Ergonomics in Agriculture: Blueberry Harvesting

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Blueberries

- Annual harvest of 79,000 tons
- Farm gate value of $130.9 million
- BC, Que and NS sell 86% of crop
- Production has not reached a plateau

- Source: Stats Canada (2006) cited in Robichaud (2006)

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Two Varieties

- High bush
- Low bush
  - Unique to Atlantic Canada
  - 6-8” tall

- Harvesting:
  - 70% machine harvest
  - 30% manual

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General thoughts

- Machine harvest:
  - More cost effective
  - Increased production has reduced labour market
  - Quality is improving
- Manual harvest:
  - Provides better quality
  - Important for fresh market sales

Common concerns

- Balance between productivity & safety
  - Maximize yield
    - Short harvest season
  - Machine human interaction
    - Moving parts
  - Minimize WRMD's
    - Low back pain
    - Wrist and hand injuries
    - Falls

Principles of Ergonomics/Human Factors Engineering

- Process:
  - The systematic application of relevant information about human capabilities, limitations, characteristics and their interaction with products, equipment, facilities, procedures and environments in work and everyday living.

Ergonomics Objectives

- **To enhance the effectiveness and efficiency of work.**
- **Change the machines, environments and procedures people use to better match their characteristics to the *system*.**

What is a system?

- A system is a set of elements developed to achieve an objective.
- Considers the relations amongst the elements and the boundaries around the elements.
- Usually has a defined input, a process and a defined output.

Main components of a *system*?

- The system consists of all of the elements that may influence the work. Most systems consist of 3 main elements which are:

Human

Machine

Environment

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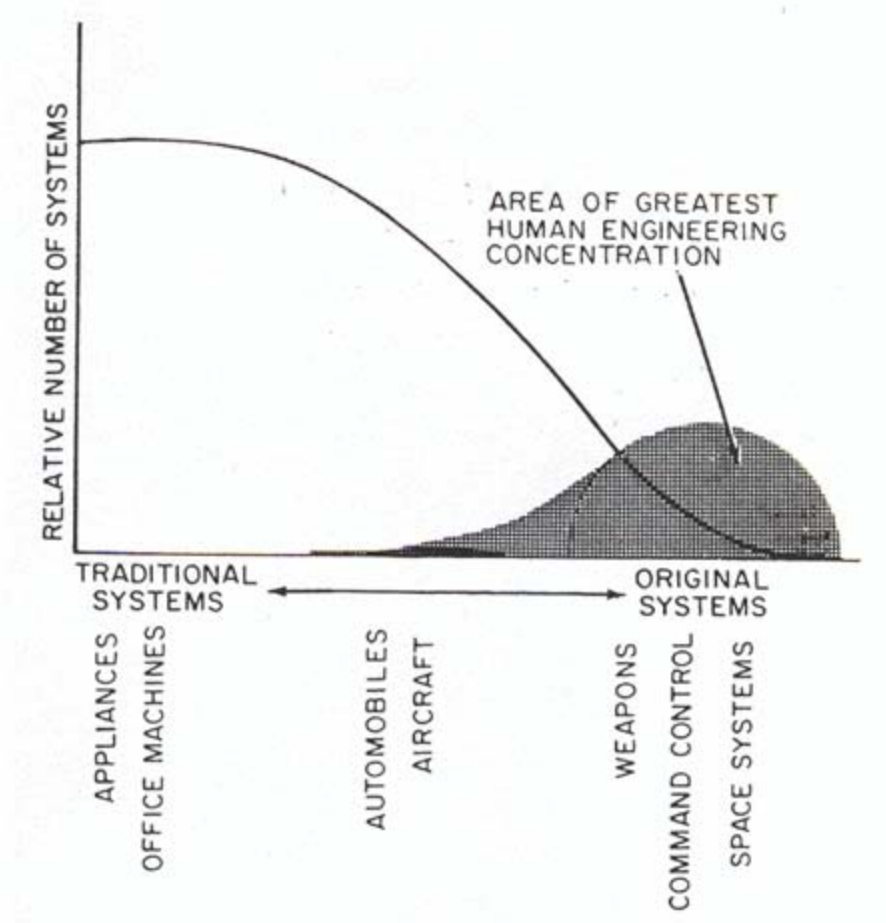
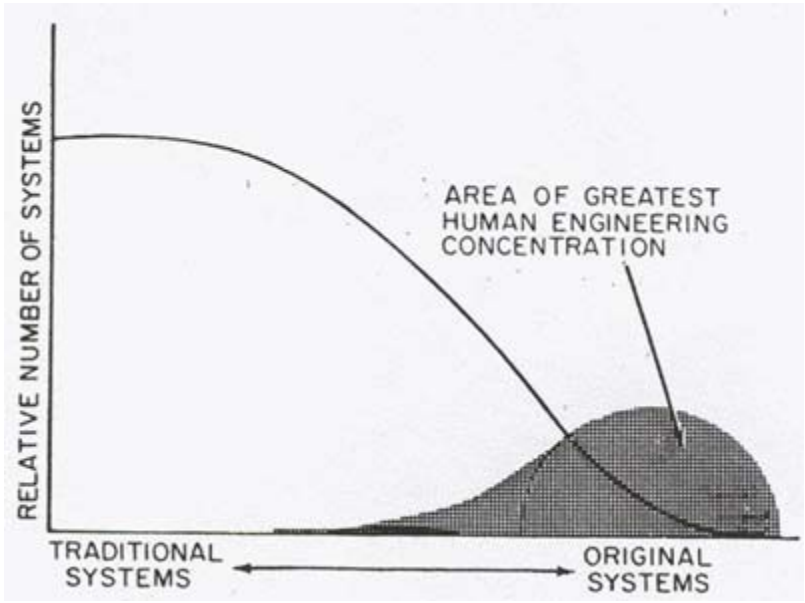
Areas which use HE/Ergonomics





HAND TOOLS

TRACTORS

PROCESSING SYSTEMS

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Types of Human-Machine Systems

- **Manual Systems**
  - **A human operator using hand tools and other aids powered by their own physical energy**
- **Mechanical Systems**
  - **A system consisting of a human operator who acts as a control device interacting with a self-powered machine**
- **Automated Systems**
  - **A system that functions with little or no human intervention. Humans are necessary to install, program and maintain/monitor these systems**

A H-M-E Chart for this meeting
(list at least 3 items under each category)

- Human
  - Sex
  - Age
  - Height
- Machine
  - Laptop
  - Projectors
  - Chairs
- Environment
  - Lighting
  - Noise
  - Temperature

- Now consider the “range” of possible scores for these items
- Identify those items that are adjustable
- Now draw lines between the items that may interact with each other

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The Human

- Anatomy
- Physiology
- Biomechanics

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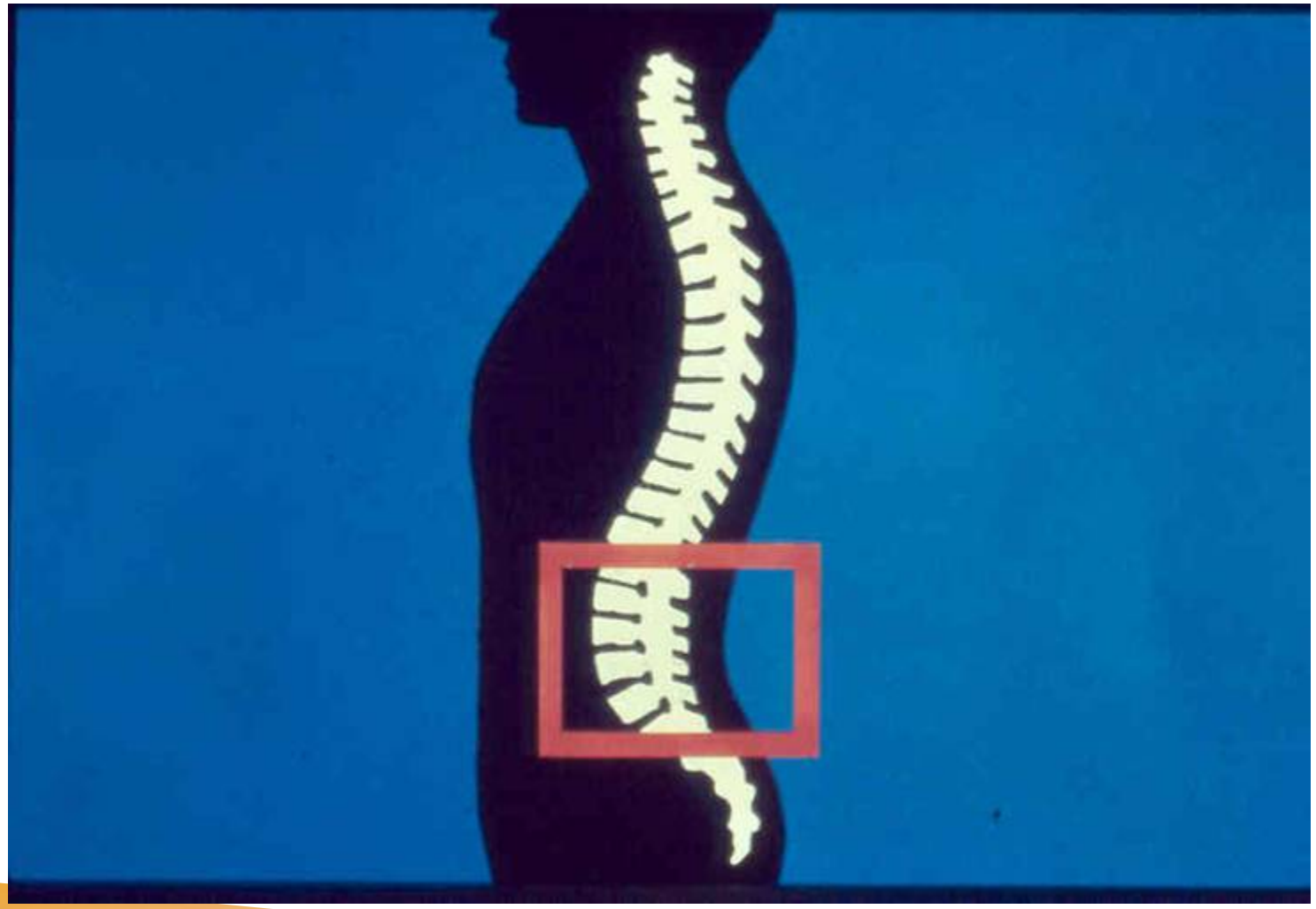
Low Back Pain - Anatomy



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The “Healthy” spinal unit

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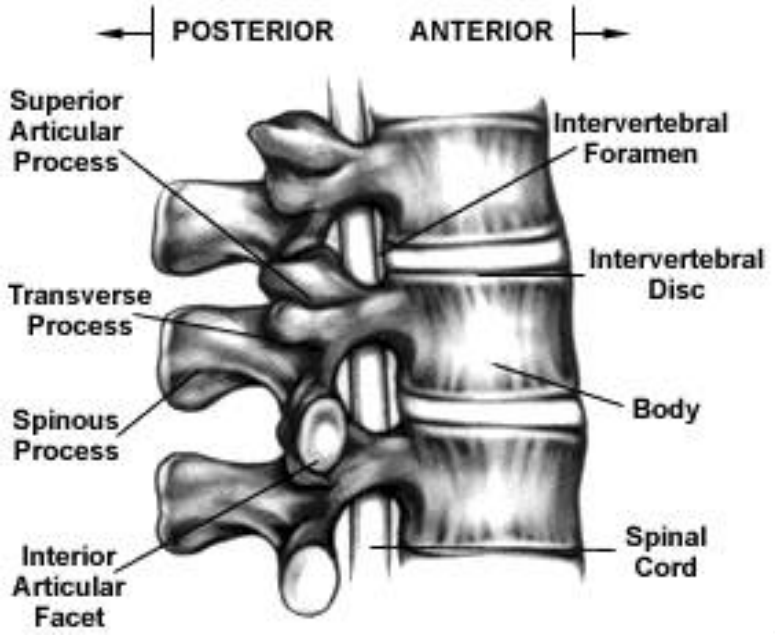
The Passive System

- Vertebrae
- Facet Joints
- Intervertebral Disc
- Ligaments



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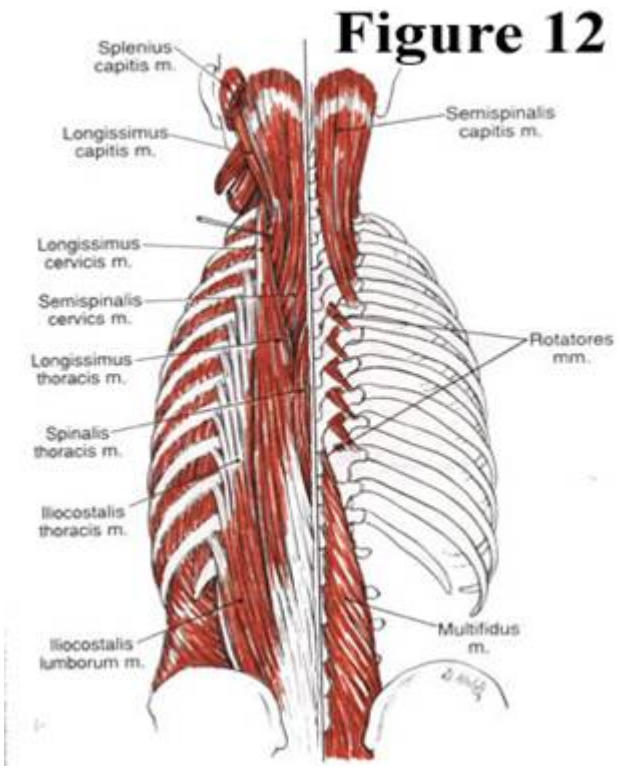
The Active System

- Musculature of the Spine
- Tendons



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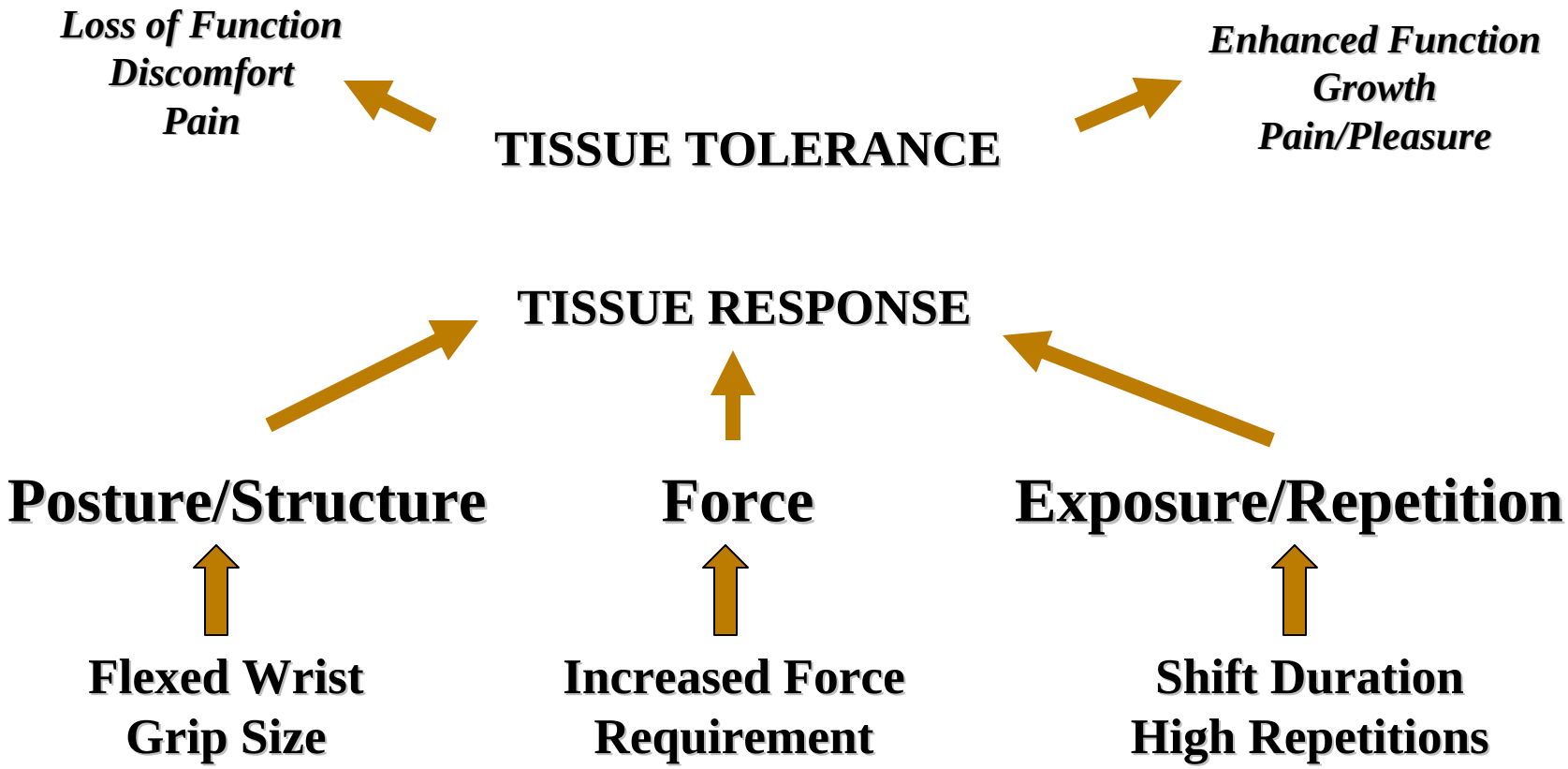
Physical Demands, Work Practices & Understanding Injury Mechanisms



Norman & Wells, 1990

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Mechanisms of Injury: Single load

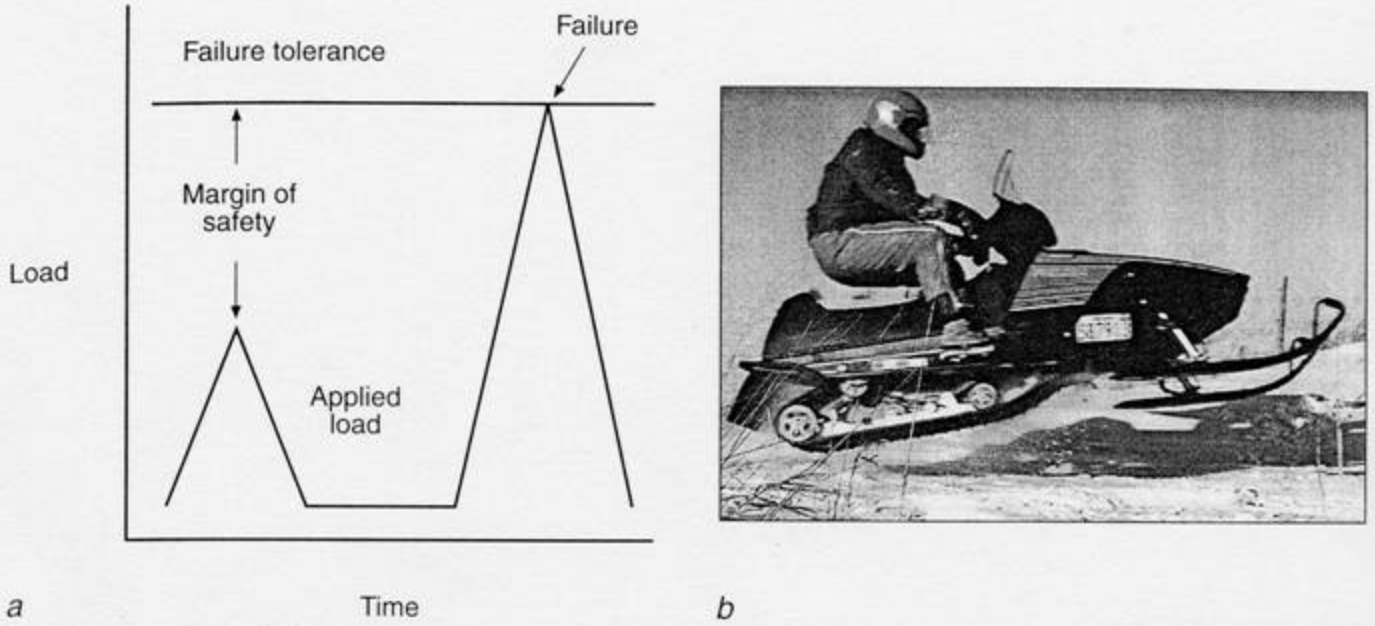


Figure 1.1 (*a*) A margin of safety is observed in the first cycle of subfailure load. In the second loading cycle, the applied load increases in magnitude, simultaneously decreasing the margin of safety to zero, at which point an injury occurs. (*b*) The Canadian snowmobile driver (the author in this case who should know better) is about to experience an axial compressive impact load to a fully flexed spine. A one-time application of load can reduce the margin of safety to zero as the applied load exceeds the strength or failure tolerance of the supporting tissues.

Reprinted from *Journal of Biomechanics*, 30 (5), S.M. McGill, "Invited paper: Biomechanics of low back injury: Implications on current practice and the clinic," 456-475, 1997, with permission from Elsevier Science.

Mechanisms of Injury: Repetitive low loads

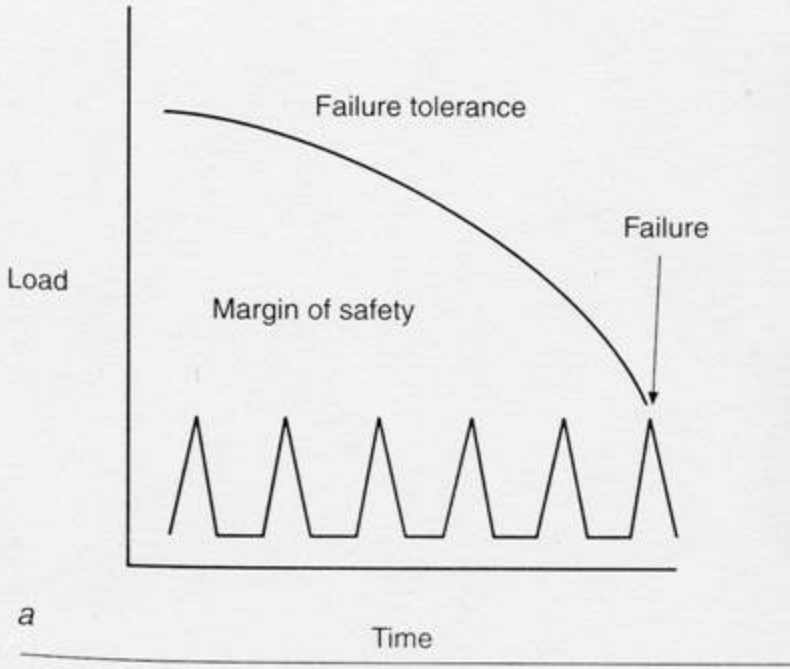
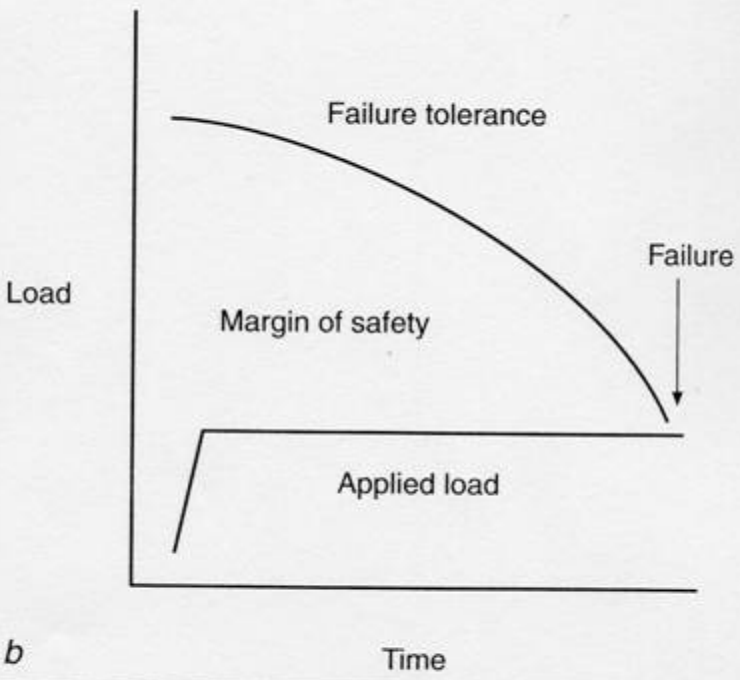


Figure 1.2 (*a*) Repeated subfailure loads lead to tissue fatigue, reducing the failure tolerance, leading to failure on the *N*th repetition of load, or box lift in this example (*b*).

Reprinted from *Journal of Biomechanics*, 30 (5), S.M. McGill, "Invited paper: Biomechanics of low back injury: Implications on current practice and the clinic," 456-475, 1997, with permission from Elsevier Science.

Mechanisms of Injury: Constant low loads



a b

Figure 1.3 (*a*) These rodmen with fully flexed lumbar spines are loading posterior passive tissues for a long duration, (*b*) reducing the failure tolerance leading to failure at the *N*th% of tissue strain.

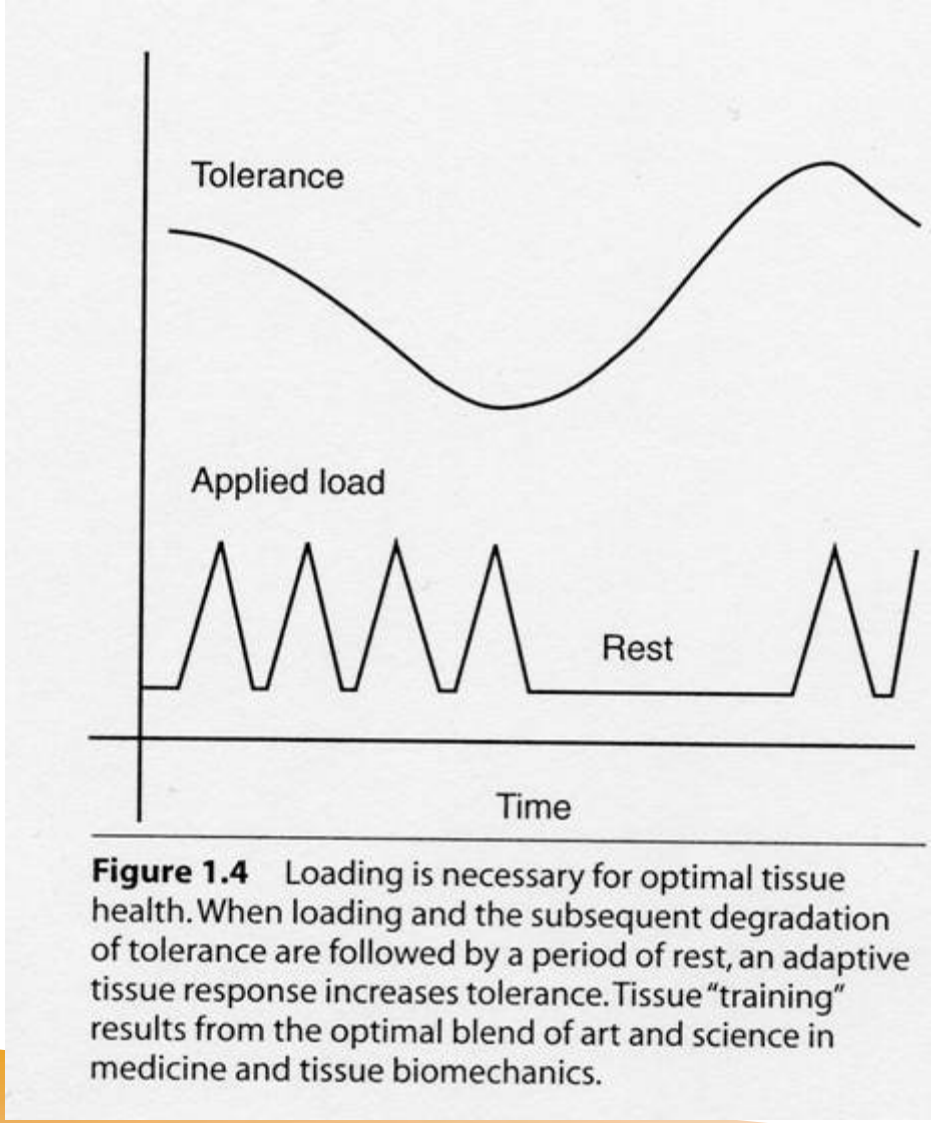
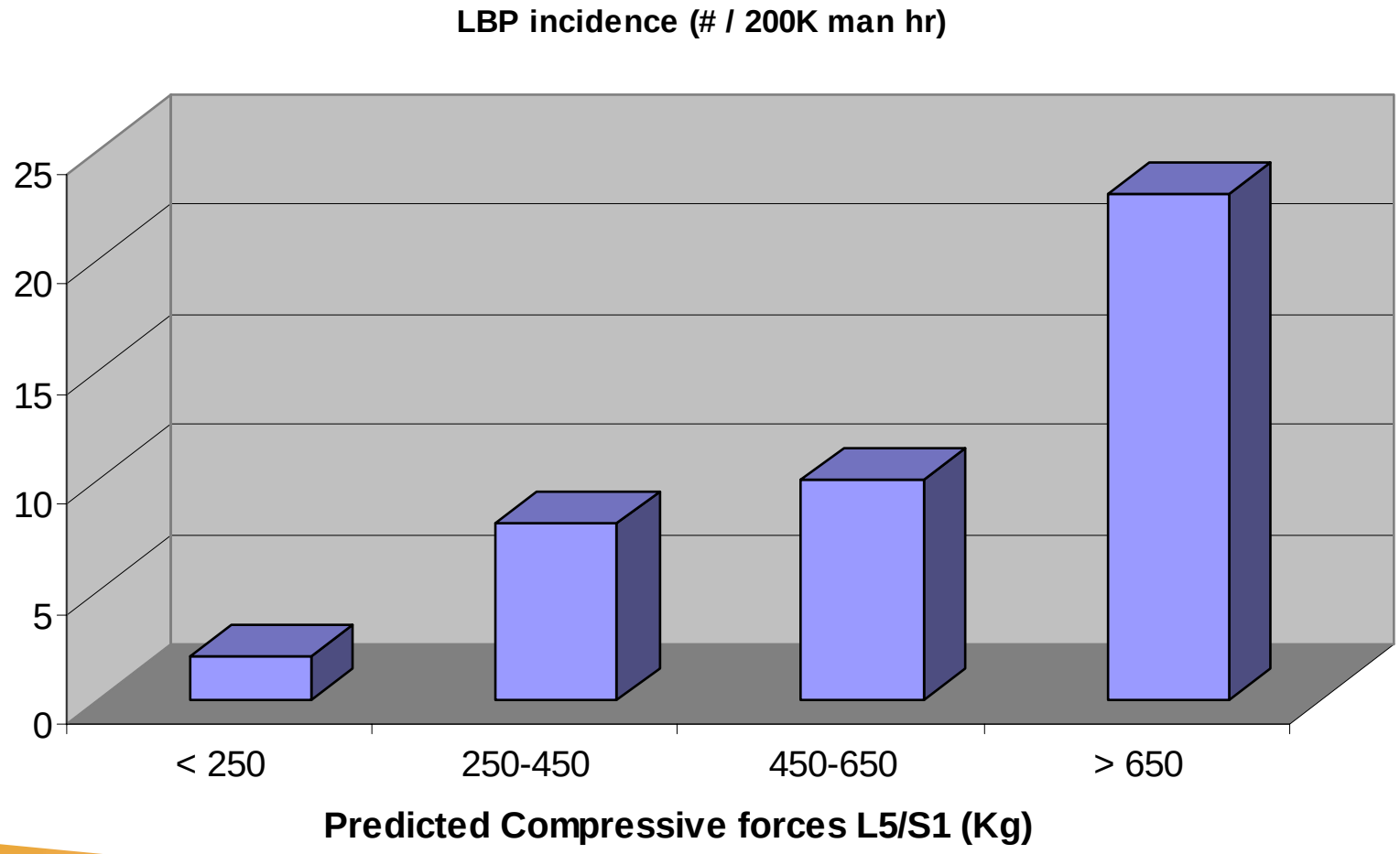


Figure 1.4 Loading is necessary for optimal tissue health. When loading and the subsequent degradation of tolerance are followed by a period of rest, an adaptive tissue response increases tolerance. Tissue "training" results from the optimal blend of art and science in medicine and tissue biomechanics.

Can the tissue tolerance change?

Spinal loads and injury risk



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Spine Instability

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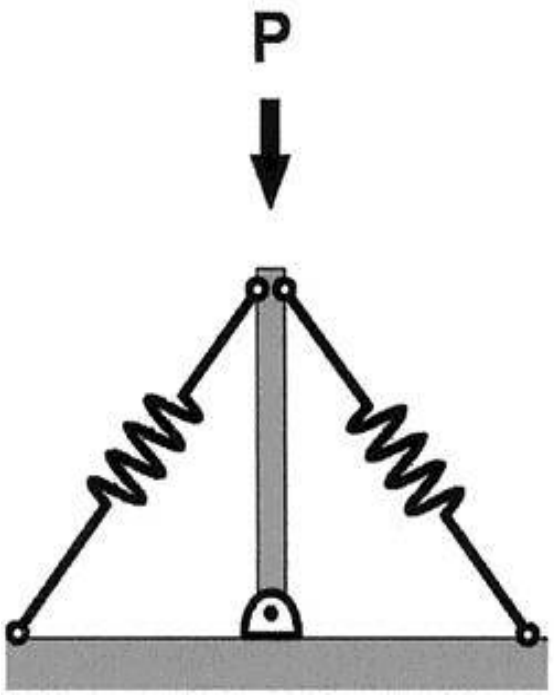
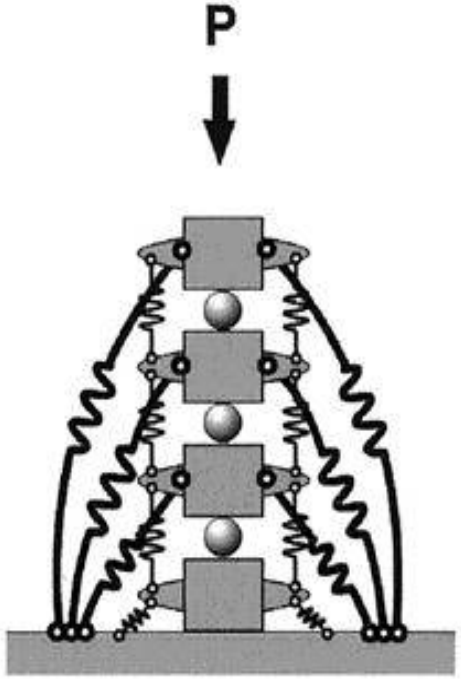
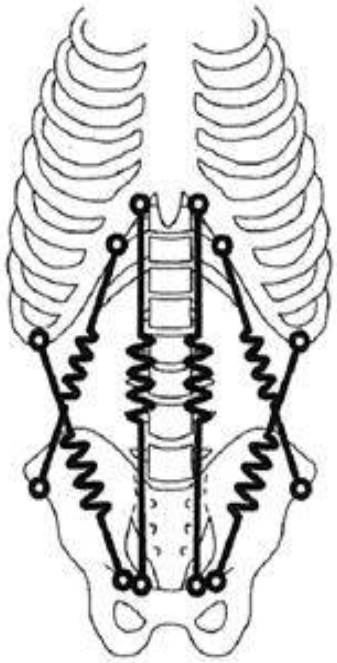
Stability







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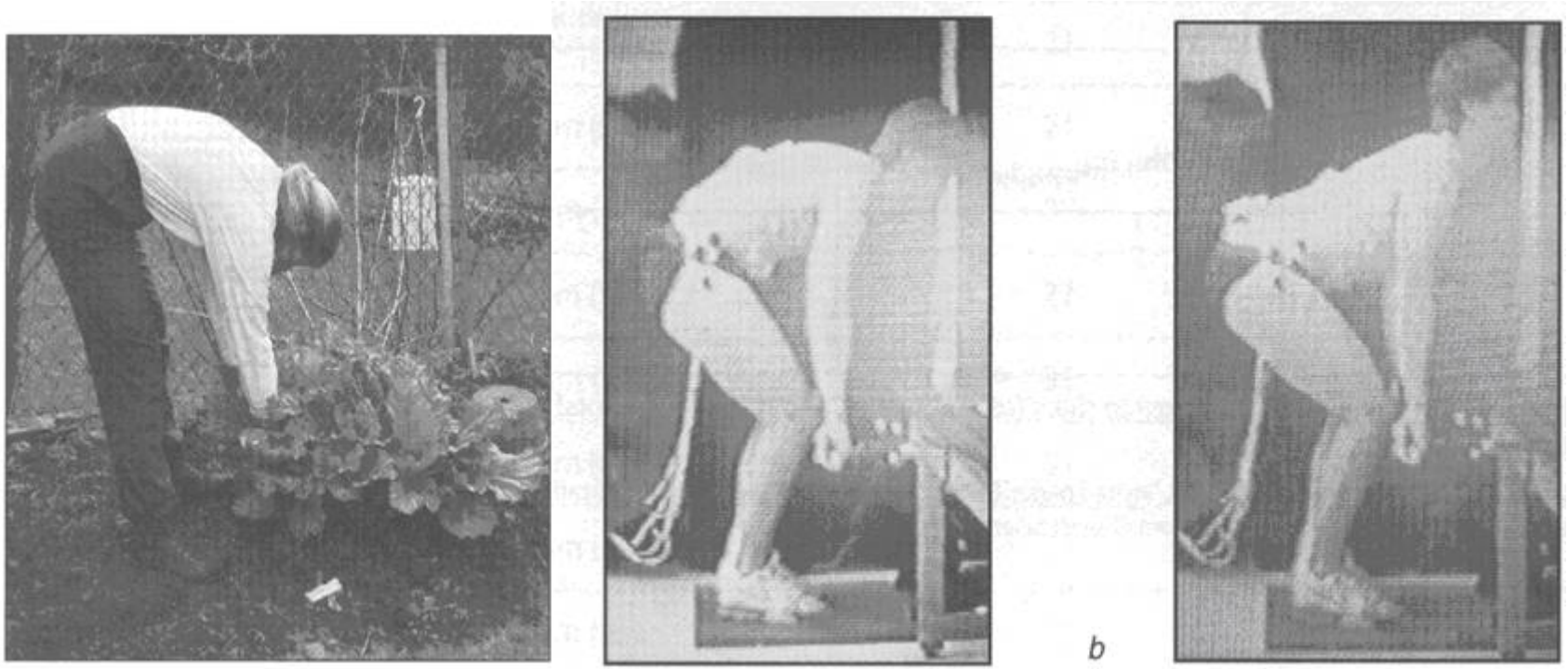
Shear forces and injury risk



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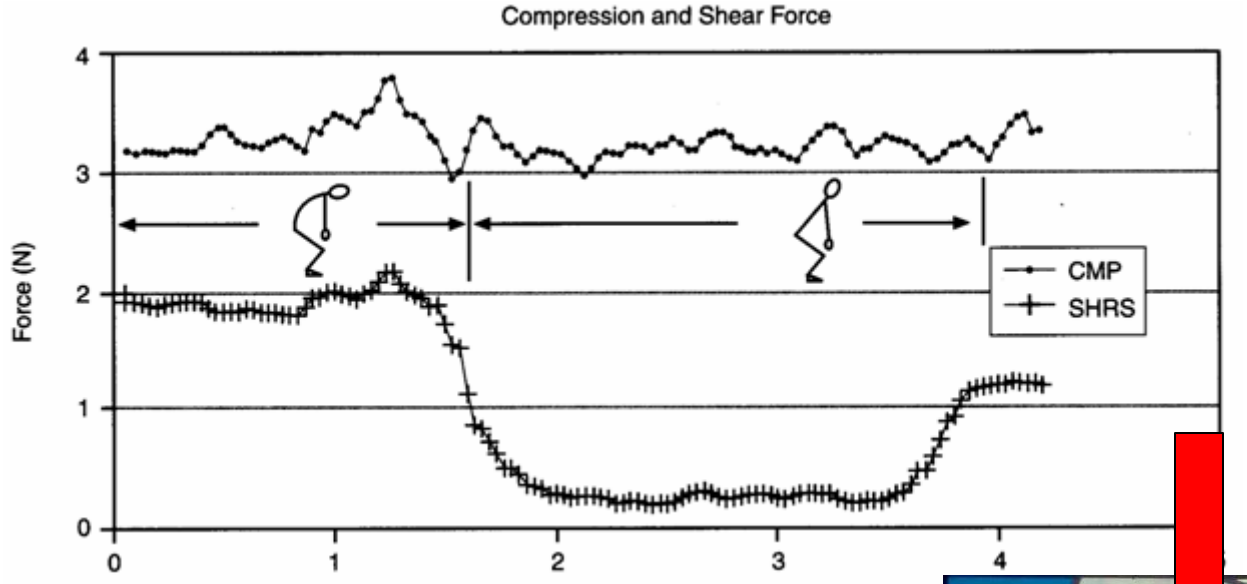
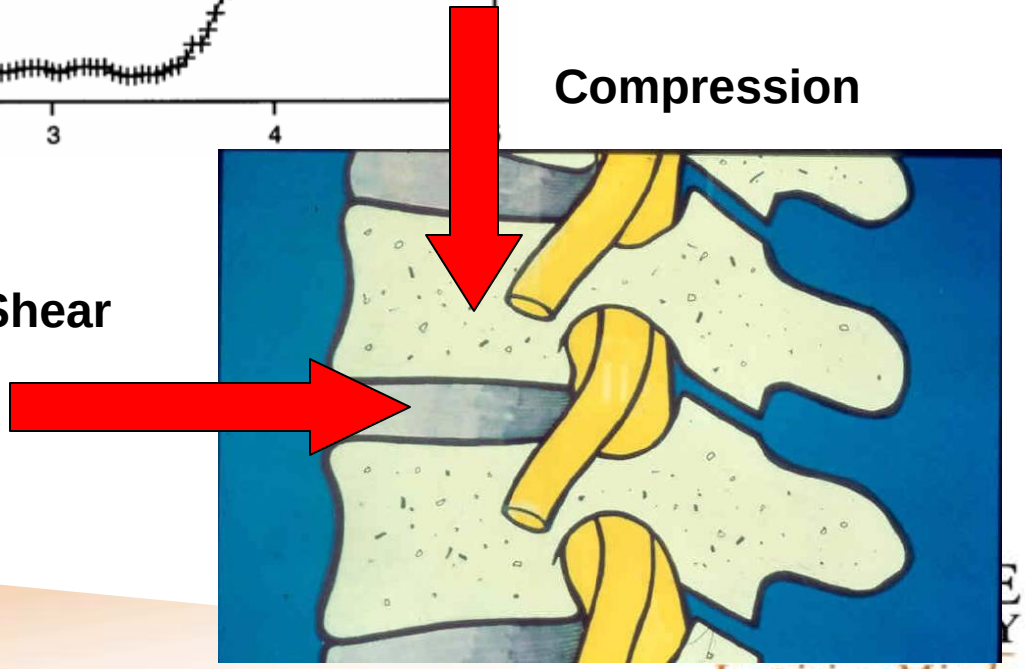
Compressive and shear forces (L4/L5)





Manual harvesting equipment

- Hand rakes:
  - Size
  - Handle size
  - Weight
  - Handle angles

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Manual harvesting equipment

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Machine harvesters

- Large scale

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Machine harvesters

- Smaller scale

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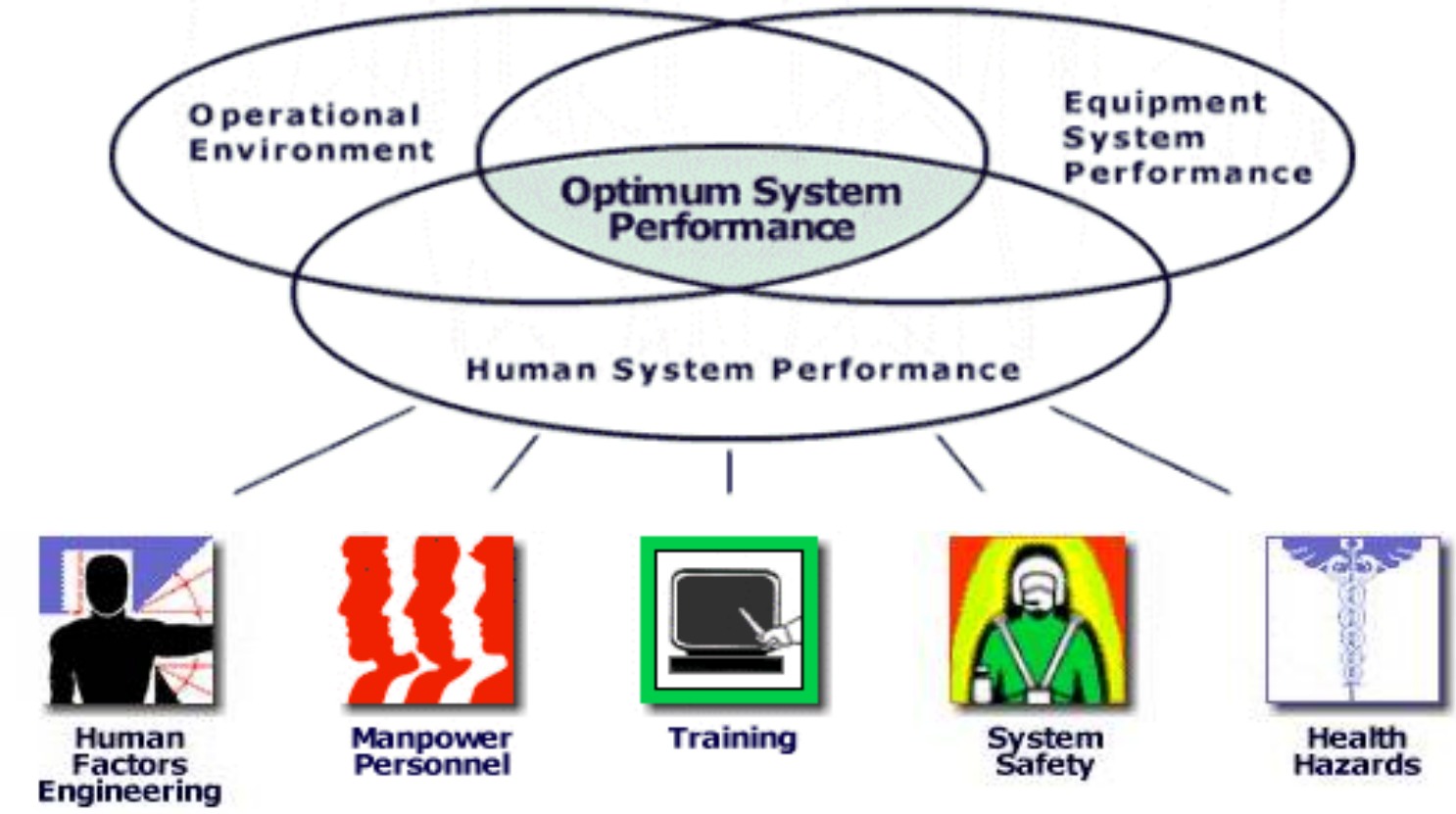
So what is the problem and what is the solution?

- Many complex systems have moved beyond Human Factors Engineering
- Now Human Factors is integrated into the early design phase of a new “system”

What is Human Systems Integration?



From DRDC-2004

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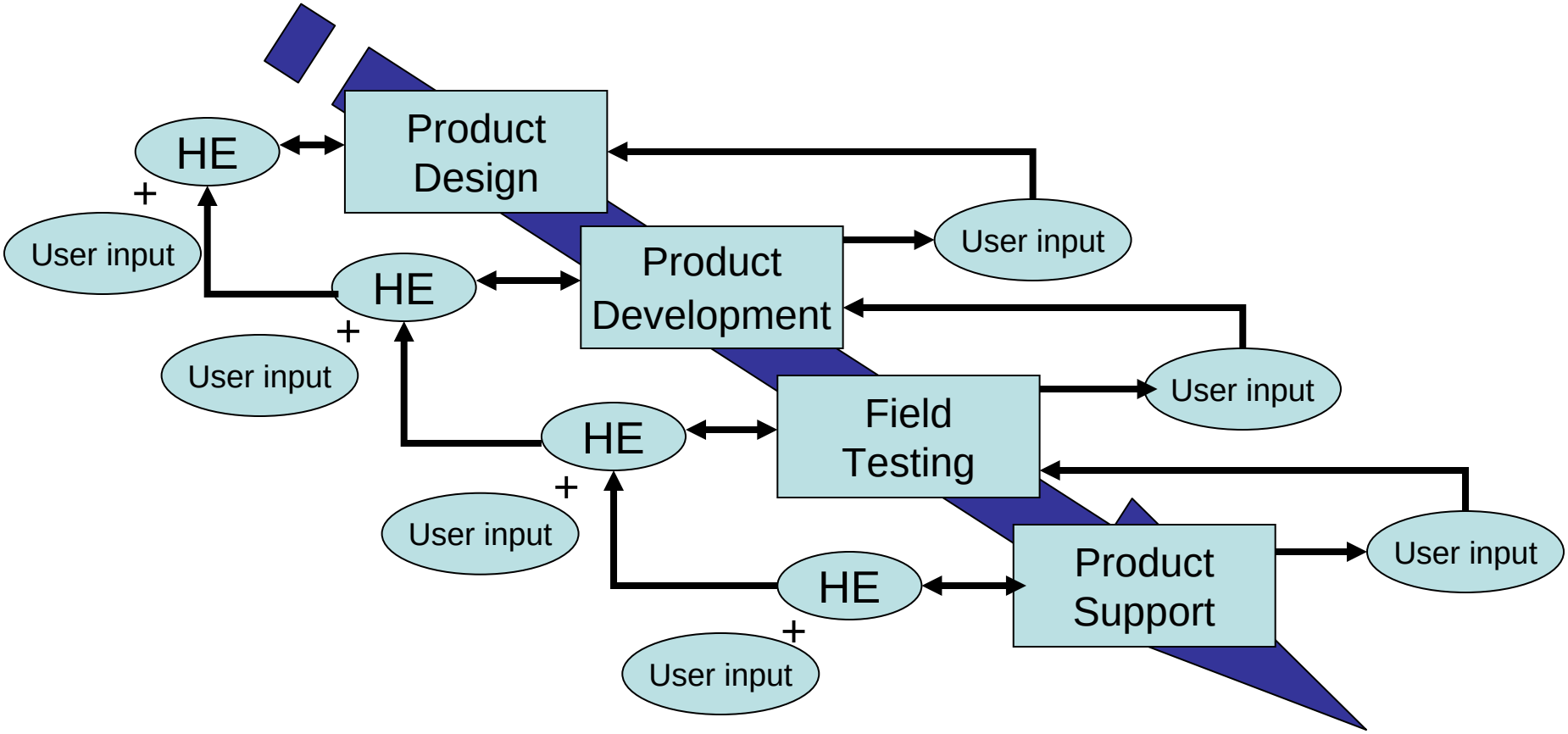
Solutions

- Build safety and ergonomics into the design
- Many ‘new’ designs are in small businesses which lack R&D for things other than the PRIMARY OBJECTIVE
  - Guarding
  - Loads

Life cycle of a new product/system



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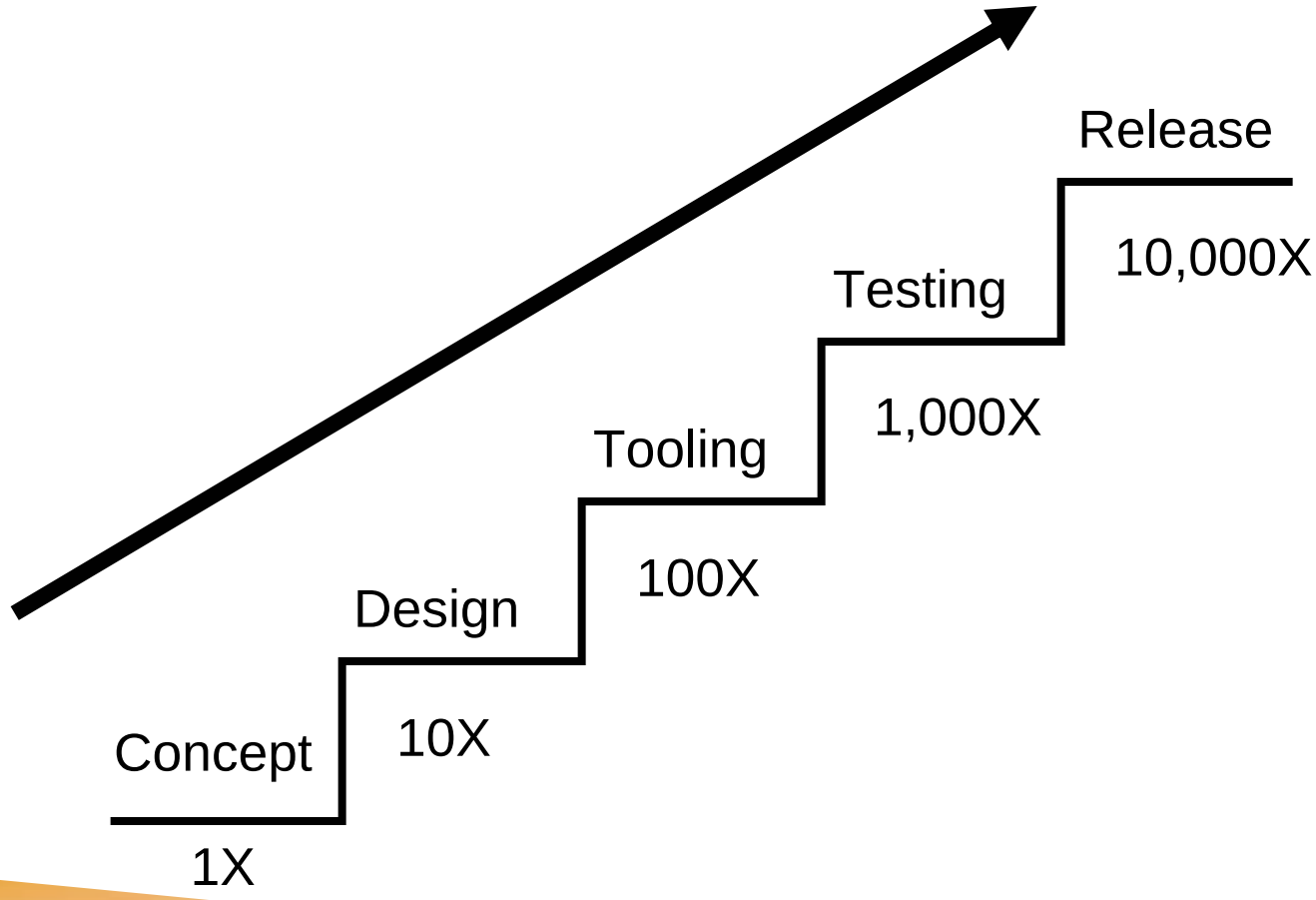
Design priorities

- Product goals
- Usability
- Human performance/error
- Emergency conditions

Cost of Design Change



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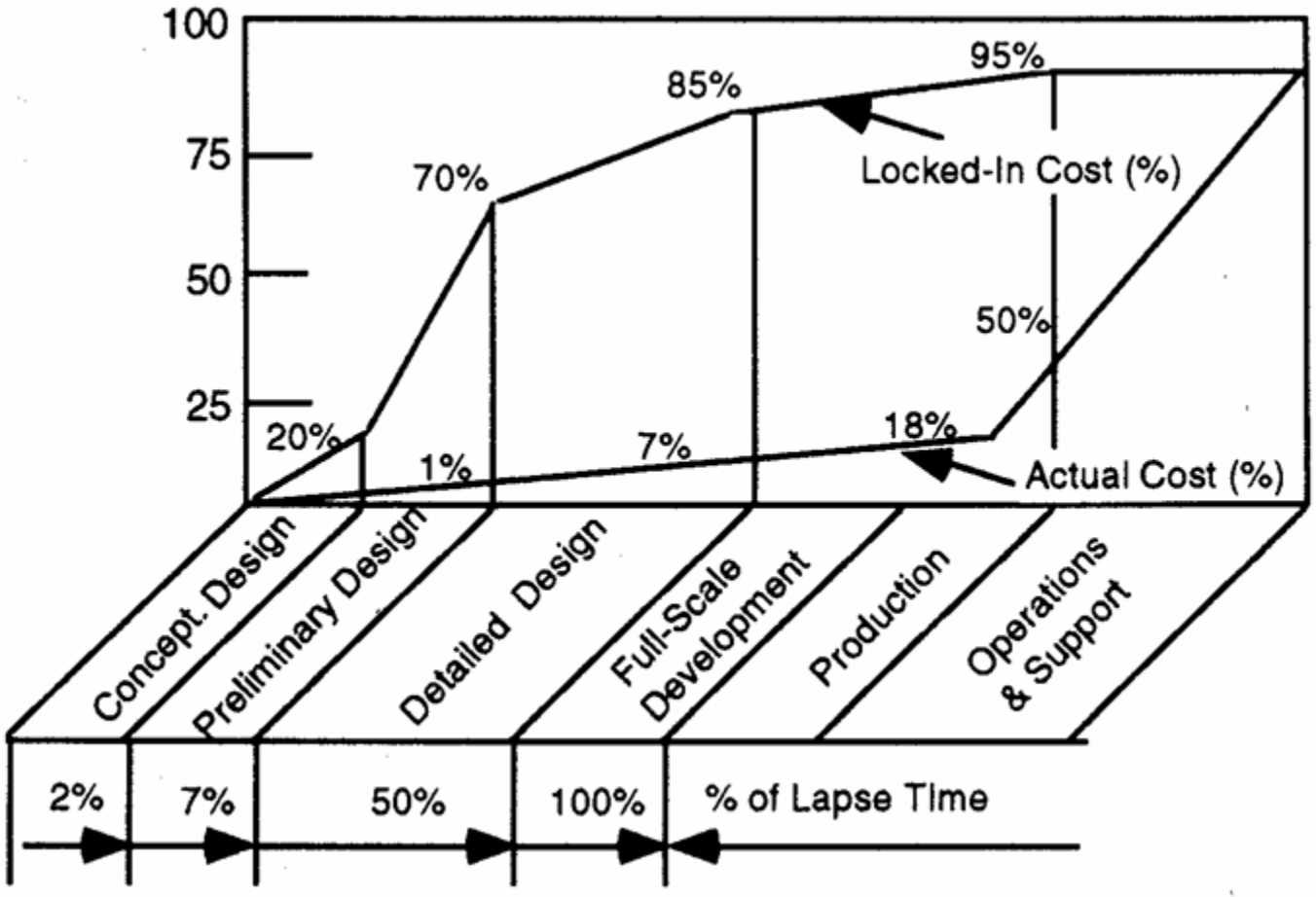
Delayed input vs costs



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How can Human Factors be used?

- **Actions**
  - Review and/or establish system goals
  - Understand human limitations and design to minimize their effects
- **How**
  - Review existing systems (design, policies, etc)
  - Model and evaluate proposed systems (early)
  - High interaction with users.
  - Ask for a review of new products before purchase!

How – By carefully moving upstream

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