The Role of Physical Therapy in Ergonomic and MSD Risk Assessment
Basic Elements of an Office Ergonomic Evaluation

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Introduction:

Ergonomics is a young science; e.g. the Human Factors and Ergonomics Society (http://www.hfes.org) was founded in 1957. However, basic elements of ergonomics have always played a critical component in the evolution of human interaction with tools, equipment and industry. The invention of the wheel, the strategic use of levers and the design of the cockpit of a modern fighter jet come to mind as examples. This modern science assesses the interface and interactions of the work design and environment with the workers relevant to work efficiencies and the prevention of injury. MSD are the most common injuries and the area of ergonomics where Physical Therapy plays a pivotal role.

Ergonomics is defined as; "an applied science concerned with designing and arranging things people use so that the people and things interact most efficiently and safely-called also biotechnology, human engineering, human factors." The Word ergonomics is taken from the Greek words, "ergon" and "nomos". Ergos means work and nomos means laws, when combined forms as laws of work". The word was coined by a Polish biologist (Wojciech Jastrzebowski) in 1857 as a general description of the application of science to the study of work.

Ergonomics has a dual purpose; to maximize work efficiency and productivity while reducing worker fatigue, improving comfort and minimizing risk for injury. This dual challenge is met successfully when all relevant factors are identified and prioritized with corrective engineering, administrative and/or worker intrinsic actions. Inherently an ergonomics program requires a multidisciplinary perspective, knowledge and approach to be effective.

Physical Therapy assumes a natural role in ergonomics because of our unique knowledge and skill basis in the movement sciences, our understanding of human function and physical performance, and our clinical background relevant to musculoskeletal disorders (MSD). It is difficult to effectively prevent MSDs if you are not thoroughly familiar with the characteristics of the problem when it manifests, and skilled in its resolution.

The Duffy-Rath System© (DRS) emerged in 1984 when recruited by Johnson & Johnson, Inc. to help resolve a growing problem of upper limb repeated strain injuries (RSI). The experience gained resolving these cases formed the basis to develop our approach to prevention of musculoskeletal disorders and disability, and subsequently our entrance into ergonomics. The

DRS program has been evolving and expanding ever since; currently 80% of our practice involves MSD and disability prevention.

There are two goals for today's lecture; first to give you a broad look at the role of physical therapy in ergonomics and hopefully stimulate your interest, and second prepare you to perform a basic office ergonomic assessment.

Part I: The Role of Physical Therapy in Ergonomic and MSD Risk Assessment

To start let's define some basic terms and review a few key concepts relevant to the ergonomic and MSD risk assessment process:

1. **Ergonomic evaluation** – this is the structured, objective measurement of the process and physical demands of jobs and work tasks with the intent of maximizing productivity while simultaneously reducing the risk for injury. There are many validated tools, instruments and processes available; for success the correct assessment tool(s) must be selected and properly applied for the targeted job or task(s) to be evaluated.

2. **Physical (functional) demand** – this is the expression of the range of motion (ROM), strength, fitness (endurance), psycho-motor, load tolerance and tool/equipment use requirements to perform a specific job or work task.

3. **Functional demand evaluation (FDE)** – this is an objective process to identify the essential functional tasks (EFT) for a job title and then measure the maximal occasional, frequent and constant physical demands for each EFT. This is also called a "functional job description". This can include a MSD risk assessment component (defined below); it is a critical requirement for the development of a JME (defined below) and is very useful for planning return to work (RTW) or return to full duty (RTFD) when an employee has been injured and disabled.

4. **Physical (functional) demand ability** – this is the measured or estimated ability of the individual or worker population to perform physical tasks and meet the physical demands of work safely and acceptably.

5. **Functional capacity evaluation (FCE)** – this is a standardized, structured battery of tests to determine the individual's maximal acceptable physical demand ability; or the ability to meet specific physical demand targets safely and acceptably (e.g. to FDE targets). This is used to help determine when/if a worker is ready to return to work or full duty after a period of disability; it is also used to help determine percentage of permanent disability. An FCE is <u>not</u> an ergonomic tool per se; rather a tool for rehabilitation, tertiary prevention and/or disability determination. The following 5 criteria must be addressed in the design of an FCE or any functional test: 1) safety, 2) reliability, 3) validity, practicality, and 5) utility.

6. **Job matching evaluation (JME)** - this is validated battery of tests to measure the physical ability of a worker to meet the physical demands of a job title as identified in a validated FDE safely and acceptably. This is also called a "post-offer physical abilities test" for the JME is a prevention effort, not a rehab tool. The intent of the JME is to help reduce risk exposure for injury that exists when the physical demands of a job are greater than the worker's physical demand ability.

7. **MSD risk assessment** – this is the objective evaluation of work tasks with the intent of rating the inherent potential to acquire specific MSDs; this identifies a priority list for engineering and/or administrative controls to mitigate higher risks for MSD. This can be a component of a comprehensive ergonomic assessment or a targeted, task-specific evaluation.

In an ideal world every job and work task would be measured and designed to minimize the risk of injury, and the physical ability of all workers would be routinely measured to insure that they are able to meet the physical demands of their work with a margin of safety. This is not the case in the real world, so guidelines and normative data are used to identify what percentage of the population of workers should be able to meet the demands safely and acceptably; e.g. revised NIOSH Lift Equation, Liberty Mutual Manual Material Handing Tables etc. Optimal ergonomic design should control the physical demands to be safe and acceptable for more than 75% of the female population of working age adults.

Physical Demand Characteristics (PDC) Groups: the US Dept. of Labor adopted the system for categorizing (ranking) the physical demands of occupations and job tasks developed by Leonard Matheson, PhD. This system ranks jobs into one of 5 categories, ranging from sedentary to those that have very heavy physical demands. The criteria for this 5-category system are based upon the magnitude and frequency of the physical demands required to perform the work tasks. These are called the physical demand characteristic (PDC) groups and all jobs in the United States have an assigned PDC rating found in the dictionary of occupational titles (DOT): www.occupationalinfo.org The PDC groups are defined as follows:

PDC Group	Occasional 0 - 33 % of work day	Frequent 34 – 66 % of work day	Constant 67 – 100 % of work day	Typical Energy Required
SEDENTARY	10 lb.	Negligible	Negligible	1.5 - 2.1 METS
LIGHT	20 lb.	10 lb. and/or walk/stand/push/ pull of arm/leg controls	Negligible and/or push/pull of arm/leg controls while seated	2.2 - 3.5 METS
MEDIUM	20 – 50 lb.	10 - 25 lb.	10 lb.	3.6 - 6.3 METS
HEAVY	50 – 100 lb.	25 - 50 lb.	10 - 20 lb.	6.4 - 7.5 METS
VERY HEAVY	Over 100 lb.	Over 50 lb.	Over 20 lb.	Over 7.5 METS

(For Further Data Related to Energy Expenditure: Ainsworth B.E., The Compendium of Physical Activities Tracking Guide (South Carolina: Prevention Research Center, Norman J. Arnold School of Public Health, University of South Carolina, 2002). prevention.sph.sc.edu/tools/docs/documents_compendium.pdf.)

It is important to note that physical demands performed frequently or constantly do not have to be as heavy as those performed occasionally for a job or work task to be categorized in a higher PDC group.

Work-related Musculoskeletal Disorders (WRMSD) - the most common MSD in industry involve the lower back, neck/shoulder and the wrist/hand. Approximately 80 - 90% of these are not the result of a single, traumatic incident or event (Dixon 1976; Kelsey 1982; Andersson 1991; Radhakrishnan 1994; Frank 1996). Duffy-Rath has collected onset information utilizing a structured interview process since 1996. Our findings have been consistent; the majority of MSD (80 – 90%) are not the result of one single traumatic event. Table 1 provides the results of a surveillance study performed at one of our clinics located onsite in a major manufacturing facility over a three-year time period.

Table 1: Mechanism of Onset for Musculoskeletal Disorders: a surveillance study of the mechanism of onset for consecutive patients referred for physical therapy evaluation and treatment to a private outpatient physical therapy clinic onsite at a major manufacturing company (Rath WW, Rath JD: unpublished data).

Body Region	NIE (No incident or event)	Incident A (Normal activity/ movement)	Incident B (Sudden, unguarded movement – no contact or apparent trauma)	Trauma (Accident, contact, struck by etc. high velocity and magnitude loading)	Total
Overall	***690***	***345***	***128***	***158***	***1321***
%	*52%*	*26%*	*10%*	*12%*	*100%*
Work-related	***462***	***295***	***109***	***103***	***967***
%	*48%*	*30%*	*11%*	*11%*	*100%*
Not W-related	***228***	***50***	***19***	***55***	***349***
%	*65%*	*14%*	*5%*	*16%*	*100%*

These non-traumatic disorders are often referred to as repetitive strain injuries/cumulative trauma disorders (RSI/CTD); commonly described as degenerative disorders when a diagnostic label is given to an aging worker. These are fatigue, use (disuse) related disorders affecting the musculoskeletal system and consequently an individual’s ability to be active and physically function to their normal capability. To get at root issues a prevention or therapeutic approach must address the individual’s entire lifestyle (work, home and play); a biopsychosocial model is most appropriate.

Since ergonomics typically applies to the workplace, the prevention of work-related musculoskeletal disorders (WRMSD) is the target for most ergonomic programs. However, when there is no single traumatic mechanism of onset the question of ‘work-relatedness’ becomes clouded by the possibility of a multitude of factors that could be relevant to the individual’s risk for onset of an MSD, the likelihood of reporting the onset as an “injury” and their risk for the problem to result in chronic pain and disability.

The work-relatedness of a MSD is clear and unambiguous when the onset is a slip and fall, a motor vehicle accident, a crush injury, struck by a falling object etc. Prevention of these disorders is a safety concern. However with RSI, CTD and/or degenerative MSD the role of workplace factors is frequently not so clear. Physical demands and work environment factors need to be assessed, but so does the worker's physical abilities and habits at work, home and play. Additionally, psychosocial factors (e.g. job satisfaction, relation with co-workers, health attitudes and beliefs, coping skills, 'downsizing' etc.) require consideration as they can be the most significant barrier to prevention or treatment efforts. This is where the biopsychosocial model trumps the biomedical model as most appropriate and effective, and issues of self-efficacy are paramount (Bandera 1997).

In most cases there are a combination of factors contributing to an individual's risk for onset of an MSD; the most effective prevention programs address all the domains of life's physical functions. The need for this is exemplified by considering the amount of time during a week a worker spends at home verses work; when a person works 8-hours per day for 5 days each week they spend 33% of their time at work each day and 24% each week. Two-thirds of the work week, and three-quarters of the calendar week is spent outside of work. The activities (and inactivity) outside of work have to play a role, if not the major role in contributing to the MSD; e.g. the lower back is stressed and strained at home, during the commute, and at play too.

Musculoskeletal Epidemiology - it is imperative that the injury prevention specialist has a solid understanding of the epidemiology relevant for each MSD target. This includes a working knowledge of the natural history for each disorder, the risk factors for onset and/or recurrence, the risk factors for reporting to a medical or healthcare practitioner, and the risk factors associated with development of chronic pain and disability.

A look at the prevalence of regional musculoskeletal pain in the general population (i.e. regardless of type of occupation, or whether or not employed) further illustrates the difficulty determining whether or not a MSD is work-related. Table 2 provides the percentage of adults (≥ 18 years) that reported regional musculoskeletal pain within the past 30 – 90 days in the United States; ranging from 7-8% reporting finger and hip pain to 15-30% reporting neck, headache, knee or low back pain (National Center for Health Statistics 2011). The better question is; "what are the relative contributions of biopsychosocial factors at work, home and play to the presence of musculoskeletal pain, impairment, chronic pain and/or disability?"

Table 2 There is a high prevalence of MSD in the general US population according to a 2010 survey; in addition approximately 1/3 of those surveyed (≥ 18 years of age) reported having joint pain and significant activity restriction in the past month (National Center for Health Statistics. Health, United States, 2010: tables 52, 53).

Severe Headache	LBP	Neck Pain	Shoulder Pain	Finger Pain	Hip Pain	Knee Pain
16.1% 3-month	29.1% 3-month	15.1% 3-month	9.0% 1-month	7.6% 1-month	7.1% 1-month	19.5 1-month

As a general rule, the risk for the onset of musculoskeletal pain can be attributed to physical demand factors; i.e. highly repetitive and/or forceful tasks, continuous reaching and manual manipulation, prolonged static loading and awkward or extreme postures etc. (NIOSH 1997;

Humphreys 1998; Vingard 2000). However the factors associated with the likelihood of a worker reporting a MSD are having previously reported one, work dissatisfaction and poor relationship with supervisor or co-workers (Bigos 1995). Risk factors associated with an MSD leading to chronic pain and disability include passive coping, catastrophizing, fear-avoidance behaviors, depression, anxiety, lack of control over work environment and a moderate association to a blue collar occupation (Linton 2000; Ijzelenberg 2005; Bergström 2007; Carroll 2008). The "New Zealand acute low back pain guide" (ACC 1997) is a good resource to review "yellow flags"; i.e. psychosocial and other factors that can interfere with a patient's recovery from LBP and contribute to chronic pain disability. These same factors apply to WRMSD in general.

Problems Associated with Accuracy of Musculoskeletal Diagnoses: a major problem with the prevention and management of MSD is the inaccuracy of the diagnoses commonly given to patients; this is a growing problem with RSI/CTD/degenerative problems in particular. X-rays, MRI and electro-diagnostic tests are frequently positive in asymptomatic subjects, rendering them unreliable as a gold-standard for diagnosis. The findings of these tests must always be weighed and correlated to the patient's history, physical examination, their reaction(s) to their problem and the functional/activity-related consequences.

In most cases modern musculoskeletal diagnostic tests have good sensitivity but weak specificity (see Table 3); consequently they are better for ruling-out a disease or disorder when negative, than to rule-in when positive. Treatment strategies and protocols that are over-reliant on these tests for diagnosis are highly likely to result in unnecessary and ineffective treatment (Hadler 2004). A recent publication on primary care research on LBP warns of the growing problem of chronic disability associated with iatrogenesis and influenced by the "LBP medical industrial complex" (Pransky 2011).

Table 3: there is a significant potential for a false positive (i.e. abnormality findings in asymptomatic people) MRI of the cervical, thoracic or lumbar spine. This renders these tests less specific, consequently not good to 'rule-in'. This a major concern for treatment protocols and strategies that are over reliant on the findings of these tests.

Lumbar MRI (upward limits)		**Cervical/thoracic MRI** (upward limits)	
Study	*% Positive*	*Study*	*% Positive*
Jensen et. al. NEJM 1994	52%	Boden et. al. JBJS 1990	28%
Boden et. al. JBJS 1990	57%	Lehto et. al. Neuroradiology 1994	62%
Weishaupt et. al. Radiology 1998	67%	Matsumoto et. al. Spine 1998 < 30 yrs	12-17%
Powell et. al. Lancet 1986	33%	Matsumoto et. al. Spine 1998 > 60 yrs	86-89%
Boos et. al. Spine 2000	76%	Matsumoto et. al. Spine 2010 (TS & CS)	46-90%
Alyas et. al. Br J Sp Med 2007	85%	Wood et. al. JBJS 1995 (TS)	73%

Three Stages of Prevention - the World Health Organization identifies 3 general types of prevention interventions: 1) *primary* – before a disease or disorder manifests; 2) *secondary* – quickly after the onset to arrest the early symptoms, signs and consequences, and 3) *tertiary* – after a disease or disorder has become established to minimize the impact and consequence.

Ergonomic assessment and design/redesign is ideally used to facilitate primary prevention. However, companies frequently initiate ergonomic actions only after the incidence or impact of MSDs reach a critical point of financial or regulatory (e.g. OSHA, workers compensation claims or rates etc.) impact. When this occurs the actions are secondary or tertiary for those already affected; primary for those not yet affected.

MSD prevention is more than ergonomics: the measurement, engineering and design of work equipment, tools, tasks and processes are very important. However, the interaction and interface of the individual human being with their work environment and the physical demands is ultimately more important. Postural and biomechanical habits, exercise and health habits related to preserving physical ability and health, and personal beliefs/attitude in managing biomechanical function and coping with musculoskeletal/health problems are ultimately most important for the prevention of musculoskeletal injury and disability. We have coined the term "musculoskeletal self-efficacy" to describe an individual's ability to manage their musculoskeletal health, wellness and physical performance capabilities; we are in process of developing an objective rating of risk exposure to develop a work-related musculoskeletal disorder and disability due to the worker's physical habits, management of work demands and coping skills; i.e. Worker Intrinsic Risk Factors© (WIRF©).

Ultimately the marriage of an excellently designed work environment with a worker that has excellent biomechanical and health habits and is self-efficacious is optimal. Table 3 identifies major components of the work environment and design and the worker that require assessment and/or measurement in order to reduce risk for WRMSD.

Table 3: The MSD prevention specialist needs to assess and/or measure the influence of factors relevant to both the work and the worker to understand the risk exposure for musculoskeletal injury.

Work Environment & Design	Intrinsic to Worker
Physical environment & conditions	Demographics
Geometry of the work tasks	Anthropometrics & ROM
Force demands of the work tasks	Strength & Endurance
Interface with worker, tools & equipment	Biomechanical & Work Habits
Frequency & duration of the demands	Lifestyle & Exercise Habits
Psychosocial Environment	Personality, Attitudes, Beliefs, Motivations & Coping Skills

Summary of the Role of Physical Therapy in Ergonomics:

Physical therapy plays an important role in the area of ergonomics that pertains to prevention and management of MSD. Our unique knowledge and skill basis can facilitate a more optimal interaction between the worker and their work environment, and address the multitude of factors outside of work that contribute to risk for onset of MSD. We play a critically important role in implementing controls of risk that are intrinsic to the worker.

The remainder of today's lecture focuses on basic elements of an ergonomic assessment followed by guidelines and instructions for office /computer-based work. It was important to first provide definitions for basic terms and concepts, and briefly discuss the impact of epidemiology and problems with musculoskeletal diagnoses. It was also important to identify the various stages of severity and impact of WRMSD and the differing risk factors; time lost (i.e. days off work along with all the associated indemnity) is the most expensive component; and it is recognized that 80 – 90% of the cost associated with WMSD is generated by < 10% of the workers who report an injury. The DRS "MSD Injury Report to Disability Progression" table below was developed to communicate this concept and emphasize the importance of primary and effective secondary prevention actions.

Duffy-Rath System© MSD Injury Report to Disability Progression						
Status Prior to Reporting (Vulnerability for MSD is dependent on history, biomechanical, exercise habits and multiple other factors)	**Report to Medical**	**OSHA Recordable Action**	**Work Restrictions**	**Days Off Work**	**Permanent Partial Disability**	**Permanent Total Disability**
Address 5 DRS elements for MS health & function, achieve positive culture change at workplace, provide a range of proactive prevention and ergonomic services to address the most relevant workplace and worker intrinsic factors	First aide actions should include biomechanical training and education. Identify need for ergonomic assessment; perform ASAP when needed.	Treatment must be active, directly address and immediately control most relevant signs and symptoms with self-treatment actions. Implement ergonomic controls when applicable.	Indentify and develop plan to control most relevant factors leading to restrictions and/or loss; objectify factors and restoration of ability; develop plan to prevent recurrence and/or progression. Get back to full activity ASAP.		Minimize impact of the many negative factors associated with MS disability (including reduced life expectancy); get back to full, potential activity ASAP; address the most relevant lifestyle factors to the individual.	
Primary Prevention		**Secondary Prevention**			**Tertiary Prevention**	

There are a wide range of services that a physical therapist can provide onsite in industry in addition to ergonomic and MSD risk assessment; e.g. job-coaching, task and/or target specific workshops, stretching and group exercise programs, functional demand evaluation (FDE), job-matching evaluation (JME), functional capacity evaluation (FCE), MSD trend analysis; a variety of consultative functions, and of course treatment.

Part II. Basic Elements of an Ergonomic Evaluation for Office Work

There are common elements to any ergonomic or MSD risk assessment regardless of the work environment; e.g. office work, light to heavy manufacturing, construction industries etc. These elements are measured, observed, rated, ranked and/or assigned relative weight in contributing to risk for injury. There are many assessment tools available with varying degrees of psychometric evaluation and evidence of reliability and validity. Your choice of a particular tool should be influenced by knowledge of reliability, validity, applicability and utility. However, regardless of the tool chosen or created the most common elements of an ergonomic assessment are:

1. **Postures** – assessment starts by noting the general body postures required to perform the tasks; i.e. sitting, standing, lying, kneeling, crawling, climbing etc. Then proceeds to assess the posture of the various body regions, starting with spine and then the joints of the upper limb and lower limb. During the assessment it is important to distinguish the worker's habit from a posture that is dictated by the job or task design.

2. **Work heights** – measure the work heights of the tables, desks, shelves etc. involved in the work and assess the fit for the individual worker(s). This is an essential component of risk assessment and frequently the target for task reorganization and/or redesign. This is a fundamental component of the work-zones concept and has strong implications for posture assessment and prevention training. Work-zones are the three dimensional analysis of the reaching demands of work tasks. An optimal work-zone encourages good spine posture and keeps the hands close (i.e. elbows at or close to body) and at the best height for the specific task. The revised NIOSH Lift Equation (Waters 1994) is a good starting resource to objectify the effect that work height, distance of reach and degree of asymmetry (see below) has for the safety of lifting and lowering task demands.

3. **Reaching demands** – identify and then measure how high, low and far the hands have to move away from the body in order to perform the work tasks. In addition, asymmetrical reaching demands need to be identified and measured, including the need to cross mid-line. Distinguish one-handed and two-handed demands, note whether or not a task can be performed alternately with either hand (e.g. mousing). Note whether or not a task requires the hands to be held in a reached position for any sustained period of time. This is a progression of the posture and work height assessment, however with further objectification. As mentioned in element # 2, this is a critical component in assessing for risk exposure and frequently the target for ergonomic redesign and worker education and training to improve work habits.

4. **Force demands** – identify the force exertion requirements for lifting/lowering, carrying, pushing/pulling, gripping/grasping, pinching etc. Once this is identified, the most important measurements involve determining the maximal occasional, frequent and constant demands to determine the PDC group and then correlating to work-zones and posture to determine MSD risk exposure. Keep in mind the importance that technique can have on force demands (e.g. a jerking initiation of a push is more stressful than a slow and steady starting force, or a worker may be grasping a tool harder than required etc.). As mentioned in the posture assessment, distinguish the demands that are dictated by the job verses generated by the worker's habits.

5. **Frequency and duration** – the frequency and duration of the work tasks, especially those that involve the greatest physical demands are critical elements for ergonomic and risk assessment. This can involve calculating the amount of time during a workday spent performing a task or task component, actually measuring or calculating the number of repetitions and/or a combination of both. This is essential to identifying the correct PDC category and to develop task-specific prevention programs.

6. **Tools and equipment** – identify and evaluate the tools and equipment used to perform the work tasks and the ergonomic impact and appropriateness of selection; observe the workers use of the tool(s). Measure weights, forces and exposure to vibration when applicable. In addition you may need to identify maintenance routines and training requirements or updates.

7. **Contact pressures** – look for evidence of contact pressure related to the work tasks as this is a significant risk factor for MSD; e.g. the wrist hitting the edge of desk, pliers handles that are too short contacting the palm etc.

8. **Workspace and environment** – assess the set-up of the workstation, the space, organization and environmental factors that can influence safe and acceptable task performance; e.g. space clearance under a desk or workstation, heat and humidity, obstructed pathways, inadequate lighting, dust etc.

An Office Ergonomic Assessment

Start your office ergonomic assessment by knowing the most common MSD associated with office work; these are disorders affecting the lower back, neck/shoulder and wrist/hand. A prevention specialist needs to be thoroughly familiar and experienced at identifying the stages of clinical presentation of these MSD from warning signals to unequivocal structural pathology; additionally they need to acquire skill and experience in educating and training patients with these MSD to take an active role in their recovery to prevent recurrence. A clinical background with a treatment approach that promotes patients to remain active during their recovery, and is education and self-treatment oriented enables the physical therapist to make the transition to prevention more easily and effectively.

The following table identifies the most common MSD encountered in office ergonomics and the primary risk factors to be controlled:

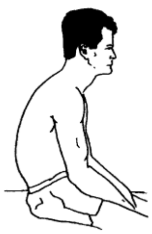
MSD	Primary Risk Factors to be Controlled
Non-specific LBP	Sitting (lumbar) posture and duration; +/- asymmetries.
Nonspecific Neck Pain	Sitting posture (forward head) and duration, reaching; +/- asymmetries.
Shoulder impingement	Sitting posture (rounded shoulders) and duration, reaching; +/- asymmetries.
Carpal Tunnel Syndrome	Wrist (and sitting) posture and duration, elbow angle(s), hand coupling, contact pressure; +/- asymmetries.
Epicondylar Syndrome, Trigger Finger, OA 1st CMC, DeQuervain's.	Elbow angles, reaching and duration/frequency hand coupling, contact pressure; +/- asymmetries.

Basic Components of an Office Ergonomic Evaluation

1. Work demands – identify work hours (i.e. hours per day, per week + OT), identify break times and whether or not micro-pauses are allowed or encouraged, identify productivity targets or expectations, identify the number of workers performing these tasks and the number of shifts (when applicable).

2. Worker Postural Habits & Awareness – to determine how to optimally adjust an individual's chair starts by showing them how to find a good alignment of their spine; or reinforcing the concept if their postural habits are good. Most people have poor postural habits sitting, are unaware of this (i.e. definition of a habit) and how to go about correcting their posture. The key points of control are the position of pelvic rotation and chest elevation.

Start by having the individual sit forward on the chair with their feet flat on the ground, knees should be at or slightly below the hips. Start in the slouched position; rotate the pelvis anterior and lift the chest to a point of strain; release the strain slightly (10 – 15%) to the point of good 'axial alignment'. This is the position they what the adjustment of their chair and the set-up of their workstation to facilitate.



Sitting slouched flexes (rounds) the back to end-range, sustaining a stretch to the posterior spinal ligaments (lower cervical to lumbo-sacral) and increasing the load/pressure on the discs. This causes a forward-head posture (lower cervical flexion, upper cervical extension).

The mechanics – the pelvis has rotated backwards and this causes the back to round, which causes the shoulders to round, which throws the head forwards.

To find a good postural alignment sitting the worker should slowly overcorrect their posture; i.e. go to the other extreme.

The mechanics – roll the pelvis forwards and lift the chest-up to the beginning point of strain, pressure or discomfort.

Good postural alignment is found by releasing the strain from the "too good" posture, achieving a more relaxed position.

The mechanics – there are only two ways to maintain good postural alignment sitting: 1) use your muscles to maintain the position, 2) lumbar support to prevent the pelvis from rotating and back support to help keep the chest up (feet should be stable on the floor or footrest).

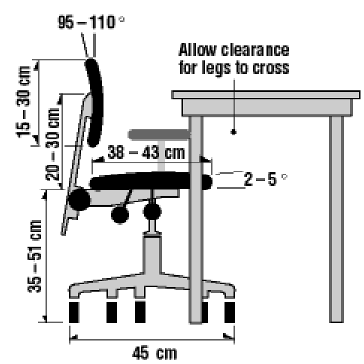
3. Chair Assessment – a good, ergonomic chair is fully and easily adjustable. The key components of the chair are the elements that need to be assessed:

- **Seat pan** – you need to assess the height, width, depth, angle and the range of adjustment. In addition you need to take note of the shape and contour of the seat, especially the front edge and the fabric. Look for contact stress on the back of the thighs and the presence of ejection factors.

Generally Accepted Measures for Most People				
Seat Depth	**Seat Width**	**Seat Height**	**Seat Angle**	**Seat Design**
Adjustable ≤ 17 inches	≥ 17.7 inches	Adjustable 15 – 22 inches	Adjustable ≥ 4 degrees	Waterfall front Appropriate material

- **Seat back** – you need to assess the height, width, angle and the range of adjustment. In addition you need to assess stiffness, note whether or not it has lumbar/back support (next element) and examine the contour to determine if it encourages or discourages a relaxed, chest-up alignment.

- **Back support** – you need to first assess whether or not there is lumbar support, and if so is it adjust in height and depth; doe sit adequately control pelvic posterior rotation to maintain good axial alignment when the individual is relaxed? Next look to see if the middle to upper back is supported well enough to keep the chest up and prevent the shoulders from rounding.



- **Arms** – if the chair has arms you need to assess their height, depth, angle and range of adjustability. Are they stable once adjusted; do they have clearance so the chair can be brought forward (i.e. under desk, table or keyboard tray) into optimal position for use of keyboard, mouse and viewing the monitor and copy stand? When the worker rests their arms on the arms of the chair look for contact stress and a neutral position of the shoulders (should be relaxed and not elevated/protracted). If the arms are too abducted this going to affect contact with the keyboard; i.e. the greater the abduction of the shoulder the greater the ulnar deviation of the wrist unless a special keyboard is used is=f this cannot be controlled (e.g. split keyboard design etc.)

- **Legs** – the most stable office chairs are designed with 5-legs; assess functionality of casters and look for obstruction to chair movement.

4. **Work Surface** – assess the desk height (standard is between 28-30 inches) and the clearance space (height, width and depth) for the thighs, positioning of the feet and movement. Note if the desk or table is adjustable; if so, identify the range of adjustment. Additionally, note if the dimensions of the top of the desk or table is adequate to accommodate the equipment, material or tools required to perform the work tasks; note any obstacles that might obstruct appropriate placement (e.g. shelving etc.).

5. **Monitor** – assess the height, depth and angle of the monitor in relation to the worker sitting in an optimal work position. The monitor should be straight ahead (square to the worker and keyboard), the top ¼ of the screen (top of the text) should be at about eye level (adjust for bifocals and trifocals) and about arms length away (range can be 18 – 34 inches). These

recommendations are affected by the size of the screen and whether or not there are multiple monitors (i.e. a growing trend in many office environments). The bottom-line is the worker in good axial alignment, can they comfortably see the screen and is there minimal to no head movement required to view the monitor. In addition assess for adjustability in angle and placement in relationship to windows and lightening to eliminate glare.

6. Keyboard and mouse – a tray is optimal if keying and mousing are the main activity all day. Assess the height, width, depth and adjustability of the tray; does the tray accommodate the mouse at the same height, distance and can it be used with either hand? The workers hands should be even or slightly lower than their elbows; there should be no contact stress to the wrist and the wrist position should be neutral or mid-range in regarding to both flexion-extension and ulnar-radial deviation.

There are many different types of keyboards and mouse on the market these days with wide ranging opinion about each of them. Assess for the worker's ability to stay in good spinal alignment, keep the elbows close, the hands even or slightly below the elbows and the wrists in a neutral position. The mouse or input device should fit the individual worker's hand, and you must always be prepared to adjust to any unique physical/anthropometric characteristics of the individual. When wrist-rests are used make sure they are not too high or narrow creating localized pressure to the wrist; nor should they interfere with the ease of keying and/or mousing.

7. Other – look for the presence and impact of these other factors:

- **Copy stands:** when used should be positioned to encourage good spinal alignment and minimize or eliminate any movement of the head.

- **Laptops:** if a laptop is used for extended periods, consider an external keyboard and mouse plugged into the USB ports and placed at the appropriate height. Then the laptop display can be positioned at an optimal height and distance. Docking stations allow plug-in use of the laptop in conjunction with an external monitor, keyboard, and mouse without requiring multiple connections for each device.

- **Headsets:** should be considered when answering phone calls while using the keyboard and mouse. The phone should not be held between your ear and shoulder as this causes too much sustained neck side-bending (end-range position for the joint plus sustained muscle contraction).

- **Glasses:** do they allow clear vision at 18-34 inches without tilting the head. People with bifocals or progressive lenses often lower their monitor to reduce neck tilt but they should also consider an examination to obtain glasses better suited for computer users and desk activities.

- **Lighting:** should be directed away from screen to reduce glare (window not directly behind or with adequate blinds). Work surface should have a matte finish to reduce glare. Lighting should be sufficient to work comfortably (lower and louvered overhead lighting to reduce glare with an added task light), older employees may need more light. Frequent micro-pauses are a must for the eyes as well as for MS.

- **Dust:** keep your monitor screen free of dust for optimal viewing.

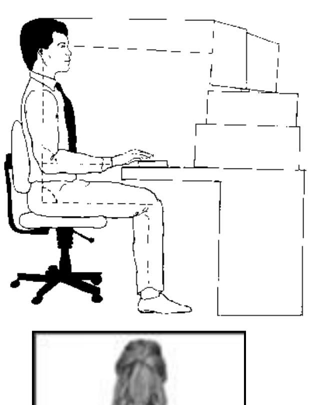
- **Noise, ventilation, temperature and vibration:** will all affect an employee's comfort level. Often facilities maintenance has to be called in for these types of issues.

- **Other ergo accessories:** there are a myriad of products to fit just about any situation. An example of an accessory we frequently use is a corner extender for people who use their computers in the corner of an L-shaped desk so that the keyboard can be pulled closer.

- **Micro-pauses** – frequent micro-pauses are recommended for repetitious, intense data entry (Balci 2004). If the worker cannot remember to do this then they should set reminders. There are software programs now that will track your keystrokes or mouse usage and remind you when you need to take a break.

- **Multi-tasking** – when there is a lot of writing, reading or reaching (i.e. for phone, calculator) simultaneously or in-between keying then the worker often leans over the keyboard creating a different set of biomechanical issues; especially when back and forth between keyboard and desk. Under these circumstances we don't usually recommend a tray, but if used the employee must commit to pushing it in when doing their paperwork.

8. **Worker Intrinsic Factors** – work habits, knowledge and skills ultimately determine how effectively a workstation is utilized and their degree of vulnerability to develop a RSI/CTD injury.



Side-view: The spine should be in good alignment, the elbow at or close to side, the wrist/hands even or slightly below the elbow and in mid-range neutral flexion-extension (remember the functional position of the hand), the feet should be flat on the floor (or footrest), knees in mid-range bend and able to move. The adjustment and positioning of the chair, the height and position of the monitor, position of the keyboard and mouse (with or without tray) and clearance under the desk or table are the key factors.

Rearview – the worker should be square to their tasks, the shoulders and upper limbs relaxed and the elbows close to the side. The adjustment and positioning of the chair arms, the height and position of the monitor, and other work demands (e.g. phone, calculator pad, printer etc.) are the key factors.

Top view – the wrist should be in a neutral, mid-range position and any reaching should be minimized. The position and type of keyboard and/or mouse, along with unique physical characteristics of the worker are the key factors.

Implementing Corrective Actions

Once you and the worker have identified their optimal postural alignment and work position, corrective actions involve adjusting the components that are causing them to deviate from this mechanically. You can score their set-up and use patterns by counting the number of risk factors on a checklist identified (e.g. OSHA checklist below) or by using an ergonomic tool that calculates a specific score that has been calibrated to the degree of risk from low to high (e.g. the ROSA tool below).

After corrections are implemented the workstation and worker should be reassessed to determine if the actions have been effective; if not, determine why and intervene again. The degree of improvement can be objectified after the ergonomic correction with the following formula:

% Risk Reduction = Initial Score – Corrected Score / Initial Score

Checklists and many of the assessment tools are helpful to remain organized as the assessor and for education and training of the worker to self-correct. There are many tools and programs available on the market for these purposes. The following two tools are a good start for learning how to perform an office assessment (OSHA checklist) and to objectify the risk (ROSA) and the percentage of risk reduction after corrective actions.

OSHA Ergonomic Solutions: Computer Workstations eTool – Evaluation Checklist

http://www.osha.gov/SLTC/etools/computerworkstations/checklist.html

This tool is available for download and covers all the essential areas that need consideration in an ergonomic assessment of a computer workstation; a hardcopy of the form is provided as a separate handout. All questions that are answered with a "no" require further evaluation and/or corrective action.

A. Working Postures – the workstation is designed or arranged for doing computer tasks so it allows your

1. Head and neck to be upright, or in-line with the torsos (not bent down/back). If "no", refer to monitors, chairs and work surfaces.
2. Head, neck, and trunk to face forward (not twisted). If "no", refer to monitors or chairs.

3. Trunk to be perpendicular to floor (may lean back into backrest but not forward). If “no”, refer to chairs or monitors.
4. Shoulders and upper arms to be in-line with the torso, generally about perpendicular to the floor and relaxed (not elevated or stretched forward). If “no” refer to chairs.
5. Upper arms and elbows to be close to the body (not extended outward). If “no”, refer to chairs, work surfaces, keyboards, and pointers.
6. Forearms, wrists, and hands to be straight and in-line (forearm at about 90 degrees to the upper arm). If “no”, refer to chairs, keyboards or pointers.
7. Wrists and hands to be straight (not bent up/down or sideways toward little finger). If “no”, refer to keyboards or pointers.
8. Thighs to be parallel to the floor and the lower legs to be perpendicular to floor (thighs may be slightly elevated above knees). If “no”, refer to chairs or work surfaces.
9. Feet rest flat on the floor or are supported by a stable footrest. If “no”, refer to chairs or work surfaces.

B. **Seating** – consider these points when evaluating the chair:

10. Backrest provides support for your lower back (lumbar area).
11. Seat width and depth accommodate the specific user (seat pan not too big/small).
12. Seat front does not press against the back of your knees and lower legs (seat pan not too long).
13. Seat has cushioning and is rounded with a “waterfall” front (no sharp edge).
14. Armrests if used support both forearms while you perform computer tasks and they do not interfere with movement.

“No” answers to any of these questions should prompt a review of chairs.

C. **Keyboard/Input Device** – consider these points when evaluating the keyboard or pointing device. The keyboard/input device is designed or arranged for doing computer tasks so the:

15. Keyboard/input device platform(s) is stable and large enough to hold keyboard and input device.
16. Input device (mouse or trackball) is located right next to the keyboard so it can be operated without reaching.
17. Input device is easy to activate and the shape/size fits your hand (not too big/small).
18. Wrists and hands do not rest on sharp or hard edges.

“No” answers to any of these questions should prompt a review of keyboards, pointers or wrist rests.

D. **Monitor** – consider these points when evaluating the monitor. The monitor is designed or arranged for computer tasks so the:

19. Top of the screen is at or below eye level so you can read it without your head or neck down/back.

20. User with bifocals/trifocals can read the screen without bending the head or neck backward.
21. Monitor distance allows you to read the screen without leaning your head, neck or trunk forward/backward.
22. Monitor position is directly in front of you so you don't have to twist your head or neck.
23. Glare (for example from windows, lights) is not reflected on your screen which can cause you to assume an awkward posture to clearly see information on your screen.

"No" answers to any of these questions should prompt a review of monitors or workstation environment.

E. Work Area – consider these points when evaluating the desk and workstation. The work area is designed or arranged for doing computer tasks so the:

24. Thighs have sufficient clearance space between the top of the thighs and your computer table/keyboard platform (thighs are not trapped).
25. Legs and feet have sufficient clearance under the work surface so you are able to get close enough to the keyboard/input device.

F. Accessories – check to see if the:

26. Document holder if provided is stable and large enough to hold documents.
27. Document holder if provided is placed at about the same height and distance as the monitor screen so there is little head movement, or need to re-focus when you look from the document to the screen.
28. Wrist/palm rest if provided is padded and free of sharp edges that push on your wrists.
29. Wrist/palm rest if provided allows you to keep your forearms, wrists and hands straight and in-line when using the keyboard/input device.
30. Telephone can be used with head upright (not bent) and your shoulders relaxed (not elevated) if you do computer tasks at the same time.

"No" answers to any of these questions should prompt a review of work surfaces, document holders, wrist rests or telephones.

G. General

31. Workstation and equipment have sufficient adjustability so you are in a safe working posture and can make occasional changes in posture while performing computer tasks.
32. Computer workstation, components and accessories are maintained in serviceable condition and function properly.
33. Computer tasks are organized in a way that allows you to vary tasks with other work activities, or to take micro-breaks or recovery pauses while at the computer workstation.

"No" answers to any of these questions should prompt a review of chairs, work surfaces or work processes.

ROSA (Rapid Office Strain Assessment)

The ROSA (Sonne 2012) is an evolution of the RULA (Rapid Upper Limb Assessment: McAtamney 1993) and REBA (Rapid Entire Body Assessment: Hignett 2000) designed to objectively assess risk for MSD related to computer work.

A final ROSA score (1 – 10) is obtained by cross-correlating the effects of a number of factors related to set-up, use and duration of the following:

Section A: Seat pan height and depth, back support an arm rests.

Section B: Monitor and telephone positioning and use.

Section C: Mouse and keyboard positioning and use.

The score in Section A (i.e. the chair score) is cross-correlated to the Monitor & Peripheral Score (Sections B & C) to yield a Final ROSA Score. ROSA final scores that are > 5 indicate high risk and need for corrective action.

An instructional manual and a score sheet have been provided. The manual has pictures to provide visual examples for rating the various factors, and the score sheet is well organized and illustrated. Scoring requires a minimal amount of practice to master. Some of criteria for deductions (i.e. reasons to increase the score) are debatable; use caution not to over-interpret some of the rating criteria (e.g. I would not consider the chair height too high if the hips are flexed to 85 degrees as opposed to the recommended 90 degrees).

Summary Office Ergonomic Evaluation

Most office ergonomic assessments can be performed in a short time period (15 minutes ±) and ultimately need to be performed by the individual worker for musculoskeletal self-efficacy. There is a growing trend in companies to provide workers with self-assessment checklists, access to training tools and resources prior to having an ergonomic assessment specialist visit the worksite. This is frequently, but not always all that is required to resolve problems and mitigate risks for MSD. The effective use of these tools requires a proclivity for problem-solving and basic musculoskeletal awareness; many of the workers at greatest risk for MSD and disability do not have these innate skills.

The most significant risk factor associated with office work centers around the amount of time spent sitting. There are the biomechanical and physiological effects of static loading to the spine that contribute to risk for mechanical disorders, particularly of the lower back (L4-5, L5-S1) and lower neck (C5-6, C6-7); this has been a historical concern and focus of the physical therapist. However recent studies have identified that there are also general health risks associated with sedentary lifestyles that affect quality of life and mortality predictions (Dunstan

2010; Owen 2010). Westernized societies are experiencing a growing epidemic of chronic diseases that are lifestyle-related that can be mitigated through the application of biomechanical and exercise science (Booth 2000; 2002); the workplace has become an important venue to promote the needed health and wellness behaviors to fight these chronic diseases.

When you step back and look at the big picture, a basic office ergonomic assessment and corrective actions are commonsense: have good posture, stay square, keep your work close and easy to reach, have your workspace organized and uncluttered, work in a well lit and comfortable environment and frequently interrupt sitting proactively or whenever warning signals of fatigue develop.

It is important to present a positive message when performing an ergonomic assessment or implementing a MSD prevention program. Repetitive strain/cumulative trauma disorders are inherently preventable provided actions are taken early and address root issues. Remember that the forces and physical demands associated with non-traumatic MSD are not capable of doing harm or damage; it is only when they are allowed to accumulate to a point of critical mass when they become a problem. Consequently all of these disorders are preventable; this has been an inherent component of the DRS prevention programs since 1984. The three stages concept illustrated below is used to emphasize the many opportunities to intervene before an MSD reaches and unequivocal pathological stage; but ultimately the individual must intervene for themselves.

Although there are correlations between physical demands at work and the acquisition of certain MSD, causation is not established so it cannot be stated that work factors alone are the cause for onset of RSI/CTD. For example, many people automatically associate the onset of carpal tunnel syndrome with office work, yet a number of scientific investigations have failed to find evidence for this (Anderson 2003; Thomsen 2008; van Rijn 2009). The issue is then confounded by problems with diagnostic accuracy (Atroshi 1999; 2003) that frequently leads to unnecessary surgery (Hadler 2004).

Our experience in industry has been that many workers labeled with carpal tunnel syndrome actually have a cervical disorder referring symptoms into the hand and/or the local hand signs and symptoms are not consistent with interference of distal median nerve conduction when utilizing strict operative definitions. This scenario applies to the most common MSD where there is no traumatic incident or event.

Your task as the ergonomic evaluator is to identify the relevant risk factor(s) and then educate and train the worker to take control; self-efficacy is the exercise of control (Bandura 1997). In this case it is musculoskeletal self-efficacy we are promoting; a concept DRS coined in 1996. When the ergonomic intervention is successful the information and tools provided to the worker lasts throughout their career and are carried-over to their home and recreational activities.

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