NATIONAL ERGONOMICS Conference & ErgoExpo®

New and Easy to Use Ergonomics Risk Assessment Tools for the Back, Distal Upper Extremity and Shoulder

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Industrial and Systems Engineering

Overview

- **New understanding of how musculoskeletal disorders (MSDs) develop**
- **New easy-to-use risk assessment tools for**
  - Lifting Tasks
  - Hand-Wrist intensive tasks
  - Shoulder intensive tasks

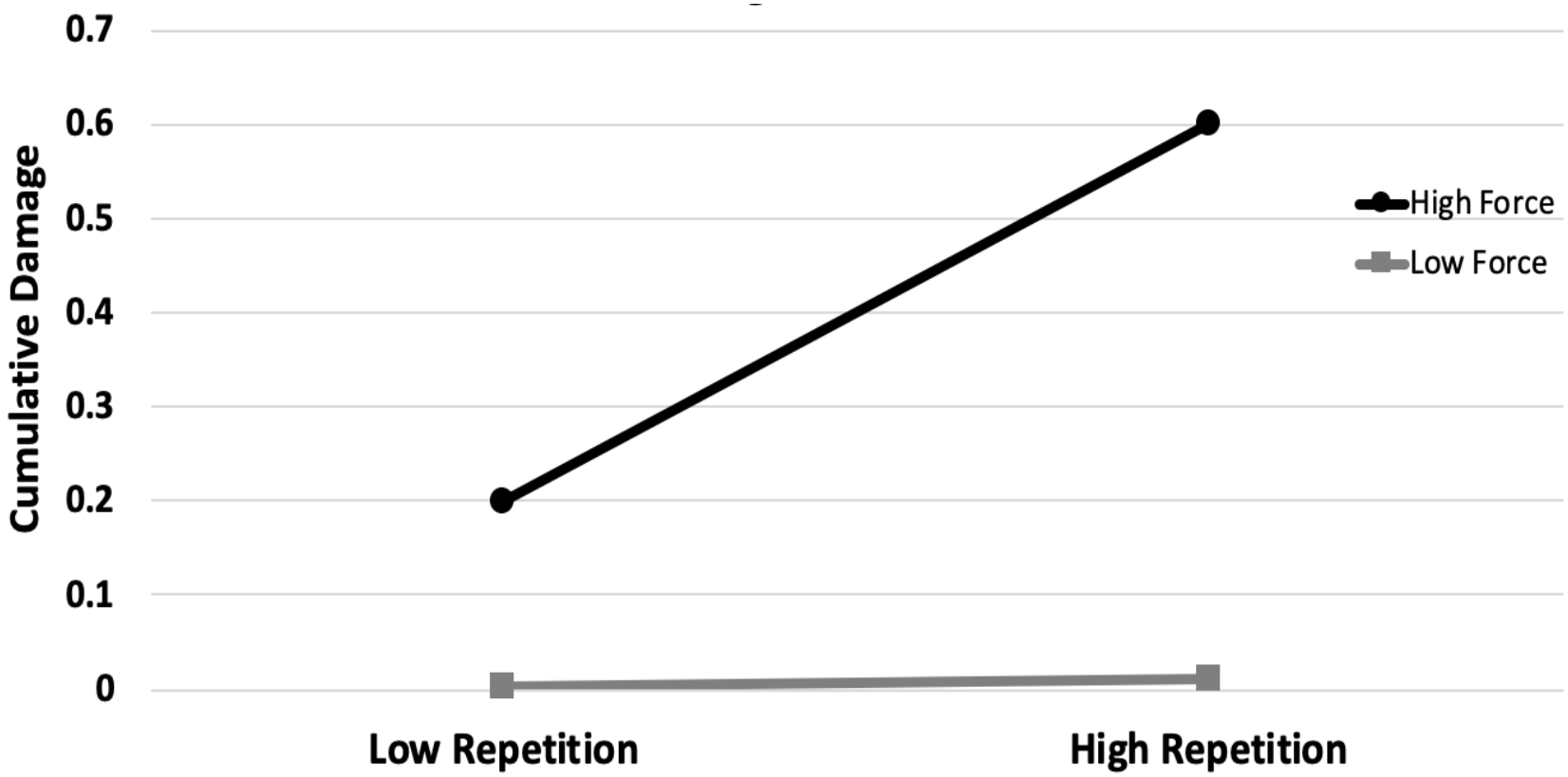
Fatigue Failure

- **The process by which *ALL* materials incur damage when subjected to repeated stress**
- **Are musculoskeletal tissues materials?**
- **Are they subjected to repeated stress?**
- **Is there evidence that musculoskeletal tissues experience cumulative damage due to fatigue failure?**

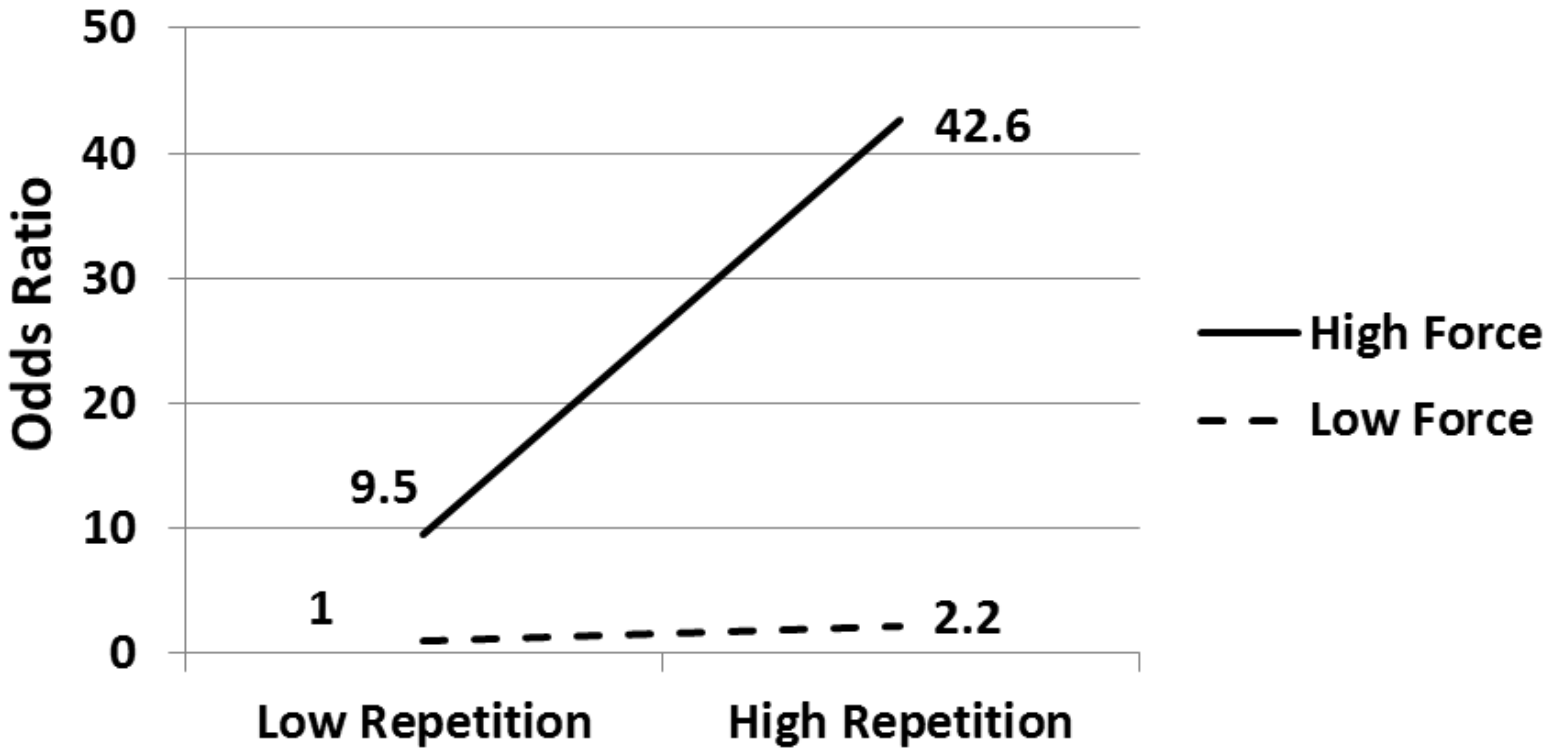
Evidence MSDs result from Fatigue Failure

- **Epidemiology studies**
  - Interaction between force and repetition consistent with fatigue failure observed (Gallagher and Heberger, 2013)
- **In vitro cyclic loading studies**
  - Tendons, ligaments, cartilage, muscle, bone all demonstrate a fatigue failure response when repeatedly stressed
- **Animal studies**
  - Studies demonstrate pathology responses predicted by fatigue failure
  - Fatigue failure demonstrated to occur *in vivo*

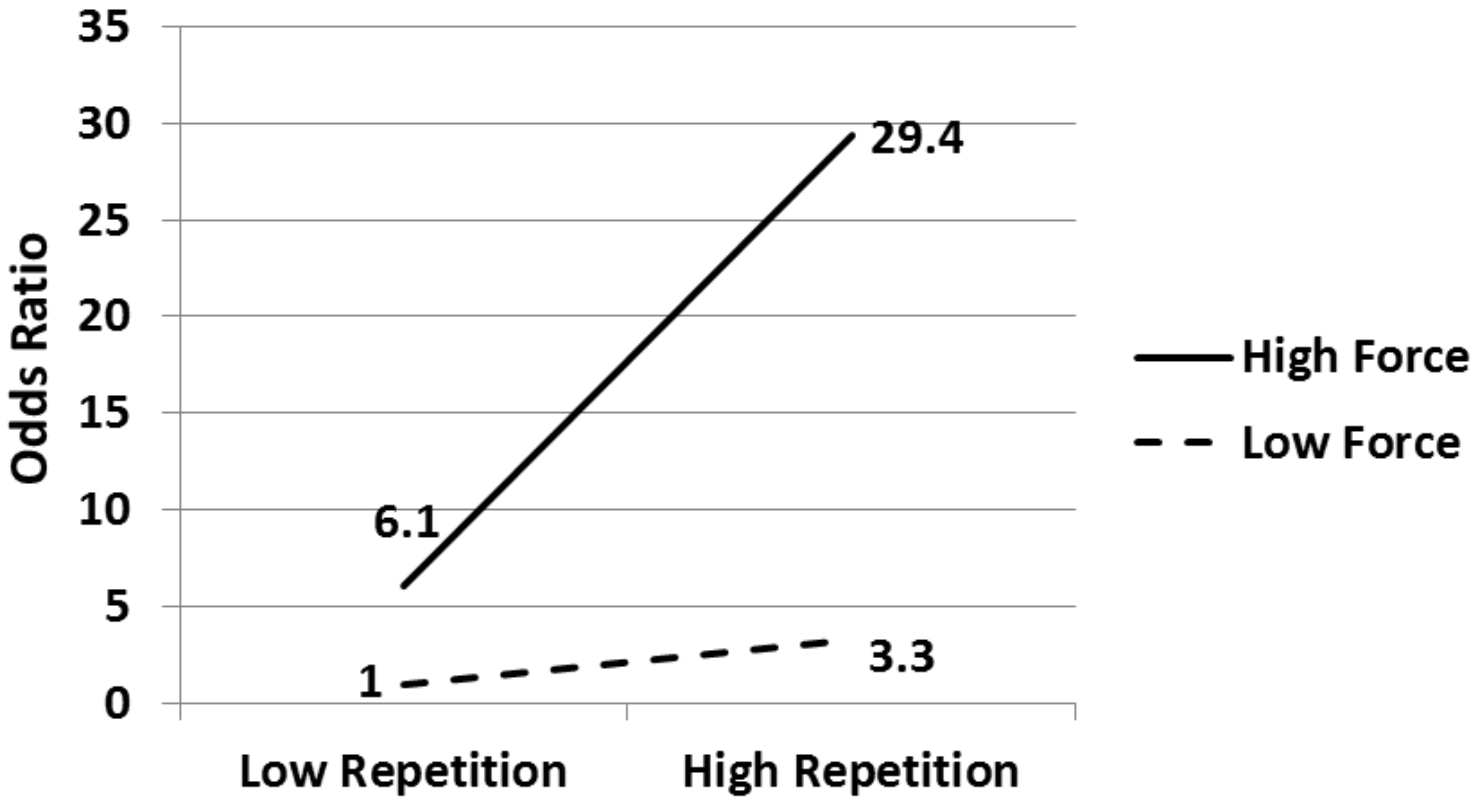
Expected Force-Repetition Interaction for a Fatigue Failure Process



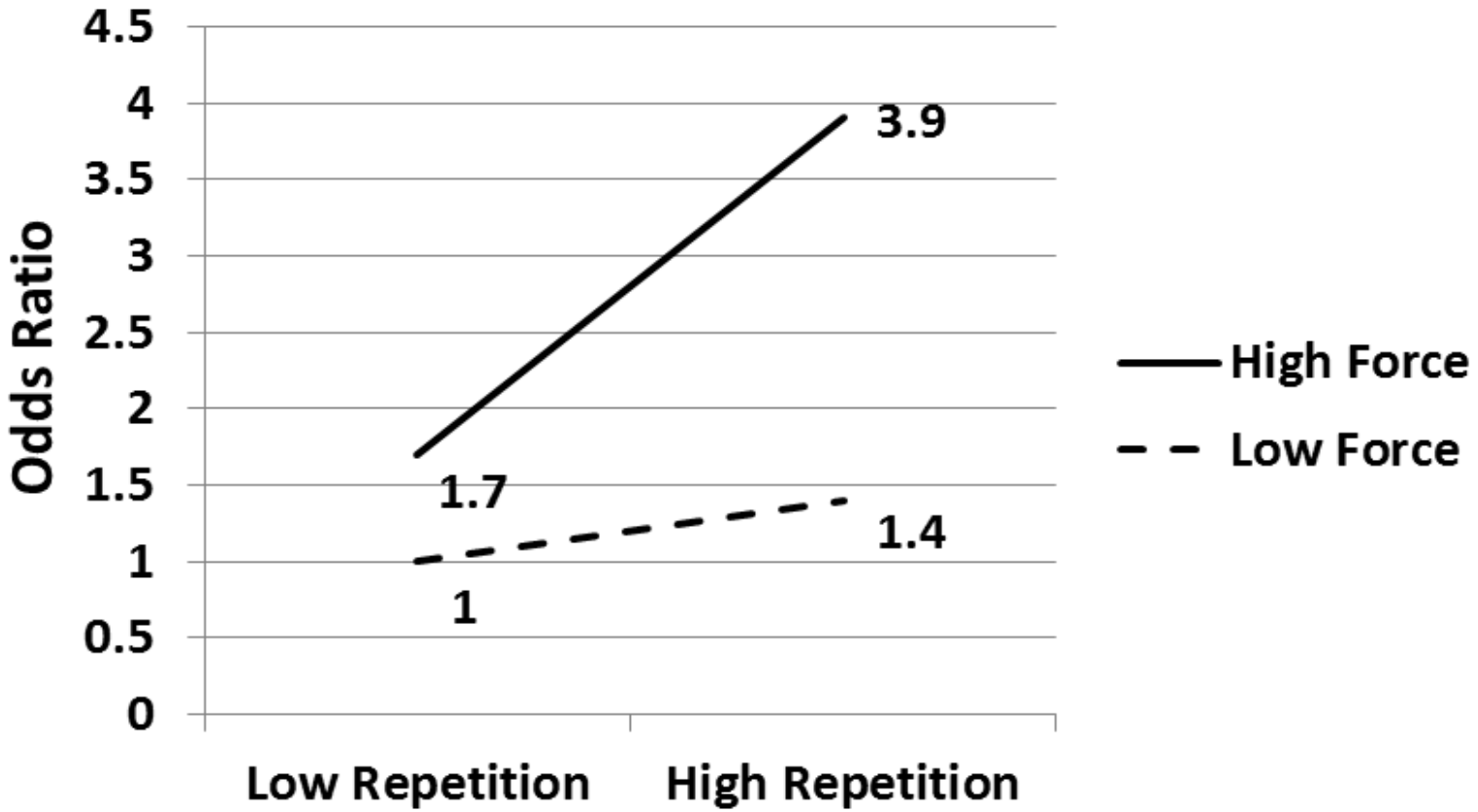
Low Back Disorders (Marras et al., 1993)



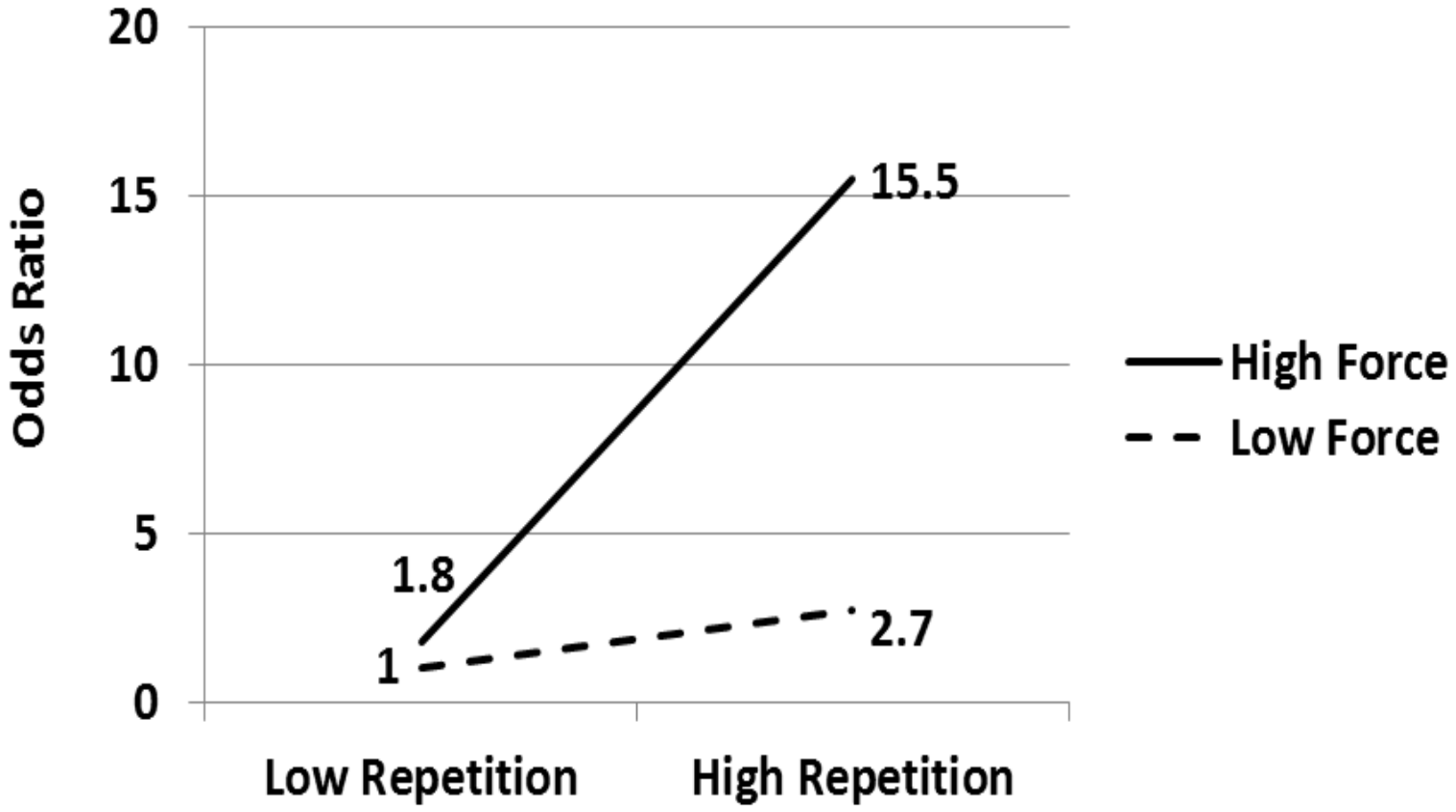
Hand-Wrist Tendinitis (Armstrong et al., 1987)



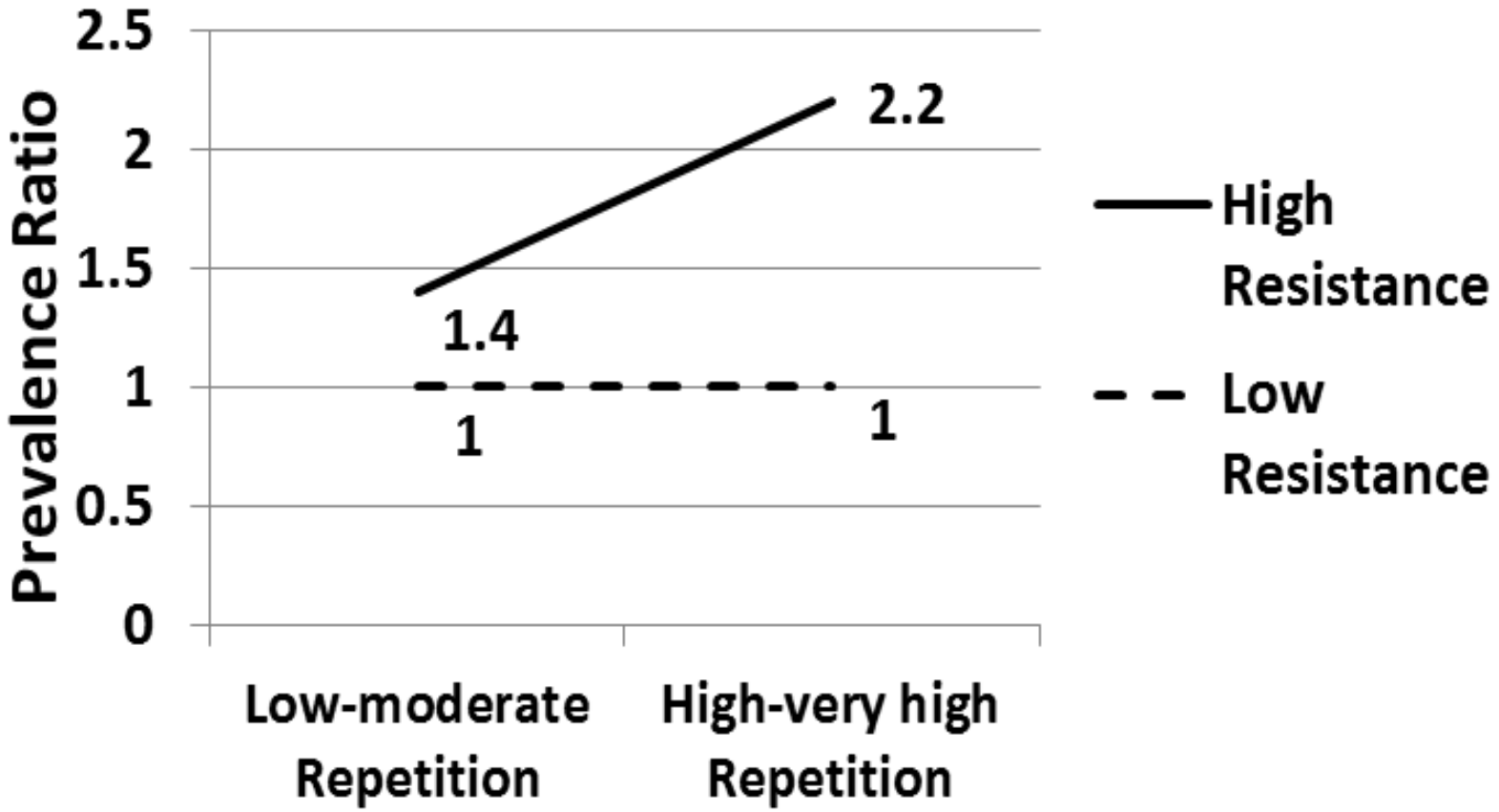
Lateral Epicondylitis (Haahr and Andersen, 1997)



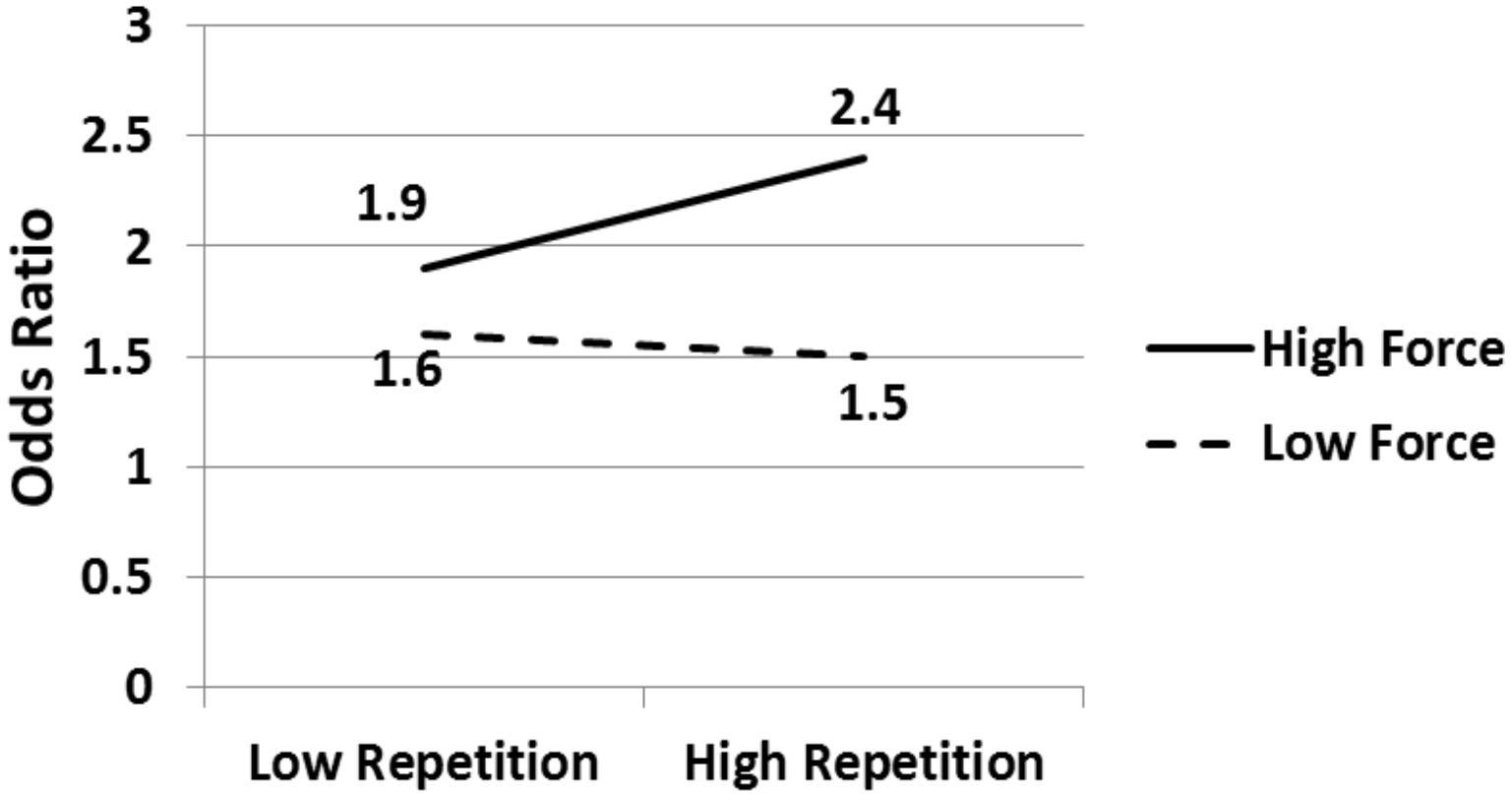
Carpal Tunnel Syndrome (Silverstein et al., 1987)



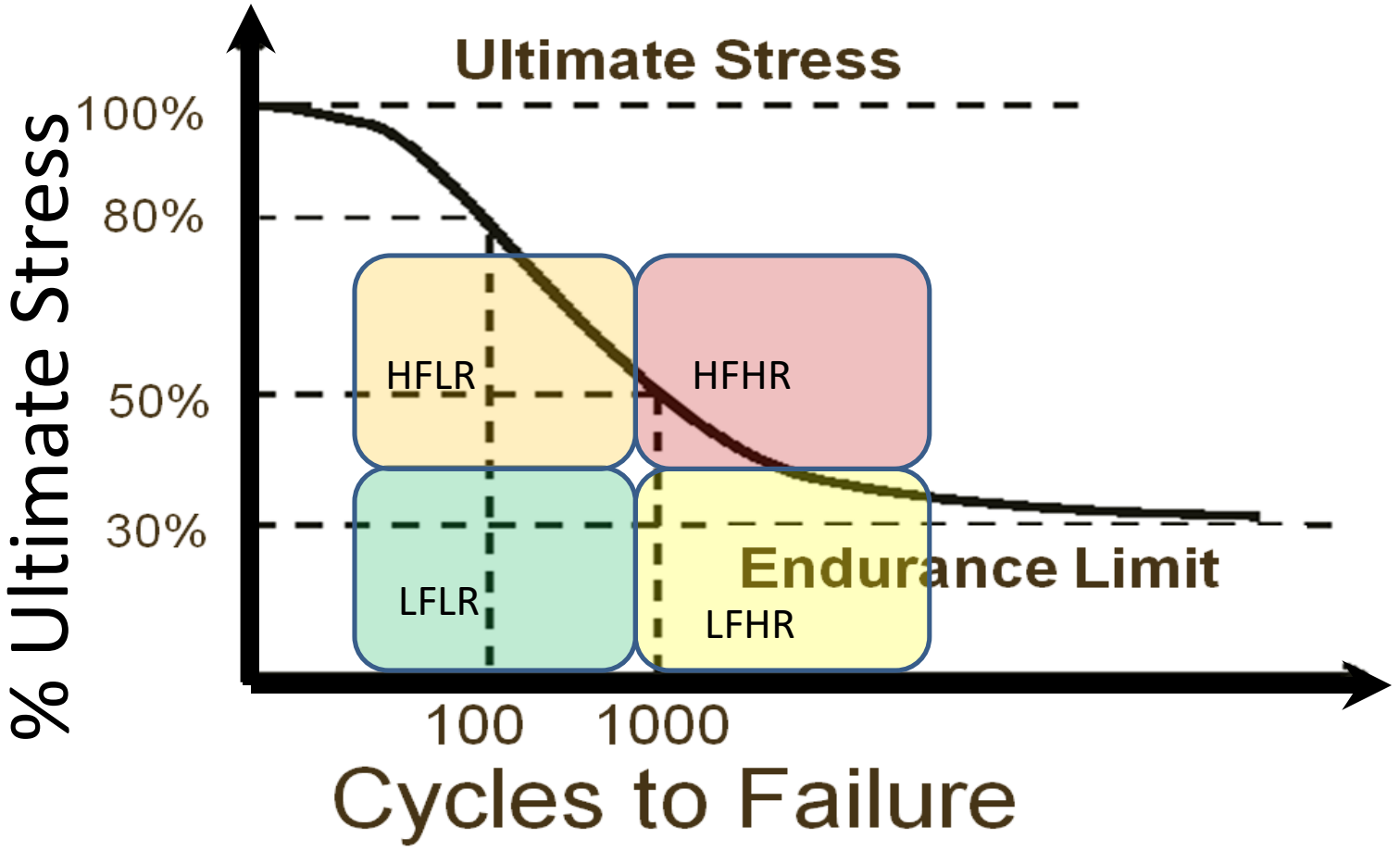
Nerve Conduction Latency (Nathan et al., 1988)



Force and Repetition for Prevalent Hand Pain (Thomsen et al., 2007)



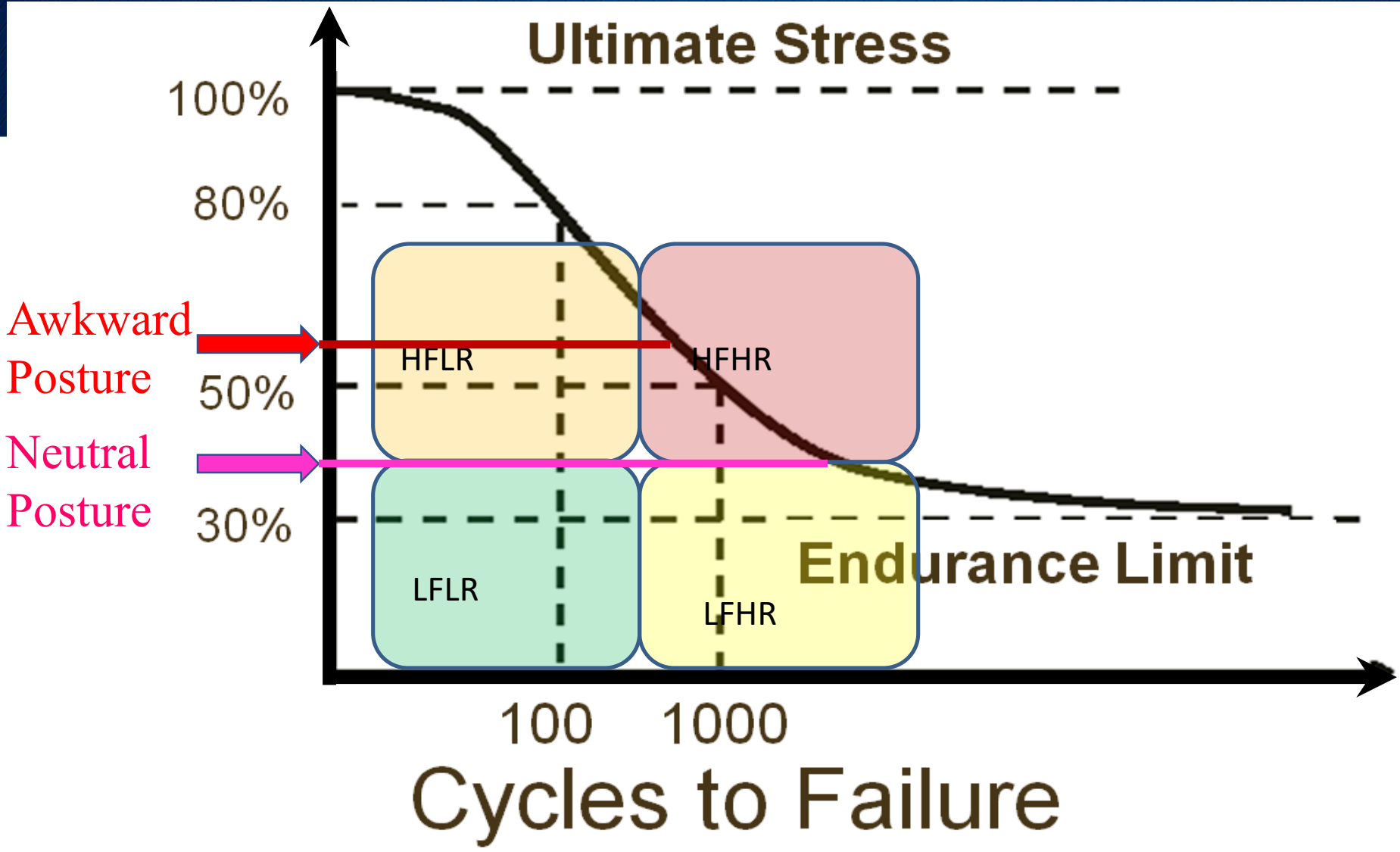
S-N Curve


Ultimate Stress
100%
80%
50%
30%
% Ultimate Stress
HFLR
HFHR
LFLR
LFHR
Endurance Limit
100
1000
Cycles to Failure

MSD Risk Factors

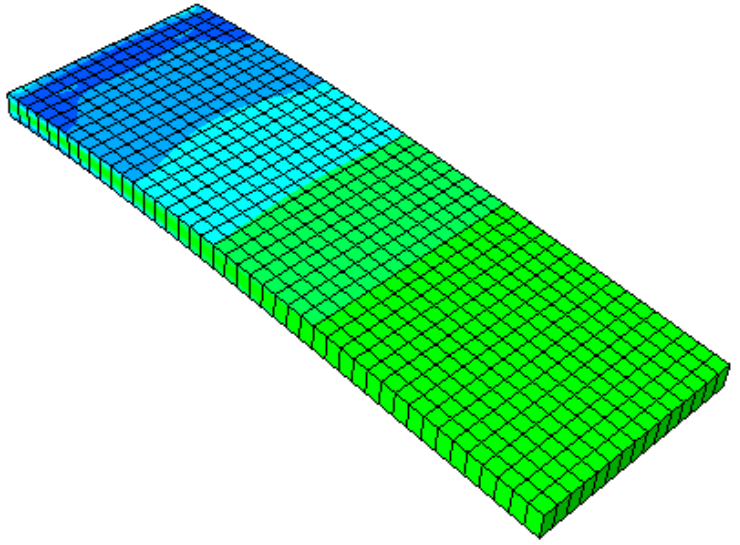
- Force
- Repetition
- ***Posture***
- Vibration

F*R interaction and Posture as an MSD risk factor



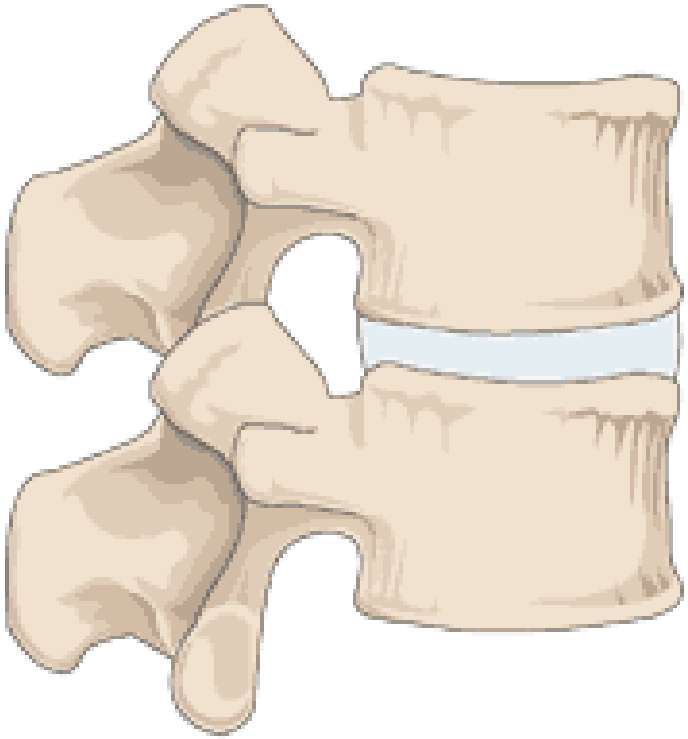
What about vibration?

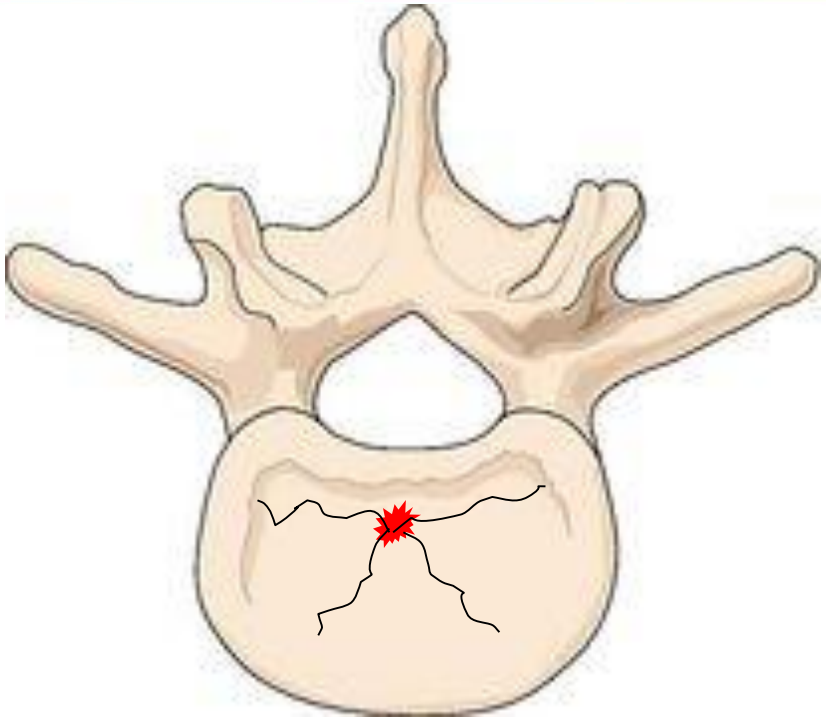
- Vibration also involves force and repetition
- Vibration is a common fatigue failure test scenario for materials



"First mode of cantilever animation" by Matjaz285 (talk) - self-made. Licensed under GFDL via Wikipedia - https://en.wikipedia.org/wiki/File:First_mode_of_cantilever_animation.gif#/

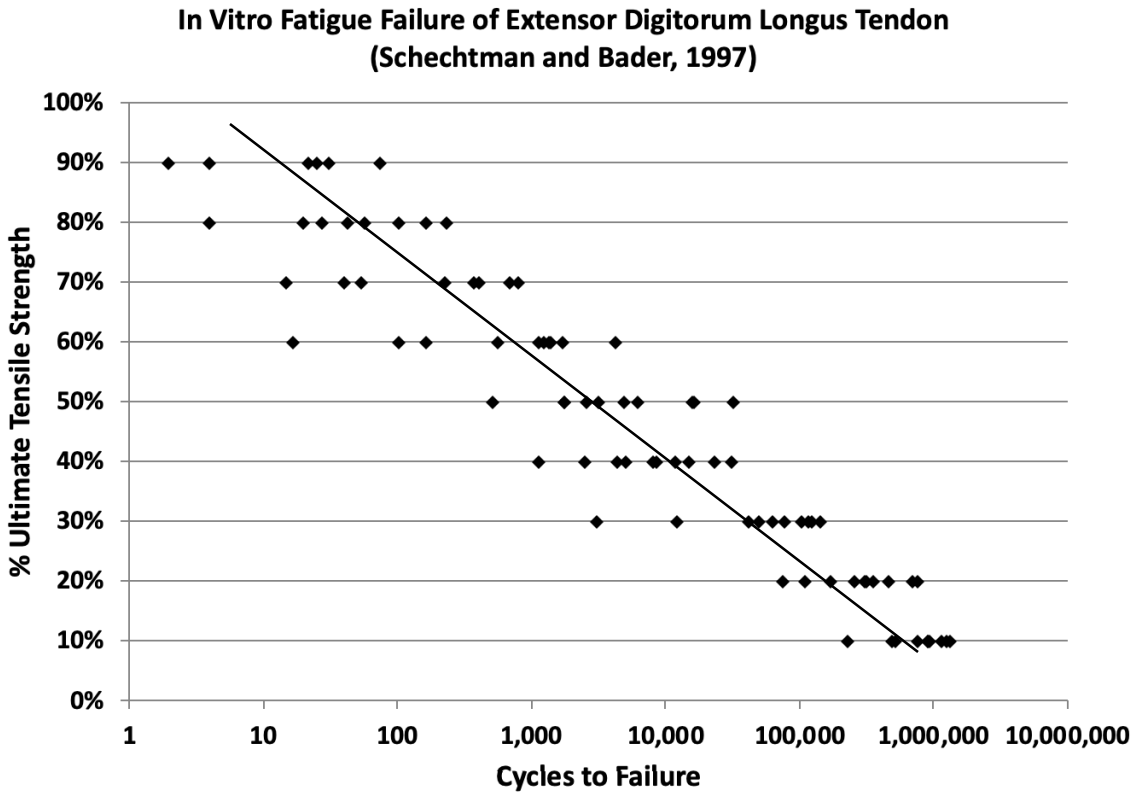
We believe Fatigue Failure is the *mechanism* by which damage to tissues occurs





Fatigue Testing of Musculoskeletal Tissue

- Tendons
- Ligaments
- Spines
- Cartilage
- Bone



Cumulative Damage Assessment (Palmgren-Miner rule)

% Ult. Strength	Cycles to Failure	Cycles experienced
60%	1000	15
50%	10000	100
40%	100000	700

Cumulative Damage Assessment (Palmgren-Miner rule)

% Ult. Strength	Cycles to Failure	Cycles experienced
60%	1000	15
50%	10000	100
40%	100000	700

$$D_{(t)} = \frac{15}{1000} + \frac{100}{10000} + \frac{700}{100000}$$

$$= .015 + .01 + .007 = 0.032$$

Key Takeaways

- As stress increases, the impact of each repetition becomes exponentially greater in terms of damage development
- The number of cycles to failure grows exponentially smaller at higher stress levels

Fatigue Failure-Based Risk Assessment Tools

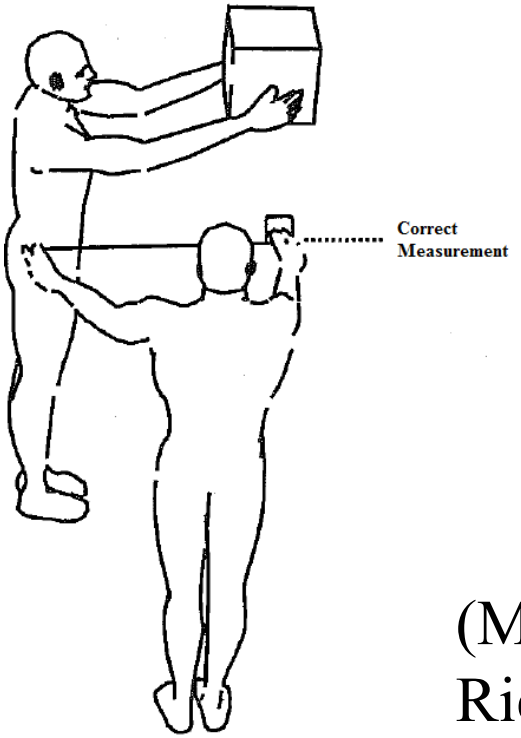
- **LiFFT – Lifting Fatigue Failure Tool**
- **DUET – Distal Upper Extremity Tool**
- **The Shoulder Tool**

The *Li*fting *F*atigue *F*ailure *T*ool: LiFFT

Inputs needed for LiFFT analysis

1. Weight of the load
2. Peak horizontal distance from hip to center of load during the lift
3. Number of repetitions for this task per day

Horizontal Distance measurement

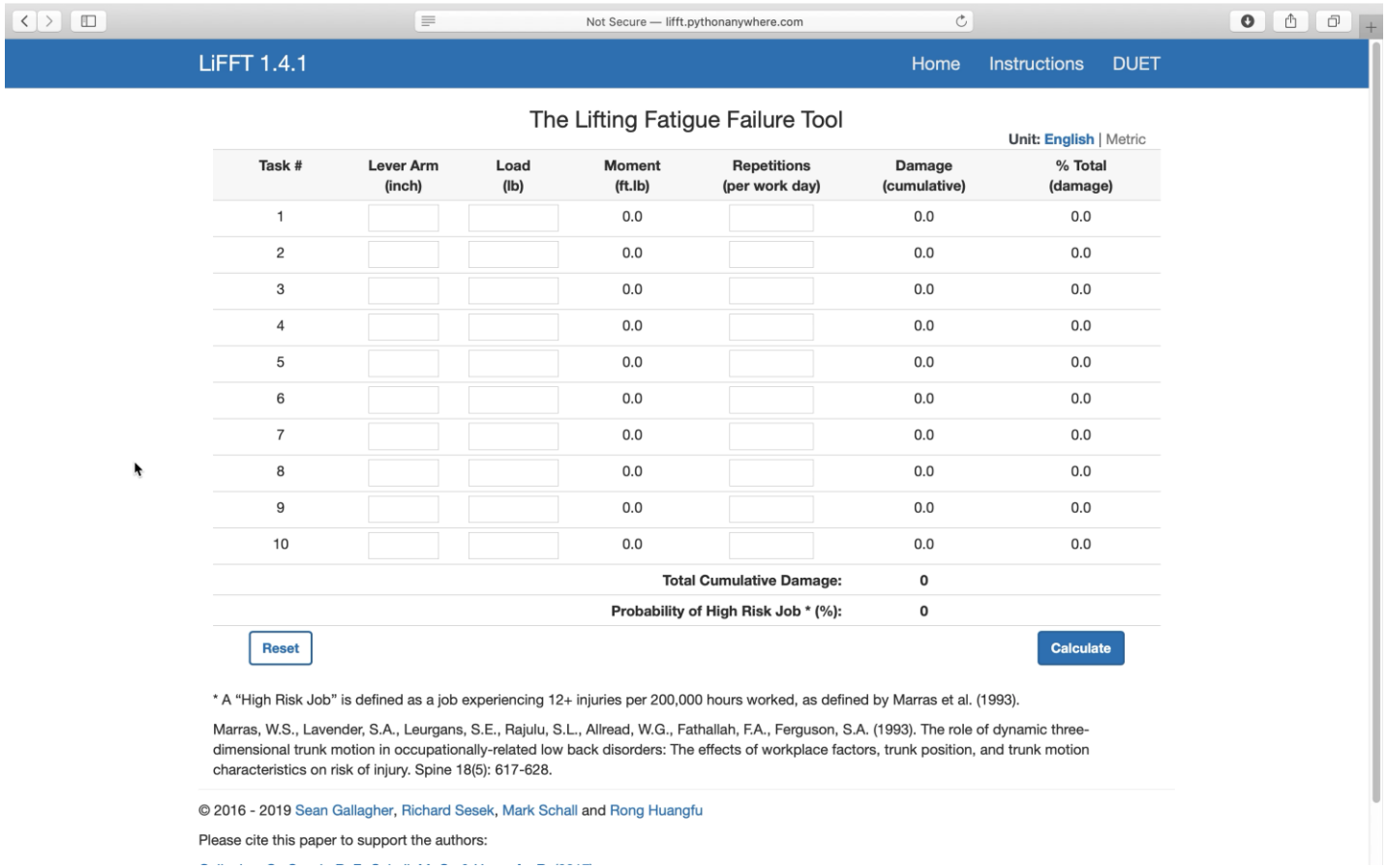


(Marras, Allread, and Ried, 1999)

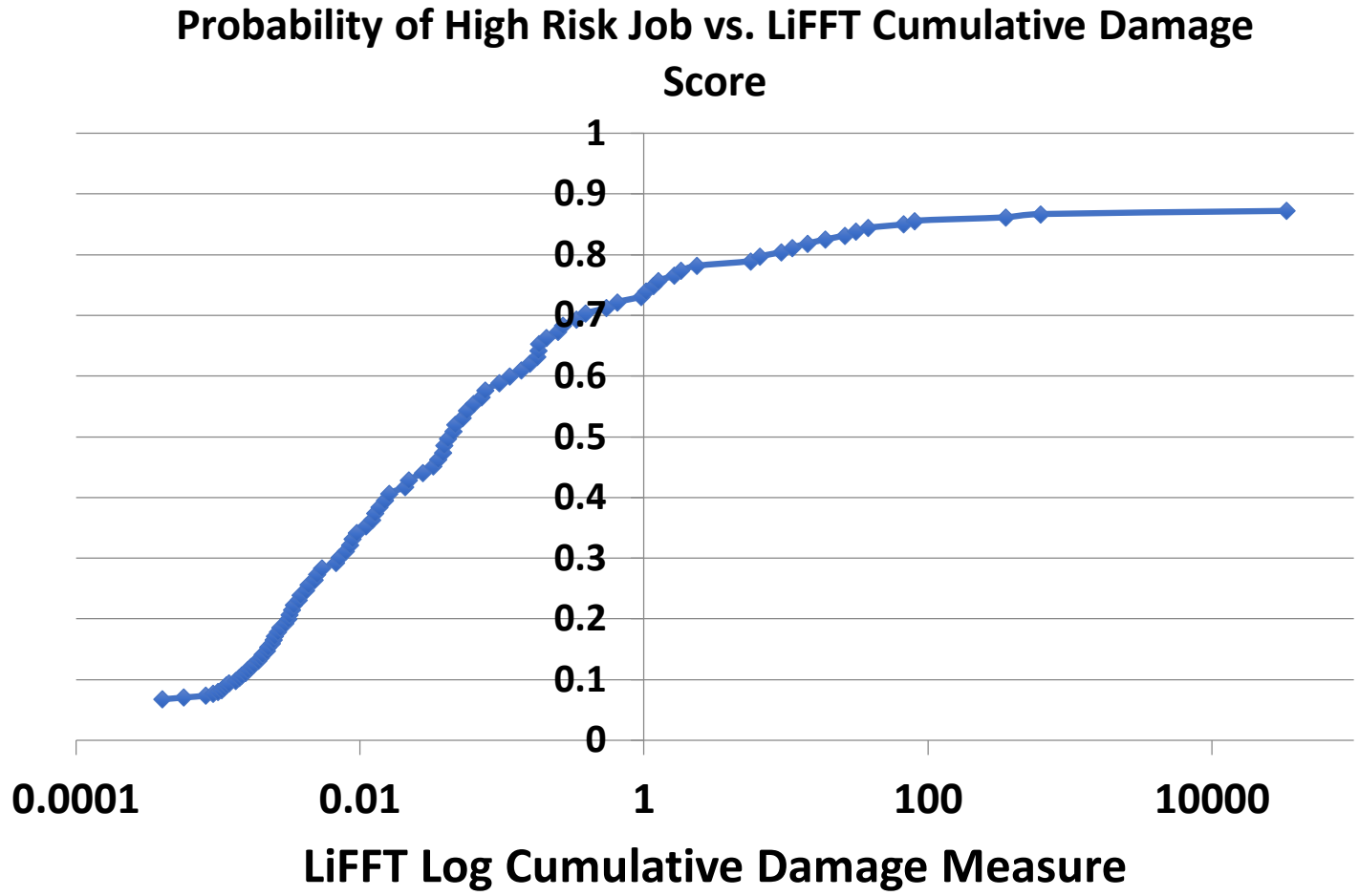
Multiple Lifting Tasks

- Could be the result of multiple lifting requirements for one task,
- Jobs with highly variable tasks
- Job rotation

Multiple Lifting Task Analysis



Does it Work?


Probability of High Risk Job vs. LiFFT Cumulative Damage Score
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.0001
0.01
1
100
10000
LiFFT Log Cumulative Damage Measure

The Distal Upper Extremity Tool: DUET

Purpose of DUET

- To develop a user-friendly risk assessment tool to help assess the risk of upper extremity MSDs (CTS, Hand wrist tendinitis, etc.)
- To provide a method assessing cumulative loading in distal upper extremity MSDs

DUET Inputs

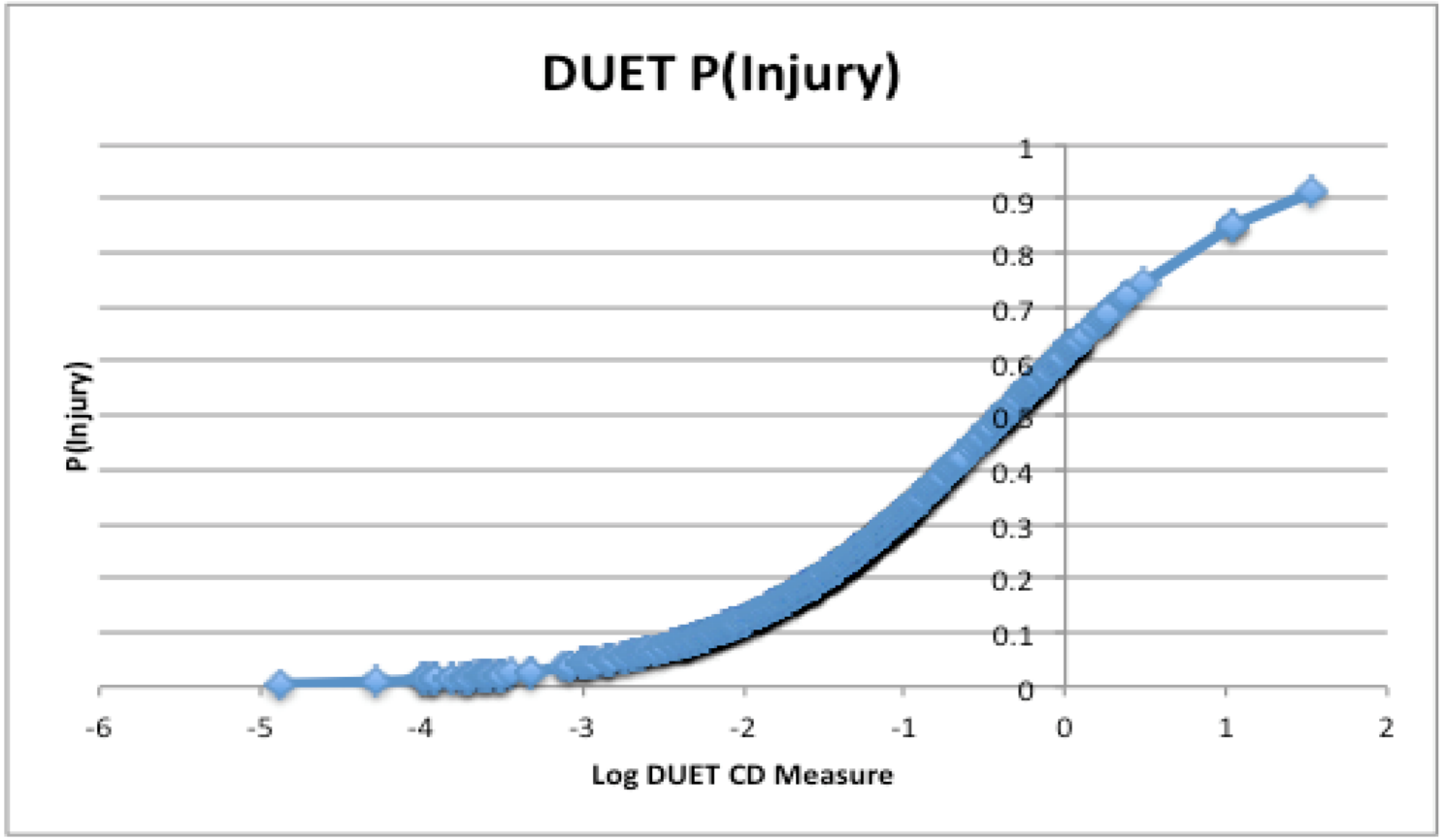
- **For each distinct task**
  - Force estimate (10-point scale) for tasks of interest
  - Number (or good estimate) of repetitions
- **Estimate of cumulative damage obtained for each task**
- **Cumulative damage for each task summed for "daily dose"**

The Distal Upper Extremity Tool

Task #	OMNI-RES Scale	Repetitions (per work day)	Damage (cumulative)	% Total (damage)
1	2: Easy	5184	0.0071	9.1
2	4: Somewhat Easy	180	0.00227	2.9
3	8: Hard	60	0.06322	81.3
4	2: Easy	3752	0.00514	6.6
5	Please select ...		0.0	0.0
6	Please select ...		0.0	0.0
7	Please select ...		0.0	0.0
8	Please select ...		0.0	0.0
9	Please select ...		0.0	0.0
10	Please select ...		0.0	0.0
		Total Cumulative Damage:	0.07773	
		Probability of Distal Upper Extremity Outcome (%):	43.6	

Reset Calculate

Does it Work?


DUET P(Injury)
P(Injury)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-6
-5
-4
-3
-2
-1
0
1
2
Log DUET CD Measure

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The Shoulder Tool

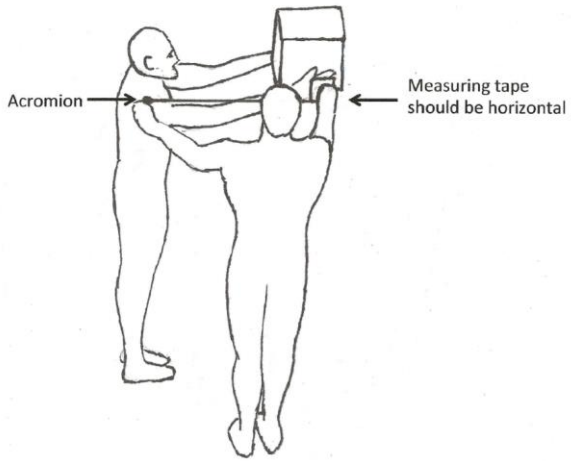
Purpose: Why this tool?

- **In 2014, Shoulder injuries and illnesses caused the longest absences from work compared to any other body part with a median of 26 days of work.**
- **To develop a shoulder specific risk assessment tool (no previous dedicated shoulder tool exists to our knowledge)**

Four pieces of information needed:

1) The type of task being performed.
2) The weight held, or force exerted by the hands;
3) The greatest horizontal distance from the acromion to the center of the hand or load during the task (using a measuring tape); and
4) The total number of repetitions of the task performed during the workday.

The Shoulder Tool



Proper measurement of the distance from the shoulder joint to the hand/load (the "lever arm").
(Drawing adapted from Marras et al., 1999)

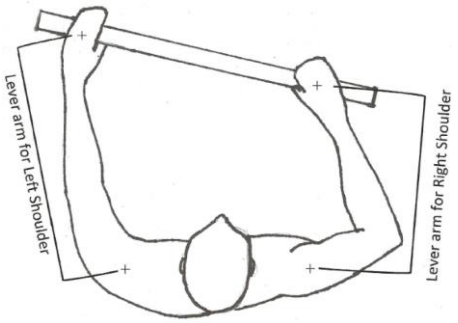
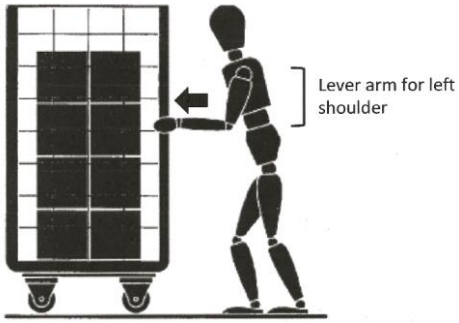
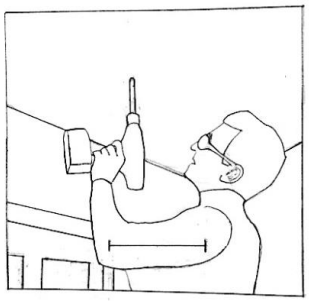


Illustration of measuring the lever arm for the left and right shoulders for a manual handling activity.

The Shoulder Tool



For horizontal pushing and pulling tasks, the lever arm for the load may be a vertical measurement as in pushing the cart shown above. We recommend obtaining pushing/pulling forces using force gauges, using the peak force observed during the exertion, for example, the initial force required to get a cart moving.



Shoulder lever arm measurement for a task involving an upward push. The same lever arm would be used for a task involving a pulling down action in the same posture

The Shoulder Tool 1.0.0 Instructions

The Shoulder Tool

Task #	Type of Task	Lever Arm (inch)	Load (lbs)	Moment (ft.lbs.)	Repetitions (/work day)	Damage (cum.)	% Total (damage)
1	Please select ...						
2	Please select ...						
3	Please select ...						
4	Please select ...						
5	Please select ...						
6	Please select ...						
7	Please select ...						
8	Please select ...						
9	Please select ...						
10	Please select ...						
						Total Cumulative Damage:	
						Probability of Shoulder Outcome:	

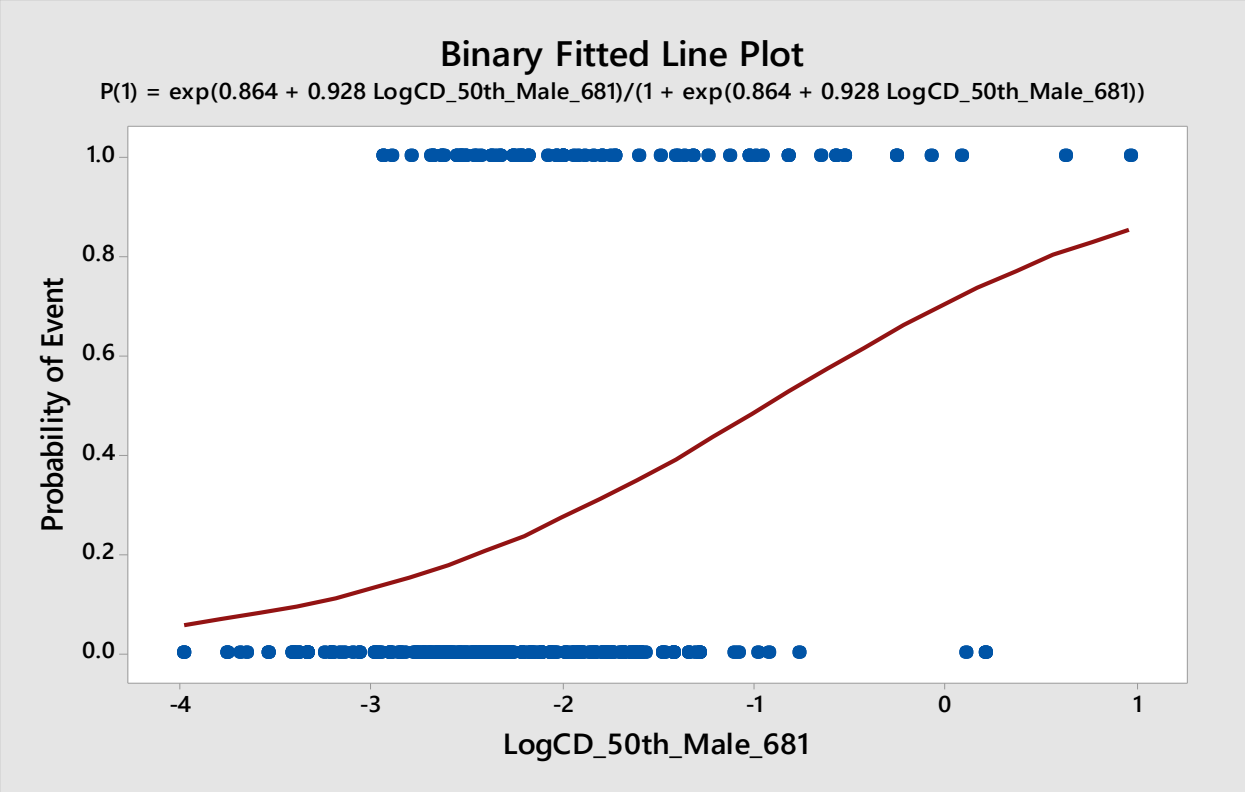
Clear Form

Save to Database

Center for Occupational Safety, Ergonomics, and Injury Prevention

at Auburn University

The Shoulder Tool Validation



Odds Ratio for First Time Office Visit (Shoulder): 2.6348 (95% CI: 1.7467, 3.9742).

Risk Assessment Tools

- **Web-based versions at**

http://lifft.pythonanywhere.com

http://duet.pythonanywhere.com

http://theshouldertool.pythonanywhere.com

- **Excel versions**

Contact me at seangallagher@auburn.edu

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BCPE Application Preparation

Presented by: Rachel Michael CPE, CHSP

Overview

- What is BCPE Certification?
- What are the educational requirements?
- What are the work product requirements?
- How do I fill any gaps found in my application?

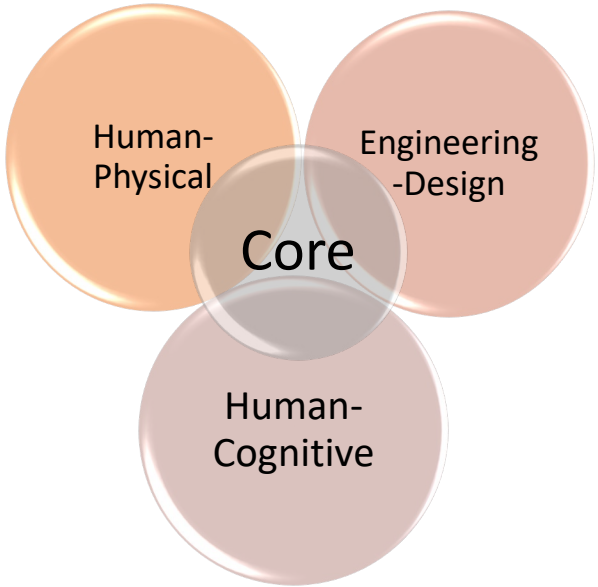
Certificate vs. Certification

Assessment-based **Certificate** Program	Professional or Personnel **Certification** Program
Provides instruction and training (non-degree granting)	Assesses knowledge, skills, and/or competencies previously acquired
Goal is for participants to acquire specific knowledge, skills, and/or competencies	Goal is to validate the participant's competency through a conformity assessment system
Assessment is used to evaluate mastery of the intended learning outcomes; linked directly to the learning event	Assessment is best used to assure baseline competencies and to differentiate professionals; independent of a specific learning event
Assessment content may be narrower in scope	Assessment content is usually broad in scope
Awards a certificate to recognize mastery of the specific learning outcomes; it is NOT a certificate of attendance or participation, which is awarded to individuals who have attended or participated in a course or training program but did not have to demonstrate mastery of the intended learning outcomes	Awards designations to recognize achievement
To earn accreditation, complies with the *ICE 1100 Standard* and follows the ACAP application procedures	To earn accreditation, complies with the *NCCA Standards for the Accreditation of Certification Programs* and follows the NCCA application procedures

BCPE Certification Process

- HF/E/UX professionals contribute to the design of all kinds of systems, such as work systems and product/service systems. Using knowledge of people's cognitive and physical capabilities, needs and limitations, HF/E/UX professionals take a systems approach to design for people.

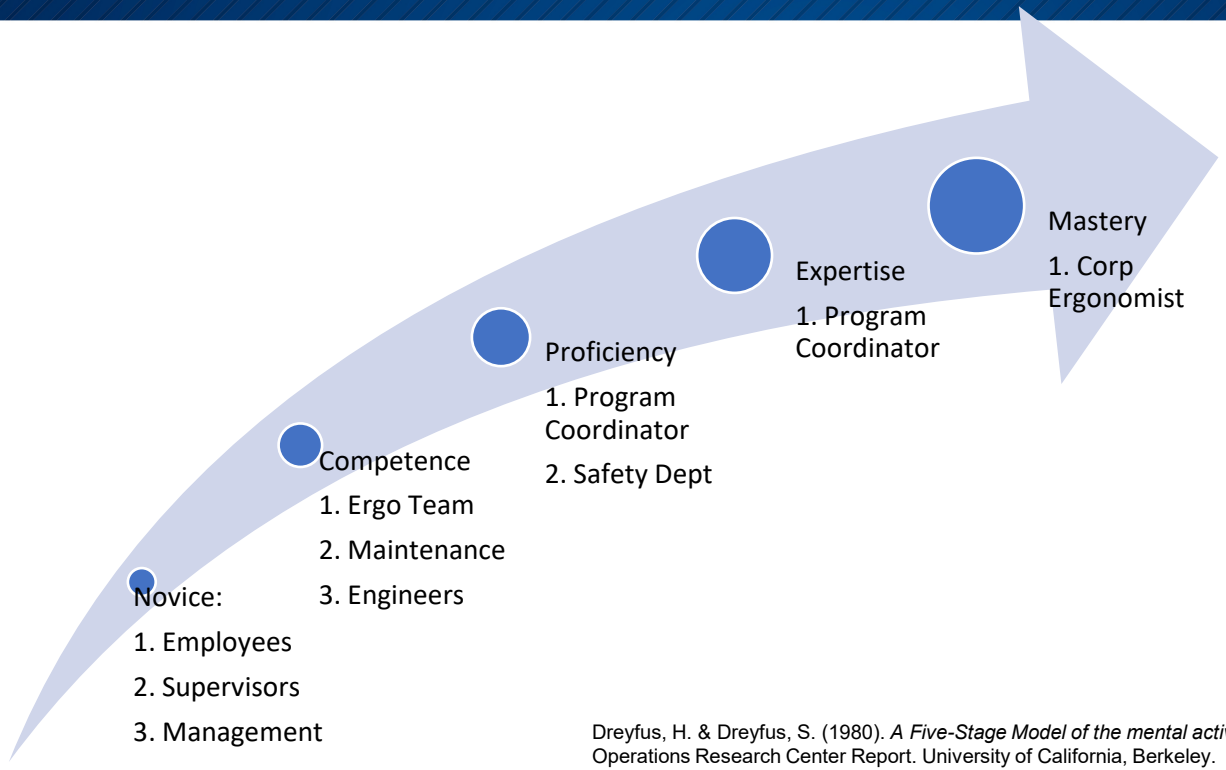
- The goal is optimal human well-being and performance with overall system effectiveness.



BCPE Certification Process

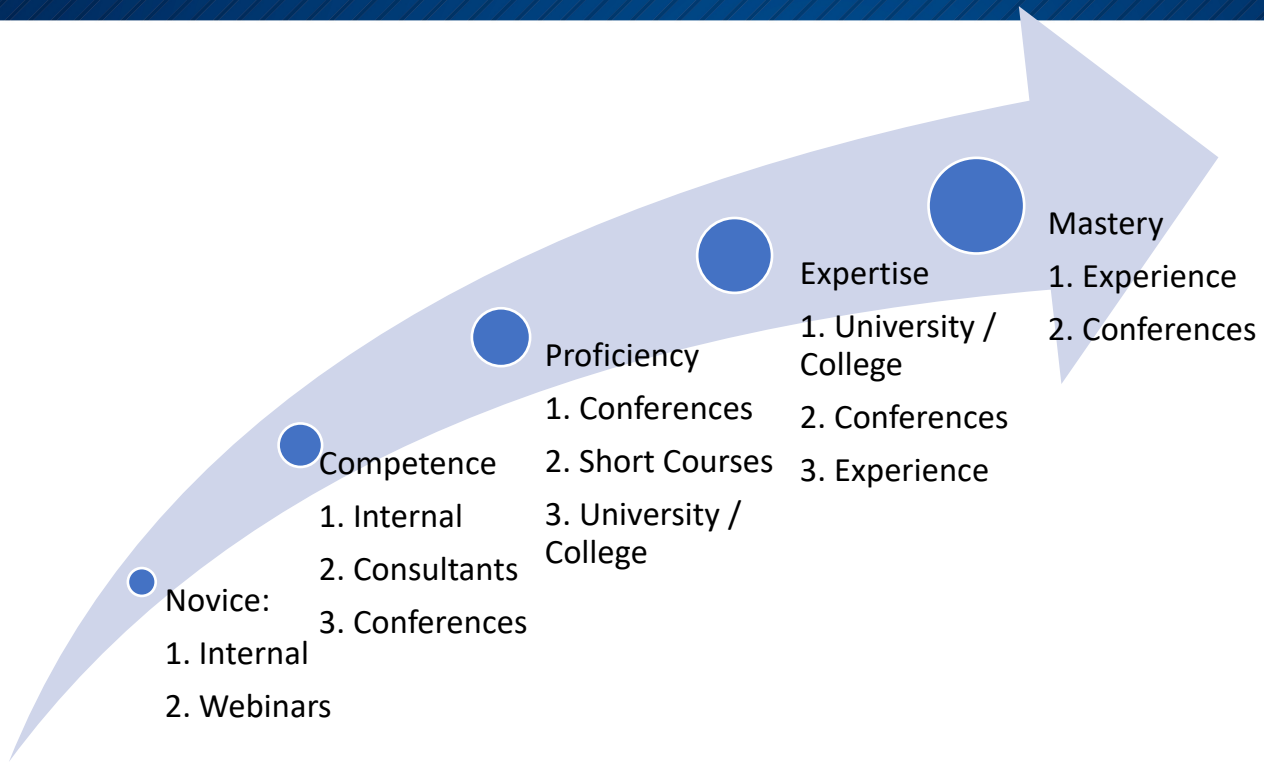
- Is BCPE Certification the right path for you and your career?
  - Do you practice ergonomics in a full time capacity?
  - Do you find yourself getting engaged in larger and more complex system designs?
  - Are you enjoying learning more about ergonomics but don’t expect it will encompass more than 50% of your work tasks?

Industrial Environment

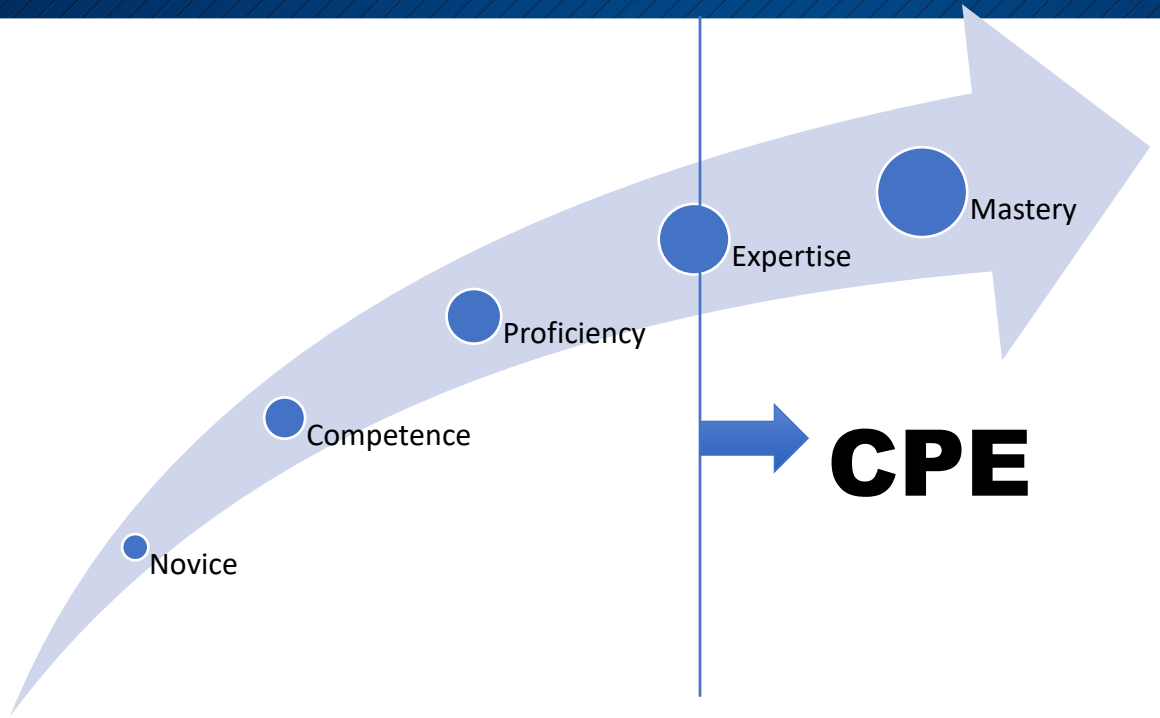


Dreyfus, H. & Dreyfus, S. (1980). *A Five-Stage Model of the mental activities involved in direct skill acquisition.* Operations Research Center Report. University of California, Berkeley.

Educational Pathways

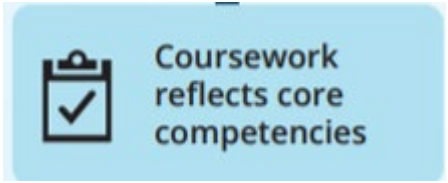


Certification and the Pathway



BCPE Certification Process

BCPE Certification Process



https://www.bcpe.org/why-certify/core-competencies/

https://www.bcpe.org/wp-content/uploads/BCPE-2019-Core-Competencies-3.25.20.pdf

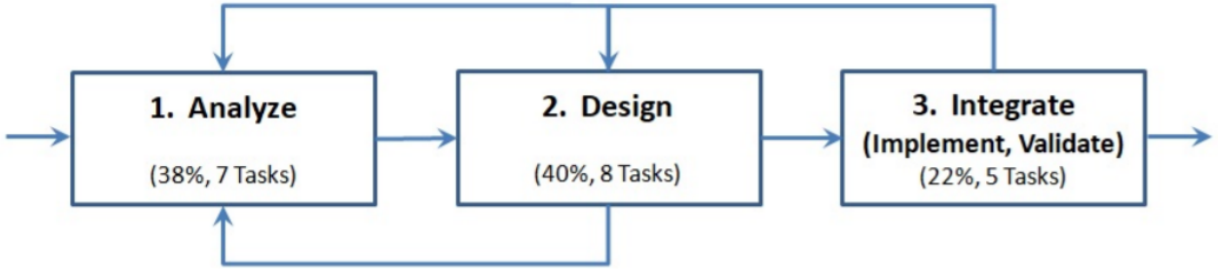
Effective for Spring 2021 Exam and Related Applications, the core competencies have been updated!

BCPE Certification Process

The Human Factors/Ergonomics/User Experience discipline is characterized by the following[1]:

- Takes a systems approach, therefore considers the broader context of the human in the environment, organization, job, and task even when focusing on a specific type of interaction.
- Is design driven, involving analysis resulting in approaches, recommendations, and actions for a design.
- Is an iterative, human-centered process as reflected in the figure below.
- Focuses on two related outcomes: performance and wellbeing, which includes efficiency, effectiveness, health, and safety.

Overview of Core Competencies (Importance %, Number of Tasks)



BCPE Certification Process

How do I determine if my coursework meets the core competencies?

https://www.bcpe.org/how-to-certify/education/

https://www.bcpe.org/wp-content/uploads/BCPE_Education-Requirements-2018.pdf

BCPE Certification Process

The BCPE® Educational Coursework Requirement

REQUIRED CATEGORIES AND TOPICS	COURSE OBJECTIVE and EXAMPLE OF COURSE TOPICS	ACADEMIC CREDIT HOURS REQUIRED*
A. Basic Principles		**3 credit hours total**
1. Systems Concepts	*Objective:* Overall system approach: To recognize the integrated (systems) nature of the field, the centrality of human beings, to use its breadth of coverage and the available knowledge base to adapt the environment to people *Example topics:* Structure and dynamics of systems: general and sociotechnical systems theory; human as a system component; human system integration; integrated view of human characteristics (physical, psychological, social) in system development; systems analysis and design; human role in automation	At least 1 credit hour My course ABC2311
2. Design Concepts	*Objective:* Principles underlying designing a system: To be able to translate general design principles, standards, guidelines and regulations into project specific requirements to which one can design. *Example topics:* Use-centered/user-centered design, ergonomic/human factors impacts on the product-design cycle, universal design, design for individuals vs. populations, aesthetics vs. functionality.	At least 1 credit hour My course HIJ1200
B. Core Background		**6 credit hours total**
1. Human Attributes 1.1 Anthropometry & Demography	*Objective:* To recognize the physical (anthropometric) and cultural characteristics and differences between people with particular reference to health, safety, comfort and performance. *Example topics:* Anthropometry, gender, culture, developmental (childhood, aging, disabilities), and ethnic variables relevant to design decisions.	At least 2 credit hours My course LMN445

- Using your transcript, fill in what courses match the objectives and topics.
- Easily understand any gaps in education.

Fill in Knowledge Gaps

I am missing key pieces, how do I fill in the Gaps?

- Short courses
- Local college/university
- Online
- Full program

Fill in Knowledge Gaps

- https://www.hfes.org

Fill in Knowledge Gaps

North Carolina State University Department of Industrial Engineering	North Carolina	MIE, MS	PhD	Yes
North Carolina State University Department of Psychology	North Carolina	MS	PhD	Yes
Northeastern University	Massachusetts	MS	PhD	No
Northeastern University Occupational Ergonomics and Health	Massachusetts	MS		No
Ohio State University Department of Integrated Systems Engineering	Ohio	MS	PhD	Yes
Ohio State University Department of Psychology	Ohio	MA	PhD	No
Old Dominion University	Virginia	MS	PhD	Yes
Oregon State University	Oregon	MS	PhD	No
Pennsylvania State University	Pennsylvania	MS	PhD	No
Purdue University	Indiana	MS	PhD	No
Rensselaer Polytechnic Institute	New York	N/A	PhD	No
Rice University	Texas	MHCIHF	PhD (MA earned en route to the PhD)	Yes

Can students attend part-time?	Yes
Are required courses offered through distance learning?	Yes, there are online courses
Are required courses offered at night?	Yes
Are required courses offered during summer?	Yes
Does the university have an HFES student chapter?	No

Fill in Knowledge Gaps

- University of California - https://coeh.berkeley.edu/
- Available online

- **University of Michigan**

Fill in Knowledge Gaps

Full M.Sc. Program offered online/part time

- https://www.derby.ac.uk/online/course/ergonomics-msc

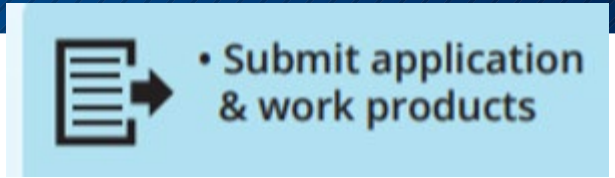
You can complete this part-time master's course in 3 years. It's really down to you to set the pace and because it's online, you have complete control over when and where you study. Studying online gives you the flexibility to study at the most convenient time and place for you. Course modules still operate within a fixed trimester but you can choose to study during the day, in the evenings or at the weekend rather than having to attend fixed lectures.

The online MSc Ergonomics course comprises three progressive stages; Postgraduate Certificate, Postgraduate Diploma and MSc:

- Postgraduate Certificate in Ergonomics you must complete 3 modules (60 credits)
- Postgraduate Diploma in Ergonomics you must complete a total of 6 modules (120 credits)
- MSc you must complete 6 modules and the Independent Study project (180 credits).

We would encourage you to complete the full MSc, but if you aren't able to, you can still gain an exit award at each stage: a PG Cert or a PG Dip.

Collect Work Product



Acceptable Work Products

- Sample work products may include, for example, relevant segments of technical reports, design papers, analysis reports, evaluation reports, patent applications, or articles authored by you in ergonomics/human factors/user experience publications. Work examples that are part of independent work, such as a Master's thesis or Doctoral dissertation are acceptable. Varied work products are encouraged to demonstrate your proficiency.
- If necessary, for context, annotate your work product or provide additional information to complement any of your products. Your work product submission should indicate your thought processes and methods you applied in performing the work.

Collect Work Product

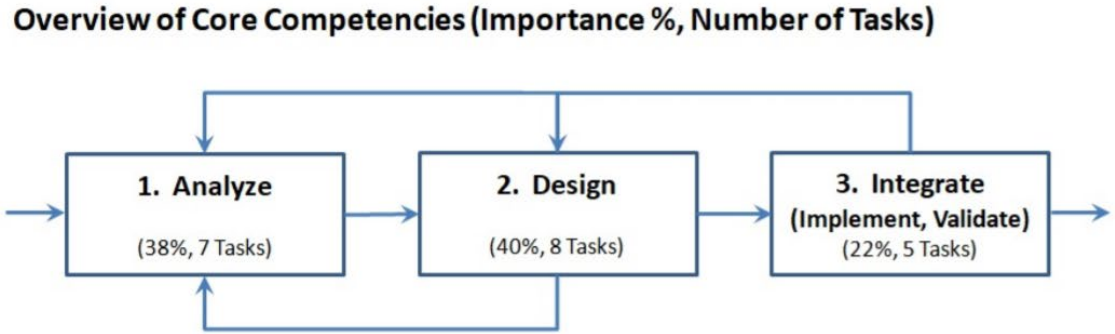
Confidential Work Products

- Work performed for the government or industry is often proprietary or confidential. All BCPE staff and volunteers involved with applications, examinations or personal information of other certificants, sign non-disclosure and confidentiality agreements.

- Applicants are also welcome to edit their products and redact sensitive information. The HF/E/UX component of the work which is being reviewed can usually be independent of knowing the brand or name of the system or device of the project.

Collect Work Product

- Work products must align with BCPE Core Competencies:



Submitting Work Product

- What does NOT meet requirements:
  - Here's 100 office evaluations I've done
  - Here's my company's form which I fill out for my job
  - Here's an essay about why my product is the best and most ergonomic product developed and everyone should use it.

Next Steps

- Once you've met the coursework and work experience requirements you are ready to submit an application. If approved, you will then be able to sit for the exam.
- The exam is available online at testing centers throughout the world.
- In person exams may also be scheduled based on need.

Summary

- If you would like to have a professional career in ergonomics, BCPE certification might be right for you!
- Certification requires both education and work experience matching core competencies.
- Information and downloads available at www.bcpe.org

Questions?

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