An Introduction to Ergonomics: Designing for the person.

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Objectives

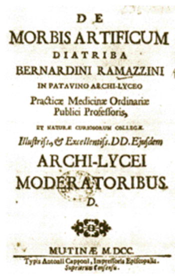
- Define Ergonomics, its history and its primary goals for improving the workplace.
- Define human capacity and work demand and understand how both are measured.
- Identify typical musculoskeletal disorders/injuries that ergonomics strives to prevent and why they occur.
- Explain how one can design to reduce risk of injury.
- Understand how research can improve a design and its implementation to practice.
- Design a research study to test an intervention of your choice.

Ergonomics Defined.

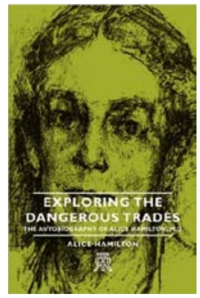
What is Ergonomics?

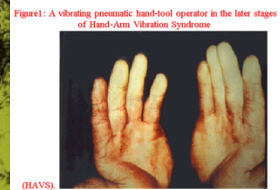
The laws (nomics) of work (ergo)

- The science of fitting jobs to people. [OSHA]
- Knowledge about the assignment of appropriate functions for humans and machines…. applied in order achieve compatibility in the design of interactive systems of people, machines, and environments to ensure their effectiveness, safety, and ease of performance. [HFES]
- **The goals of ergonomics are to decrease risk of injuries and illnesses to improve worker performance, to decrease worker discomfort and to improve the quality of work life.** [American Industrial Hygiene Association]

Bernardini Ramazzini (1633-1714)
"Diseases of Workers"

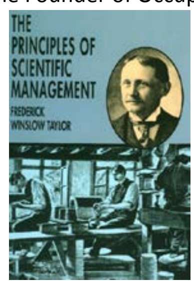




Alice Hamilton (1869-1970)
The Founder of Occupational Medicine

Gilbreths (1868-1972)
Time and Motion Studies

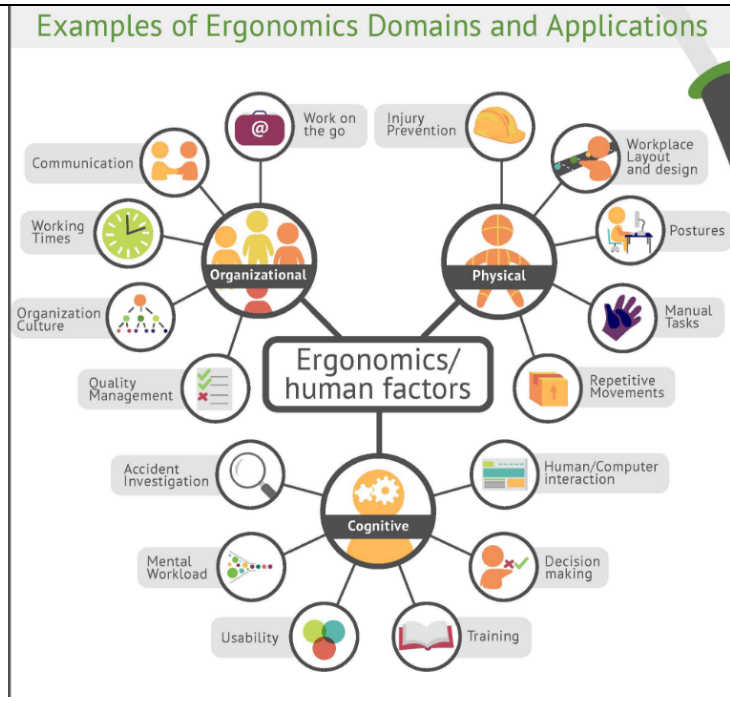
Ford (1863-1947)
The Assembly Line



Frederick Taylor (1856-1915)
The Father of Scientific Management

Post-Taylorism Era

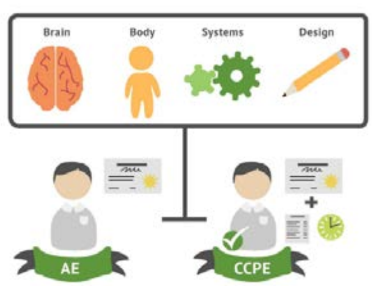
- Improve communication
- Align goals of employees and managers
- Encourage employee participation
- Use a problem-solving approach vs. imposing the 'one best way'
- Job enrichment
- ↑manager/employee discretion



https://www.ace-ergocanada.ca/about/about_ergonomics/ergonomics.html

Multidisciplinary

- Human Factors (Applied Psychology)
- Engineering
  - Industrial
  - Biomedical
  - Mechanical
- Occupational Health
  - Medicine
  - Rehabilitation/Therapy
  - Nursing
- Industrial Hygiene

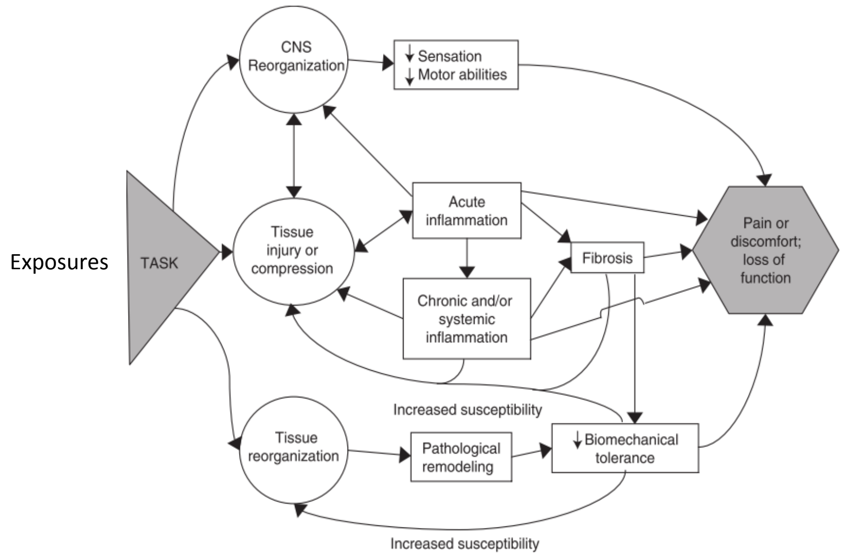


Why Ergonomics Today?

- U.S. Companies pay $62 Billion/Year for Workplace Injuries
- The annual cost to U.S. business of lost-time workplace injuries is greater than the gross domestic product (GDP) of 91 countries
- 356,910 WMSDs* in private industry in the United States *
  - Incidence rate of 29.8 per 10,000 full-time workers
  - Median of 12 days away from work
  - Accounted for 32% of all injuries and illnesses reported to BLS

http://www.lco-cdo.org/vulnerable-workers-final-report.pdf; Bureau of Labor Statistics. Nonfatal Occupational Injuries and Illnesses Requiring Days Away From Work, 2015. Available at: http://www.bls.gov/news.release/osh2.nr0.htm.

Balancing Human Capacity & Work Demand



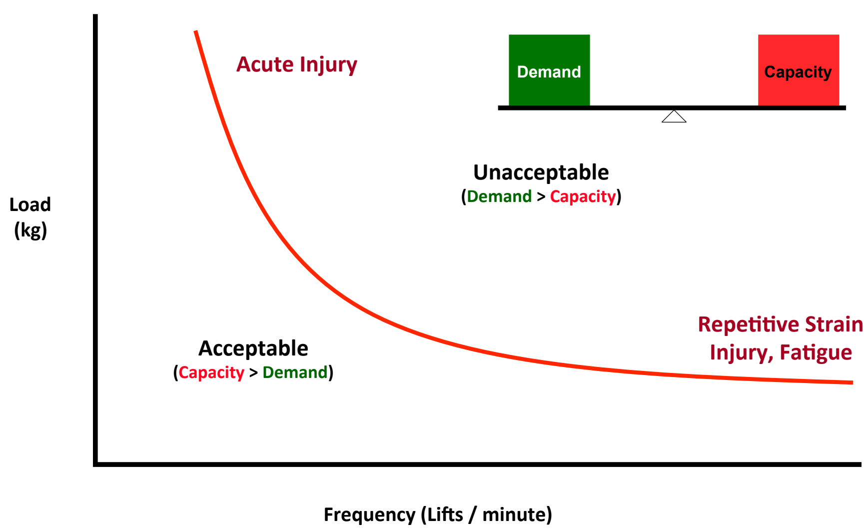
PHYSICAL RISK FACTORS

- Force
- Repetition
- Awkward postures
- Mechanical or contact pressure
- Environmental factors: vibration, cold temperatures, excessive light/sound

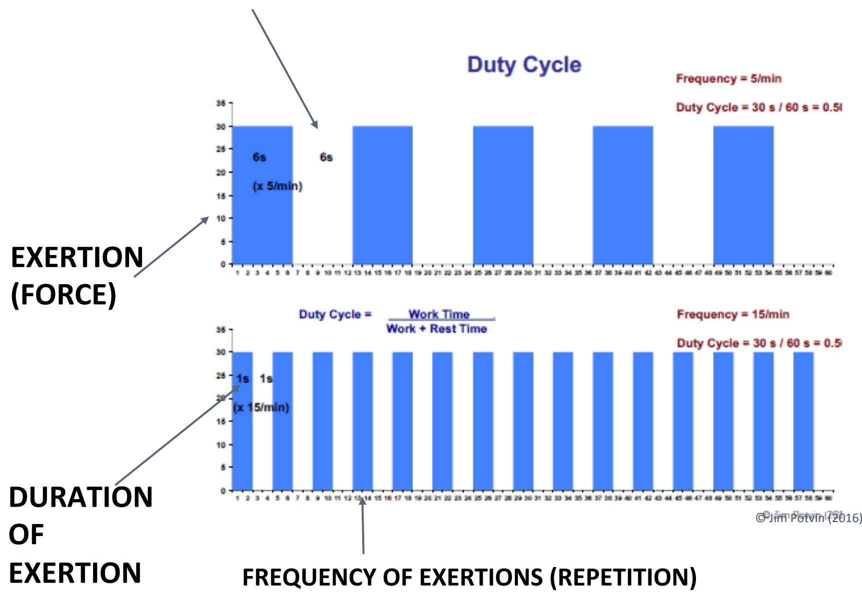
Don't forget personal and work psychosocial factors also increase risk for MSDs.

Recognizing Physical Risk Factors

Acceptable Loads (Injury or Fatigue)



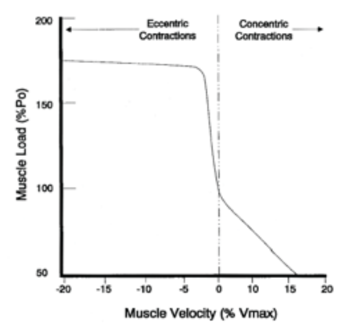
Demand

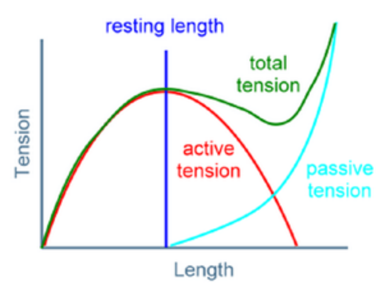


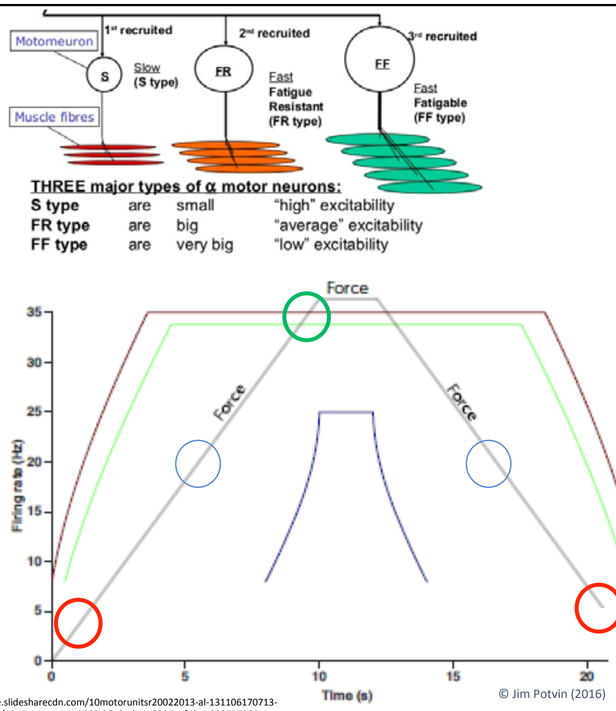
Capacity

Force production influenced by:

- Number of motor units activated
- Muscle fiber type
- Muscle architecture (PCSA)
- Muscle Length
- Velocity & Type of Contraction
- Muscle Fatigue







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Capacity

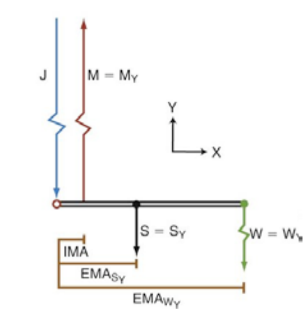
Fatigue: decreased ability to generate force (%MVC)

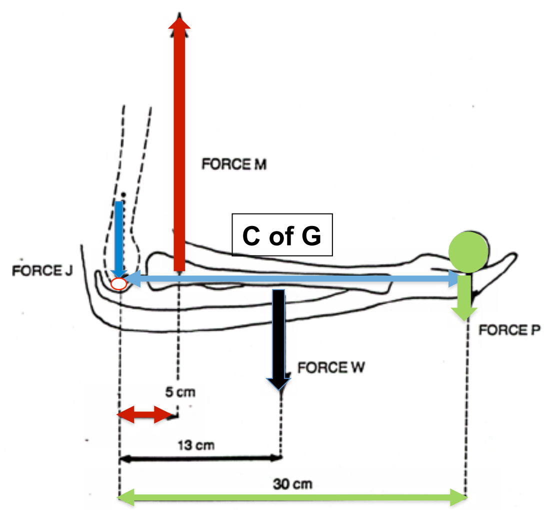
Symptoms: discomfort, pain, tremor, endurance

"Cinderella Fibers"

Demand vs. Capacity

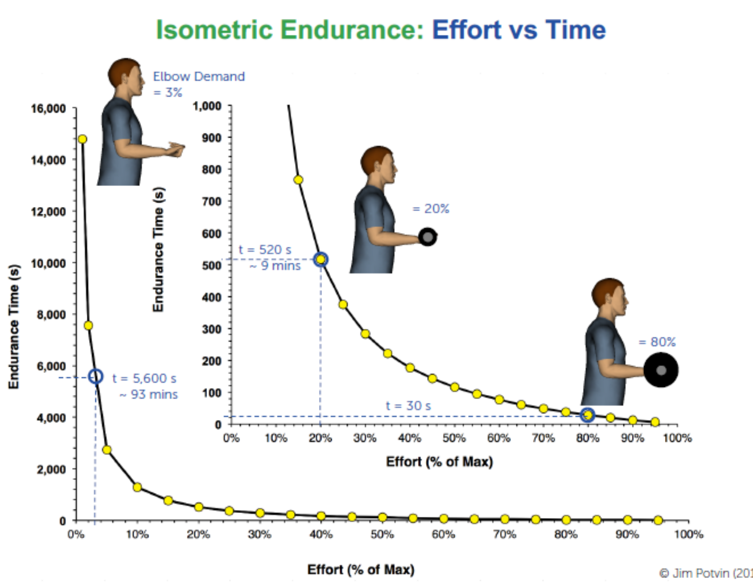
Torque = Force x moment arm





Torque $_{external}$ **= Torque** $_{internal}$

Demand vs. Capacity



Measurement	Magnitude	Duration/Recovery
Force (scale, force guage, dynamomter)	N, #, Kg	Minutes or Hours %time % time above threshold
Repetition	°/s; $°/s^2$; reps/min Reps/cycle time	
Contact Stress (scale/ruler)	N/cm^2	
Awkward Posture (goniometer)	° ; %	
Env: Vibration (accelerometer)	m/s^2; hz	
Env: Temp.	°C; °F	

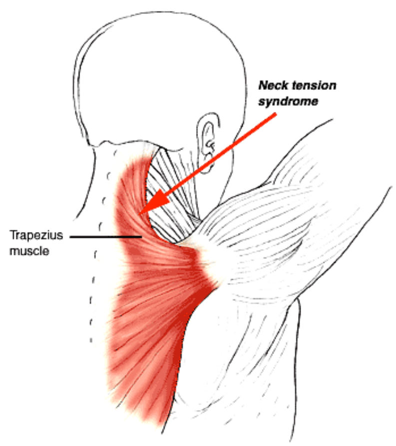
Musculoskeletal Disorders (MSDs)

Work-Related Musculoskeletal Disorders (WRMSDs)

Characteristics

- Gradual symptom onset
- Not preceded by an acute event
- May be worse at night
- Better during weekends or vacations
- Symptoms in more than one spot
- Few objective findings
- Few definitive laboratory tests

Neck Tension Syndrome



- Incident Rate = 31.5 per 10,000 FTEs
- Among a large Danish Cohort Study:
  - 12 month prevalence 31%
  - Point prevalence: 21%
  - Prevalence Chronic Symptoms >3mos): 14%

•Aching discomfort at the base of neck/upper back- can be unilateral
•Headaches due to radiating pain
•Intermittent neck muscle spasms
•Tenderness to palpation

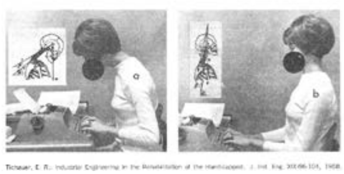
Picavet HSJ, Schouten JSAG. Musculoskeletal pain in the Netherlands: prevalence, consequences and risk groups, the DMC study. Pain.2003;102:167-78.

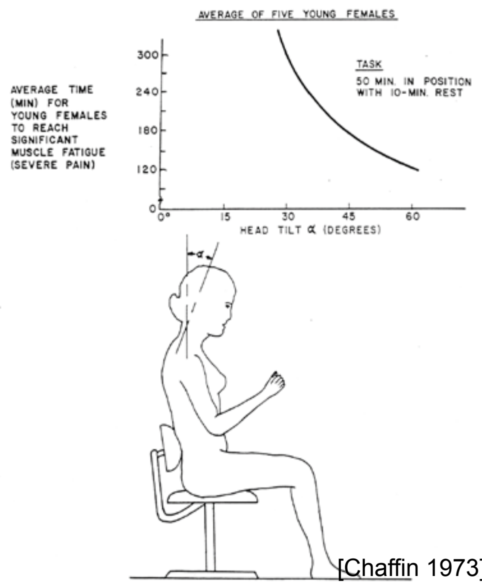
Neck Tension Syndrome

Palmer & Smedley, 2007

Systematic Review (N=136; n=21)

- Static Neck Loading
- Repetitive or forceful shoulder work
- High Job Strain

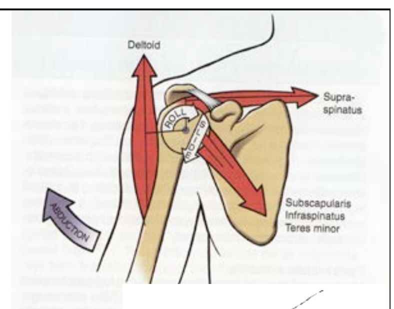


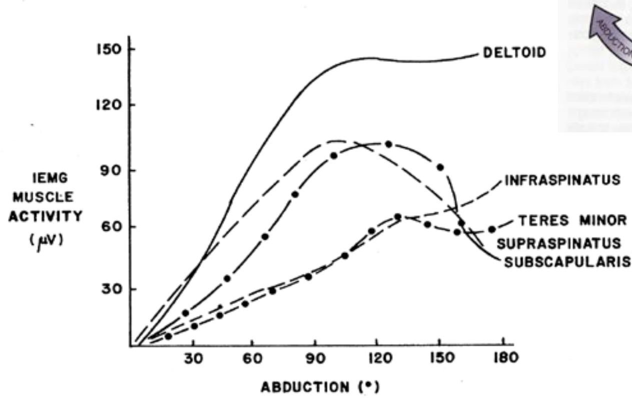


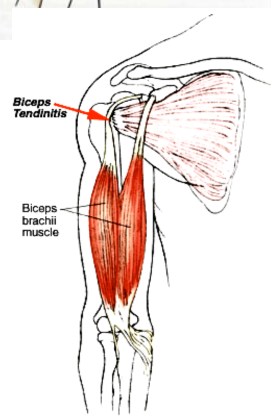
[Chaffin 1973]

Shoulder Disorders

Supraspinatus tendon gets impinged under coracoacromial arch







Microtrauma of bicipital tendon (long) as it passes through the bicipital groove of humeral head

Shoulder Disorders

Time to Fatigue for Unsupported Reach Activities

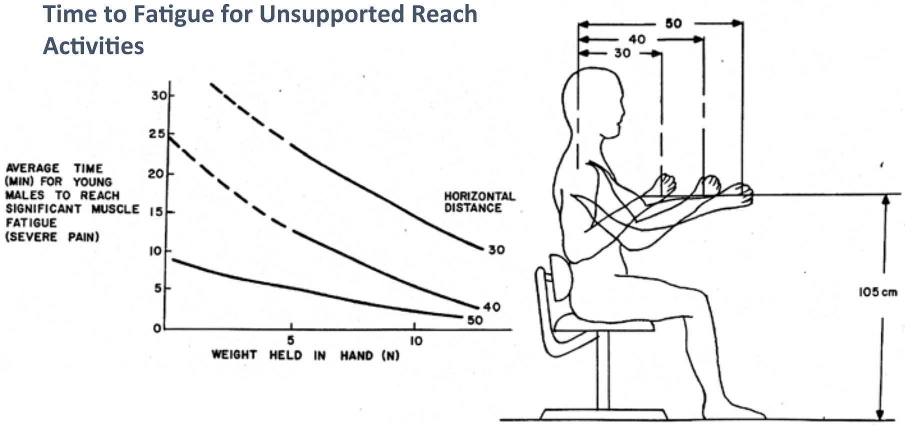


Figure 10.15 Expected time to reach significant shoulder muscle fatigue for different forward arm reach postures. The elbow is unsupported. The greater the reach, the shorter the endurance time (Chaffin, 1973).

Shoulder Disorders

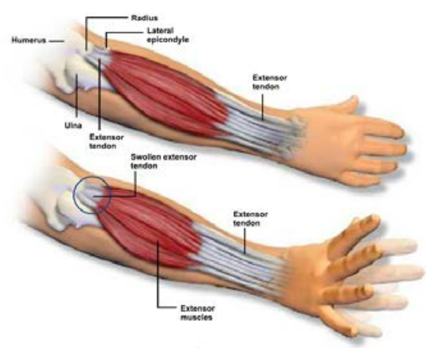
Systematic Review (N=1739; n=17)

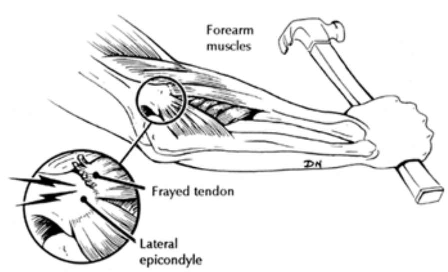
- High Force (OR 2.8 - 4.2)
  - >10% MVC
  - Lifting>20kg >10x/day
  - High hand exertion >1hr/day
    - o heavy grip ≥9% time or any heavy pinch
- High Repetition (OR 1.04 - 4.7)
  - Shoulder movements
  - Hand exertions (>2hrs/day)
  - Hand arm vibration
  - Working with hand above shoulder height
  - Working ≥45° for ≥15% of time- Reaching
- High Psychosocial Demand (OR 1.5 - 3.19)

vanRijn RM, Huissted BMA, Koes BW, Burdorf A. Associations between work-related factors and specific disorders of the shoulder- a systematic review of the literature. Scand J Work Environ Health 2010;36(3):189-201.

Examples

Lateral & Medial Epicondylitis





Lateral & Medial Epicondylitis

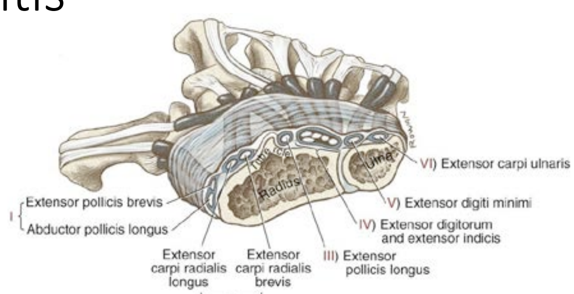
Systematic Review (N=633; n=13) on elbow disorders and work related factors

- Lat. Epi. associated with:
  - Handling tools >1 kg (ORs of 2.1–3.0)
  - Handling loads >20 kg at least 10 times/day (OR 2.6)
  - Repetitive movements >2 h/day (ORs of 2.8–4.7)
- Med. Epi. associated with:
  - Handling loads >5 kg (2 times/min at minimum of 2 h/day),
  - handling loads >20 kg at least 10 times/day,
  - High hand grip forces for >1 h/day,
  - Repetitive movements for >2 h/day (ORs of 2.2–3.6)
  - Working with vibrating tools >2 h/day (OR 2.2)

vanRijn RM, Huissted BMA, Koes BW, Burdorf A. Associations between work-related factors and specific disorders at the elbow: a systematic review of the literature. Rheumatology. 2009;48:528-536.

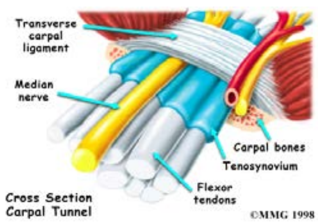
Wrist Tendonitis

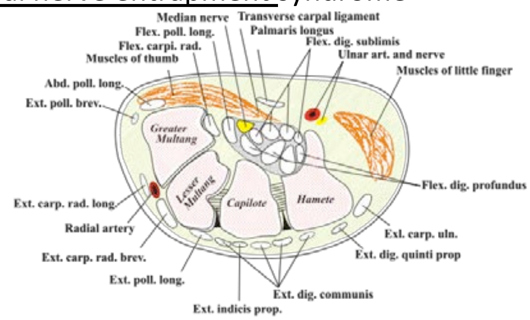
DeQuervains Syndrome: Irritation of EPB & APL tendons or synovium under sheath



Carpal Tunnel Syndrome (CTS)

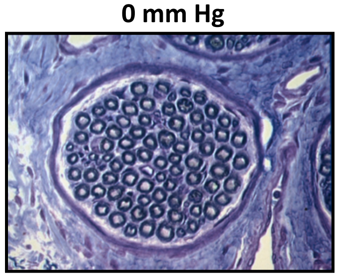
- 2 million outpatient visits for CTS
- Over 400,000 outpatient carpal tunnel release surgeries per year
- 50% 1 month lost time
- 11% lost or changed jobs
- Most common <u>peripheral nerve entrapment</u> syndrome





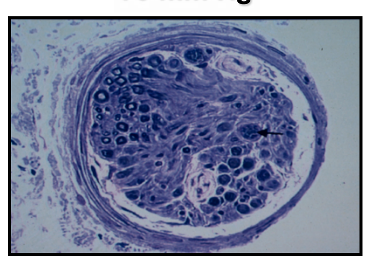
Carpal Tunnel Syndrome (CTS)

0 mm Hg



Mild perineural edema

70 mm Hg



Epineurial fibrosis
Perineurial thickening
Loss of myelin
Axon dropout

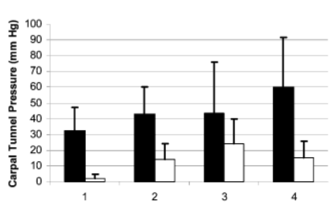


Fig. 2. Carpal tunnel pressure is elevated in patients with carpal tunnel syndrome (filled columns) in comparison to healthy controls (open columns) as demonstrated by these four studies: 1. (n= 15, 12) [6], 2. (n= 46, 16) [18], 3. [34] (n= 72, 21), 4. (n= 647, 31) [7].

Nerve Compression - 4 weeks

Rempel DM, Diao E. Entrapment Neuropathies: pathophysiology and pathogenesis. Journal of Electromyography and Kinesiology. 2004:14; 71–75

Keir PJ & Rempel DM. Pathomechanics of peripheral nerve loading: evidence in carpal Tunnel Syndrome. Journal of Hand Therapy. 2005:18(2); 259-269.

Wrist Tendonitis & CTS

- Biomechanical factors associated with CTS
  - Peak hand force (Borg CR10 ≥ 3)
  - Forceful hand repetition rate (>3 exertions/min)
  - % time in forceful hand exertions (> 11%)

- Biomechanical factors **not** associated with CTS
  - Total hand repetition rate
  - % time any hand exertions
  - Wrist posture

- Similar findings for Wrist Tendonits

[Forceful = ≥9N pinch force or ≥45N of power grip]

Harris-Adamson C, Eisen EA, Kapellusch J, Garg A, Hegmann KT, Thiese MS, Dale AM, Evanoff B, Burt S, Bao S, Silverstein B, Merlino L, Gerr F, Rempel D. Biomechanical risk factors for carpal tunnel syndrome: a pooled study of 2474 workers. Occup Environ Med. 2015;72(1):33-41

Hand Arm Vibration Syndrome

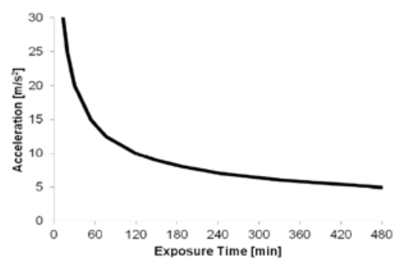
Changes in sensory perception which can lead to permanent numbness of fingers, muscle weakness and, in some cases, bouts of white finger.

Stage	Grade	Description
I. Vascular Component		
1	Mild	Occasional blanching attacks affecting tips of one or more fingers
2	Moderate	Occasional attacks distal and middle phalanges of one or more fingers
3	Severe	Frequent attacks affecting all phalanges of most fingers
4	Very Severe	As in 3 with trophic skin changes (tips)
II. Sensorineural Component[2]		
0SN		Vibration exposed - no symptoms
1SN		Intermittent or persistent numbness with or without tingling
2SN		As in 1SN with reduced sensory perception
3SN		As in 2SN with reduced tactile discrimination and manipulative dexterity

[1] This system is based upon: (1) removal of the unquantifiable areas - difficulty at work, home, and hobby activities; (2) discarding of the seasonal component; (3) the Syndrome to be separated into two major areas - vascular and sensorineural; (4) separate staging of each hand.
[2] The staging is made for each hand. The final grade of the disorder is indicated by the stage and the number of affected fingers in each hand (e.g. Stage/Hand/No. of digits).

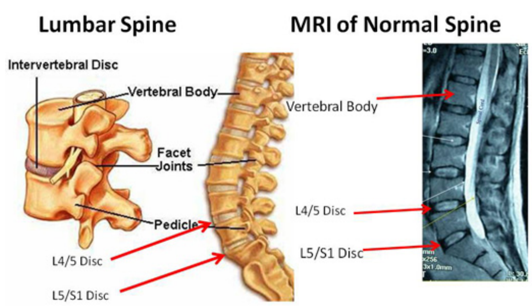
Hand Arm Vibration Syndrome

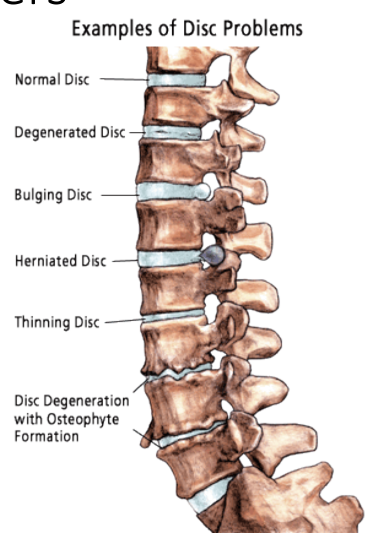
- Vibration (ISO Standards 2631-5349)
  - Magnitude
  - Frequency
  - Direction
- Worker
  - Exposure Duration
  - Posture
  - Contact Location
  - Applied Force
  - Temperature



Lumbar Spine Disorders

Basics of the Lumbar Spine





Lumbar Spine Disorders

0.5 %	**Postlaminectomy syndrome**
2.2 %	**Spinal stenosis**
1.1 %	**Herniated lumbar disc with myelopathy**
13.5 %	**Herniated lumbar disc without myelopathy**
3.3 %	**Sciatica**
0.6 %	**Possible instability**
3.9 %	**Probably degenerative changes**
74.9 %	**NONSPECIFIC BACKACHE**

Classification published in: Krause et al., 2004, Physical workload, ergonomic problems, and incidence of low back injury: a 7.5-year prospective study of San Francisco transit operators, Am J Ind Med 2004; 46:570-585 (Appendix shows 62 different ICD-9 codes with severity ranking and grouping)

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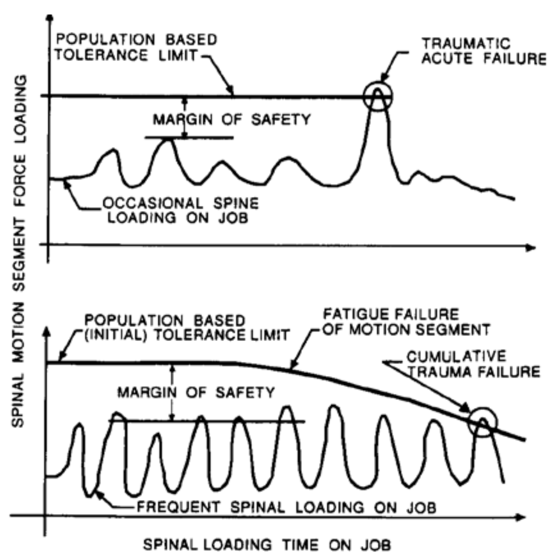
Biomechanical Criteria
Spinal Motion Segment Failure



Traditional Model

Revised Model
(McGill, 1997)

Evidence from Epidemiological Studies

Strong Evidence (++) Evidence(+) Insufficient (0)	Force	Repetition	Awkward Posture	Static Posture	Combo	Vibration
Neck & Neck/ Shoulder	+	+	++	.	.	0
Shoulder	0	+	+	.	.	0
Elbow	+	0	0	.	++	.
Hand/Wrist Tendonitis	+	+	+	.	++	+
Carpal Tunnel Syndrome	+	+	0	.	++	
Hand Arm Vibration	.	.	.	.	.	++
Back	++	.	+	0	.	++

Assessment of Risk for Injury.
Demand vs. Capacity

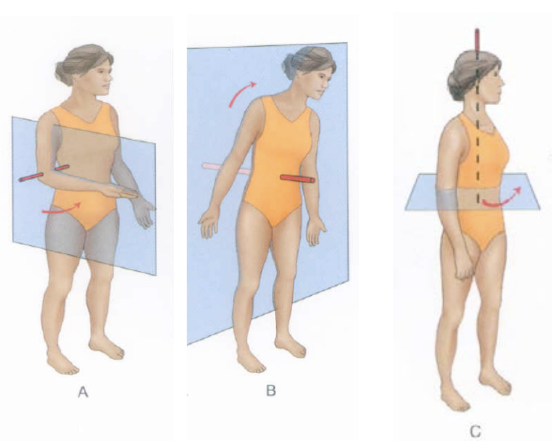
The Lumbar Motion Monitor
(spinal kinematics)

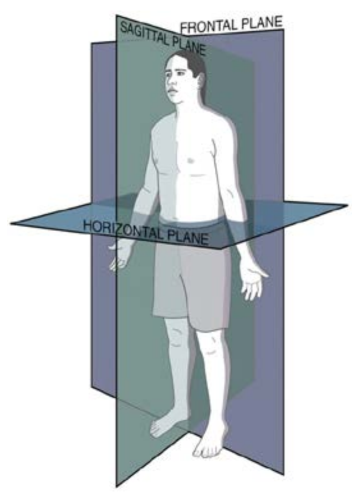
PURPOSE

Capture instantaneous and continuous 3-D motion of the back during actual MH tasks

Kinematics

Rotational movements occur in a plane & around an axis





Using LMM for Ergonomic Risk Assessment

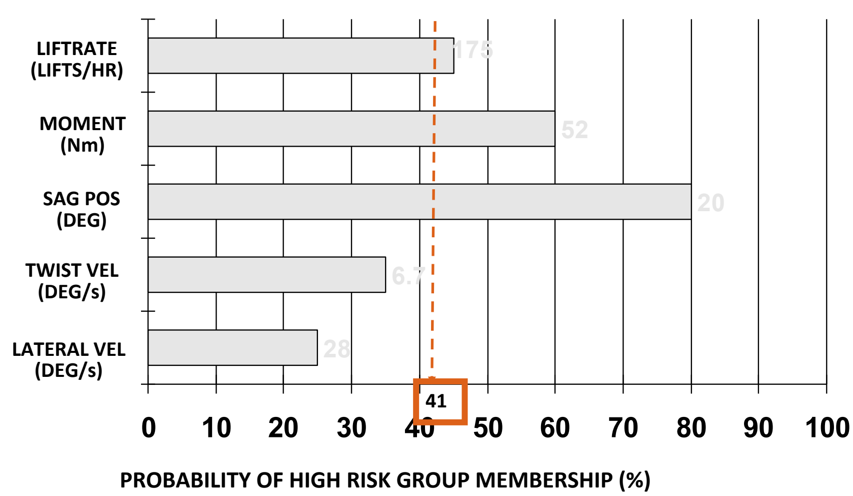
- Appropriate for repetitive/dynamic lifting, lowering, & other MH tasks

Steps:

- Measure motion and key workplace risk factors
- Assess LBD risk (Marras et al., 1993)
- Redesign the workplace
- Re-assess risk and injury records (longitudinally)

WORKPLACE AND MOTION RISK FACTORS (RISK MODEL)

=EXP(-3.8+(0.0014*liftrate)+(0.024*moment)+(0.02*avg sagittal position)+(0.061*avg twist velocity)+(0.036*peak lateral velocity))/(1+EXP (-3.8+(0.0014*liftrate)+(0.024*moment)+(0.02*avg sagittal position)+(0.061*avg twist velocity)+(0.036*peak lateral velocity)))



LMM- Assess Effectiveness of Ergonomic Intervention

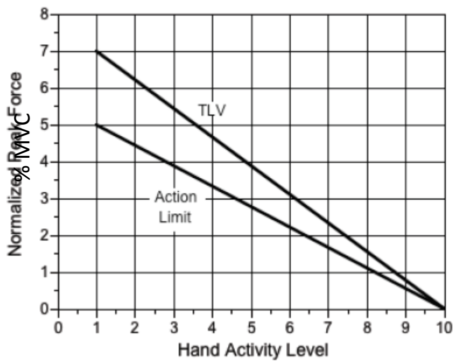
- Reduce extreme sagittal flexion (% of time can be quantified)
- Eliminate pinch grip

Lumbar Motion Monitor- Summary

- It emphasizes the role of *motion* in the risk of low back disorders (LBDs)
- Provides a detailed quantitative risk assessment tool based on trunk motion and workplace factors & comparison with large database of MMH jobs
- The "probability" provides relative risk of different lifting jobs/tasks → prioritization; redesign efforts
- Cost and expertise level could be high esp. for small employers

ACGIH TLV for Hand Activity

TLV for Hand Activity



$$HAL = 6.56 \ln D \left[\frac{F^{1.31}}{1 + 3.18\, F^{1.31}} \right]$$

$$F = \left(\frac{\text{exertions}}{\text{work time}} \right) \quad \text{and} \quad D = 100 \left(\frac{\text{work time}}{\text{work time} + \text{rest time}} \right).$$

TLV for HAL Score = NPF / (10- HAL)

TLV (≥0.78): high risk-needs analysis/ job design

AL to TLV (≥0.56 & <0.78): intermediate risk; surveillance and general controls recommended

<AL (0.56): low risk

Hand Activity Level (HAL) Rating

Ratings of repetition take into account two factors:
1) amount of recovery time within the cycle
2) how fast the hands are moving
Conflates frequency of exertion, duty cycle of exertion, and speed of work into a single measure.

0	2	4	6	8	10
Hands idle most of the time; no regular exertions	**consistent, conspicuous long pauses; or very slow motions**	**slow steady motion/ exertion; frequent brief pauses**	**steady motion/ exertion; infrequent pauses**	**rapid steady motion/ exertion; infrequent pauses**	**rapid steady motion or continuous exertion, difficulty keeping up**

Scores between anchor points can be used

Estimation of Normalized Peak Force for Hand Forces

%MVC	*Subjective Scale*		*Moore-Garg Observer Scale* (Alternative Method)	*NPF*
	Score	Verbal Anchor		
0	0	Nothing at all		0
5	0.5	Extremely Weak (Just Noticeable)	Barely Noticeable or Relaxed Effort	0.5
10	1	Very Weak		1
20	2	Weak (Light)	Noticeable or Definite Effort	2
30	3	Moderate		3
40	4		Obvious Effort, But Unchanged Facial Expression	4
50	5	Strong (Heavy)		5
60	6		Substantial Effort with Changed Facial Expression	6
70	7	Very Strong		7
80	8			8
90	9		Uses Shoulder or Truck for Force	9
100	10	Extremely Strong (almost maximum)		10

Normalized Peak Force (NPF) = % MVC /10

NPF = [Peak Task Grip Force / Maximum Voluntary Contraction) *100] / 10

Borg G. Psychophysical scaling with applications in physical work and the perception of exertion. Scand J Work Environ Health 1990; 16(suppl 1):55-8

Quantifying Peak Force Force Matching

Measure Task Force

- Grip span of dynamometer is set to match task
- Worker performs a few cycles of the task
- Worker mimics task squeezing the dynamometer with the same force they apply to the packages
- Repeat 3-5 times and average ($Force_{task}$)

Measure Maximum Force - Max. Voluntary Contraction (MVC)

- Worker squeezes grip dynamometer as hard as possible for 3 seconds in the same posture the hand is in when doing the task
- Repeat this 3 times and take an average ($Force_{max}$)

Calculate % MVC = ($Force_{task}$ / $Force_{max}$)* 100

For example, if
$Force_{task}$ = 60N
$Force_{max}$ = 120N

% MVC = 50%
NPF= 50/10= 5

- Note this will differ by individual worker; thus this method is best when wanting to quantify an individual's exposure and his or her risk for an MSD.

- **Get and erect shipping carton**: 5s Right and left hands used together (100%work)- 3 exertions
- **Pack six 1Kg boxes**: 15s Alternate use of right and left hands (40% work) – 3 exertions
- **Close case and aside into taping machine**: 2s Right and left hands used together (100%work) – 2 exertions

Total Cycle Time = Time to construct carton + time to pack carton + time to close & aside carton

= 5s + 15s + 2s = 22s

Exertion Time = (1.0 x 5s) + (0.4 x 15s) + (1.0 x 2s)

Duty Cycle = exertion time/cycle time * 100

= 13s/22s]*100 = 60%

Recovery time = 22sec-13sec = 9 sec

Frequency = # exertions/second (exertions / total cycle time)

= 3 exertions + 3 exertions + 2 exertions = 8 exertions/22 seconds = 0.36 exertions/second = 0.36 Hz

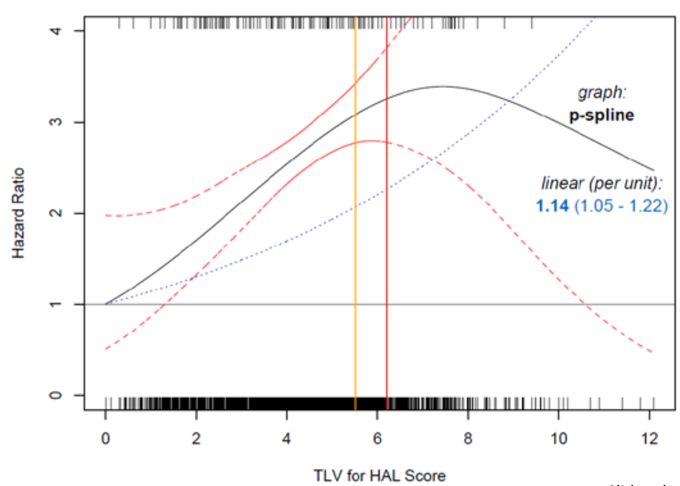
Quantify HAL from Frequency and Duty Cycle

$$HAL = 6.56 \ln D \left[\frac{F^{1.31}}{1 + 3.18\, F^{1.31}} \right]$$

HAL = 6.56 * ln 60[0.36 $^{1.31}$ / (1 + 3.18 * 0.36 $^{1.31}$)]
= 6.56 * ln 60 [0.26 / (1+3.18*0.26)]
= 6.56 * ln 60 [0.26/1.83]
= 6.56 * ln 60 [0.142]
= 6.56*4.094[0.142]
= 3.814

Risk Assessment

HR = 1.14 $^{(PF + 0.3*HAL)}$



Slide adapted from Jay Kapellusch

ACGIH TLV for HAL

Exposure[1]	N=2751 (n=186)	HR*
TLV for HAL $_{\geq 0.56\ \&\ <0.78}$		1.73 [1.19-2.5]
TLV for HAL $_{\geq 0.78}$		1.48 [1.02-2.13]

Exposure[2]	N=2299 (n=84)	IRR*
TLV for HAL $_{\geq 0.56\ \&\ <0.78}$		1.95 [1.21-3.16]
TLV for HAL $_{\geq 0.78}$		2.70 [1.48-4.91]

Risk increased for those above the Action Limit –current cutoffs might not be sufficiently protective

1 Kapellusch JM, Gerr FE, Malloy EJ, Garg A, Harris-Adamson C, Bao SS, Burt SE, Dale AM, Eisen E, Evanoff BA, Hegmann KT, Silverstein BA, Thiese MS, and Rempel D. Exposure-Response Relationships for the ACGIH TLV for Hand Activity Level: Results from a Pooled Data Study of Carpal Tunnel Syndrome. Scand J Work Environ Health. 2014;40(6):610-20.

2 Bonfiglioli R, Mattioli S, Armstrong TJ, Graziosi F, Marinelli F, Farioli A, Violante FS. Validation of the ACGIH TLV for hand activity level in the OCTOPUS cohort: a two-year longitudinal study of carpal tunnel syndrome. Scand J Work Environ Health 2013;39(2):155-163.

Demand ≤ Capacity by Design

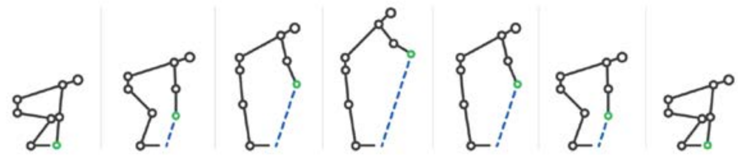
HANDPAK

POTVIN
BIOMECHANICS INC

Setting Acceptable Ergonomic Limits
For the Upper Extremities During Single &
Repetitive Efforts

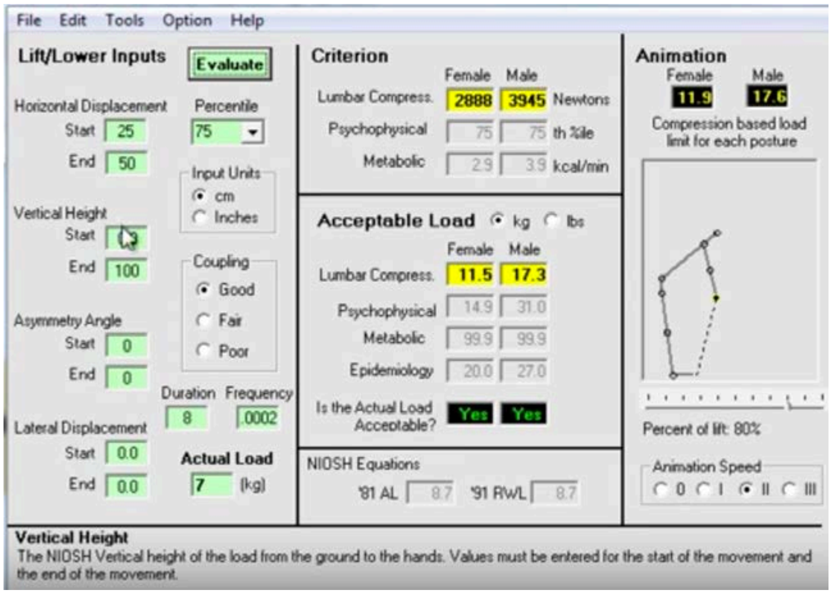
Setting acceptable loads for lifting and lowering by integrating all the information and deciding on the acceptable load based on the most appropriate criterion, or criteria, to base the limit.

BAKPAK™



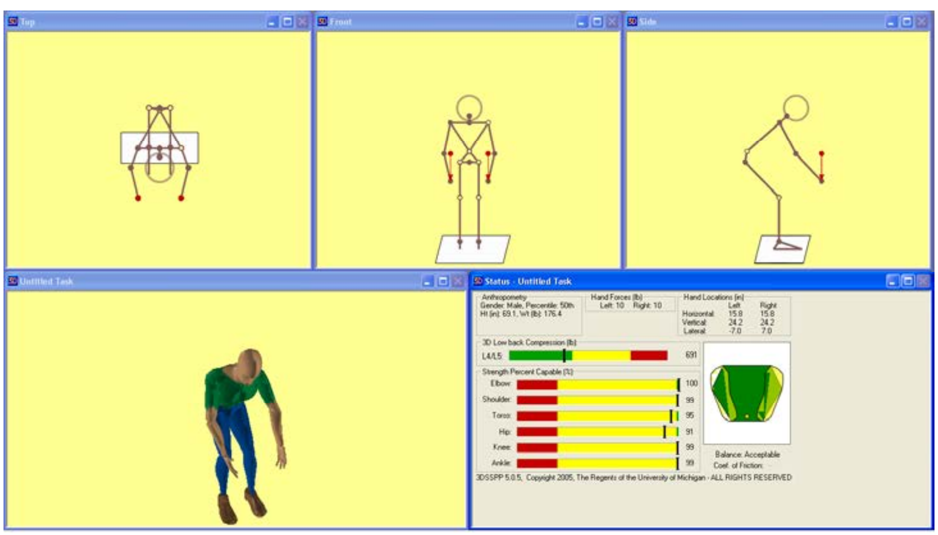
HandPak Wrist Strength Study Summary

Torque	Grip	Study	Female	Male
Wrist Flexion	Power Grip	1972 - Nordgren	■	
		1983 - Vanswearingen	■	■
		1990 - Anderson et al		■
		1995 - Snook et al	■	
		1998 - Al Eisawi		■
		1999 - Imrhan & Jenkins (max value)		■
		2004 - Greig & Wells	■	■
		2007 - Seo et al (JoB v40)	■	
		2008 - Seo et al	■	■
Wrist Extension	Power Grip	1968 - Backlund et al		■
		1972 - Nordgren	■	
		1995 - Snook et al	■	
		1999 - Imrhan & Jenkins (max value)	■	■
		2004 - Greig & Wells	■	■
		2007 - Seo et al (JoB v40)	■	■
		2008 - Seo et al		■
Ulnar Deviation	Power Grip	1983 - Vanswearingen	■	■
		1997 - Snook et al	■	
		2001 - Ciriello et al	■	
		2002 - Ciriello et al	■	
		2004 - Greig & Wells	■	■
Radial Deviation	Power Grip	1983 - Vanswearingen	■	■
		1998 - Al Eisawi		■
		2004 - Greig & Wells	■	■
Pronation	Power Grip	1972 - Nordgren (mean L&R)	■	
		1994 - Kramer et al	■	■
		2002 - O'Sullivan & Gallwey		■
		2005 - O'Sullivan & Gallwey		■
		2006 - Matsuoka et al	■	■
	Key Grip	1968 - Backlund et al		■
		1972 - Nordgren	■	
		2004 - Greig & Wells	■	■
	Screw driver	1986 - Mital et al (posture #5)	■	■
Supination	Power Grip	1968 - Backlund et al		■
		1972 - Nordgren	■	
		1994 - Kramer et al	■	■
		2002 - O'Sullivan & Gallwey		■
		2005 - O'Sullivan & Gallwey		■
	Key Grip	1968 - Backlund et al		■
		1972 - Nordgren	■	
		2004 - Greig & Wells	■	■
	Screw driver	1986 - Mital et al (posture #5)	■	■

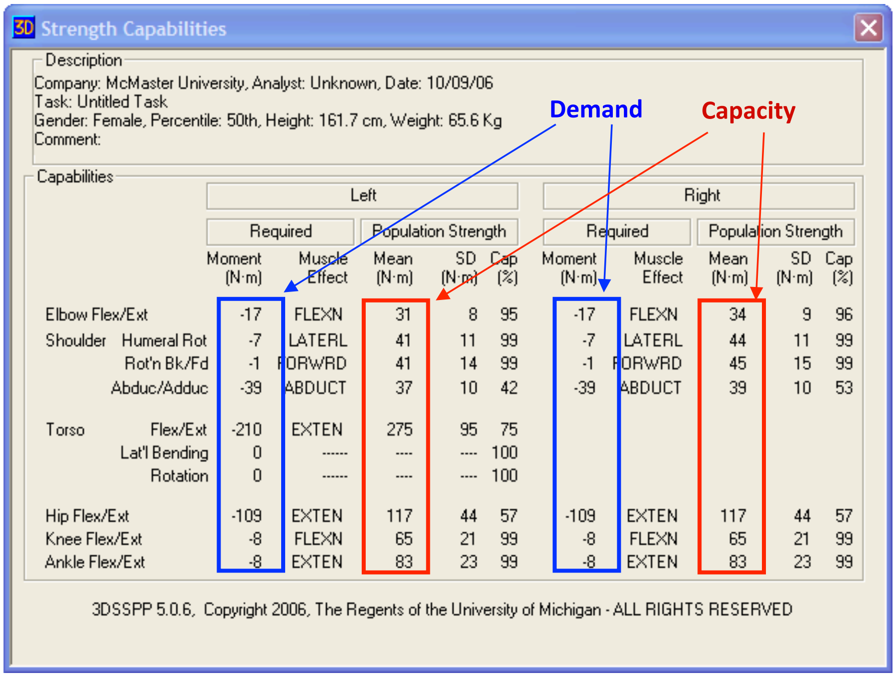


https://www.youtube.com/watch?v=o8F7VUzepVE

3D Static Strength Prediction Software (3DSSPP)



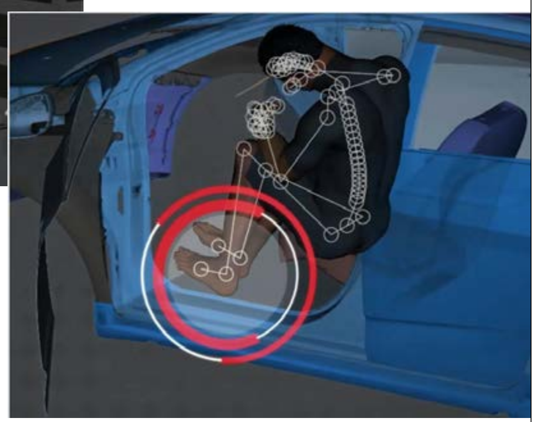
https://c4e.engin.umich.edu/tools-services/3dsspp-software/
https://www.youtube.com/watch?v=ub8XNaEHDA4



Description
Company: McMaster University, Analyst: Unknown, Date: 10/09/06
Task: Untitled Task
Gender: Female, Percentile: 50th, Height: 161.7 cm, Weight: 65.6 Kg
Comment:

Capabilities

	Left					Right				
	Required		Population Strength			Required		Population Strength		
	Moment (N·m)	Muscle Effect	Mean (N·m)	SD (N·m)	Cap (%)	Moment (N·m)	Muscle Effect	Mean (N·m)	SD (N·m)	Cap (%)
Elbow Flex/Ext	-17	FLEXN	31	8	95	-17	FLEXN	34	9	96
Shoulder Humeral Rot	-7	LATERL	41	11	99	-7	LATERL	44	11	99
Rot'n Bk/Fd	-1	FORWRD	41	14	99	-1	FORWRD	45	15	99
Abduc/Adduc	-39	ABDUCT	37	10	42	-39	ABDUCT	39	10	53
Torso Flex/Ext	-210	EXTEN	275	95	75					
Lat'l Bending	0	------	----	----	100					
Rotation	0	------	----	----	100					
Hip Flex/Ext	-109	EXTEN	117	44	57	-109	EXTEN	117	44	57
Knee Flex/Ext	-8	FLEXN	65	21	99	-8	FLEXN	65	21	99
Ankle Flex/Ext	-8	EXTEN	83	23	99	-8	EXTEN	83	23	99



https://www.youtube.com/watch?v=KImGWaGynqU

SANTOSHUMAN

Design to Research to Practice.

Testable Hypothesis

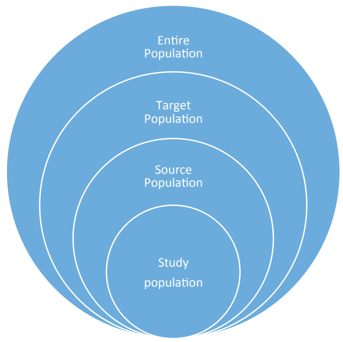
- **Null Hypothesis**: Ho = there is no association between the exposure and the outcome in the source population
- **Alternative Hypothesis**: Ha = there is an association between the exposure and the outcome in the source population

A good hypothesis will have a strong rationale to support it.

Population

Population Identification?

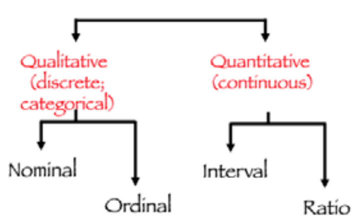
Inclusion & Exclusion Criteria?



Variables

Independent variable: The treatment, exposure or predictor variables; the variable manipulated by the investigator

Dependent variable: The outcome variables are the ones being measured to determine the affect or outcome of the independent variable



Research Study Designs

- Non-Experimental:
  - Cross Sectional Study
  - Cohort Study
  - Case-Control Study

- **Experimental:**
  - **Parallel Study**
  - **Cross Over Study**
  - **Factorial Study**

Experimental Studies

- Investigator allocates the Exposure/ Intervention
- Randomization of Exposure or Intervention
- Subjects are followed over time to document development of outcome

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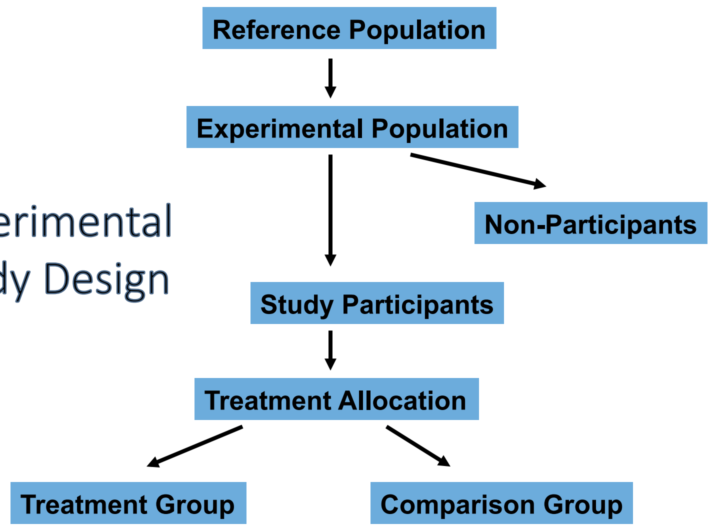
Experimental Study Design



Outcomes Statistically Compared

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Parallel Design

- Each individual participant allocated to group that receives only one treatment
- Comparison group gets current standard treatment or placebo
- Groups are followed up and outcomes assessed in a consistent way

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Crossover Design

- **Each treatment is administered to each patient at different times in the study**
  - ❑*Order of treatments*, not persons, is randomized
  - ❑Permits within-person comparisons of treatment effects
  - ❑Less confounder variability within persons than between persons--increases study power
  - ❑May improve recruitment—everyone treated
  - ❑Requires treatments that act in the short term
    - ➢e.g. blood pressure medication

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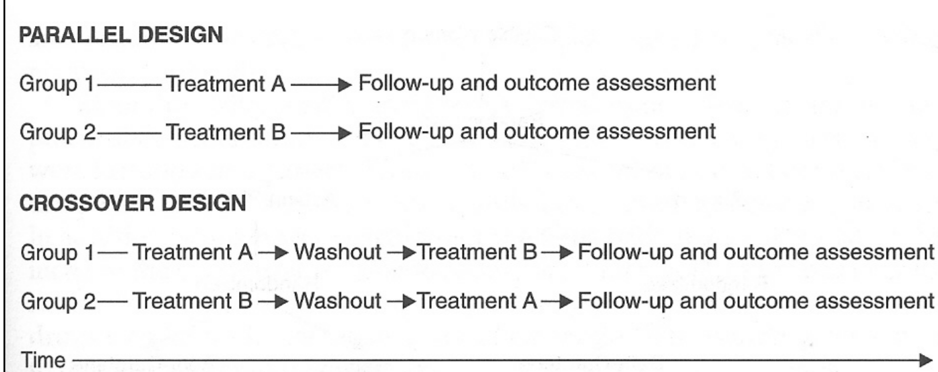
Parallel vs. Cross Over Design



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Ref: Aschengrau & Seage. *Essentials of Epidemiology in Public Health*, 2nd Ed. 2008

Factorial Design

- Two or more treatments tested together using a common placebo control group
- The interaction of the treatments can be evaluated.
- The two treatments must be compatible (i.e., synergy of side effects must not make the regimen hazardous)
- Not appropriate for treatments with the same physiologic mechanism of action

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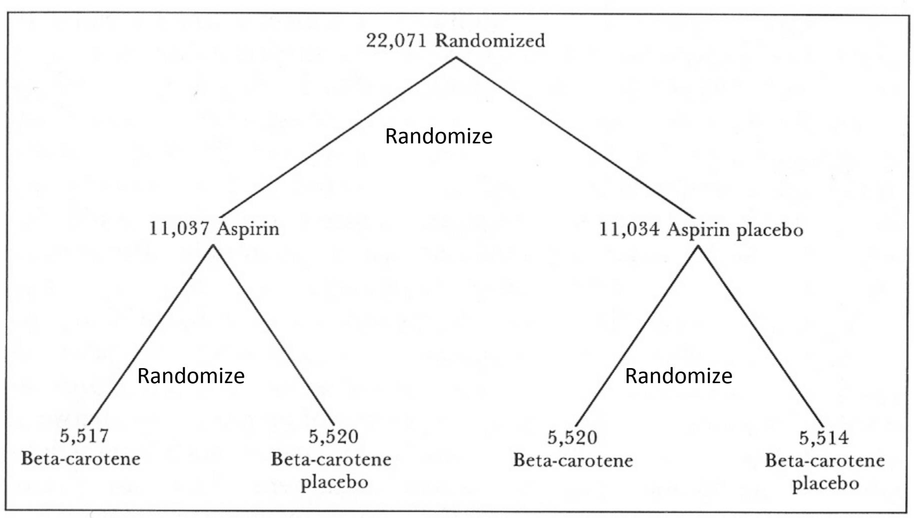

Fig. 8-3. Randomization scheme for a two-by-two factorial design: Physicians' Health Study.

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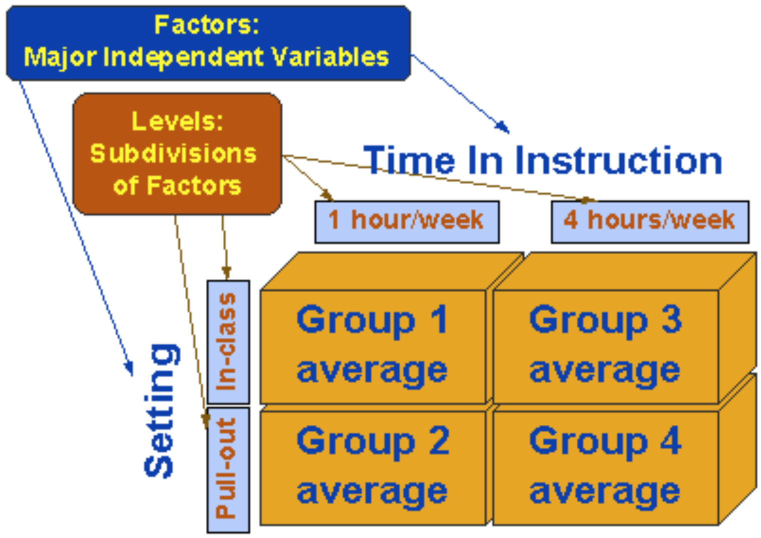
Ref: Hennekens & Buring. *Epidemiology in Medicine*. 1987



Randomization

- Randomization equalizes the groups on all potential confounding factors (the association with the exposure is eliminated)
- Each individual has the same chance of receiving each of the possible interventions
- Eliminates conscious or unconscious bias due to physician or patient selection, or other unknown factors
- Methods of Randomization
  - Simple randomization
  - Blocked randomization
  - Stratified randomization

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Simple randomization

Each individual should have the same chance of receiving each possible intervention:

- Random number table
- Random number generator (computer)

As each subject enrolled, assign the next occurring random number: even numbers get treatment A and odd numbers get treatment B

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Blocked randomization

- Guarantees treatment group sizes will be equal
- Study has treatment groups A and B- Block size to be used = 4
- Identify all possible permutations of A and B with equal numbers of A's and B's for N = 4

AABB
ABAB
ABBA
BABA
BAAB
BBAA

These are the six different ways to arrange two As and two Bs

- Randomly select one permutation for each block. Allocate subjects in entry order

80

Stratified randomization

- Ensures that each study group has sufficient numbers of subjects in categories of key variables (e.g., age, gender or ethnicity).
- Define a small number of stratification categories (e.g., 10-year age strata) and randomly select study subjects (possibly using blocked method) within them.
- May mean that some eligible people within the most populous stratification categories are not included in the study.

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Non-Random Allocation Methods

- Alternating patients between treatments
- Based on day of week of allocation
- Based on month of birthday
- Last digit of hospital record number (odd or even)

There is the possibility of systematic error in allocation to treatment groups.

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Other Steps

Methods

- Frequency of measures
- Duration of protocol
- Data processing approach
- Data summary
- Statistical analysis

Results & Discussion

- Visual Presentation
- Interpretation
- Statistical Significance vs. Clinical Significance
- Application to Design
- Application to Practice

Designing an intervention study.

Background

- 1.8 million people who work in hotels, about 25% of which are responsible for cleaning hotel rooms (Bureau of Labor Statistics, 2008)
- Primarily women of color and/or immigrant status (Wial & Rickert, 2002)
- At risk for developing MSDs based on psychosocial and physical risk factors (Krause et al, 2005; Krause et al, 2009)
- Injury rate is higher than any other type of hotel worker at 7.9/100 workers and 3.2/100 workers (Buchannan et al, 2009)

Bed Making

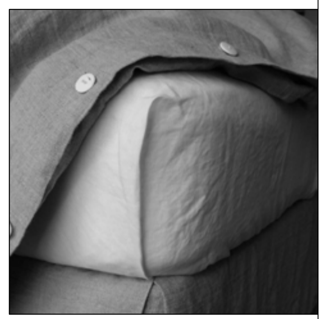
http://images.travelnow.com/hotels/1000000/30000/25700/25606/25606_85_b.jpg

Introduction of luxurious mattress in 1999 set off **"hotel bed wars"**

To compare biomechanical, physiological & subjective outcomes while making luxurious hotel beds:

- with and without a mattress lift tool
- while using fitted versus flat bottom sheets





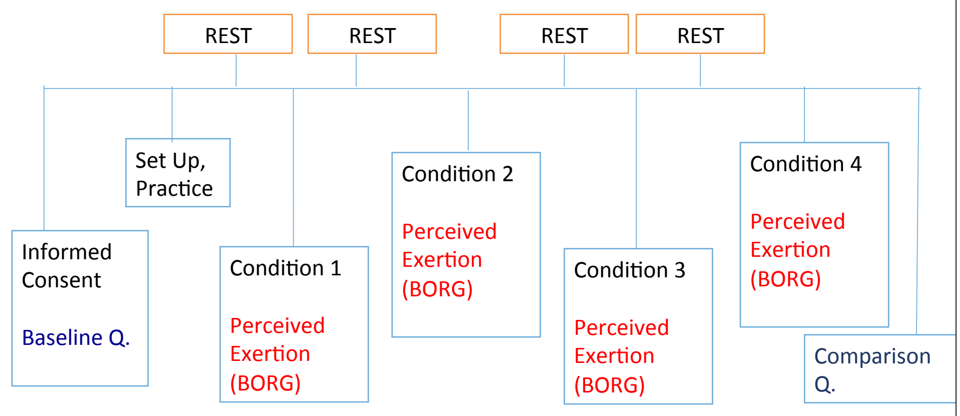
Methods

- **16 Hotel Room Cleaners** from local SF Bay Unions
- **Inclusion Criteria**
  - At least 6 months full time hotel room cleaner
  - English or Spanish speaking females
- **Exclusion Criteria**
  - an active or recently filed (within 1 year) workers compensation claim
  - Severe (≥6) pain over the past week
  - Untreated High Blood Pressure

Methods

- Multi-factorial Cross-Over Design
- Randomized order of Conditions- 2 trials each

	Flat Sheet	Fitted Sheet
No Tool	Condition 1	Condition 3
Tool	Condition 2	Condition 4

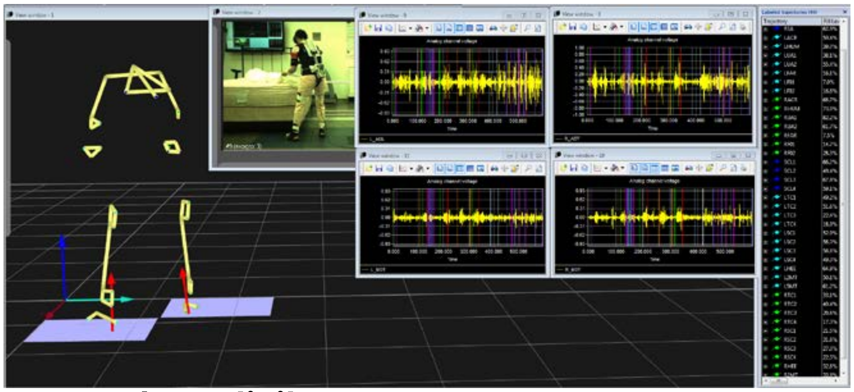


Methods

Baseline Questionnaire

- Demographic data
- Work experience
- Productivity requirements at work
- Discomfort in past 4 months
- Medication use for discomfort
- Work Disability Measures

Methods



Muscle Activity

- Wireless surface EMG (Delsys Trigno)
- Flexor digitorum superficialis(FDS), extensor digitorum(ED), Biceps Brachii (BB)

Motion Capture

- 15 camera system (Qualisys Oqus) 44 Markers
- Video- Task & Subtask identification
- Body segment kinematics

Methods

Physiological Measures

- Pre & Post Blood Pressure (manual oscillometry)
- Continuous HR Monitoring (Garmin)

Three-dimensional kinematics of the spine

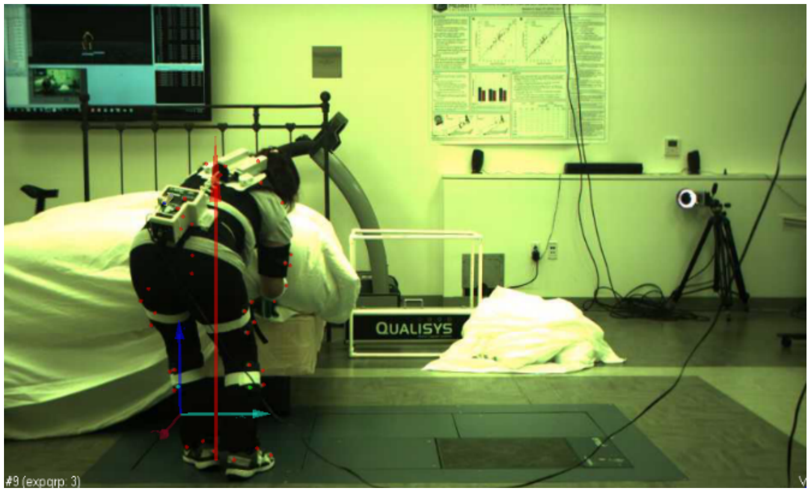
- Lumbar Motion Monitor (iLMM1; nextgenergo)
- Continuous angular position, velocity and acceleration (Marras et al. 1993; Marras et al. 1995)

Perceived Exertion

- Borg CR-10 (Borg, 1998)

Comparison Survey

- Preference
- Usability
- Perceived effectiveness



Your turn!

- Design an intervention study to test the impact of a design/intervention of your choice on workers
- Identify the following:
  - Overall Question
  - Testable Hypotheses
  - Population
  - Independent & Dependent Variables
  - Protocol Details
  - Roughly, how would you interpret & apply your data to the re(design) of the intervention and/or to practice

About the UC Ergonomics Program

UCSF/ UCB Ergonomics Research & Graduate Training Program

Through research and education, we aim to understand the mechanisms leading to Work Related Musculoskeletal Disorders (WRMSDs), then identify and evaluate equipment designs and work practices that reduce the risk of WRMSDs while optimizing human performance.

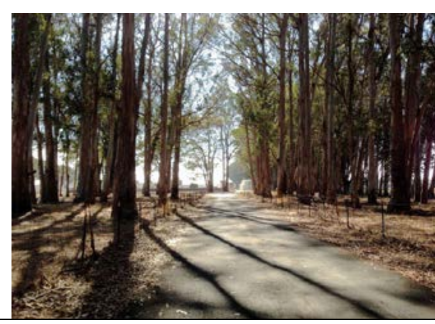
Multidisciplinary Team

- Director
- Senior Engineer
- Students
  - School of Public Health (3)
  - School of Engineering (6)
  - School of Medicine (3)
  - Other (1)
- Visiting Student Scholars (4-6 annually)
- Visiting Scholars
- Team of affiliated Professors and Industry experts

Laboratory Resources

3,000 square feet space at Berkeley Global Campus

- Fabrication shop (metal, wood)
- Tool Room
- 4 laboratory spaces
- Main Conference Room/Library
- Offices & Student workstations
- Shuttle service to main UCB Campus
- Plenty of parking
- Access to beautiful SF Bay and bay trails



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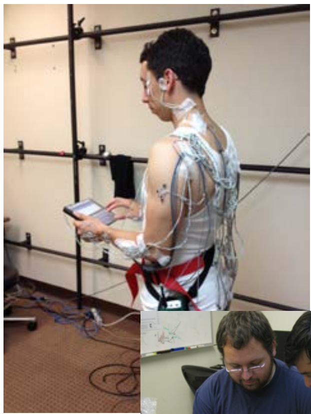
Test Bench Lab

Controlled room designed to study the impact of different tools on vibration, force, and silica dust exposure

- Fabrication shop (metal & wood)
- Outdoor area to produce consistent concrete test blocks
- Controlled room specified for silica dust exposure assessments

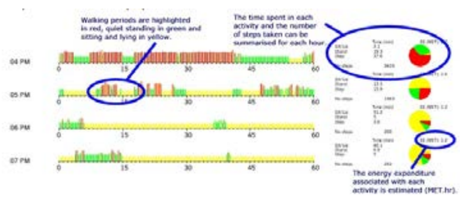
Biomechanics Lab



- Upper Extremity Motion Capture (Optotrak)
- Electromyography (Neurometrix)
- 3D Kinematic System (Noraxon-Myomotion)
- Various force transducers, accelerometers, strain gauge transducers
- Software Applications (SolidWorks, MVTA, Stata etc)

Work Physiology Lab

- Supports laboratory and field based measurements of cardiovascular workload
- Includes:
    - Treadmill, stairs
    - Ambulatory blood pressure cuffs (Spacelabs)
    - Chest worn heart rate monitoring devices (Actiheart)
        - Garmin (same day)
        - Actiheart (week long)
    - Activity monitors (Activpal)
        - Accelerometer based device to quantify time in various postures and activities



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Human-Computer Interaction lab

Dedicated space to developing and testing gestures

- Leap Motion
- Kinect
- Occulus

Areas of Research

Exposure Assessment

Ergonomic research and policies have suffered from insufficient exposure assessment methods. New technology ("wearable devices") is allowing us to quantify exposures in new and exciting ways.

Epidemiology

Identifying causal associations between physical exposures and various MSDs, cardio-metabolic diseases and/or related work disabilities is a critical step to developing appropriate solutions.

Prevention through Design

Prevention through design research spans multiple industries and applications yet share commonalities in purpose; to prevent MSDs through better design of tools, equipment, gestures and work space.

Translational Research

Applying research to practice is critical to ensuring that workers gain the health benefits possible through new discoveries. By partnering with organizations that work with unions and other labor groups, we help implement new technologies and knowledge in the field.

Developing an Upper Extremity Exposure Dosimeter

- Our primary objective is to develop a methodology for estimating grip force, repetition and wrist posture using inertial measurement units (IMUs) and surface electromyography (sEMG).
- A secondary objective is to use sEMG and IMU data to quantify simultaneous exposures of grip force, repetition and wrist posture during various upper extremity tasks.

Cardiovascular Strain Assessment in Hotel Housekeepers

- Cleaning tasks require high levels of physical activity which could exceed the recommended levels of relative aerobic workload
- Cleaners have several factors that place them at increased risk of CVD
- Purpose: to evaluate the impact of high occupational physical activity on the cardiovascular system of hotel room cleaners

Association of heavy load carrying, MSDs and womens' health issues among women in developing countries.

- Health impacts such as low back pain and incontinence affect an individual's capacity to carry out daily activities, including their ability to work and care for children
- Purpose: To understand the association between heavy load carrying, MSDs and POP in women of developing countries.

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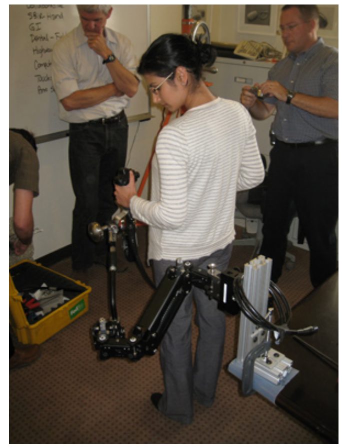
The ergonomic impact of a colonoscope stand during endoscopies.

- A prior study by our group found that 60% of endoscopists surveyed suffered from a musculoskeletal complaint related to endoscopy procedures.
- Peak thumb pinch forces often exceeded thresholds of 10N and left forearm mean muscle activity ranged between 20-50% of maximum voluntary contraction.
- Purpose: to assess whether the use of a colonoscope stand reduces physical exposures during endoscopies.



The influence of drill bit sharpness on silica dust and vibration exposure.

- Prior work has shown that drill bit sharpness does impact both the amount of silica dust exposure as well as hand arm vibration.
- The precise impact of drill bit wear on exposures is not known, particularly for different types of drill bits (hollow vs. solid).
- Purpose: To quantify how sharpness of drill bits (hollow and solid) influence silica dust and vibration exposure.

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The impact of exoskeletons on shoulder and spinal kinematics, muscle activation patterns and fatigue during lifting and overhead tasks.

- The objective of this experiment is to evaluate how the a trunk or upper extremity exoskeleton affects spinal kinematics and muscle activation patterns in a worker performing repetitive lifting or overhead tasks under different conditions.

Questions & Comments

http://ergo.berkeley.edu

Carisa.Harris-Adamson@ucsf.edu

References

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