Mechanisms Of Therapeutic Exercise Progression

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Background

- Physiotherapist (1988)
- McKenzie Diploma (1998)
- Editor, MIUSA / MII Journals (1998 - 2006)
- Educator (PT; PTA) (1995 - present)

- Endurance sports coach
  - running, triathlon
- Top 20 pro, Ironman World Championships, Kona, HI
- Sub-24:00 finisher at Western States 100 Mile Endurance Run
- Gold medalist, 800m and 1500m, 2011 World Masters Athletics
Background


“Running Injuries: Etiology And Recovery-Based Treatment” (with Bridget Clark, PT) in 3rd edition of “Clinical Orthopedic Rehabilitation” (2011)

Smart Life Project™

Sports Science Solutions for Training, Rehab, And Life

Scientific Mechanisms Applied to Rehabilitation and Training

Why This Topic?

The vast majority of "treatments" have little to no confirmed scientific basis …

... yet we claim to be focused on "evidence-based practice"
Why This Topic?

There are too many clinicians using yellow theraband forever …

… yet we promote ourselves as the experts in therapeutic exercise

We have 50+ years of cellular physiology research …

… and yet we choose to ignore it

Objectives

- Identify and examine the current scientific literature on therapeutic exercise and tissue repair

- Identify the three primary components of Recovery-Centered Training and explain their relevance to therapeutic exercise progression
Objectives

- Discuss the physiological mechanisms underlying tissue repair and development in the context of therapeutic exercise
- Define the principles of mechanical loading and their application to therapeutic exercise programs

Objectives

- Implement optimized therapeutic exercise progressions utilizing the critical parameters and dosage of various loading strategies

Agenda

- Introduction and Overview
- Evidence-Based Cellular Physiology
- Mechanisms Of Therapeutic Exercise
- Failure Of Traditional Approaches To Therapeutic Exercise
- Recovery-Centered Training
- Building Capacity
- Progression And Clinical Application
- Question And Answer
Evidence

1. that which tends to prove or disprove something; ground for belief, proof.
2. something that makes plain or clear.
3. data presented to a court or jury in proof of the facts in issue and which may include the testimony of witnesses, records, documents, or objects.

Belief Systems

The impact of our belief systems may be greater than the evidence

Ross (1994):
- "Our beliefs are the truth;
- The truth is obvious;
- Our beliefs are based on real data;
- The data we select are the real data"
Belief Systems

“The inability to challenge our belief systems in the face of good scientific evidence is the primary limiting factor in the advancement of both health care and coaching, as well as human performance and injury prevention”

(Besselink, 2008)

Principles And Practices

Principles = Why
Practices = What

Hippocrates

“First, do no harm;
Second, revere the healing powers of nature”
Alf Nachemson

“... it is within the interest of our patients, and ourselves, to prescribe simple and inexpensive methods in which the known clinical, biological, and mechanical factors can serve as guides”

(1979)

Evidence-Based Cellular Physiology

50+ years of research in cellular physiology

Apply these well-established principles
Principles

1. Homeostasis
2. Feedback Loops
3. Stimulus – Response
4. Specific Adaptation to Imposed Demands
5. Wolff’s Law … or “Form Follows Function”

Principles

6. Critical Parameters
7. Periodization
8. Tissue Repair / Remodel
9. Pain
10. Competent Self Care

Homeostasis

- “The maintenance of relatively stable internal physiological conditions under fluctuating environmental conditions”
- The human body is an amazing, resilient, adaptive complex of structures and mechanisms
- Self-regulation
Feedback Loops

Stimulus - Response

Stimulus – response …

… and maintaining homeostasis …

… is the basis for everything we do
Stimulus - Response

Training stimulus and adaptation response

Balance Stimulus And Response

Human adapt to the demands imposed upon them
- Astronauts
- Students

SAID Principle
Wolff’s Law

- Bone will adapt to the loads placed on it
- “Not just for bone anymore”!
  - Collagen
- “Form Follows Function”

At The Cellular Level …

Goal: “Turn on the gene”

Anabolic versus catabolic processes

Exercise Is Like Medicine

“Therapeutic Dose” is critical!

Every stimulus (exercise) has a desired cellular response
Critical Parameters

Critical parameters include:
- Dosage
- Potency
- Frequency
- Timing

Exercise Is Like Medicine

What if too much ...

... or if not enough?

Periodization

Training, detraining, and periodization
Periodization

Time is inherent to the process of recovery and adaptation

"Timing is everything"
(Besselink, 2012)

"Time is on my side, yes it is ..."
(Kai Winding, 1963; Rolling Stones 1964)

Overuse or Under-Recovery?

Tissue Repair

Phases of tissue repair and remodeling

- Acute inflammatory phase
  Days 0 – 3 (5 to 10 possible)
- Fibroplastic/repair phase
  Days 3 – 21
- Remodeling phase
  Days 21 – 6 months – 2 years
Tissues Require ...

... especially in the fibroplastic and remodeling phases

Acute Inflammatory Phase

Days 0 – 3 (can be up to 5 to 10 days)

- Gentle movement
- "Your friend, not your foe"

Fibroplastic Phase

Days 3 – 21

- "Prime Time" at the cellular level for protein and collagen synthesis
- "Prime Time" for mechanical loading
Remodeling Phase

Duration = 6 weeks to 2 years

- Still very responsive to mechanical loading
- "Form Follows Function"

Pain

- Primary types:
  - Central
  - Chemical
  - Mechanical
- Consistent behaviors

Chemical Pain

- Sufficient chemical concentration to activate nociceptors
- Causes can include:
  - Trauma
  - Acute inflammatory response
- Constant symptoms – "car stereo"
Mechanical Pain

- Mechanical deformation of tissue
  - Sustained loading
  - Repetitive loading
- Constant or intermittent symptoms
- No *pathology* need exist ("bent finger")

Competent Self Care

Can the patient perform the necessary loading strategies *on their own* to promote optimal repair and remodeling?

Mechanisms
Mechanisms

Mechanisms of Optimal Human Performance

Mechanisms of Injury Recovery

Mechanisms of Injury Prevention

(Besselink, 1992)

Mechanisms Of Injury

- Trauma
- “Overuse”
- “Under-Recovery”

Injury occurs when the rate of application of stimulus exceeds the rate of adaptation of the tissues.
Mechanisms

- Tissues
  - Nervous
  - Muscle
  - Connective
    - (Epithelial)
- "Systems Thinking"

Mechanisms - Cellular

**Cellular Level**
- Protein synthesis
- Collagen synthesis
- Mitochondrial density
- etc...

**Changes in...**
- Tendon tensile strength
- Muscle strength
- Cartilage volume
- etc...

Mechanisms

Stimulate desired cellular activity to

"turn on the gene"

and attain desired cellular response
Mechanisms

- What mechanical loading strategy is required to accomplish this?
- What are the necessary critical parameters of mechanical loading?
- Assess via appropriate symptomatic, mechanical and functional responses

Mechanisms

- Tissues
  - Nervous
  - Muscle
  - Connective
  - Epithelial

- Loading Strategies
  - ?

Mechanotransduction


Mechanotransduction


Critical Parameters

Critical parameters include:
- Dosage
- Potency
- Frequency
- Timing

Nervous Tissue

- CNS Recruitment
- Motor patterns
- Synaptogenesis
- Facilitation and inhibition
- Loading Strategy?
 Muscle Tissue

- Number of muscle fibers recruited
- Velocity of muscle fiber recruitment
- Mitochondria = cellular powerhouse (active muscle fibers only) = endurance
- Collagen component
- Loading Strategy?

 Connective Tissue

- Bone
  - Tension, compression, shear
  - Fluid flow
- Collagen
  - Tendon – tension
  - Cartilage – compression
  - Ligament - tension

 Failure Of Traditional Approaches
Alf Nachemson

“Most of us in our present state of ignorance get 70 – 80% good results … “

Traditional Approaches

- Insufficient or inappropriate exercise parameters to elicit desired (or optimal) physiological response
- Garbage In, Garbage Out
- Modalities as a passive mechanical loading strategy

Woollard et al (2011) JOSPT

"Change in Knee Cartilage Volume in Individuals Completing a Therapeutic Exercise Program for Knee Osteoarthritis"

- Loss of cartilage volume
Therapeutic Exercise

- Stretching, quadriceps setting, SLR
- Leg press at 70% of 1-RM: 3 x 10
- PT 2x per week for 6 weeks
- HEP 2x per week for 4 weeks

Based on the critical parameters, would I expect anything different?

Problem

“The inability to challenge our belief systems in the face of good scientific evidence is the primary limiting factor in the advancement of both health care and coaching, as well as human performance and injury prevention”

(Besselink 2008)

Recovery-Centered Training
 Systems Thinking

- Involves understanding the behavior of the system as a whole
  - Peter Senge "The Fifth Discipline"
- Recovery-Centered Training – A Model Of Human Performance
- (Mechanical Diagnosis And Therapy)

Recovery-Centered Training

- A systems approach to human performance
- What good is a training session if I don’t do what is necessary to recover from and adapt to it?
Recovery-Centered Training

- Mechanical
- Cognitive
- Nutritional

Recovery-Centered Training

- Mechanical
  - Neuro-musculo-skeletal system
  - Cardiovascular system

Recovery-Centered Training

- Cognitive
  - Central nervous system
  - Endocrine system
  - Immune system
Recovery-Centered Training

- Nutritional
  - “Fuel”
  - “Building Blocks”
  - Water
  - Vitamins and minerals

Building Capacity

The capacity to withstand physiological or psychological stressors over a sustained period of time
Building Capacity

- Engine (power output)
- Fuel tank
- Fuel economy
- Cooling system
- Fuel supply
- Chassis And Suspension
- Maintenance

Work = "the amount of energy transferred into or out of a system, not counting energy transferred by heat conduction"

Work = Power x time

Work = Force x Velocity x Time

What is the primary mode of therapeutic exercise (mechanical loading strategy) required to attain the desired cellular response?

What are the critical parameters necessary to accomplish this?
Building Capacity

Intensity is your friend – not your enemy

Stimulus - Response

Mechanisms
- Tissues
  - Nervous
  - Muscle
  - Connective
  - Epithelial
- Systems (RCT)
- Loading Strategies
  - Intensity
  - Intensity
  - Intensity
  - Intensity
### Scenarios

- Stress reaction
- Osteoporosis
- Osteoarthritis
- Capsular tightness
- Tendinopathy
- Derangement
- Weight loss
- Muscle strength
- Muscle endurance
- Post-surgical ROM
- Neuromotor facilitation
- Neuromotor inhibition
- Flexibility
- Aerobic capacity / deconditioning

### Tissue Repair / Remodel

- Acute Phase = 1 to 3 days = "your friend, not your foe"
- Fibroplastic = up to 3 weeks = "prime time" for mechanical loading
- Remodeling = 6 weeks to 2 years = still very responsive to mechanical loading

### Practices

- Benchmarks and baselines
- Apply mechanical loading strategies
- Assess response to mechanical loading strategies
Responses To Loading Strategies

- Symptomatic
- Mechanical
- Functional

Responses To Loading Strategies

- Symptomatic
  - Changes in pain rating; centralization / peripheralization; diffuse / local
- Mechanical
  - Changes in ROM; strength; dural signs
- Functional
  - Changes in functional testing / benchmarks

Progression
Progression

- Based on Symptomatic, Mechanical, and Functional Responses to Loading Strategies
- Need benchmarks and baselines!
- Critical parameters

Responses To Loading Strategies

- Symptomatic
- Mechanical
- Functional

Progression

- Daily reassessment of loading strategies
Progression

- Standardized progressions dependent on loading strategies!

Progression

- "Hurt Not Harm"
  - Safety
  - Appropriate loading

Progression

- Progression will vary depending on the ability of the patient to adapt to the imposed demands
  - Age
  - Metabolic status (i.e. hypothyroidism)
Limiters

- Signs and symptoms of "under-recovery" (Recovery-Centered Training)
  - Mechanical
  - Cognitive
  - Nutritional

Recovery-Centered Training

Cortisol

- A primary limiter of recovery and adaptation
- Stress hormone – synthetic version is hydrocortisone
Cortisol

- Effects:
  - Increase blood glucose
  - Inhibit protein synthesis
  - Inhibit fibroblast production
  - Increase water excretion
  - Decrease gene transcription
  - Immunosuppression
  - Competes with testosterone at the cellular level

- Insufficient fuel leads to "hibernation"

- Elevated blood cortisol – with all the associated effects

Recovery-Centered Training
It All Starts With The CNS

Cognitive Loading Strategies
- Are cognitive loading strategies appropriate in an injury recovery periodization?
- Effect of cortisol on injury recovery
- Is this a part of the physical therapist’s scope of practice?

Cognitive Loading Strategies
- Autogenics
- Life stressors
- Sleep
- Visualization / imagery
- Massage
- Yoga
- Meditation
Nutritional Loading Strategies

- Are nutritional loading strategies appropriate in an injury recovery periodization?
- Effect of cortisol on injury recovery
- Is this a part of the physical therapist's scope of practice?

Importance for training and recovery
- Facilitate optimal adaptations
  - Carbohydrate - fueling
  - Protein - development
  - Antioxidants - immune function
  - Water - cellular function

Clinical Applications
Scenarios

- Stress reaction
- Osteoporosis
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Clinical Applications

- Mechanisms
- Progression
- Limiters

Competent Self Care

Is It Enough?
Competent Self Care

“Give a man a fish
and you feed him for a day.

Teach a man to fish
and you feed him for a lifetime.”

Chinese Proverb

Alf Nachemson

“... it is within the interest of our patients, and ourselves, to prescribe simple and inexpensive methods in which the known clinical, biological, and mechanical factors can serve as guides”

(1979)

Hippocrates

“First, do no harm;
Second, revere the healing powers of nature”
Competent Self Care

- Can the patient perform the necessary loading strategies to promote optimal repair and remodeling on their own?
- What is the role of the PT?
- Competent self care and health mentorship is an opportunity for the PT profession

Challenge Your Thinking!

“We can't solve problems by using the same kind of thinking we used when we created them.”

(Einstein)

Reference List

Reference List


Question And Answer

For More Information:

- Smart Life Project
  - www.allanbesselink.com/slp

- “RunSmart: A Comprehensive Approach To Injury-Free Running”
The Finish Line Is Upon Us!

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