and a 17% increase in productivity.[60]

The summary concluded that the best results were seen when organizations did the following:[61]

- Had employees participate in planning changes.
- Evaluated workstations and provided individualized recommendations.
- Provided adjustable workstations and chairs with training to users.
- Evaluated and improved lighting, glare, temperature, noise and other environmental factors.

Unfortunately, what I primarily observe in the field, is that most employers engage in reactive ergonomics with a medical accommodation after a report of an injury rather than proactive ergonomics that could potentially prevent the losses in productivity and the needless spend of healthcare dollars.

As we saw in the figure above, viewing the monitor was the primary factor in the cascade of poor ergonomic body positioning. **Monitor Arms** are a largely underutilized resource to address this challenge. They typically clamp to the back edge of the desk or thru a grommet hole. They have a hydraulic strut or spring to offset the weight of the monitor, making it effortless to raise and lower your monitor(s) to the proper height for ergonomic viewing. With their hinged arm design they also can be moved in and out for proper focal length. The monitors can typically be tilted and/or rotated (portrait mode usage), and these arms free up a tremendous amount of desk space, especially if the monitors are already sitting up on boxes, reams of paper or plastic stands.



Monitor arm specifications to consider include reach (A), height range (B), and height above the desk surface (C). Matching weight range to your monitor's weight is also imperative.

A 2008 study conducted at the University of Utah indicated the estimated increase of productivity due to use of dual monitors was found to be 29% for workers doing spreadsheet tasks and 44% for those doing text-based tasks. The study also found that shifting to newer widescreen format monitors resulted in productivity gains translating to 10 extra days of work per year.[62] These productivity increases have resulted in a surge of dual arm designs. Some dual arm configurations allow for independent movement of each arm, while others fix the monitors relative to one another. While this makes them easier to adjust, most users like the independent arms as it facilitates collaboration with co-workers.

Independent arms on multi arm units as pictured above provide greater flexibility for positioning monitors.

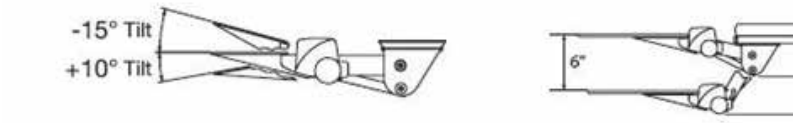
Security personnel, TV producers and stock traders all look at multiple monitors as part of their job, so monitor arm systems capable of holding 8 units are commonplace in these types of environments.

If you're considering making the switch to monitor arms, ensure mounting compatibility with the arm and the monitor. Most monitors have four mounting screw holes 100mm (4") apart. This is called the VESA standard. Many Apple monitors and about 10% of PC models do not have the VESA-mount holes so an accessory mounting plate may need to be purchased. Also make sure the monitor weight matches the capability of the arm. Arms are rated to work within a specific weight range and have an adjustment screw to properly offset the monitor weight. Monitors are becoming larger but also lighter. Lastly, if shopping for a multi-monitor arm system, make sure the arms can accommodate the width of your monitors and still provide adequate reach to meet your needs.

Keyboard trays (KBT) are designed to bring the computer keyboard down to a level below a desk that matches your seated elbow height. The picture of poor ergonomic positioning above, illustrates the pitfalls of keeping the keyboard and mouse on top of the ill-fitted desk. KBTs mount under the desk surface and typically have a track which allows them to slide in (fully retracted) and out (extended toward the user) and anywhere in between. You typically need at least a 21 – 22" track to get a KBT to fully retract under the desk, thereby hiding the platform and keyboard. Ergonomic KBTs are height adjustable (usually ranging from 2 – 3" above the desk to about 5 – 6" below). Some will go as high as 7 – 8" above the worksurface but are rarely used nowadays with the advent of cost-effective sit stand units which provide a greater benefit particularly as it relates to stability.

Ergonomic KBTs also have a tilting platform with a range of -15 to +10 to 15 degrees. Negative tilt (fingers positioned

lower than the palms) is generally the more important feature, as a downward slant is crucial for keeping the wrists in a neutral (straight) position when typing. Maintaining extended wrists while typing is a known potential risk factor for developing carpal tunnel syndrome (CTS). A negative tilt angle of -5 to -8 degrees is felt to be ideal for maintaining neutral wrist angles.[58]



A slightly negative (downward) tilt best for keep wrists in neutral flex/ext angle while typing. A positive tilt might be used for a non-touch typist.

Keyboard trays also typically have some form of cushioned palm rest to softly support the hands when typing. A mousing wrist rest is typically an optional piece, as mouse type will dictate whether a padded support will be helpful.

The KBT platform can take many sizes and shapes. There are two basic designs: a 19" wide platform with some form of accessory mousing surface, or an all-in-one board, typically 25 – 27" wide that can accommodate keyboard and mousing on the same surface.

KBTs with accessory mousing surfaces will typically provide a surface that pivots or swivels off the corner edge on the same plane as the keyboard, or a clip-on unit that hovers over the keyboard on a plane higher than the keying surface. In both instances, these accessory surfaces typically loosen over time and eventually provide an unstable mousing surface. They also dictate a side for the unit to be mounted, which doesn't encourage both left & right mousing, only unilateral mousing, which can be a problem if overuse syndromes are presenting.

All-in-one platforms allow for same plane keying and mousing and provide greater flexibility. Mousing surfaces are present on both the left and right sides of the platform allowing for ambidextrous, bilateral mousing, which can be a helpful strategy for dealing with an overuse issue. The larger platforms also allow for different types of keyboards (Wave style, Split or Hinged etc) and different types of mice (roller mouse, touch pad, trackballs).

Whichever style platform is deemed more desirable, make sure its width will fit in the available desk opening. Again, desk depth dictates the length of the track, and you typically need a minimum of 22" for the keyboard to fully retract under the desk.

All-in-one board, mouse and keyboard on same plane

Clip mouse hovering above small platform

Keyboard trays are a great way to make a standard sized desk work for someone whose sitting elbow height is less than the desk height. For example, the 5'4" female typically has a seated elbow height of about 23". At a standard desk, their hands would need to be placed about 5.5" below the work-surface for proper ergonomic sizing.

A word of caution however. KBTs only work effectively for the individual who is a genuine touch typist. If the user is a hunt & peck typist, application of a KBT will force the user to flex their neck in order to see the keys. Using the positive tilt feature is a decent solution to help make the keys more visible while minimizing neck flexion, provided the tray is not positioned too low.

Keyboard trays are generally not a good solution for the taller user despite their ability to go above desk height, largely due to the fact that the mechanism mounted under the desk can interfere with thigh clearance.

We know from Harrison et al that the sitting position that places the least amount of compressive force on the L5 disc is a torso with a thigh angle of 135 degrees.[63] Since that position is pretty extreme and doesn't place the head in a good position for computer use, a 110 degrees thigh-torso angle is recognized as a preferred compromise for recumbent sitting.[64] We also know from research by Nachemson and Efstrom that intradiscal pressures for recumbent sitting are about the same as standing, and 90% higher when seated and leaning forward with a torso and a thigh angle of about 70 degrees, and 40% higher when seated at a 90 degrees thigh-torso angle.[65]

Standard Ergonomic Chairs provide a wide array of adjustability to allow the chair to uniquely fit the individual. They are typically designed to provide stable support to some percentage of the back, the extent of which is dictated by the chair model; midback, highback, tallback.

Backrest shapes vary, and their selection depends on user comfort and/or clinician preference. Some are wider toward the top, narrow at the bottom. Others are tapered toward the top, wider at the bottom, and others are of uniform width. Some have exaggerated lumbar and kyphotic (front to back) curves in an effort to mimic spinal geometry.

Everyone has their own idea of an "ergonomic" chair. They come in all shapes and sizes. Some features are gimmicky, and others driven by designers rather than ergonomists.

I prefer to use an reverse-tapered backrest whenever I can; narrower at the top (thoracic region) wider at the base (lumbar region) with a wraparound support to stabilize the lumbopelvic region. By providing freedom of movement of the shoulder girdle, it facilitates mobility. When you sit in a reclined angle in these chairs (made possible thru the use of keyboard trays and monitor arms), gravity works to pull the shoulders back, opening the chest and stretching the pectoral muscles which counteracts the natural tendency of the shoulders to roll forward during long bouts of computer work in conventional workspaces. Opening the chest helps create more efficient breathing and research has demonstrated heart rate reduction during performance of standard office tasks.[66]

Similarly, ergonomic chair seats come in many shapes and sizes; contoured, flat, saddle-shaped, concave or convex, again depending upon user comfort, and/or clinical preference based on specific pathologies affecting the user.

Typical adjustments to look for in a good quality, standard ergonomic chair include:

- seat pan slide to accommodate differing thigh lengths, with the goal being 2 – 3 finger widths between the front edge of seat and the back of the user's knees.
- height adjust for differing shin lengths with the goal being feet flat on the floor or on a footrest,

- independent back angle adjustment, allowing for support in either an upright position or a more recumbent one depending on the user's task and comfort level,
- back height adjustment or specific lumbar adjustability to place the support in the desired spot
- height and width adjustable arms (more about arms below)
- "rock or lock" lever, the ability to free float in the chair or lock it at a specific recline or upright angle. If the chair has this feature, a tension knob should also be present to control the amount of force required for rocking. A thin user needs less tension than the larger individual.

Additional upgrades to an ergonomic chair might include:

- seat pan tilt to raise or lower the hips relative to the knees. Users with specific hip pathologies may opt for their knees to be slightly lower than the hips for example.
- headrest for head and neck support. I will sometimes use a headrest simply to provide tactile feedback to the user to help prevent craning of their neck, as they will often do to better see the monitor or as muscles fatigue.
- inflatable lumbar support or built-up thoracic padding
- coccyx or peroneal cutouts for users with specific nerve/pain issues
- sophisticated foam options for extra comfort or pressure distribution.
- heavier weight ratings for larger-sized users

I prefer to work with seating manufacturers who provide a level of customization of their chairs based on specific ergonomic requirements we identify in the field. I can literally select ala carte style specific features for my client's needs. In my experience, I have found very few manufacturers who offer various sizes of seat pans but then can also customize within a size. As an example, consider the plus-size female

who may be only 5'2", but 250 lbs. She may need a 25" wide chair, but the standard depth for that pan may be 22". At 5'2" she wouldn't have the thigh length to warrant such a depth, so I can get 2" trimmed off the front and still maintain the integrity of the seat design.

Stools can also be of ergonomic design, with taller cylinders and limited tilt capability. 99% of the stools I see in the field also have footrings, intended as a place to rest one's feet to prevent them from dangling. Inevitably however, they are often used as a means to help the user get into the chair, and often times slip down as the locking mechanism fails. I frequently see the footrings located just above the chair base. But my primary complaint with foot rings is that they encourage the sitter to sway his/her feet rearward, compressing the back of the knee against the chair edge, and cutting off blood and nerve supply to the lower extremity. I use the analogy of a garden hose. Think of what happens to the flow of water when you kink the garden hose even just slightly. The knee flexion angle one needs to maintain to use the footring creates a similar kink, either having to make the heart work harder, or reducing blood supply to the lower extremity.

As an alternative to the footring, I prefer to recommend either a tall foot rest that can be placed forward of the stool or a system like NeXtep which gives a flat surface for foot placement and a secure means of getting atop the stool. The nice thing about a system like NeXtep is that it travels with the stool as the stool is moved, and it can be swiveled out of the way easily if need be.

NeXtep Platform concept provides a great way to get the users feet flat and in front of them during stool use.

With stools, it's also important to consider use of locking casters (sometimes referred to as braking casters). Braking casters can be used to prevent the stool from rolling away when the user goes to sit on it, an odd but more-frequent-than-you'd-think source of falls in the workplace. An alternative would be to consider standoff glides on 2 of the 5 arms of the base and casters on the other 3.

Use of arms on ergonomic chairs is a subject of some debate within the industry. A recent EMG-based study showed that muscle activity in the shoulders drops dramatically if the typists arms are not supported and keyboard is close to the user.[67] It simply boils down to hand position.

Chair arms often prevent chairs from tucking in under the worksurface, forcing the user to sit further away from their keyboard. I prefer a 360 degree swiveling arm in which the armrest length is offset; in the standard position it may be 8" in front of the stem of the arm and when you rotate it 180 degrees, there is approximately 3" of arm overhang. This allows the user to get in closer to the desk, but still have good forearm support when sitting away from the desk. The swiveling armrest also allows one to rotate the arm into the same angle along the axis

of the forearm as it's positioned during typing should one need that support for medical reasons.

Most arms are made of a molded urethane that is fairly hard with little give. Maintaining one's elbow and forearm on this dense material can certainly lead to nerve compression type symptoms. I prefer to specify my arms with a cushioned foam wrapped in a softer material such as Brisa for comfort. It's not as robust as a molded foam, which means it requires some care to prevent ripping.

360° rotating arm from SOMA. Note how the stem is offset, resulting in different amounts of overhang, depending on the orientation of the arm

Non-Standard Ergonomic chairs may provide stabilization on the anterior side of the torso (such as dental hygienist chairs, or welder's chairs), or at the level of the pelvis/hips (Core chair).

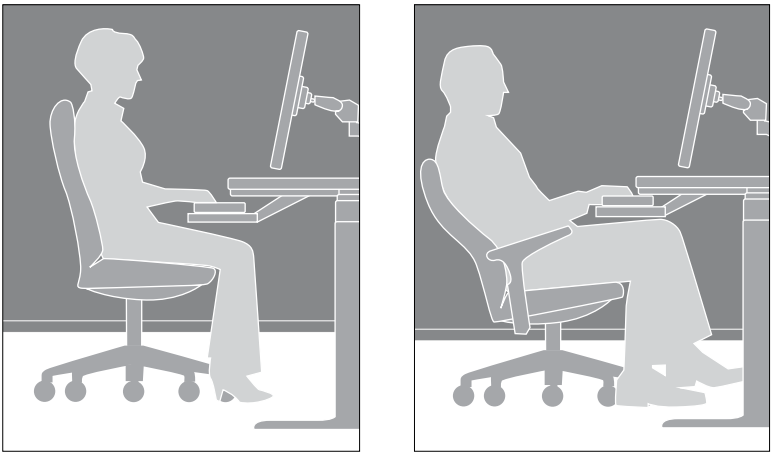
Other chairs, such as kneeling chairs, direct sitting loads thru the legs and knees and therefore offer no stability to the back but provide a geometry to facilitate an upright posture.

Hag Capisco a good example of anterior support for the trunk during forward flexed work activity.

Kneeling chairs allow for upright posture but force knees into excessive flexion.

A word about gymballs or exercise balls as chairs: the consensus amongst ergonomists and therapists is to **not** use gymballs as "ergonomic" chairs. While dynamic in nature and a great means of engaging core musculature, the user will fatigue and eventually begin to slouch over time. The inevitable poor posture and possible risk of falling off the ball as fatigue sets in, potentially creates harm to the user and corporate liability.

Keyboard trays, monitor arms and effective ergonomic chairs can work in concert to promote healthy work postures designed to minimize fatigue, maximize back support, and reduce compressive force on the spine. I don't necessarily feel as though "Sitting is the New Smoking" as some would suggest, but I do feel that "poor sitting" without frequent change in posture will definitely create harm for many reasons to be discussed later in the book.



Examples of chairs, monitor arms and keyboard trays working together to ensure healthy, least stressful seating postures.

Office-based Sit Stand Solutions can be classified as either complete desks or what I call "Desk-on-Desk" products or "DoD" for short. In either case, the goal of these devices is to provide a means of raising the workspace so that the user can stand, reduce the force on the spine, and obtain the healthful benefits of postural change. Scandinavian countries have a sit-stand adoption rate of 75 – 90% and are seemingly always rated in the top 10 healthiest countries in the world. I tend to think it's not a coincidence. Unfortunately, not all devices encourage the frequency of postural change that is desired due to their size or means of adjustment.

With a **complete height-adjustable desk**, the entire desk surface travels up and down. Height ranges vary by model, but look for one that is capable of at least meeting the ANSI-BIFMA recommended range of 22" to 48". Frank Gonzales, CPE, from the Colorado State University suggests a range of 22" – 50" to be truly ideal.[68] The only product that I know of that fits that criteria is the LifeDesk® by Right Height Manufacturing.

The mechanics of how height adjustable desks work vary,

classified as either spring loaded/counter weighted units, pneumatic/hydraulic, crank and electric. The pros and cons of each are listed below:

Counter-weighted – calibrated to a specific load range, any deviation from which affects the ability of the desk to go up/down. It raises and lowers quickly, but usually requires some muscular effort in each direction depending on load levels despite counterweighting. Typically limited to 1 or 2 leg desk styles.

Pneumatic/hydraulic – usually requires user generated downward force for the surface to be lowered. Sometimes they have so much spring in the lower position, they can come up rapidly and cause injury. They adjust quickly — sometimes too quickly. They are also limited to 1 or 2 leg desk styles.

I have a customer who has reported two workers comp claims due to these types of devices. One, a back injury from pushing a single column downward, and one, a jaw injury where the user was leaning over the table when the lever was released to engage upward movement and the underweighted device sprang up quicker than anticipated.

Crank – assume about 5 cranks per inch, and with the average travel being 15", it takes a long time (75 cranks, by my math) to raise/lower and doesn't lend itself to frequent postural change. Frequent turning of the crank can lead to overuse syndromes in the upper extremity.

Electric – usually about 10 seconds to transition from sit to stand, but can move the highest load of all the desk types. They may be configured in single, dual, three or even four leg options. Some have programmable presets via a memory switch and can come with a digital display showing height.

> **Note:** Only consider electric sit stand desks with a dedicated motor for each leg. There are less costly units in the marketplace that use a single motor to drive multiple legs. Single-motor units are more susceptible to failure.

Prices of electric desks have fallen dramatically over the last 5 years. To leverage the investment made in the office furniture and preserve the cosmetics of the office, consider purchasing an electric base only and use it to easily make a sit-stand unit out of your existing desk.

Desk-on-Desk or DoD solutions are often rapid to deploy, provide a quick transition from sitting to standing, but aren't really suited for the majority of workers. **It is estimated that these solutions only ergonomically fit about 5 – 10% of the population.[69] Since desk heights are already too high for average individuals, placing a DoD atop the existing worksurface, raises the keyboard even further for sitting, resulting in even worse ergonomics for seated use! They therefore become a standing only option which defeats the said purpose.**

It's evident that the design of some of these devices also results in incorrect placement of monitors relative to the position of the keyboard, thereby putting the monitors too low, resulting in a sustained neck flexion posture. On more than one model, the user has to flex forward to raise the device to the standing position and partially lift to initiate movement of the device. In my experience the requestor of these devices typically has back and/or neck pain, and needs to stand for pain relief. **I see these devices as a potential exacerbation of the problem, not the solution.**

Some of these devices have a center post design resulting in a tall profile, so the aesthetics of the office that were so carefully crafted by the interior designer, and paid for by the orga-

nization, now create an unsightly environment when these devices start showing up on desks.

Lastly, many of these devices are designed with a worktop that is significantly smaller than one's desk. By the time you add a monitor or two, a keyboard, a calculator and coffee mug, there is little to no room for documents or phone etc. Please read Appendix 1 for a more detailed discussion of DoD solutions.

Lighting – It is estimated that up to 70% of office workers experience symptoms of CVS[70] or "Computer Vision Syndrome" which may include headache, dry eyes, blurred vision, and eye irritation. The constant focus/refocus on our screens creates eye strain. Proper lighting levels and quality of light can play a crucial role with office ergonomics. If ambient light levels are too high, there isn't sufficient contrast for viewing computer screens Monitors should be positioned 90 degrees to windows to minimize the strain caused by glare. The 20-20-20 rule is also effective for reducing the symptoms of CVS. Every **20** minutes, take **20** seconds to look at a spot at least **20** feet away.

As employers have lessened the ambient light in the office to reduce energy consumption costs and provide greater contrast for computer use, task lights become essential, especially for an aging workforce. The typical 50 – 60 year old needs 5 – 6 times more brightness to be able to read items as that of a 20 – 25 year old since the aging eye lens transmits only 20% of light it used to.[71] The presence of cataracts may reduce light transmission to as low as 2%.[72] LED task light technology has become significantly more affordable and is the solution of choice. Look for a brighter, white light in the 4000 – 5000K range for reading rather than the yellower 2700K light. To prove it to yourself, try reading under LED versus conventional CFL or florescent. Natural light/daylight is closer to the 5000 – 6500K range.

Ergonomic Accessories – consist of items such as mice, keyboards, footrests, laptop holders, mats. Some areas where I see these accessories as being essential:

1) Use of laptops/tablets – need external peripherals as prolonged use of the laptop keyboards and built-in mice or touchpads will eventually lead to MSDs. Place the laptop/tablet on an arm or use with a holder to place the screen in the proper location. Using the laptop unelevated on a standard height desk will lead to chronic neck issues, headaches and shoulder pain over time.

2) Larger people (especially if broad in the shoulders/chest) – arm spacing is wider, therefore use of a standard keyboard is too narrow, placing the wrists in significant ulnar deviation. Consider keyboards that either hinge or separate so that left and right side can be placed in front of each hand, respectively.

3) Hand/wrist/elbow tendonitis – consider mousing alternatives, Vertical mice keep the forearm in neutral, reducing strain and have been shown to minimize forearm muscle activity. The various types of Rollermouse units help reduce index finger clicking and are great for use with multiple monitors. The Rollermouse slidebar allows rapidly positions the mouse on any screen, and facilitates quick drag and drop activity. Trackballs and/or foot pedals are other solutions in this category for more significant issues.

4) Footrests are a great alternative to the traditional stool footring as discussed earlier. Footrests also allow for postural alternations and weight shifting should the user engage in standing in their workplace. Lastly, footrests are necessary if the user's chair cannot be adjusted such that the user's feet are flat on the floor.

5) Headsets are essential for anyone who spends time

on the phone. Most headsets today are wireless which is an essential feature as it encourages standing, walking or pacing (depending on cube size) while conversing. This is a great way to interrupt static postures with some movement and activity. I prefer a headset in which my ears are covered; either monoaural (single ear) or binaural (both ears). These are especially invaluable for call centers or open environments where noise and distraction may be commonplace and one's focus on the conversation is essential.

6) Ergo mats (anti-fatigue mats) in the office environment are handy for those who are choosing to stand in their workplace. Some would argue that if you need a mat, you are standing too long and that postural change should be more frequent. Those with cement floors or very thin carpet, should have some cushion to ease the strain on the feet and lower extremity joints. Consider a mat that has some sponginess and/or contour to help provide a dynamic engagement of the lower extremity muscles which helps with venous return and requires dynamic muscle co-contraction for development of foot/ankle proprioception. Some mats now offer features allowing one to stretch the muscles of the lower leg.

Move at Work

Dr. James Levine at Mayo Clinic has published the concept of NEAT or non-exercise activity thermogenesis.[73] In other words, the idea of burning calories and engaging in movement while not in a dedicated exercise session at the gym or at home. Activity in the workplace or at home/leisure such as standing, walking, even fidgeting increases energy expenditure — as much as 2,000 kCal per day for the most active.[74] Sitting in an office in front of your computer generally increases energy consumption by 5% over basal metabolism (the energy to exist). Simply by standing up and walking just

1 – 2 mph, the calorie burn rate doubles.[75] A recent study by Levine and his team showed fidgeting and the use of dynamic seating increased energy expenditure by 20%.[76] Dr. Levine's research clearly shows a correlation between NEAT and obesity. Those with more NEAT tend to be leaner. Some ideas for incorporating NEAT into your day:

- Standing desks
- Park further away from the office to encourage walking
- Walk or bike to work depending on proximity
- Taking the stairs whenever possible
- Walking over to see a co-worker rather than calling
- Standing or walking meetings
- Walking breaks
- Fidgeting
- Go outside for lunch
- Frequent stretches
- Smaller water cup for more frequent trips to fill up
- Dynamic movement chairs

I have found that treadmill desks are best used when participating in conference calls, checking emails, reading manuscripts or other busy work. As we walk even at low speeds, we tend to lose dexterity which makes accurate typing difficult. A study performed at The University of Massachusetts Lowell Department of Work Environment showed the average typing accuracy decreased by 20% when using a treadmill desk. Most desk treadmills have speed limiters, but losing focus while walking can still be dangerous on a machine with rotating drums and a rubber belt.

In keeping with the paradigm of frequent postural change, if you want to have a treadmill desk, I have found the best way

to do it is to have a sit stand desk, 72" desk width minimum (84 – 96" is better), and put the treadmill to either the left or right side of the desk and your chair to the opposite side. Monitors should be mounted on arms in the center of the desk so they can be biased to one side or the other depending on the side of the desk you're using. A wireless keyboard and mouse is also necessary for easy transition to either position. If you are 6' or taller, you'll want to remember to get a sit stand desk with the tallest height range, (The LifeDesk goes to 51") as the bed of the treadmill will typically be 4 – 6" above the floor.

Example of standing conference table and walking treadmill conference room

Treadmill desks are a significant investment which typically stand to benefit one individual. A more effective deployment is to have multiple units in a dedicated space where they can be reserved for at least 30 minutes at a time. I have also seen walking conferences held in treadmill rooms. Energy levels are higher and ideas flow better when folks are standing or walking. Meetings also tend to be shorter, with less idle chit-chat. The same is true with standing conference tables.

Whether it's walking on a treadmill, walking the hallways of your building, or getting outside for some fresh air, the health benefits of frequent motion are well-documented and worth the time allowance that they take. The body of evidence is increasing every month. Consider some examples below:

Standing and walking for even short (5 minutes) bouts after prolonged sitting reduced blood glucose levels in post-menopausal, prediabetic females. Compared with uninterrupted sitting, standing reduced the post meal rises in glucose levels by 34% compared with a 28% reduction for walking. Post meal insulin concentrations rose by 20% with standing versus 37% for walking on the day of the intervention. On the day after, those who had interrupted their sitting with standing on day 1 still had a 19% reduction in post meal glucose levels compared with those who had been sitting on day 1 while walking on the previous day reduced the glucose levels by 17% on day 2.[78]

A similar study of actual office workers (2 males, 8 females, aged 21 – 61) who stood for 3 hours after lunch, showed an average reduction in glucose levels of 43%. [79]

A recent study in Australia showed that short bouts of light intensity walking (3 minutes every 30 minutes) were significantly effective at reducing fatigue levels when compared to those of their sedentary counterparts.[80]

An international panel of expert researchers in the field of ergonomics, sedentary behavior and prolonged inactivity came together to form a consensus position to serve as a guideline for employers. An excerpt is printed below: [81]

> *The derived guidance is as follows: for those occupations which are predominantly desk based, workers should aim to initially progress towards accumulating 2 h/day of standing and light activity (light walking) during working hours, eventually progressing to a total accumulation of 4 h/day (prorated to part-time hours). To achieve this, seated-based work should be regularly broken up with standing-based work, the use of sit–stand desks, or the taking of short active standing breaks. Along with other health promotion goals (improved nutrition, reducing alcohol, smoking*

and stress), companies should also promote among their staff that prolonged sitting, aggregated from work and in leisure time, may significantly and independently increase the risk of cardiometabolic diseases and premature mortality.

Alternative Solutions

I like and greatly appreciate that the authors of the aforementioned position statement recognize the scope of this problem and also mention improving nutrition and reducing stress as health promotion points of emphasis. As mentioned in chapter one, stress levels and poor nutrition are significant factors in the problems facing American businesses.

Researchers from Duke University and The University of Pennsylvania suggest that for stress management programs to be effective, they have to be "accessible, convenient, and engaging to the employees" as well as cost-effective and economically sustainable for the organization.[82]

A randomized controlled study examining the effectiveness of therapeutic yoga and mindfulness-based programs for reducing stress, enhancing emotional well-being and improving work performance was conducted with 239 employee volunteers. The volunteers were randomly assigned to one of three interventions: yoga, mindfulness meditation, or a control condition that provided the participants with a list of insurance-provided resources (fitness center discounts, wellness coaching opportunities etc.) The researchers found that compared to the control condition, the therapeutic yoga and mindfulness based programs both lead to significant improvements in perceived stress levels and reduction in sleep problems; suggesting these strategies are viable interventions to implement in the workplace.[83]

While more anecdotal than scholarly research article, the CEO at

Aetna Insurance is a big fan of yoga and meditation. He made free yoga and meditation classes available to all employees. Twenty-five percent have participated in at least one class and those who have report, on average, a 28% reduction in their stress levels, a 20% improvement in sleep quality and a 19% reduction in pain. They also have become more effective on the job, gaining an average of 62 minutes per week of productivity each, which Aetna estimates is worth $3,000 per year per employee.

A recently published study conducted at Harvard showed that use of relaxation and resiliency training techniques including meditation, yoga and biofeedback resulted in 43% reduction in healthcare utilization and over 50% reduction in yearly visits to the ER.[84]

While ergonomics is the main focus of this book, it would be naive to think that it is the universal fix in light of all the complicating factors presented in Chapter One.

A more thorough analysis of additional alternative solutions may be the subject of subsequent editions of this book.

Chapter Three: The Workspace Assessment Process

On Site Assessment

When we get the call to come in to assess, it typically means the employee is suffering from some sort of MSD, and it's gotten the point where they need some sort of equipment intervention or workspace modification. The HR or EHS department has already gone thru a basic ergonomic checklist, made changes, and the employee either hasn't responded or HR/EHS isn't sure what the best equipment solution is. We do either an onsite assessment or we can have them provide us with a few snapshots of the workspace. Next to the tape measure, I think the cell phone camera is probably the "MVT" — most valuable tool — for ergo folks, as pictures are worth a thousand words.

If we are able to come and assess in person, I'll engage in dialogue with the employee to find out in their words what's going on. Listening to the end-user you can glean a lot of information that HR or EHS probably doesn't realize regarding the employee's job. I'll ask to observe the employee in their workspace and ask them to pretend I wasn't there and just work for a bit so I can understand how they relate to their

surroundings. Depending on their reported issues, I try to envision a causative factor or factors based on what I am observing and I ask a lot of questions if they can't tell me the specifics of their job.

It's important to realize that the area of pain may not be the area of dysfunction. Typically you can look to the joint above or the joint below to find a causation to the pain. Forearm pain about the elbow, may be caused by abnormal or repetitive movements at the wrist or elbow. Similarly, perhaps the employee's mouse is outside the immediate reach zone and they are externally rotating their shoulder to mouse with simple wrist movements. Distal mobility (i.e. wrist motion) requires proximal stability (muscles in the upper arm need to fire to stabilize) as physical therapists or ATCs (athletic trainers) might say. The elbow nor the shoulder is moving but the force of firing muscles is putting stress on the elbow, possibly manifesting in some form of epicondylitis (overuse syndrome).

Another example of this concept is low back pain in the lumbar spine. Keep in mind that while the pain generator may be in the low back (disc bulge, as an example), the true dysfunction may actually be located below in the hips (excessive tightness, most commonly) or above (weakness in the abdominal muscles) or both.

Whenever we assess a space and have direct access to the end-user it is essential to be positive and confident that we will find a solution that will work for them and help ease their pain. By reinforcing confidence that the solution we provide is going to work, the power of suggestion helps get their mind on the path to healing.

Often times the end-user will drop subtle clues (or sometimes not so subtle) that give insight into what is really happening. It's important to listen, but not feed into what they are saying since its simply their perspective of the situation. Don't pry,

just listen. They might say things like:

> *"It's about time, I've been waiting so long for them to do something for me"*
>
> *"They keep bringing me crappy chairs to try"*
>
> *"The lady down the aisle got a full desk, why am I getting this thing"*
>
> *"I just want a stand up desk"*

These little off-handed comments can suggest that the end-user isn't happy with their job or their employer or let you know their ultimate goal (I'm only gonna be happy when I get a desk). While it's important to acknowledge that you hear them and understand their situation, you should not discuss any recommendation or possible solutions with them. That conversation should only be had with the supervisor or HR/EHS personnel.

Several studies in the 90s and early 2000s suggested that employee job satisfaction and relationships with their boss and co-workers were two of the more significant determinants for success in return to work from worker comp claims. Some employee statements may tell you that no matter what products you bring or modifications you make, they still aren't going to get better. So while you can show compassion, don't acknowledge those negative statements. Just exude confidence and tell them "the solutions I provide have successfully worked with so many others and gotten them out of pain and the same will be true for you."

As part of this process, I like to get employee buy-in in terms of selecting the solution they are most comfortable with. By getting their "Buy-in" the odds of success are significantly higher as shown by the Washington Dept of Labor Analysis cited earlier in Chapter One. For example, I'll bring 3 – 4 chairs with me for them to try. I give them the ability to

pick a couple that they can then try for a week. Let them establish in their own mind that this new chair is going to help them get better. The mind is such a powerful force in the healing process, the more you can do to get the end-user to be confident that this is going to work, the greater the odds of success and case closure.

When you show up for the assessment, be very observant. Make mental notes, or use your camera to snap photos to trigger your memory. (Ask permission first before taking any photos.)

Aside from the workspace, things to note may include:

Level of organization. Is desk full of clutter? Stuff everywhere may indicate they are either overworked, overwhelmed, or just plain disorganized. This may give potential insight into whether they truly want to be healed.

Amount of **food in the workspace**. I realize some folks are so busy that they need to eat lunch at their desk while working. I'm talking about more than that, like snacks everywhere. Evidence of crumbs and wrappers. I have been in union-operated call centers where food is everywhere. Food is a way that we as a species deal with stress. I find if perceived stress is high, these folks tend to be more high-maintenance, needy and less likely to be satisfied with an ergonomic intervention.

Photos, personal effects. I'll look to see if there is something that we may have in common as a means of establishing a rapport. People like to talk about their kids or pets, places they've been. Having something in common can help establish in their mind that you are a "friendly" and there to help them.

In terms of the physical workspace, again, tape measure and camera are key. Be sure to have a note pad and pen to jot notes or sketch out layouts.

Observe the relative positioning of the computer, keyboard and mouse. Where is the monitor and at what height? Where is the keyboard? What type of mouse are they using? I will also often see a keyboard tray tucked away under the desk. Ask about it, why it's not used. Could be a relic that's garbage, or a modern unit they inherited. Ask "Why?" Maybe they want it removed altogether as part of the workspace modification, which you can offer.

Ask what types of computer work they do. Simple typing? Online research? Spreadsheet work with lots of small typeface and cells?

Ask if they are a touch typist. This greatly affects the placement of the keyboard and whether you offer a keyboard tray or not. Ask about any vision correction. Those with bifocals may need the monitor lower than what traditional ergonomic principles tell us.

What items are in their immediate reach zone, and what needs to be in their immediate reach zone? Adding machine or calculator? Stapler? Phone?

Speaking of phone, ask how much time they spend on the phone. Do they have a headset? If not, suggest one to the supervisor if appropriate. There's nothing worse for the neck than cradling the phone between the ear and shoulder, while typing and/or mousing. A wireless headset also allows standing and walking while on the phone, which is a great way to alter posture and burn calories during the workday.

Look for papers and/or reference materials that are frequently used. Accountants may transcribe from financial documents, engineers may rollout their drawings, lawyers may pull out case briefings. It's important that the necessary space is allocated for those needs, whether it be flat on the desk or tilted in front of the monitor on a document holder.

Sit in the employee's chair, how does it feel? Is it something you could or would want to sit in all day? How are the adjustments? Broken seat mechanisms? Signs of wear? Fixed armrests or gouges in the arms suggesting it doesn't fit under the desk? How does it roll? Perhaps it requires substantial leg force to roll over the carpet, exacerbating a low back condition. All valuable insights gleaned by keen observation.

Observe for the presence of a heater. Muscles don't respond well when cold. How cold is the office during the winter workday? Look to see if the air conditioning is blowing down on the client from the ceiling. Perhaps the user's workspace is located on an outer wall made of cement or cinder block which conducts cold during the winter months. I actually had a client whose large metal desk was along an outer, north-facing wall made of cinder block. Her desk was cold to the touch in winter and, as a result, made her cold.

If you are assessing for a sit stand unit, take a look at the desk segments. Are there sections that lend themselves to easily being converted to sit stand? Would a 2 leg be sufficient or does the whole L need to go up with a 3 leg? Is there space between the panel and the worksurface if the user's desk is in a cube? What kind of under storage is there in the form of pedestal files? Are they hanging from the desk or on the ground? How much are they used? Will they be missed if they are removed to accommodate a sit stand? Look at tack boards, overhead bins and shelving. Can an elevating desk clear all obstacles? Will the monitors hit the bins/shelves if the desk is raised?

Observe if there are windows and how much brightness there is. Is there glare on the monitor? Is the monitor positioned 90 degrees to the window or are there shades on the windows. Ask if the sun comes in during certain times of the day. How much ambient light exists and what is the quality? Is the facility illuminated with florescent bulbs?

Lastly, observe or ask the user their height. Don't ask their specific weight. Observe body style. Are they tall and lithe or short and plump? If you feel weight is questionable related to their chair, discuss this with the HR or EHS professional. Perhaps ask them for a weight range, or have them fill out a fitting form such as those pictured later in this chapter. If you are recommending a new chair, get measurements for proper design and specification.

Remote Assessment

Depending on the client's location, it may be impractical to visit the workspace in person. Perhaps your schedule may make a timely visit impossible (we like to provide response within 72 business hours whenever possible).

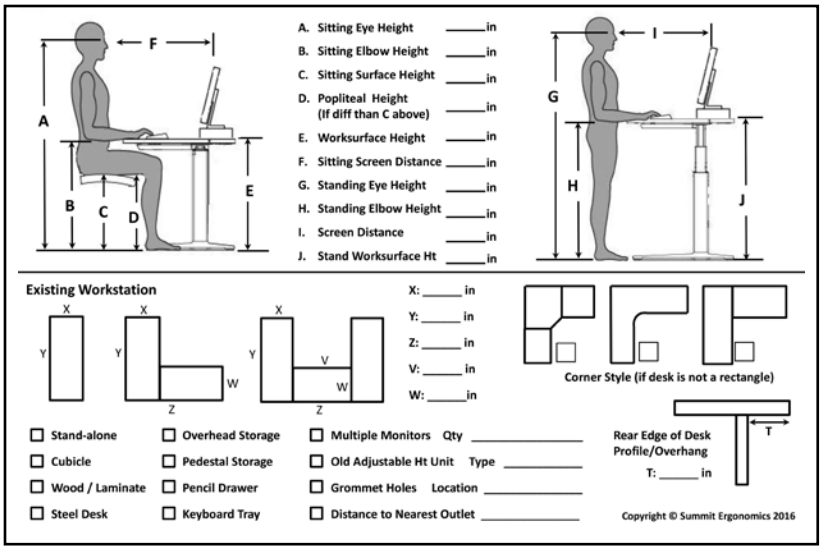
For those situations, we have remote data collection forms that we can provide the HR or EHS professional so that they can collect the data we need to provide a custom solution for their employee. We ask that they snap a couple photos and email them to us. Examples of perfect pictures are below. Side and rear angle views are essential.

Photos from behind and from the side give great perspective and insight to the situation and the relative positioning of the items in the end-user's workspace

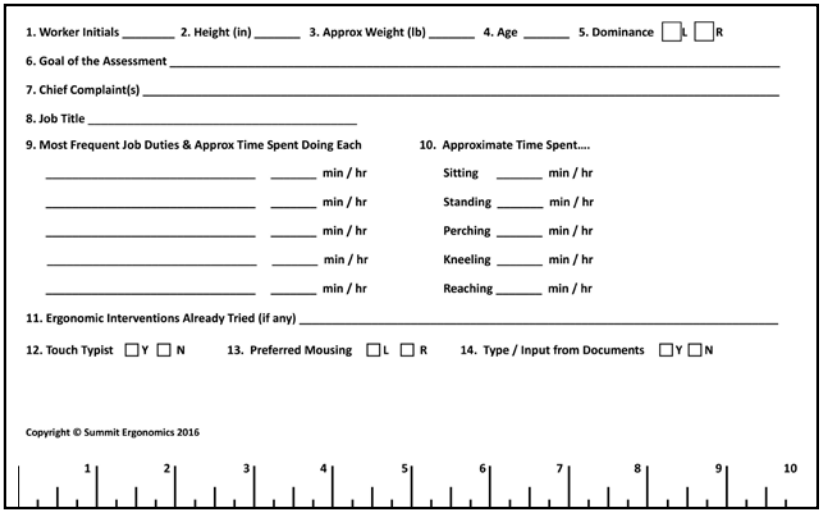
We also ask them to collect data on our remote assessment worksheets which are downloadable from our website summitergo.com. This data helps give us physical dimensions to quantify what we observe. Using the photos above as an example, we see the user's chair is too big, the desk is too high, and the monitor is too far away. So, if we can get some measurements it helps us steer the solution in the right direction to solve the problem within the constraints provided by the client.

Knowing information about the desk geometry and construction is also helpful if we think a sit-stand solution is an option, as we can provide suggestions as to whether the existing top can be repurposed for use with an electric height base. Knowing what obstacles exist help formulate the most cost-effective viable solution and the logistics of executing the modifications.

Even just knowing whether there is an overhang of desk on the back edge can avoid peril. I have made the mistake of recommending a monitor arm, sent a tech out to the field with a clamp mount, only to find a rear panel on the desk which prevents mounting. Poor planning resulting from poor observation creates avoidable delays for the employee who is in pain, the HR administrator and needless costs to the provider of the equipment.

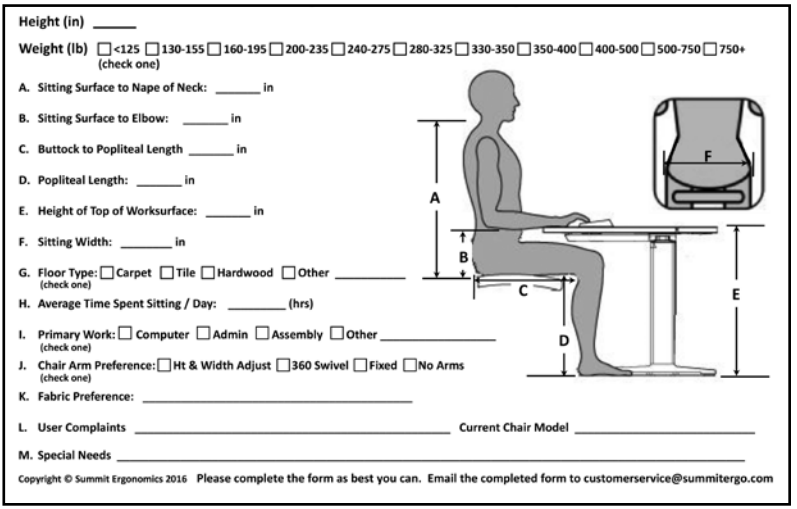


Page 1 of our assessment form gives information about the user in their current space and data regarding the physical construction of the worksurface(s). Also gives us insight to what obstacles may exist



Page 2 of the form gives us end-user info, helps us quantify time spent doing particular work tasks, what ergonomic solutions have been tried already. The handy ruler at the bottom is just in case one forgets their tape measure.

If the goal of the assessment is to get a new chair for the employee, and we are not able to get onsite to measure, then we'll ask to have our remote chair fitting forms completed (see below).


Height (in) _____

Weight (lb) ☐<125 ☐130-155 ☐160-195 ☐200-235 ☐240-275 ☐280-325 ☐330-350 ☐350-400 ☐400-500 ☐500-750 ☐750+
(check one)

A. Sitting Surface to Nape of Neck: _____ in

B. Sitting Surface to Elbow: _____ in

C. Buttock to Popliteal Length _____ in

D. Popliteal Length: _____ in

E. Height of Top of Worksurface: _____ in

F. Sitting Width: _____ in

G. Floor Type: ☐Carpet ☐Tile ☐Hardwood ☐Other _____
(check one)

H. Average Time Spent Sitting / Day: _____ (hrs)

I. Primary Work: ☐ Computer ☐Admin ☐Assembly ☐Other _____
(check one)

J. Chair Arm Preference: ☐Ht & Width Adjust ☐360 Swivel ☐Fixed ☐No Arms
(check one)

K. Fabric Preference: _____

L. User Complaints _____ Current Chair Model _____

M. Special Needs _____

Copyright © Summit Ergonomics 2016 Please complete the form as best you can. Email the completed form to customerservice@summitergo.com

Chair assessment form: all information is important, but the crucial data are items C, D, E & F

The essential measurements for sizing the chair are items C, D, E & F. C and F allow us to customize the seat pan as necessary. The relationship of items D and E tell us whether we can accommodate the need with a stool or a standard chair, and the necessary cylinder height. Our goal is to have the user's feet flat on the ground or flat on a foot support of some sort.

Other elements of the form help us determine a caster type to recommend, whether additional cushioning may be necessary based on how much sitting is done, and whether arms are preferred. Based on the work environment, the client might need a particular fabric (vinyl for a hospital or ESD for a circuit board assembly company as examples). We also like to know what the user doesn't like about their existing chair

and what type of chair. If sitting in a mesh chair is giving them problems, we're not going to recommend a different mesh chair. Special needs might include a degenerative hip condition, or a nerve issue that causes sensitivity in a particular area. It's all important to know for properly specifying a chair that the end-user will be happy with.

These assessment tips are based on field experience, interaction with the many different parties involved in this process, as well as having read many reports prepared by assessors seeking solutions for their clients. Since these are ergo issues, we know the end-user is in discomfort and that the employer has an obligation to provide reasonable accommodation in a timely manner. It's incumbent upon us to minimize the elapsed time between evaluation and solution provision. By utilizing some of these tips, we can help shortcut the process and eliminate the need for obtaining more information. My hope is that our assessment forms, which can be found at www.summitergo.com, can serve as a cue or reminder to collect the necessary details to help implement a successful intervention as quickly as possible.

Chapter Four – Case Studies I: Accommodating for Furniture Size Mismatch

Case Study 1

An assistant director of a library in New Hampshire reported low back pain and neck pain radiating into her shoulder and forearm and symptoms consistent with carpal tunnel syndrome. Upon our site visit we discovered that she is 4'10", thin and sitting at a traditional metal desk that was 29" high, 30" deep with a 19" computer monitor sitting in the middle of her desk. Her keyboard and mouse were positioned on top of the desk. Her chair was clearly too large for her, and ergonomic sitting postures were not possible. We found her sitting on the front edge of the chair since the seat pan was encroaching upon the back of her knees. She was leaning forward to utilize the keyboard and mouse, elbows bent to about 70 degrees of flexion. Her chair was positioned at a taller cylinder setting to help her reach, but this created a bit of neck flexion since the monitor was too low. Her legs were swayed back with her dangling feet resting on the base of the chair, an all too common typing posture.

BEFORE: Client positioned at former desk with too large a chair. Less than 90° angles at the knee and elbow restrict proper bloodflow to the extremities.

Our goal was to get her to sit properly with feet flat on the floor, and torso engaged into the backrest of the chair for support. We measured her normal hand height when seated in this position, and it was found to be 21". She was interested in having the ability to stand, so we sourced her an electric **sit stand** desk called The **LifeDesk** that has lowest height range capability of 22" (assuming a 1" thick top). We opted to recommend a 24" deep top to keep all desktop items within her shorter-than-normal reach. We sourced her an ErgoCentric Saffron petite chair, with an extra short cylinder, and no arms so that her seat could be set low enough for her feet to remain on the floor without need for the stool. The seat pan was extra shallow to accommodate her short femur length. We recommended a dual monitor setup by Right Height to enhance her productivity as she has multiple programs open at any given time, which also helped minimize the amount of mouse clicking. The monitor arms also serve to bring the computing tasks to her so she could sit with back supported by her chairback, simultaneously relaxing the traps, upper back and shoulder musculature. By eliminating the chair arms, she could slide her chair in close to the desk, and com-

fortably interact with her mouse and keyboard with minimal shoulder flexion. Due to her diminutive stature, we also recommended a Contour Rollermouse to prevent any sort of external rotation of the shoulder needed to reach her mouse, normally positioned to the right of a standard keyboard. The Rollermouse essentially centers all the mousing activity just below the spacebar of the keyboard. It's also a great input device for dual monitor configurations as it allows toggling between screens with its slidebar.

AFTER: Client positioned at her new desk with petite chair. Desk is lowered to sitting elbow height. Upgraded monitors and Rollermouse have enhanced her productivity and comfort levels.

Symptoms cleared within a couple weeks of integration of her new setup. Her only issue was the learning curve associated with the new mouse (typically 1 – 2 weeks) but she now reports that she loves the mouse and would never go back to the old one. She is standing for 20 minutes when she comes into the office in the morning and right after lunch by simply remembering to raise her desk whenever she leaves the office. With therapy and her desk modifications, she is now totally asymptomatic.

Case Study 2

A nurse at an assisted living facility reported soreness and extreme tightness in her midback, lower cervical spine, and shoulders. She was seeing a PT for treatment and they recommended she have a workspace assessment done. She is 5'3" in good shape and uses a laptop for all EMR documentation of the facility's population.

She has a standard wooden desk 24" x 60" and 29.5" high and sits in the standard company issued chair, which is oversized for her with moderate ergonomic adjustability. Thus, the seat pan was too deep for proper sitting.

She commented to me, "But I only sit here for a max of an hour at a time. I'm usually up and around, in the exam rooms, meeting with the residents." While she knew the ergonomics were bad, she figured the minimal time she spent at her desk wouldn't be a problem. After a couple of years, she found herself with discomfort severe enough to be seeing a therapist 3 times per week.

BEFORE: Client positioned at executive desk with oversized chair, keying directly on laptop. Unelevated laptop use typically creates neck flexion issues. Note elbow flexion and space between her torso and the chairback.

After assessing the workspace, I came back later in the week with several ergonomic accessories that I felt would be of benefit. I clamped a monitor arm to the back edge of her desk, and mounted it with a laptop holder from Right Height. This raises the laptop off the surface of the desk and puts the LCD of the laptop at the proper height for best viewing with a neutral neck angle. I asked her IT department to provide an external mouse and keyboard, since the laptop functions are no longer usable while it is in the holder. I normally prefer wireless accessories for ease and portability, but IT only had wired units. Most IT departments prefer hardwired external devices, as wireless can often be lost in large office environments and require battery changes or recharging. Fortunately, the wired devices simply plug into the USB ports of the laptop and are auto-detected for easy transition.

There are other types of laptop holders that are essentially height adjustable platforms that allow you to use both the laptop keyboard and mouse rather than external devices. I've tried these in the past and my clientele has complained of the bounce associated with typing on the laptop. You also still have the fundamental problem of the hand/eye height differential typically resulting in long periods of sustained neck flexion during laptop use. The external peripherals and the use of the Right Height monitor arm with the laptop holder address those issues.

Her seated hand height was measured at 23.5" and fortunately she was a touch typist. I provided a Right Height keyboard tray (KBT) and had it centered in the available space. She was adamant about not wanting a KBT, as her previous experiences with them caused her to "always bang my knees." I explained my rationale and she reluctantly agreed.

Based on her symptomology, I selected 2 chairs to bring her from our demo inventory to see what she liked in terms of sitting preference. One of my seating philosophies with local

clients is to bring several chairs to try, explaining the benefits of each to them. I then have them sit in each, properly sizing each one. Inevitably the end user will choose 1 or 2 that are more comfortable for them above the others. I feel this strategy typically yields a better outcome, by getting "buy in" from the end-user. If they feel a part of the decision making process, I have found that the odds of successful case resolution are much greater.

I suspected she'd opt for the Buzz Seating Pronto Chair with a Thorback option. I selected it for her specifically because of the tapered back design (narrower at the top, wider at the bottom of the backrest.) It also has additional padding in the thoracic area of the chair, leading to the feeling of firm contact/support for an area that is often under supported. I felt a recumbent sitting position would help get her shoulder musculature to relax. She opted for a slightly more upright sitting position, still utilizing the keyboard tray so we could keep the chair lowered in such way that her feet were flat on the floor.

She wanted to try this new setup for a couple weeks before committing to purchase; she started feeling better within a couple days. Combining physical therapy with her new ergonomic setup, she is now symptom free and very pleased. Another case where the employer saw an instant return on a relatively small investment in ergonomics.

AFTER: Client now able to engage the backrest of the chair, type at a more desirable 90° elbow flexion, and maintain a neutral neck

Case Study 3

A phlebotomist who is 5'2" and right handed had a small (6' x 8') blood draw room in which to work. She had managed to accommodate her needs in the small space, but she was experiencing symptoms of shoulder pain, neck and back pain and wrist pain. It was affecting her ability to pursue her passion for yoga. Upon assessment, there were several areas for ergonomic improvement in the draw room.

The work surface that holds the computer, monitor and printers was installed at a height of 30"; too high to be used comfortably by someone 5'2" whose seated elbow height was about 23". It is also too low for effective use while standing as her standing elbow height was about 38". Since the existing medical stool was reported to be "too uncomfortable" for sitting, the phlebotomist was standing for the majority of the day. Her interaction with the computer therefore typically occurred while standing, and the low work surface height

resulted in significant degrees of neck flexion and wrist extension when typing and mousing.

Due to the crowded work surface, the positioning of the mouse behind the keyboard also created an awkward combination of shoulder rotation and flexion as well as wrist deviation for the user whether she was sitting or standing. These postures can be fatiguing when the volume of patients is constant.

The refrigerator was located on the floor, under the specimen processing counter. Extreme bending and/or squatting was required to place fluid samples into the fridge. Additionally, the refrigerator door swung out into the room. Due to the proximity of the fridge to the work surface (about 30"), some deft footwork, balance and deep squatting was required to maneuver to gain good visibility into the fridge for swapping specimens in and out, as needed, and to avoid hitting herself on the desk corner.

The specimen processing counter is an area of frequent standing on a hard floor.

I recommended that the following changes be made:

1) Shorten the width of the existing cantilevered work surface from 48" to 27" and reinstall it in the corner to support the printers in their current position.
2) Purchase and install a StableRise® by Right Height Manufacturing in the space created by cutting the work surface. The StableRise mounts to the wall and creates an adjustable height work surface with a range of 25" to 48" when installed 6" above the floor (for easy cleaning). The antimicrobial work surface is 27" x 19" which will allow the keyboard and mouse to be on the same plane. Include the monitor holder option which will create additional space on the worktop.

3) Find a strong, deep shelf which would facilitate raising the fridge approximately 12 – 15", also creating space under the fridge for the dry ice cooler.

4) Re-orient the hinge placement on the refrigerator door so that it swings toward the wall, making access to it much easier.

5) Purchase an ErgoCentric 3 in 1 stool. This product allows for traditional stool sitting with a back rest, but also allows the user to perch in an upright position for standing and bench work heights, taking load off the lower extremity. The unit is lightweight, has rubber glides for safety, and 2 casters for easy maneuverability when needed.

6) Purchase an ergonomic mat (1' x 5') which would enhance the benefits of standing and minimize discomfort on the lower extremities. The hygiene mat provides the best combination of ergonomics and cleanability. Its beveled edges eliminate the potential of a tripping hazard.

BEFORE: Worksurface holding the computer and printers. Note the awkward position of the mouse governed by the shortage of space on the work surface.

BEFORE: Fridge location under the specimen processing counter. Bending to get into the fridge was awkward at best. Risk of catching the work surface sharp corner with one's backside was great. Fridge hinges were on the wrong side.

AFTER: StableRise® installed and raised to suitable working height for standing. The 27" wide work surface provided plenty of room for the keyboard and the mouse. It can be lowered for comfortable sitting a well. Fridge moved from old location to make for easier access and eliminate risk of hitting worksurface with backside. Cushioned walkway on the hardfloor using a 1x5 Ergomat. Plenty deep enough for this phlebotomist's size 5 feet.

AFTER: Fridge elevated 12" to reduce the severity of bending and squatting for storing samples.

Ergocentric 3-in-1 stool for effective perching and sitting in an open angle posture. Rubber stops on the frame ensure stability and 2 casters give you rolling capability for easy moving

We worked with the referral source to coordinate the timing of the physical changes of the room with the delivery of the ergonomic accessories to minimize the disruption within the department. One year post intervention, the phlebotomist continues to be pain free and pleased with all the accessories we recommended. The referral source is extremely pleased as is the hospital employer.

Chapter Five – Case Studies II: "I Need a New Chair!"

I wish I had a dollar for every time a potential new customer said to me or my staff, "I need a new chair." As we have already discussed, the poorly designed workspaces of America essentially force the worker to sit on the front edge of their chair in what we like to call the "praying mantis position."

Note the positional similarity between the computer user and the praying mantis insect

The chair user's torso never sees the backrest of the chair. Some industrial designer or healthcare clinician went to great lengths to research, design and create the chair backrest, yet it's rare that the backrests actually get to support users as

the designer intended. You can have the most expensive or sophisticated chair design in the world, but unless you are sitting properly, the chair will do you no good.

So when I hear "I need a new chair," the first thing I do is ask to see the workspace either in person or in photos to see how the user is sitting while working. If the user is at a local company, myself or a staff member can pay a visit and actually sit in the chair. If the user is great distance away, I like to have one of their coworkers snap a photo on their smartphone and shoot an email over. A single glance can often tell if the chair is in fact the problem. Too often I have seen workers incorrectly sitting in $700 – $800 office chairs and complaining it's the chair. Sometimes it is the chair, but sometimes it's the position of the monitor and keyboard not allowing the existing chair to work as designed. In my experience, it is often both the chair and the workspace layout. There are still a lot of 20 – 30 year old office chairs in existence.

Case Study 4

I recently was called in to do an assessment for a multinational conglomerate. The executive (who was of very short stature) had told facilities that she needed a new chair. Upon my arrival I found her to be sitting in a very nice ergonomic chair with all the possible settings necessary to fit her every need and desired sitting posture. She was complaining of pain between her shoulder blades. The seat pan may have been just slightly too deep by a finger's width, but nonetheless it was a quality, supportive chair.

Her two monitors were sitting on the back edge of her cube workspace, and her keyboard was on top of the work surface, despite the newer keyboard tray she had mounted under her desk. I demonstrated some sitting postures designed to reduce the pain in her midback and determined she could

really use monitor arms to complement her existing chair and keyboard tray. She said she would try that but wanted to also try some of the petite chair samples that I had brought with me. She found one she liked best, so I let her try it and also mounted two single monitor arms, one from each side of her center work surface. In the course of further discussion she asked me if a sit stand desk would be a better solution. I told her that for the pain she was describing, it probably wasn't a viable solution.

After a two week follow up, she indicated that she felt the new chair and monitor arms were helping, but she reiterated her desire for a sit stand desk. She also began talking about how hectic life has been since her baby was born eighteen months ago, and that she hasn't slept well since the birth of her child. Where did all this come from?!

I explained all this to the EHS Manager that had brought me into the plant, and I told him I didn't think that she'd rest until she got her desired sit stand desk. I felt like there were other issues at play here and that she was possibly exhibiting some non-organic symptomology with the case most likely not getting resolved until she got her sit stand desk. He agreed, and requested that we go thru an exhaustive evaluation process so that everyone in the plant wouldn't be asking for sit stand units.

Three months after her initial request, she now complained of generalized back discomfort. She was still sitting on the front edge of her chair, despite the training and coaching. "Old habits are hard to break" she said. Permission for her sit stand was granted. I just saw her a week prior to typing this and she is now "feeling good."

Case Study 5

A professor from a local college contacted us requesting a new chair due to significant lower back pain he was having. He was referred by the occupational therapist who services the college. She's very thorough and had already gotten him a monitor arm and keyboard tray. He was alternating his sitting postures but was still having pain. He was sitting in a popular brand of contract furniture chair provided by the college, a very sleek looking chair, but average ergonomics at best. Its idea of lumbar support is a thin plastic sleeve that slides up and down the lower portion of the backrest. Its back angle could only be locked in 4 positions, and didn't provide the support this individual needed. Its thin padded seat was not comfortable either.

I brought him a couple of smaller chair choices to pick from, but he quickly settled on the SOMA Contour. My reasoning for its immediate success is that I had properly sized the backrest and seatpan specific to his shorter than average 5'6" but lithe frame.

I love the SOMA chair, especially for clients who have tried a myriad of chairs over time, seemingly unable to find one that's comfortable. It's my "go to" chair whenever I have a client with severe low back pain. The SOMA's reverse-tapered back rest is in my opinion the best design I have come across and I have hundreds of satisfied users that reinforce my opinion. Features of the SOMA that make it my favorite include the way the lower backrest wraps around the kidneys to stabilize and support the user and the seemingly perfect level of padding in the thoracic region. The tapered back which allows for shoulder mobility and results in opening the chest in recumbent sitting is its best attribute.

While it sounds like a miracle chair, the caveat is that the SOMA chair is so highly customizable it requires a good knowledge of the user's issues and must be sized and specified correctly to be truly successful.

The professor's back pain cleared within days, and he wound up buying the same chair for his home office and one for his wife, albeit smaller as she was 5'3". Prior to receiving the chair, she was also sitting in a popular brand of contract furniture "ergonomic" chair, but sadly in the wrong size.

A special note: if you're going to provide an employee with the most popular office chair in existence, make sure it's the right size for the employee. They come in small, medium and large: A, B & C.

The 2 most popular brands of contract furniture chairs. A frequent source of back pain for workers, especially when size is mismatched for the employee.

I consider the SOMA chair as my "Go-To" chair whenever the customer has tried many chairs without success and/or is currently suffering with significant LBP. The tapered backrest has been shown to provide many health benefits and has inspired many copycats but it's never been duplicated for its effective support.

Case Study 6

Here is a case my staff to this day ridicules me about. The general manager of a chemical supplier was of average build, but he was recently promoted to this position from a production supervisor role in which he was constantly on the shop floor with lots of standing and walking. His main job tasks now involved a lot of computer work, doing budgets, reporting, management and sitting it on conference calls.

Within 6 months of all this seated desk work he began suffering from neck and back pain severe enough that he was seeing an acupuncturist. I came into his workspace and saw a large old wooden desk. His monitor was all the way back to the rear edge of the desk, with his keyboard on top of the desk. At the time, he was sitting in a conference room chair, and had several other chair models sitting in the corner that he would rotate through.

When he referred to documents for his reports, he would place them between his keyboard and the edge of his desk, creating frequent significant neck flexion as he alternated between viewing the document and his monitor, and craning his neck to see the monitor. He would also lay his arms on the desk to support them as he typed.

BEFORE: The client had 8 chairs in his office, circulating through each one every hour in an effort to remain comfortable at work. Here he is sitting in a Liberty conference chair.

Being that he had become a touch typist, I recommended the recumbent sitting position along with keyboard tray and monitor arm to provide a posture that would relax his neck and shoulder musculature. I recommended a headset for his conference calls that would allow him to stand and walk around his office while listening/participating. I brought in four chairs for his review. Two were quickly eliminated, and two he liked. He went back and forth. One of the chairs I provided had a mesh back for breathability and a headrest (the ErgoCentric 3 point pivoting headrest is the best in the industry in my view) which I theorized would give him not only support for his ailing neck, but tactile feedback to help remind him not to crane. "If you're not feeling the headrest, then you're lurching forward to see the monitor," I explained. The other chair had a contoured SOMA seat that he really liked. He couldn't make a decision, so I volunteered that he could take a week to sit in each and decide which worked best for him.

When I followed up to see how he was doing, he replied that he wanted the SOMA seat with the ErgoCentric back and headrest. Needless to say, that was not the answer I expected nor a convenient solution as this involved two different manufacturers. He insisted that it needed to be that way.

Our philosophy is that "nothing is impossible" so we provided the pricing, had it approved and ordered the chair to his specifications. One chair was ordered along with the parts needed from the other manufacturer, essentially creating the "hybrid chair" in "our laboratory." At the time of delivery and installation, we also trained the user on how we wanted him to use his monitor and keyboard tray, and how to position his headrest. The customer is ecstatic with his chair and new setup and is now out of pain. He has since upgraded his monitor to a larger size to help his efficiency working with multiple screens and spreadsheets.

We affectionately refer to this solution as the "Franken-Chair" since it was cobbled together from two totally different chairs in "the laboratory."

AFTER: Monitor arm, keyboard tray and chair that supports recumbent sitting working together to provide a comfortable work posture for the end-user.

The ErgoCentric t-Centric Hybrid formed the basis of the "Franken-Chair" due to its contoured mesh back, and 3 point pivoting headrest that the customer insisted on. The contoured seat and 360° swiveling armrests were from SOMA Ergonomics.

Chapter Six – Case Studies III: Medical Accommodations

Case Study 7

A 55-year-old female with an arthritic hip condition had hip replacement surgery. Her job responsibility was in administrative support, and primary lobby greeter at a prestigious business school. She sat behind a large, encircling, built-in oak reception desk that had a marble top. A condition of her return to work approval by her physician was that she be provided an accommodation that allowed her to stand for part of her workday. In addition, she was not allowed to sit in the standard, college-issued seating since excessive hip flexion (i.e. greater than 90 degrees) can cause dislocation of the joint replacement.

We were brought in to provide a solution as the high-profile visibility of this location was not conducive to some of the off the shelf standing solutions available as they are not cosmetically appealing. Modification to the lobby area was not an option, and there was very little room available for an accommodation.

BEFORE: Main lobby area for a local college business school with built in oak desk with marble top.

We opted for a small sit stand unit. Working with the engineering design team at Right Height Manufacturing, we created a LifeDesk designed with special brackets that would accommodate a small (28" wide x 24" deep) top. Most electric sit stand desks have a minimum of a 42" top width.

This top had to fit within a small nook of the existing desk, and hold a monitor, keyboard and mouse combination. We were also able to match the marble top with a laminate of similar pattern.

We specified a 3-in-1 stool from ErgoCentric to allow the returning employee to lean/sit with an open angle at the hips with a tilted seat. The 3-in-1 also provides the safety of a stool base that doesn't slide out, using a combination of glides and casters on the base. By tilting the stool with the glides off the floor and only resting on the two casters (wheels), the stool can be easily rolled as well. As long as the glides are in contact with the floor, it provides a stable support for the leaning individual.

AFTER: Physician-prescribed sit stand solution in standing position, tucked within the allotted nook

AFTER: Now that the patient has fully healed from her surgery, she is able to use her LifeDesk® while seated as well.

Case Study 8

A hospital's pediatric audiologist was facing retirement due to disability as a result of a degenerative hip condition caused by years of competitive ice skating. Surgical complications made the pain so intense she could not work for more than an hour at a time — if she could even get to work, as the car rides caused excruciating pain.

She ordinarily would be seeing patients in clinic for 4 – 6 hours per day, frequently lifting and holding her young (< 2 year old) patients, then writing chart notes the remainder of the workday. Her desk was 66" x 30" and of standard height. She had a bank of drawers on the left that was about 18" wide and a pedestal on the right of similar width, leaving her a center space approximately 30" wide for her legs and chair.

Her desire was to see if alternating sitting and standing throughout the day could help her tolerate the pain. A recommendation was made by another vendor to use a Desk-on-Desk (DoD) standing solution to give her the flexibility to stand and sit.

That DoD unit was assembled and placed on the doctor's desk. I was called in to assess the situation when it was determined by the doctor that this proposed solution was not going to work effectively for her. We found:

1.) In the down (seated) position, the keyboard tray stuck out so far from the base of the unit that the doctor had a) trouble seeing her monitor, and b) could not reach the front edge of her desk from her chair while seated, thereby making simple tasks like answering the phone and writing difficult.

2.) The DoD unit was placed on the center of the existing desk because of the limitation created by the file storage under the desk. The width of the unit, with all the accessories attached, along with

the lack of foot room due to the configuration of the pedestal unit prevented the doctor from having a place to write; an essential function of her job.

3.) When the DoD unit was in the standing position, the doctor's standard desk was too low to allow her to write notes or take notes while using the phone. Bending at the waist increased her pain. Sitting at the desk was now a challenging situation with the DoD unit and the file drawers in the way.

4.) When seated, the doctor relied on her upper body strength pushing against the desktop to assist her from getting out of the chair. When her chair was in the position pictured below, she first needed to push her chair away from the keyboard tray to clear it. Without the ability to push against the desk, she had to use her legs to push herself causing a significant increase in pain.

BEFORE: The desk on desk solution originally presented created many issues for the doctor including an inability to reach her desk and the items on her desk.

After I reviewed the workspace, I felt the best solution for the doctor to truly be able to sit and stand comfortably at work was an adjustable height desk with a retractable under mount keyboard tray and a monitor arm manufactured by Right Height.

The Right Height monitor arm allowed the doctor to bring her monitor closer to her eyes when she was seated and typing on the keyboard. The Right Height arm is equipped with a pneumatic cylinder to counterweight the monitor so it is very light and requires minimal force to move. The monitor position was dictated by whichever vision correction method she chose on any given day, (low with bifocals, normal with contacts). When she needs to write, she can simply push the monitor aside or fold the monitor arm, making the entire desktop free for use.

The purpose of the keyboard tray was twofold: 1) its negatively angled position keeps the wrists in the neutral position while typing, regardless of the posture, and 2) it allowed the doctor to occasionally sit in a somewhat recumbent position that will support her upper back, while leaving her extremely sensitive low back untouched; a position she indicated felt most comfortable to her.

The Right Height keyboard tray has a lubricated slide bearing track for ease of mobility. It is simply pushed underneath the desk to allow the doctor to get as close as she needed to the front edge of the desk for writing or talking on the telephone. There is no risk of the doctor banging her knees on the unit as it neatly tucks out of the way.

AFTER: The frequent postural change made possible with this full desk sit stand provided the symptom relief needed for the doctor to work productively, thereby avoiding disability. The monitor arm gave her flexibility in positioning depending on vision correction mode chosen, glasses or contacts.

The tears of joy and the hugs (literally!) the doctor gave me when she realized this solution was the miracle she was hoping for makes this case one of my all-time favorites.

With an investment of approximately $3500, our client, a major disability insurer, was able to avoid a huge payout (reported later to be over two million dollars) since the doctor had close to 20 years left of income earning potential. The doctor simply wanted to return to her patients and work with minimal pain. She returned to work at 20 hours per week and after three months was granted a full return to work of 40 hours per week with minor work restrictions in her schedule.

Case Study 9

This case involves a young 5'4" female computer specialist with idiopathic scoliosis, whose condition worsened after a serious car accident. She recently (1 year ago) had a surgical procedure that left her with both thoracic and lumbar fusions in an attempt to stave off the gradual progression of her abnormal lateral spinal curvature. Her employer fortunately had a stay-at-work insurance product which granted her access to an ergonomic assessment and accommodation.

By the time I was called in to see her by the VRC (vocational rehabilitation counselor) employed by the insurer, she had been back at work for about 3 months. Making matters worse she had slipped on some ice and had sprained her pelvis and was in discomfort when sitting. In spite of all this, she had done remarkably well with her rehabilitation, displaying only moderate spinal motion restriction.

As a contractor, her onsite assignments typically lasted from a month to a year. She is at the mercy of her client in terms of the furniture she is provided to work at. Her job requires use of many computers and operating systems, and she inevitably sits the majority of the time as she tests software function and usability.

I was provided pictures showing some of her recent furniture configurations since her return to work.

As a result of these set ups she complained of significant tension in her shoulders and the base of her neck as well as bilateral wrist pain.

Due to her fusions, she reported that upright sitting as well as standing are the most pain free positions for her. Her interview with the VRC also indicated that she frequently used multiple programs simultaneously and conventional mousing was one of the causes of her wrist pain. She also experienced hip pain due to the slip and fall. Upon further questioning I found that she was not a touch typist.

I therefore recommended and got approval for:

- an electric sit stand desk to provide a means of lowering the keying surface to the correct height for her and can easily be raised to a suitable standing height.
- a dual monitor arm with laptop holder on one side and provision for a widescreen monitor on the other,
- a Rollermouse to reduce the shoulder activity and reaching

associated with her other mouse that could facilitate easy transition between her laptop and secondary monitor

- a 6" step to provide a means of postural alteration for her hips as needed
- a SOMA chair with the characteristic reverse-tapered back, but in this case a convex seat pan to help open up the hips and relax the musculature.
- I had requested her IT department to provide the accessory monitor as well as an external keyboard to plug into her laptop.

There was also the requirement for the setup to be able to travel with the end user to her assignments. Based on her car's cargo space (with the seats down) I gave her a 30" x 60" top, and we added locking casters to the LifeDesk base for portability. She will have access to staffing to pack and remove her setup at her client's offices. Her contracts often last 6 months or more, so frequent packing is not a concern.

When I arrived to deploy her new ergonomic setup, I found her sitting in an overly large chair with no ergonomic adjustability and her laptop on a desk as pictured below:

BEFORE: No ergonomic adjustability in her current set up.

AFTER: End user at her new sit stand desk. Unfortunately IT had not brought her new monitor or keyboard at the time of the photo.

Her current setup now provides her the freedom and flexibility to change her posture frequently prior to feelings of discomfort setting in. She was trained in proper heights for her sit stand and how to adjust her chair for support in different sitting postures.

The casters on her LifeDesk give her the portability needed to transport the desk down to the loading dock where co-workers can load it into her car for re-deployment at her next long term assignment.

The end-user reports a newfound comfort level at work and is very happy with her setup. As a result, the VRC and insurance company are very pleased with the end result as well.

AFTER: End user standing at her new sit stand desk, utilizing a step stool to help unweight her sprained hip.

Chapter Seven – Case Studies IV: "Want to Stand? Choose Wisely My Friends"

The increase in popularity of employees wanting to stand within the workplace over the past three years has been dramatic from what we have observed. While we have been aware of the health benefits of standing in the workplace for close to 20 years now, the recent media coverage of the dangers of sitting for extended periods, coupled with the significant price reductions has now brought standing desks to the forefront.

As a result a number of makeshift devices have emerged in response to this — specifically Desk-on-Desk (DoD) devices such as the VariDesk® , Ergotron® and Kangaroo® to name a few. While they do encourage the user to stand, it is questionable at best whether the public is truly being served with these types of solutions. From an ergonomic perspective, these devices unequivocally do more harm than good and feedback from my customer base confirms this premise.

We know that the real key to healthy work postures is frequent change and movement. DoD devices do not encourage any type of sitting since they are placed on top of a desk that is already too high. Ironically, many of the users of standing

solutions are folks with back pain, and there is a high probability that these devices will exacerbate the pain when they transition from sitting to standing and vice versa. We also know from years of assembly line work that too much standing is not healthy either.

Below you will find some case studies related to this and you can also find a more detailed analysis of this challenge in this book's appendix.

Case Study 10

A female attorney in her mid-thirties, 6'1" tall, shared her desire to stand with her firm's HR department. She was granted permission to purchase a Varidesk unit, model Pro36, which she placed on a side table standing 29" high. Her two monitors were way too low for proper viewing despite the Varidesk being in its highest position.

Attorney purchased a Varidesk® after seeing it advertised on TV. Shortly thereafter it was determined that the monitor height was insufficient so we were called to install monitor arms upon it.

As a consequence, the attorney developed neck pain and we were called in to see about adding a dual monitor arm onto her Varidesk. We were able clamp the arm on the back edge of the device to raise the monitors high enough for the attorney

to rid her of her neck pain.

After 2 months, we received another call from the HR department about the attorney. They indicated the attorney's neck pain had returned but was different than last time. She had also developed tendonitis in her wrists.

As I spoke with the attorney, she indicated that she had been doing client research preparing a patent filing and had been using many reference books and articles. Her Varidesk worktop didn't give her the space she needed to spread out.

Initially, she attempted to use her desk supporting the Varidesk, but this forced her to look down and flex her neck, and, when that wasn't working, she began sitting more frequently which caused her to user her keyboard at an elevated height due to the Varidesk design.

At the attorney's request, we removed the Varidesk and made her side table into a sit stand work table by placing a LifeDesk base underneath it. We removed the Right Height dual monitor arm from the Varidesk, and installed it onto the table as well.

She now has an entire 30"x 54" worksurface that she can elevate and lower as needed, capable of spreading all of her needed documents out comfortably.

BEFORE: Varidesk® with monitor

AFTER: Worktop with Lifedesk®

Case Study 11

A marketing director for a call center of a national company out of New York, authorized the purchase of sit-stand systems for her department. They had a nicely appointed office with thirty Herman Miller Resolve desks 48" long x 24" deep, and had already invested in some ergonomic equipment, including Humanscale keyboard trays and monitor arms. I provided a couple different sit stand options for their review with the primary recommendation being to place LifeDesk legs underneath the Resolve desks and make the height adjustable sit stand surfaces.

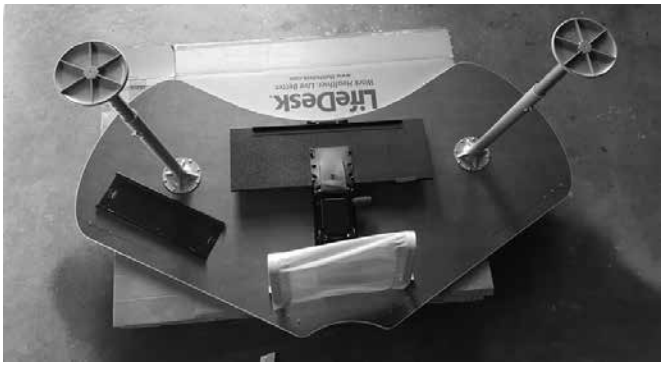
The decision was made to use Ergotron Workfit S units with a cross beam to accommodate dual monitors which

provided a savings of about $100 per station over the sit stand desk base recommendation. We supplied the Ergotron unit shown, and the customer's IT department mounted the monitors and performed all the wire management. A design advantage of the Ergotron device over other Desk-on-Desk (DoD) unit is that the keyboard has the ability to go below desk height. That being said, it still suffers many of the same limitations of the other devices including limiting the workspace available and instability of the keyboard platform.

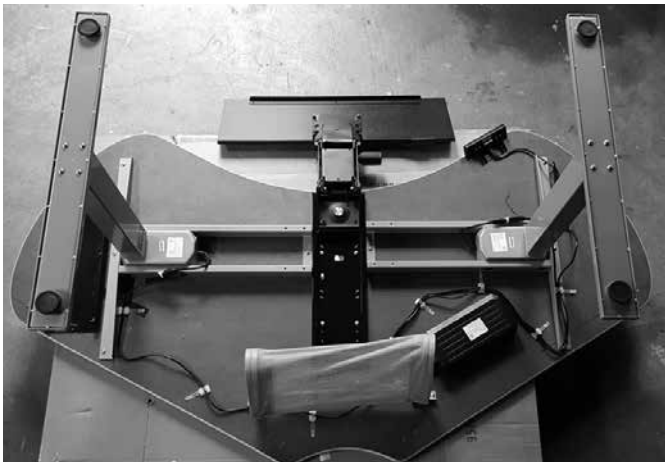
Two months after the Ergotron units were installed, I received a call from the facility manager that the team wanted them removed and replaced with the original solution I had specified. Apparently, it was determined that the aesthetics of the office were significantly compromised by the appearance of the Ergotron units towering over the 42" panel heights despite the attention paid to the wire management. Additionally, the team felt the functionality of the small work surfaces was inadequate for their needs.

We found ourselves having to disassemble and remove the Ergotrons after IT came in to undo the wiring of the hardware onto the devices and install the original LifeDesk solution under the work surfaces and then have IT come back and rewire the computer systems for a second time.

All of this had to happen after hours so as not to disturb the day to day operation of the department. The keyboard trays were fortunately still on the desks, as we had simply pushed the trays into the fully retracted position under the desk and rotated them toward the rear to accommodate the Ergotron clamp mounts.



The Herman Miller Resolve top pictured upside down with keyboard tray, wire management basket and track for CPU holder. The rear of the desk was secured via brackets on the panel system to stabilize the whole construct.



The LifeDesk® Electric Height Adjustable frame mounted to the underside of the top. The frame pieces were separated to accommodate the keyboard tray track. The CPU mount track was relocated to the left of the left leg. 27" long feet were used to maximize overall desk stability since the monitor arms were to be mounted on the rear of the desk.

Unfortunately for the customer, their decision to save $100 per workstation, wound up costing them an extra $700 each after the new product purchase, installation and IT support to reinstall the arms and monitors.

Case Study 12

An IT professional located in Tampa, FL suffering from severe back pain provided a physician's note for a standing solution. Through his HR department, he provided us a photo of his workstation and asked for a recommendation as to what we could do for him. He uses 5 monitors as part of his job, which are mounted on a set of arms. The workstation was a cube that was 8' wide x 6' deep.

BEFORE: Fixed height desk 8' long with 5 monitors.

Metal storage pedestals on the left supported a portion of the work surface. These storage units had no tops, so raising the work surface would have exposed the contents of the files. The right side of the desk was supported with additional storage units as shown.

Matching laminate was used to create two work surfaces to break the 96" space into a 32" wide top to span the storage pedestals, and a 62" surface was placed on top of a LifeDesk electric height adjustable legs to complete the workstation. A 1" gap was provided to allow generous clearance for the up/down motion of the desktop. Due to the point load associated with the weight of the clamp-mounted monitor stand, we reinforced the desktop with a metal beam to prevent potential sagging of the worktop.

The completed sit-stand project with 5-monitor mount used to alleviate the user's backpain.

Chapter Eight: Future Ergonomic Challenges

I see a number of future ergonomic challenges being created by four distinct drivers;

1) Our society's reliance on technology
2) Poor nutritional choices and options
3) Financial pressures both on corporations and individuals
4) The aging workforce.

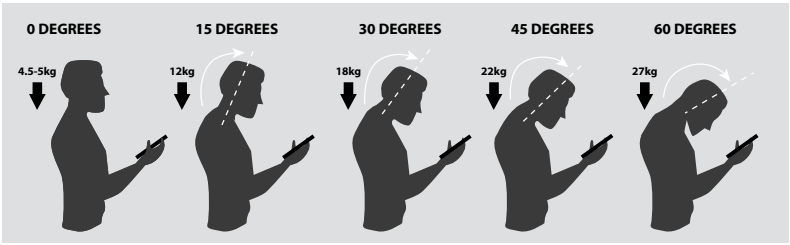
Our children, the next generation of workers, have been using gaming consoles, computers, tablets and phones from very a young age. The effect of their relative level of sedentary lifestyle coupled with the use of these devices in typically non-ergonomic positions remains to be seen.

Imbalanced muscle forces on skeletally immature spines could potentially lead to a host of degenerative changes. Clinicians are already beginning to see structural changes in the cervical and upper thoracic spine at very young ages. This could greatly impact the incidence of work-based injury in the future, and it's not necessarily unique to children. Ride on any mode of public transportation and observe the extensive usage of smart phones being used for texting, browsing the web, or

playing games; the majority of these smartphone users are in constant neck flexion.

Typical scene on public transportation anywhere these days. Dependence on our smartphones for communication and entertainment is leading to a new medical diagnosis of "Texter's Neck" aka "Anterior Head Syndrome"

Forward tilting of our head (which is roughly the weight of a bowling ball) significantly increases pressure on the lower cervical discs due to the torque this imbalance of weight causes. Long term, these additional forces can result in a flattening of the normal cervical curve leading to a myriad of degenerative changes.



Note the relative effect on cervical force as the head angle increases more forward.

Another area potentially affecting the future workforce has to do with current nutrition levels and what we eat as a society. The fact is, poor nutrition leads to premature disease states. As proof, consider teens with eating disorders. Even after they are cured they are typically osteopenic (reduced bone density) and have very brittle bone structure as young adults leading to premature degenerative skeletal issues.

Our reliance on fast food, chemical-laden processed foods and genetically modified foods will affect how our bodies age over time. The incidence of food sensitivities/allergies is currently at an all-time high, and it's been proven that exposure to certain foods can set off the body's own inflammatory process. Chronic inflammation is thought to be a mechanism behind the development of many disease states.

We already stated in chapter 1 how nutrient poor diets impact the ever expanding size of current workers – 68.8% of American adults are considered overweight or obese. More than 1 out of 3 American adults (35.7%) is now considered obese and that number is expected to approach 50% by 2030. We have already begun to see design modifications to chairs, as the standard weight rating of 250 lbs has risen to the 280 – 300 lb range as well as a proliferation of chair models rated for 350 lbs and above.

It's been proven that obese workers generally experience more injuries and have more expensive worker's compensation claims than non-obese workers. Comorbidities associated with obesity provide complicating factors, slowing the healing process and delaying return-to-work. In 2014, it was estimated that costs to businesses exceeded $13 billion a year in lost productivity from obesity.

Chairs with ratings to 1000 lbs constructed with dual cylinders, dual bases, dual back rest brackets, immovable steel arms, and special foam are now being requested with greater frequency

Another issue is the financial pressure on corporations. In an effort to relieve the burden of real estate costs, employers have been shifting the standard office paradigm thru hoteling and work at home programs. If workspaces are smaller and fewer people are in the office, less real estate is required. We have begun to see companies lease out their vacant space to generate additional revenue.

Hoteling, sometimes referred to as "hot desking" or "beach toweling," is an open environment concept where personal assignment of a desk/office/cube no longer exists. You simply find yourself an unoccupied desk, plug in your laptop and get to work. With hoteling, the assumption is that on any given day only half to two-thirds of the workforce will be in the office; some will be traveling for work, while others will be working from home.

The hoteling workspace is typically a series of sit stand desks laid out in pods or in an end-to-end benching orientation. Privacy panels are typically lowered (if they exist at all) to

facilitate collaboration with team members who are ideally positioned nearby.

One benefit of the hoteling concept is that the employee most likely has access to a sit stand desk leading to better ergonomics and healthier, more frequent posture changes.

The feedback I receive when I ask HR and facility personnel about hoteling however, paints a different picture. Some common complaints include:

- Ambient noise levels within the office affecting phone use and/or productivity
- Having to go to special areas to take/make phone calls
- Stress of having to find a desk
- No routine, every day is different
- Inability to have impromptu meetings that foster creativity. Everything needs to be planned and meeting rooms booked.
- Hesitancy to stand at one's desk for fear of "standing out" amongst sitters
- Fear of sitting while others around you are standing, imposing an intimidation factor
- Lack of privacy
- Lack of personal effects at your desk to remind one of home and loved ones, often the motivation for being at work.
- Lack of productivity due to distraction of co-workers. Many prefer work at home to actually get their work done.

Working at home creates its own issues, as few employers offer standard issue furniture or significant enough budgets for the worker to obtain satisfactory furnishings. Since workspaces are no longer overseen by EHS, Facilities or HR, the un-assessed workspace could be setting up the worker

for developing MSDs over time. If the home office worker is tasked with outfitting their own home workspace with no financial support from the employer, odds are the furnishings will be budget-based and largely unfunctional. No co-workers are present to remind one to "sit up," or "change your posture," and no one from the ergo/wellness committee is able to check in on ergo offenders.

Lastly, as stated in Chapter Two, the aging workforce is working longer past retirement age due to any number of financial pressures. By 2020, 25% of Americans will be older than age 55 and 1 in 5 workers will be over age 65. Incidence of MSDs amongst older workers is highest due to the degenerative process and the lack of elasticity in our tissues as we age. This will only continue to worsen as the number of baby boomers working longer continues to increase.

Older workers present many of the same challenges as the obese population, the net result being more claims, extended recovery times, pre-existing conditions and comorbidities affecting the recovery process. In an effort to deal with the issues head on, NIOSH recently launched its National Center for Productive Aging and Work. Ergonomic programs will need to factor the special needs of the future workforce.

Future Ergonomic Product Designs

Technology-wise, I see the ergonomic industry dealing with thinner and lighter computer hardware. I see tablets and products like the Surface becoming the norm, replacing the PC in the office. Mounts for positioning the tablets to reduce the aforementioned neck flexion issues, yet retain their touch screen functionality will likely be a trend in the near future.

Perhaps we see a movement to voice control systems for our data input to minimize the need for typing and mousing. Unfortunately for some of us, typing and mousing is the only

exercise we engage in. OK, I am being facetious here, but you get what I mean.

The wearable sensor industry has exploded with gadgets that allow us to quantify our activity levels and sleep quality. I can envision the data that's currently being collected being used to drive programs and innovation to help curtail the costs of inactivity.

Dr. Levine used instrumented undergarments to collect data on movement for his NEAT studies. Could similar tools be used with surface electromyography and biofeedback training to tell us when our muscles are approaching tension levels that exceed certain thresholds?

We've begun to see smart desks, controlled by apps and internal software. Could smart chairs be far behind? For example, a system of built in sensors telling us if we're not sitting properly or if sitting loads have exceeded certain thresholds. I know at least one manufacturer that is pursuing the idea.

We've seen the concept of self-driving cars come to reality recently. Hopefully the ergonomics of the vehicle's interior design will take into consideration our society's thirst to be connected at all times with forward-facing electronic or heads-up displays. Knowing that extended sitting from longer commute times is contributing to the health problems of society, perhaps vehicle designers will consider providing more recumbent type seating arrangements mimicked after Zero G environments.

Blue screen filters have begun appearing as options on various computer operating systems and smart phones.

Appendix I – Ergonomic Pitfalls of Desk on Desk Sit Stand Units

Due to the overwhelming data and media coverage of the dangers of sitting and inactivity, Varidesk-type standing devices, aka Desk-on-Desk (DoD) solutions, are all the rage. The ads on TV and the internet, coupled with their perceived low cost and "out of the box, no assembly required" packaging have made them quite popular. Advertised as a standing solution, research has shown that even while standing, these DoD products do not fit 90 – 95% of the population.

Medical research also supports that too much standing isn't healthy either. Consider the health issues that plague factory workers, retail sales, pharmacists and bank tellers to name a few. Swollen feet, venous insufficiency, varicose veins, leg cramps, low back pain, hip/knee/ankle pain are all documented side effects of excessive standing.

Some combination of sitting and standing is necessary to minimize the risk of developing some form of musculoskeletal disorder (MSD). Varidesk-like devices do not support proper sitting ergonomics, and for a myriad of reasons to be explained in this report, they do not provide good ergonomics while standing either.

Most desks/work surfaces are set to 28.5 – 29.5" high. Anthropometric data shows that individuals who are 6'1" will have a sitting elbow height of 29.5". Placing a Desk-on-Desk solution on top of a standard desk typically results in the keyboard being raised an inch or two higher than its normal position due to the thickness of the keyboard platform or work surface that its sitting upon, thus exacerbating already poor typing ergonomics. This keyboard height of 30 – 32" is really only suitable for individuals 6'2" – 6'3", a very small segment of the population.

In an attempt to make their setup more functional, I have had customers add keyboard trays to the underside of the desk, thereby providing 5 – 6" of additional range for accommodating proper hand position. Not only does that add upwards of $200 – $250 to the cost of the DoD solution, but I have seen firsthand many desktops begin to bow under the weight of a Varidesk-like unit — especially when a keyboard tray has been added.

The lowest position for the Varidesk unit pictured leaves the worktop sitting 4.5" above the existing desk. This makes writing and other desk-based activities quite cumbersome while in the sitting position for the average user.

DoD solutions typically have limited sized work areas. Ergotron WorkFit S is 15" x 23", and Varidesk seems to be the largest, with some models upwards of 48" wide. Below is a table summarizing work surface size of the common DoD units. Placing all essential items

on top of the workspace leaves little room for anything else and can seem quite cluttered, limiting productivity.

Desk on Desk Model	Workspace Dimensions (in)
Ergotron Workfit S	23 wide x 15 deep
Ergodesktop Kangaroo	28 wide x 24 deep
Varidesk Pro Plus 48	48 wide x 29.5 deep
Humanscale Quikstand	28 wide x 17 deep
Innovative Winston	30 wide x 22 deep
Ergotron WorkFit T	37.5 wide x 23 deep
Ergotech	41 wide x 25 deep

Remember, the bigger the work surface, the heavier the unit, meaning multiple people are needed to install them and the greater the risk of the unit permanently bowing the work surface supporting it.

The work surface size of even the largest DoD solutions is not conducive to the use of reference documents to supplement one's work tasks. Note the user's adaptive posture as he strains to see the set of architectural plans. I have clients who are

attorneys, accountants, engineers and architects who have used this type of desk and all have complained of this limitation.

Limited desktop space results in poor fitting/overlapping of newer model widescreen monitors (24"+) on the smaller Varidesk-like models. Many units now have integrated dual monitor holders (or optional in some cases) to help address this limitation. Varidesk in fact now sells a dual monitor arm, adding an additional $195 to the price of the unit.

To lift the work surface of units like the Varidesk, the user must reach the side handles, depress them, and lift up. Many of the

handles are located on the side, nearer the center or back of the platform. Due to this handle location, reaching while flexing at the waist is required to engage the life mechanism. In my experience, the end-user who wishes to stand, often has significant back pain (hence the desire to stand). The position and force required to lift these DoD units may exacerbate their LBP condition. Some units are spring loaded to help offset the weight of the items on the desktop, but depending on load capacity it may still require some vertical lifting. Some units are now motorized but figure on paying an average of $200 for this added option.

Conversely, the spring-loaded design may require downward force to lower the work surface. Again, depressing the handles to release the mechanism, then push down as pictured.

Perhaps the most troubling design flaw with the original DoD units was that placing the unit at the height that the hands at the proper ergonomic position for keyboard use, typically resulted in the monitors being in the wrong position. Long term use of this posture may result in headaches, neck pain, shoulder tension etc due to cervical flexion. The design of many units has since been corrected with a lower keyboard surface, but single surface units still exist, so "buyer beware."

Use of a laptop on these units puts the user is an even worse position for developing neck, shoulder and upper thoracic spine discomfort.

In the upmost position, the work surface of the Varidesk pictured extends beyond the front of the desk, forcing the end-user to stand further away from their desk.

With limited space on the Varidesk work surface, frequently used items such as the telephone fall outside the primary reach zone, thereby creating potential hazards.

Ergotron Workfit S

Innovative Winston

Ergodesktop Kangaroo

Humanscale Quickstand

DoD units as pictured above either require being clamped to the desktop or provide a very heavy stabilizing foot. These units tend to be very bouncy for typing due to their cantilevered work surfaces. Customers of mine who have purchased these have complained about the tall profile, and how they stick out above the panel systems, destroying the esthetic of the office furniture/cube design.

Varidesk has 11 distinct points at which the work surface can be set, anywhere from 5" above the desk to 16" above the desk. The user must insure that the pin fully inserts into the desired hole or risk the unit slipping down into the next setting.

While there are many safeguards to prevent serious injury while using Varidesk-type lift mechanisms, one can only speculate what would happen if the lift mechanism were to fail or the pin did not fully insert at the desired setting.

A multitude of Desk-on-Desk (DoD) units have entered the marketplace despite poor sitting and standing ergonomic design for 90 – 95% of the population. Units are advertised as a "cost-effective" means of providing a standing solution. Standing all day is not deemed a healthy alternative either. Frequent postural change is recommended.

Depending on the unit purchased, the reality is that you may also need to factor in additional costs such as a monitor arm and a keyboard tray to make it truly ergonomic. A $395 advertised price may quickly approach $800 as a result.

Additional costs such as desk reinforcement to prevent bowing, 2 laborers to lift unit into place/install/and perform IT function wire management may also be necessary and factored into the total implementation costs.

Beside poor positional ergonomics, limitations of "Desk on Desk" Solutions may also include:

- Taking up entire desk footprint and usable space.
- Forcing user further away from the desk space.
- Inability to place reference documents on provided desktop
- Compromising office esthetics
- Injury risk due to lifting and lowering weighted desktops.

For a more scientific treatment of the ergonomic issues, consider additional reading: https://rmi.prep.colostate.edu/wp-content/uploads/sites/4/2016/05/Height-Adjustable-Platforms.pdf

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