

# Ergonomics: Maximizing Safety & Efficiency Through Design

The Greater Cleveland Safety Council

February 8, 2012

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# Ergonomics

The Science of fitting jobs to people to:

- ▶ Obtain the optimal match between the Work, Worker, and Workstation.
- ▶ Prevent Musculoskeletal Disorders
- ▶ Get the job done right.
- ▶ Improve Safety **AND** Productivity **AND** Quality **AND** Worker Satisfaction.

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# MusculoSkeletal Disorders (MSDs)

- ▶ MSDs “accounted for 29% of all workplace injuries and illnesses requiring time away from work in 2010”.

<http://www.bls.gov/news.release/osh2.nr0.htm>

- ▶ MSDs: “cases where the nature of the injury or illness is sprains, strains, tears; back pain, hurt back; soreness, pain, hurt, except the back; carpal tunnel syndrome; hernia; or musculoskeletal system and connective tissue diseases and disorders, when the event or exposure leading to the injury or illness is bodily reaction/bending, climbing, crawling, reaching, twisting; overexertion; or repetition. Cases of Raynaud’s phenomenon, tarsal tunnel syndrome, and herniated spinal discs are not included.

<http://www.bls.gov/iif/oshdef.htm>.

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# Work-Related MusculoSkeletal Disorders (WMSDs)

Conditions that develop over a period of time and are the result of repeated micro-injuries to the body's tissues resulting in pain and diminished or loss of function.

- ▶ Tendonitis
- ▶ Tenosynovitis
- ▶ Tennis Elbow
- ▶ Golfer Elbow
- ▶ Carpal Tunnel Syndrome
- ▶ Bursitis
- ▶ Lower Back Pain
- ▶ Cervical (neck) Pain
- ▶ Thoracic Outlet Syndrome

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# MusculoSkeletal Disorders (MSDs)

- ▶ Sprains, strains & tears = 40% of lost work cases in 2010.
  - ✓ Causes:
    - 43% - overexertion
    - 11% - falls on same level
    - 8% - contact with equipment
  - ✓ Injury site:
    - 36% - back
    - 12% - shoulder
    - 26% - lower extremity
  - ✓ Median recovery time:
    - All cases - 10 days
    - Shoulder - 21 days
    - Carpal Tunnel - 27 days

<http://www.bls.gov/news.release/osh2.nr0.htm>

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# MusculoSkeletal Disorders (MSDs)

- ▶ Estimated Shipyard Direct Injury Costs for MSD Injuries (medical + indemnity) by Part of Body

Body Part	Est. Cost	Body Part	Est. Cost
Ankle(s)	\$2,390	Knee(s)	\$7,472
Arm(s), unspecified	\$7,725	Leg(s), unspecified	\$849
Back	\$6,996	Neck	\$5,961
Elbow(s)	\$4,691	Shoulder(s)	\$4,960
Finger(s)	\$735	Wrist(s)	\$3,925
Hand(s)	\$6,857		
		Mean Musculoskeletal Injury Cost	\$5,523

Based on analysis of available participating shipyard compensation data from 1996 – 1998 (Does not include contusions or fractures)

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# Ergonomic Concerns

**Force,**

**Repetition,**

**Posture,**

**Environment,**

**Fitness**

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# Ergonomic Concerns

**Force**, Repetition, Posture, Environment, Fitness

## ▶ **Dynamic Overexertion**

- > 7 lbs of hand force
- Using gloves
- Pinch Grip  $\geq$  2 lbs
- Power Grip  $\geq$  10 lbs
- Repetitive throwing of a heavy load
- Pulling a load
- Lifting a moderate weight in an awkward posture

## ▶ **Some people are stronger than others**

## ▶ **Lifting: in or out of the “Power Zone”**

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# Ergonomic Concerns

**Force**, Repetition, Posture, Environment, Fitness

## ▶ **Static Overexertion**

- Maintaining a load for a **loooong period of time**
- Results in **starving the muscles**
- Examples:
  - Sitting in one place without breaks
  - Holding arms up on a work surface
  - Holding shoulders up to reach the surface
  - Vision:
    - Focusing at the same distance

## ▶ **You and I are designed to MOVE**

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# Ergonomic Concerns

Force, **Repetition**, Posture, Environment, Fitness

- ▶ < 30 seconds per cycle
- ▶ > 1,000 parts per shift
  - Typing on a computer = 176,280 strokes / shift
- ▶ Repetitive wrist motions (especially “**dishrag**”)
- ▶ Especially a concern if **Force or Posture** are also involved

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# Ergonomic Concerns

Force, Repetition, **Posture**, Environment, Fitness

- ▶ **People will adapt themselves** to their workstation, rather than adjusting it
  - People are **different sizes**
    - (BWC Anthropometric Data)
- ▶ **The body follows the eyes**
  - The **head (then the body) moves** to see an object
  - **Size and clarity** determine how much movement

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# Ergonomic Concerns

Force, Repetition, **Posture**, Environment, Fitness

- ▶ **Head, Neck and Trunk**
- ▶ **Shoulders and Upper Arms**
- ▶ **Elbows and Forearms**
- ▶ **Wrists and Hands**
- ▶ **Thighs, Lower Legs**
- ▶ **Feet**

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# Ergonomic Concerns

Force, Repetition, **Posture**, Environment, Fitness

## ▶ Head, Neck and Trunk

- **Head Upright:**
  - **Bent down** risks muscle strain
  - **Tilted back** risks muscle strain and vertebral stroke
- **Trunk** facing forward
  - **Twisting to either side** increases muscle strain
  - **Slouching** risks pinching nerves by spine
  - **Leaning forward** risks lower back pain
    - It's **OK to lean back** into backrest with lumbar curve supported
- **Lifting while bending**, twisting or out of balance risks muscle strain, disk, or nerve damage
  - **Abs protect the spine**

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# Ergonomic Concerns

Force, Repetition, **Posture**, Environment, Fitness

## ▶ Shoulders, Upper Arms

- **Shoulders**
  - **Reaching** forward increases shoulder muscle load AND
  - Moves center of gravity forward straining lower back
  - **Heavy load on shoulder** straps (especially on one side) strains shoulder & back muscles
- **Upper Arms**
  - **Moment arms** increase when arms are not close to the body,
    - **Abduction** sideward works deltoids
    - **Extended forward** moves center of gravity forward straining lower back

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# Ergonomic Concerns

Force, Repetition, **Posture**, Environment, Fitness

## ▶ Elbows and Forearms

- **Elbows**
  - Extended outward puts arms & wrists in awkward posture
  - Holding elbows/arms up = 8 lbs per side
- **Forearms**
  - **Rotation** of the arms (outward to the sides)
  - **Flexing** (bending at elbow): dynamic vs. static
  - **Hyperextension** of elbow is extremely hard
  - **Pronation** (rotation with palms down) increases muscle effort
  - **Supination** (rotation with palms up) increases muscle effort

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# Ergonomic Concerns

Force, Repetition, **Posture**, Environment, Fitness

## ▶ Hands

- Jarring and vibration
- Forceful thumb pressure
- Palmar base pressure
- Trigger finger motions

## ▶ Wrists

- Extension / Flexion / Ulnar and Radial Deviation
  - All add strain in the Carpal Tunnel
- Forceful gripping when wrist is not in neutral
- Cold temperatures

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# Ergonomic Concerns

Force, Repetition, **Posture**, Environment, Fitness

## ► Feet

- **Sitting** work
  - Dangling legs over edge puts pressure on underside of thigh
  - Stretching legs out
    - Lowers the knees
    - Increases pressure on underside of thighs
    - Pulls lower back away from support of backrest.
- **Standing** work
  - Static posture compresses joints
  - Fatigue leads to leaning on objects

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# Ergonomic Concerns

Force, Repetition, Posture, **Environment**, Fitness

## ▶ Mechanical Stress (**Contact Stress**)

- Hands or forearms resting on sharp edge (like **table edge**)
  - Contact Pressure Points
- Hand in contact with sharp objects (like **tool handles**)
  - **Restricts** blood flow
  - **Damages** soft tissue
  - **Increases** tendon friction
  - **Presses** on nerves

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# Ergonomic Concerns

Force, Repetition, Posture, **Environment**, Fitness

## ▶ **Vibration**

- 10-40 hz. presents risk of carpal tunnel syndrome (**CTS**)
- 25-150 hz. Presents risk of hand-arm vibration syndrome (**HAVS** or “white finger”)
- Whole body vibration (**WBV**) can lead to back disorders

## ▶ **Temperature**

- Optimum for sedentary work 72°
- Above 78°: decrease in psychomotor performance
- 80° - 90°: serious mental and psychomotor decrement plus fatigue
- Below 64°: - degradation in motor coordination
- Below 55°: - hand dexterity reduced by 1/2 , strength reduced, considerable shivering

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# Ergonomic Concerns

Force, Repetition, Posture, **Environment**, Fitness

▶ **Noise**

- 40 – 50 db preferred.
- Above 70 db conversation difficult
- Uncontrolled noise alerts “Fight or Flight” mode

▶ **Fumes**

- You have to breath.

▶ **Glare**

- Can lead to **Visual Discomfort**

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# Ergonomic Concerns

Force, Repetition, Posture, **Environment**, Fitness

- ▶ Major causes of **Visual Discomfort**
  - Glare from **overhead lights**
  - Glare from **windows**
  - Inadequate **lighting**
  - Small **size** of viewing object
  - Individual Factors
    - Uninterrupted Viewing Time (**lens muscle fatigue**)
    - Uncorrected **Visual Disorder**
  
- ▶ **“The Body follows the eyes”**
  - Leads to posture change

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# Ergonomic Concerns

Force, Repetition, Posture, Environment, **Fitness**

- ▶ **Physical fitness** for the job  
(industrial / office athlete)
  
- ▶ **Mental / psychological fitness** for the work demands
  - Four out of ten people find their work is monotonous and repetitious
  - Closely controlled, restricted work aggravates the risk of disorders

[http://www.av.se/dokument/statistik/english/Musculoskeletal\\_ergonomics\\_statistics.pdf](http://www.av.se/dokument/statistik/english/Musculoskeletal_ergonomics_statistics.pdf)

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# Design Issues

## Force, Repetition, Posture, Environment, Fitness

- ▶ **Dynamic:** Design for different Strengths
  - **Strength:** Design for the population
  - **Power Zone** for lifting
    - Above the knees, below the shoulders, close to the body
    - Fitness for the task
  - Use assistive **tools**
- ▶ **Static:** Keep it moving
  - Build **moving activities** into jobs
  - Encourage visual **focus variety**

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# Design Issues

Force, **Repetition**, Posture, Environment, Fitness

- ▶ **Organize** the work to reduce repetitions
- ▶ Let **machines** do repetitious work
- ▶ Keep **forces low** as possible when working
- ▶ Keep **postures neutral** when working

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# Design Issues

Force, Repetition, **Posture**, Environment, Fitness

- ▶ People will **adapt themselves** to their workstation, rather than adjusting it
- ▶ Design for **different anthropometrics**
  - Clearance: 95% male
  - Reach: 5% female
- ▶ The **body follows the eyes**
  - The head (then the body) moves to see an object
    - (size and clarity determine how much we move)
- ▶ **Strong Abs** protect the back

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# Design issues

Force, Repetition, **Posture**, Environment, Fitness

## ▶ Head, Neck and Trunk

- **Head Upright**
  - Not bent down
  - Not tilted back
- **Trunk facing forward**
  - Not twisted to either side
  - Not slouching
  - Not leaning forward
- Its OK to **lean back into backrest**
  - With the Lumbar curve supported
- **Avoid lifting while bending, twisting or out of balance**

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# Design issues

Force, Repetition, **Posture**, Environment, Fitness

## ▶ Shoulders, Upper Arms

- **Shoulders**
  - In-line with the torso
  - Avoid heavy load on shoulder straps (especially on one side)
- **Upper Arms**
  - Generally perpendicular to the floor
  - Close to the body,
    - Not extended sideward
    - Not extended forward

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# Design issues

Force, Repetition, **Posture**, Environment, Fitness

## ▶ Elbows and Forearms

- **Elbows**
  - Close to the body, not extended outward
  - If sitting, lightly supported on soft armrests
- **Forearms**
  - If typing: Parallel to the floor
  - If lifting: In the power zone
  - Limit Pronation (rotation with palms down)
  - Limit Supination (rotation with palms up)

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# Design issues

Force, Repetition, **Posture**, Environment, Fitness

## ▶ Hands

- The Hand is not a hammer!
- Avoid forceful thumb pressure
- Avoid Palmar base pressure
- Beware of trigger finger motions
- Straighten the wrist when squeezing with the fist

## ▶ Wrists

- Avoid Extension / Flexion / Ulnar and Radial Deviation
- Reduce loads
- Keep the wrists warm

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# Design issues

Force, Repetition, **Posture**, Environment, Fitness

## ▶ **Sitting**

- **Thighs**
  - Parallel to the floor (or hips slightly above knees)
  - Fully supported by the chair
    - 2-3 fingers between back of knees and front of seat
- **Lower Legs**
  - Perpendicular to the floor

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# Design Issues

Force, Repetition, **Posture**, Environment, Fitness

## ► Feet

- **Sitting**
  - Rest the Feet flat on the floor
    - Or on stable footrest if desk cannot be lowered
  - Support feet with footrest when legs stretched out
    - Reduces pressure on underside of Thighs
    - Creates force vector to hold lower back into lumbar support of backrest.
- **Standing work** (design it like a bar)
  - Foot rail
  - Sit / stand support
  - Rounded / padded table edges
  - Floor surface with “give”

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# Design issues

Force, Repetition, Posture, **Environment**, Fitness

- ▶ Control the **Noise & Fumes**
  
- ▶ **Vision:** Work Place Adjustments
  - Lighting
  - Viewing object Location
  - Viewing object Size (if on a display)
  
- ▶ **Health and Comfort Strategies**
  - Micro Vision Breaks (“20-20-20”)
  - Visual Exercise (Palming, Distant Focus, and Blinking)
  - Corrected Vision - EYE EXAMS

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# Design issues

Force, Repetition, Posture, Environment, **Fitness**

- ▶ **Physical fitness** for the job
  - Core Strength (Abs)
  - Stretching keeps the tendons flexible.
  - Movement pumps blood & nutrients –  
Keeps muscles healthy
- ▶ **Mental / psychological fitness** for the work demands
  - Work that is interesting to the workers
  - Workers who are interested in the work

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# THANK YOU

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