



Biomechanics and Beyond: Unleashing Human Resiliency

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Objectives

- Key elements of effective biomechanics
- Applying the elements to injury prevention
- Measuring the improvement



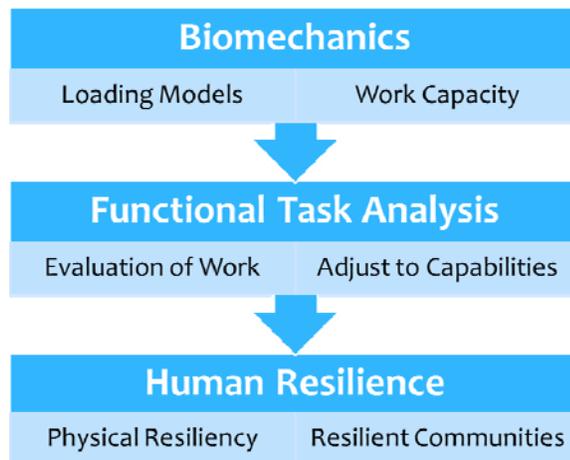
Resilience

- The ability of an individual to “bounce back” after experiencing stress¹

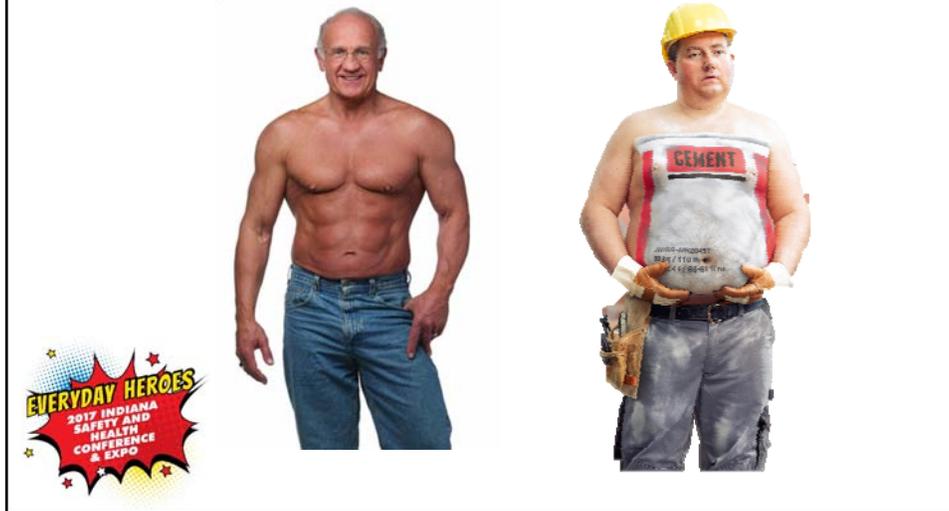


(1) *Airman and Family Resilience*, Rand, 2015, P 9.

Resiliency and Biomechanics



Why do we even need to talk about this?



The Problem by the Numbers \$\$\$\$

- MSDs account for more than 50% of disabling health conditions reported by adults in the U.S.
- MSDs cost \$809.1 Billion dollars (2016 dollars), or 4.4% of the estimated 2016 U.S. GDP.
 - Occupational MSDs account for an estimated \$25.1 billion (2016 dollars) of that amount.
- In any given year, 12% TO 14% of the adult population will visit their physician for back pain.



Sources: <http://www.boneandjointburden.org/2014-report>
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=UNIFIED_AGENDA&p_id=4481

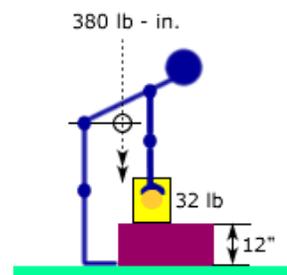
Need a New Solution

- Traditional rule based, equipment engineering improvement focused ergonomics programs have limitations:
 - Costly in a budget constrained world
 - Long time-lines
 - Relieves the employee of the responsibility of their health
 - Low employee adoption



Biomechanics

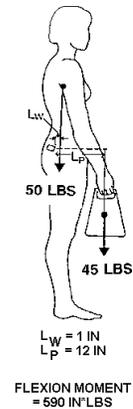
- The study of the physical interaction of workers with their tools, machines, and materials so as to enhance the workers performance and minimize the risk of MSDs.



Biomechanics Overview

Key Concepts:

- Load-Tolerance
- Moments and Levers
- External and Internal Loads
 - Arrangement of Body's Levers (posture!)
 - Length-Strength Relationship
 - Force-Velocity Relationship



Basic Biomechanical Concepts



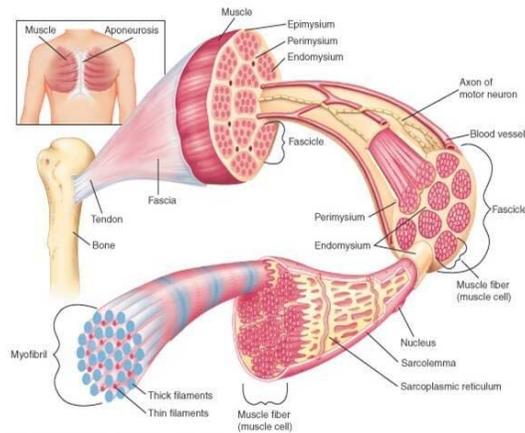
• Biomechanics Objectives:

- Determine biomechanical properties of the body.
- Determine biomechanical work capacity of the body.
- Develop and utilize biomechanical modelling to predict loads on a body
- Develop rules to maintain safe load limits.

Source: dorsaVi, <http://us.dorsavi.com/viperform/>

Basic Biomechanical Concepts

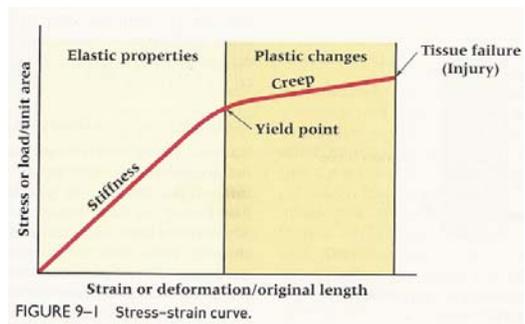
- Study of Human Structures:
 - Tendons
 - Ligaments
 - Fascia
 - Muscles
 - Cartilage
 - Bone
- Predicts forces acting on these structures and their behavior.



Basic Biomechanical Concepts

- Mechanical Injury
 - Stress-Strain Curve: the relationship between tissue properties when stretched.
 - Trauma: physical injury produced by internal or external force.

The Stress-Strain Curve



Source: Prentice, William. *Principles of athletic training*. McGraw-Hill Education, 2011.



Basic Biomechanical Concepts

- **LOAD = Tolerance of the structure**

IF

LOAD > Tolerance of the structure

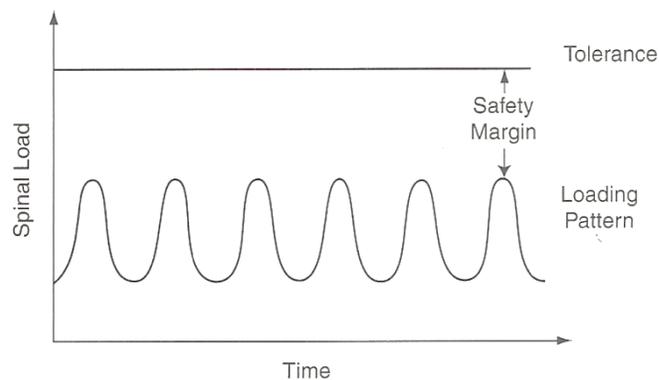
- Acute: application of force so large it exceeds the structure's tolerance leading to injury.
- Cumulative: repeated application of force that incrementally wears the structure to the point tolerance is below force loads, resulting in injury.



Source: Marras, William S., and Waldemar Karwowski. *Fundamentals and assessment tools for occupational ergonomics*. CRC Press, 2006.

Simple Load-Tolerance Model

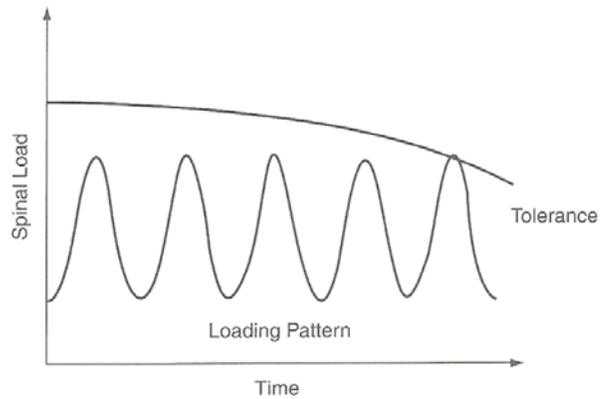
- Tolerance is the point at which tissue damage (trauma) occurs.
 - Tissue destruction
 - Inflammatory response



Source: Marras, William S., and Waldemar Karwowski. *Fundamentals and assessment tools for occupational ergonomics*. CRC Press, 2006.

Real World Load Tolerance

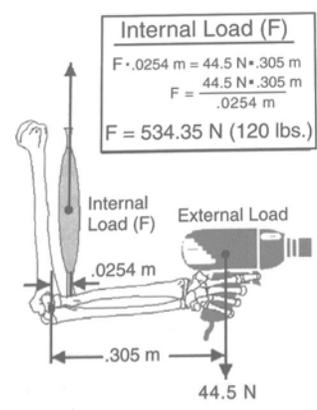
- A realistic concept of biomechanical risk for cumulative trauma loads.
- **Tolerance is not constant!**



Source: Marras, William S., and Waldemar Karwowski. *Fundamentals and assessment tools for occupational ergonomics*. CRC Press, 2006.

Basic Biomechanical Concepts

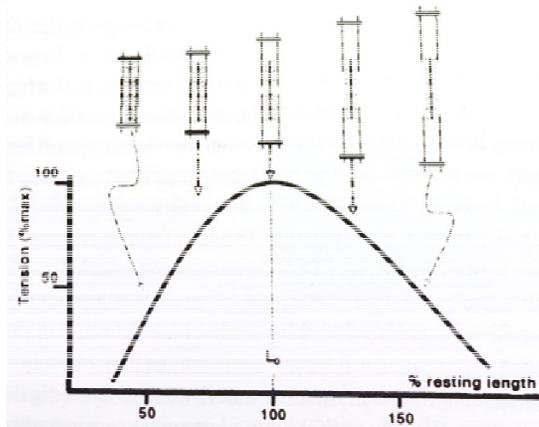
- External and Internal Loading
 - The physical location and arrangement of the body's muscular connection points greatly impacts strength and endurance.
 - Internal loads are typically 10 times the force of external loads.



Source: Marras, William S., and Waldemar Karwowski. *Fundamentals and assessment tools for occupational ergonomics*. CRC Press, 2006.

Basic Biomechanical Concepts

- The Length-Strength Relationship
 - Muscle strength is **maximum** at the **mid-point of contraction length** (resting length).
 - Risk of muscle strain is greatly increased as the **muscle reaches full contraction or extension**.



Source: Marras, William S., and Waldemar Karwowski. *Fundamentals and assessment tools for occupational ergonomics*. CRC Press, 2006.



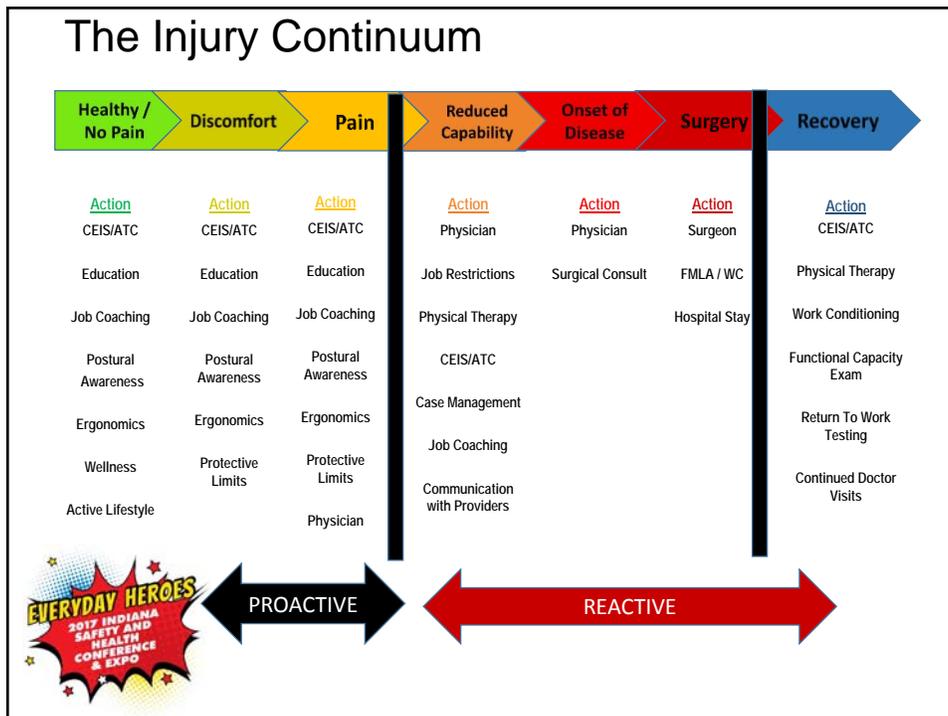
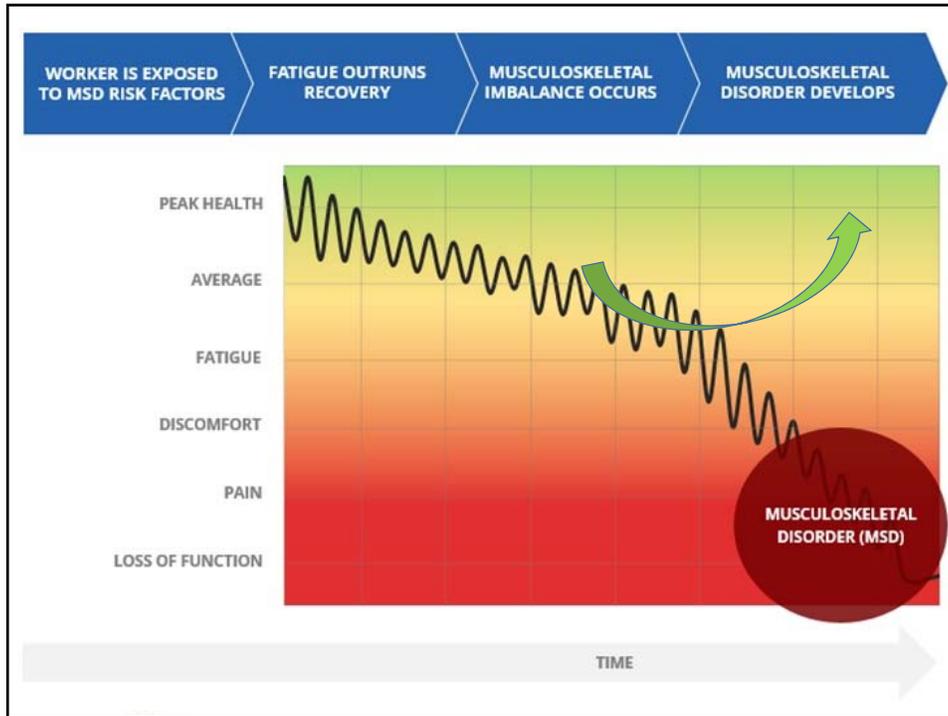
Physical Resiliency

- Physical resilience refers to the body's capacity to adapt to arising challenges, maintain stamina and strength in the face of demands, and recover efficiently and effectively when fatigued, acutely damaged or microbially besieged.
 - Physical fitness
 - Postural awareness and efficiency
 - Adequate rest and recovery practices
 - Belief that the person is in control

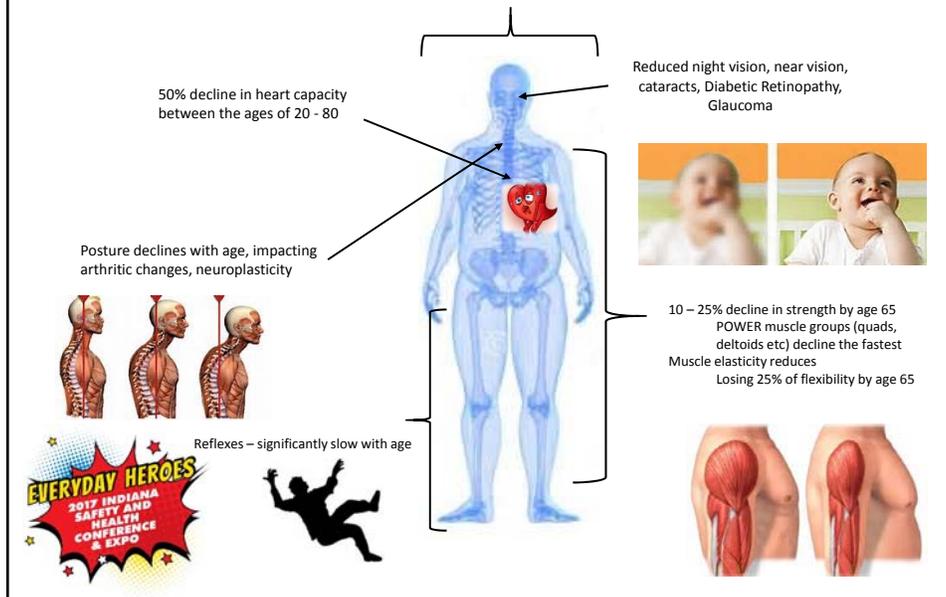


Source: United States Air Force,
<http://airforcelive.dodlive.mil/tag/resiliency/>





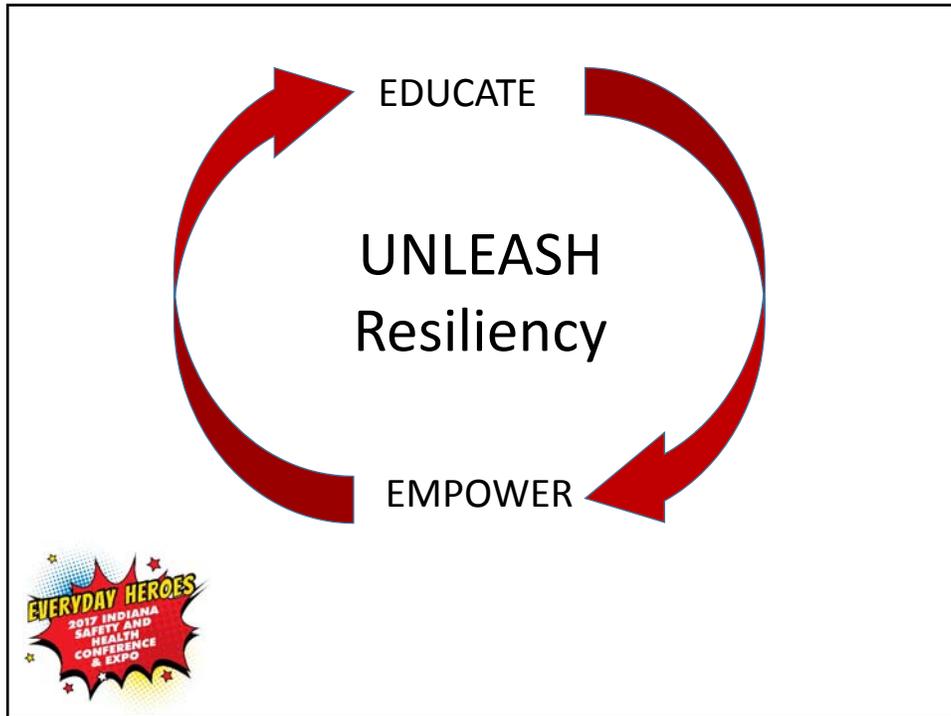
Physical Resilience as it pertains to AGE



Other Changes

- Sleep: reduced in total, and reduced deep sleep
- Greater susceptibility to temperature extremes
- Kidneys: reduce in size and function. Tolerance to toxins reduces, risk of dehydration increases
- Bone: reduced density
- Learning capability reduces





Putting it all Together: Human Resiliency

- Human (individual) resilience:
 - Is NOT consistent day to day
 - Is NOT consistent person to person
 - Ability declines with age
- Bend the curve of TOLERANCE
 - External biomechanics
 - Enhancing individual resilience



Source: Meadows, Sarah O., Laura L. Miller, and Sean Robson. *Airman and Family Resilience: Lessons from the Scientific Literature*. No. RR-106-AF. RAND PROJECT AIR FORCE SANTA MONICA CA, 2015.

CRITICAL FACTOR

- Recognize the IMPACT of **EARLY** reporting
- The DEFINITION of EARLY – with the first **symptom**
- The Definition of SYMPTOM – **ANY** discomfort, ache or pain



QUESTIONS

