Physical Therapy
Guest Lecture

Specificity of Adaptation
THERAPEUTIC APPLICATIONS

Courtney Jensen, Ph.D.

Thursday, October 5, 2017

Your body is fragile and tentative;
its building blocks are ridiculously unstable.

- Increase or decrease your core temperature…
- Increase or decrease your pH…
- Increase or decrease your blood gases…
- Increase or decrease your blood sugar…
- Increase or decrease cellular hydration…
- And so on… Each has a potentially lethal consequence.

Survival happens in a narrow window.

Your body is fragile and tentative;
its building blocks are ridiculously unstable.

* **Thermal stress** (heat, cold)
* **Hypobaric stress** (high altitude, hypoxia)
* **Hyperbaric stress** (subterranean expeditions, underwater diving)
* **Spaceflight** (effect of microgravity on circulation and body tissues)
* **Conditions and quality of the air** (humidity, wind chill, pollution, allergens)
* **Travel stress** (disrupted circadian rhythms, sleep deprivation)
* **The internal environment** (pregnancy, aging, psychological stress)
* **The living environment** (the microbiome, infections, illnesses, diseases)
* **Hostile environments** (military stress, extreme employment or athletics)
* **Nutritional factors** (starvation, malnutrition, obesity)
* **Sensory stress** (noxious sights, smells, noise)

Your environment is not a narrow window.

How do we tolerate the breadth and diversity of stresses placed upon our tissues?

Biological purposes of life:

1. Self preservation, and **2.** Replication of the gene.

On some level, these are the same thing. How else would the gene replicate if the host was always dying?

Some responses are relatively permanent;
Other responses are relatively impermanent.

ALL very different phenomena

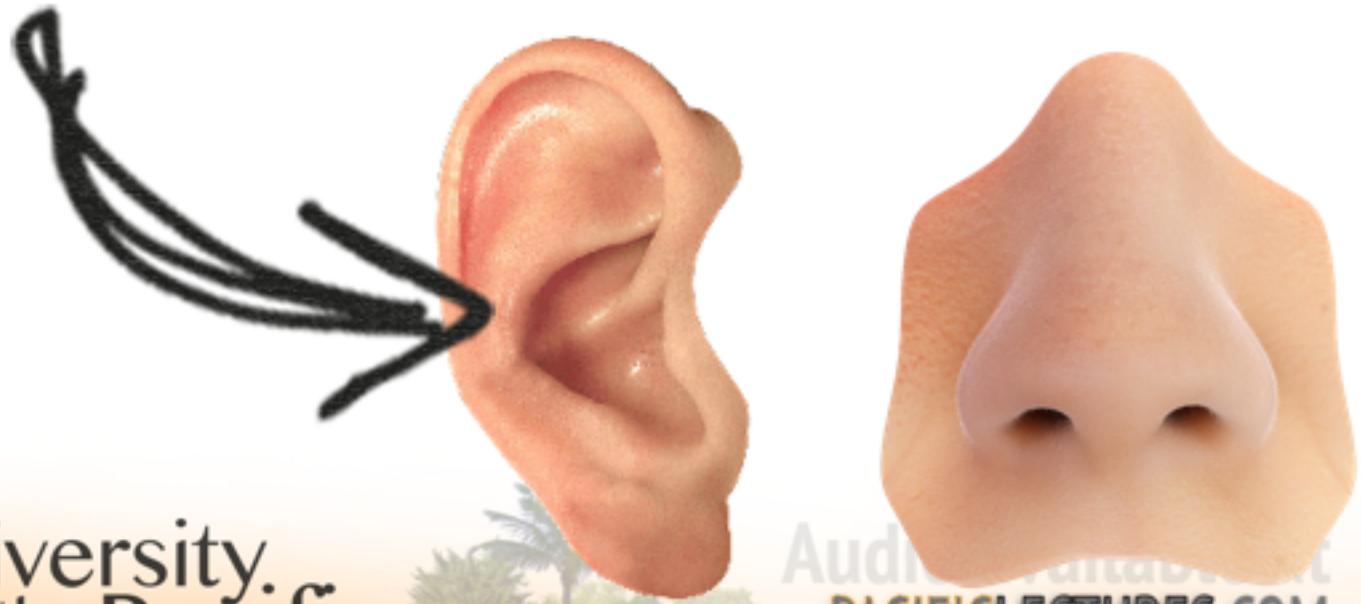
- Habituation
- Sensitization
- Accommodation
- Adaptation
- Genetic Adaptation

Some responses are relatively permanent;
Other responses are relatively impermanent.

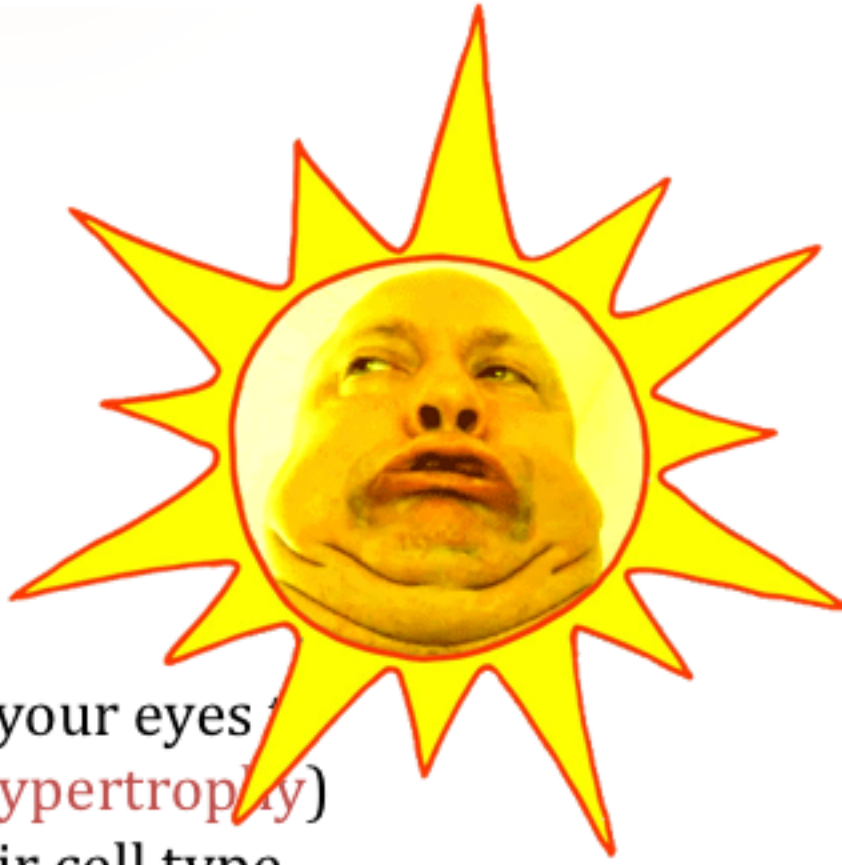
All living cells, organisms, creatures (etc.) spend their lives making changes to better tolerate their environments. Types of changes:

Habituation: Decrease in sensitivity to a stimulus.

Sensitization: Increase in sensitivity to a stimulus.



Accommodation vs. Adaptation



Adaptation

What is it?

A chronic change:

If bright lights caused the cells in your eyes t
multiply (hyperplasia) or grow (hypertrophy)
or shrink (atrophy) or change their cell type
(metaplasia), and the changes were relatively
permanent, that would be adaptation.

We adapt to tolerate our environment,
but no two adaptations are the same.

1892: Julius Wolff publishes
The Law of Bone Remodeling.

Discusses the metabolism of bones.

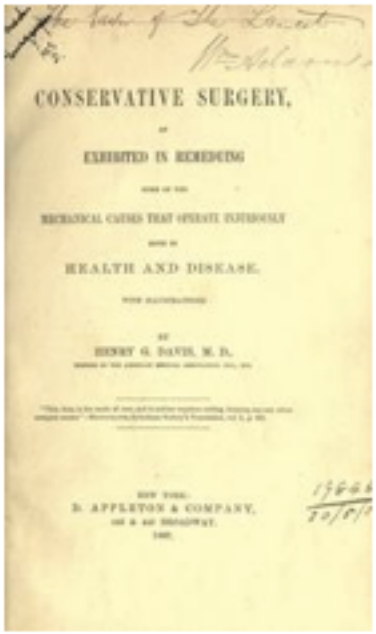
Architecture of bones can be altered with mechanical loading.

And the nature of the load matters.

Came to be known as "Wolff's Law".

We adapt to tolerate our environment, but no two adaptations are the same.

1867: Henry Gassett Davis publishes his (slightly less famous) book, *Conservative Surgery*.



CONSERVATIVE SURGERY,

EXHIBITED IN RECREDING

HEALTH AND DISEASE.

D. APPLETON & COMPANY,

Ligaments ("or any other soft tissue") adapt to the forces of stretching with a lengthening response.

"Davis's Law".

Regarded as a corollary to Wolff's.

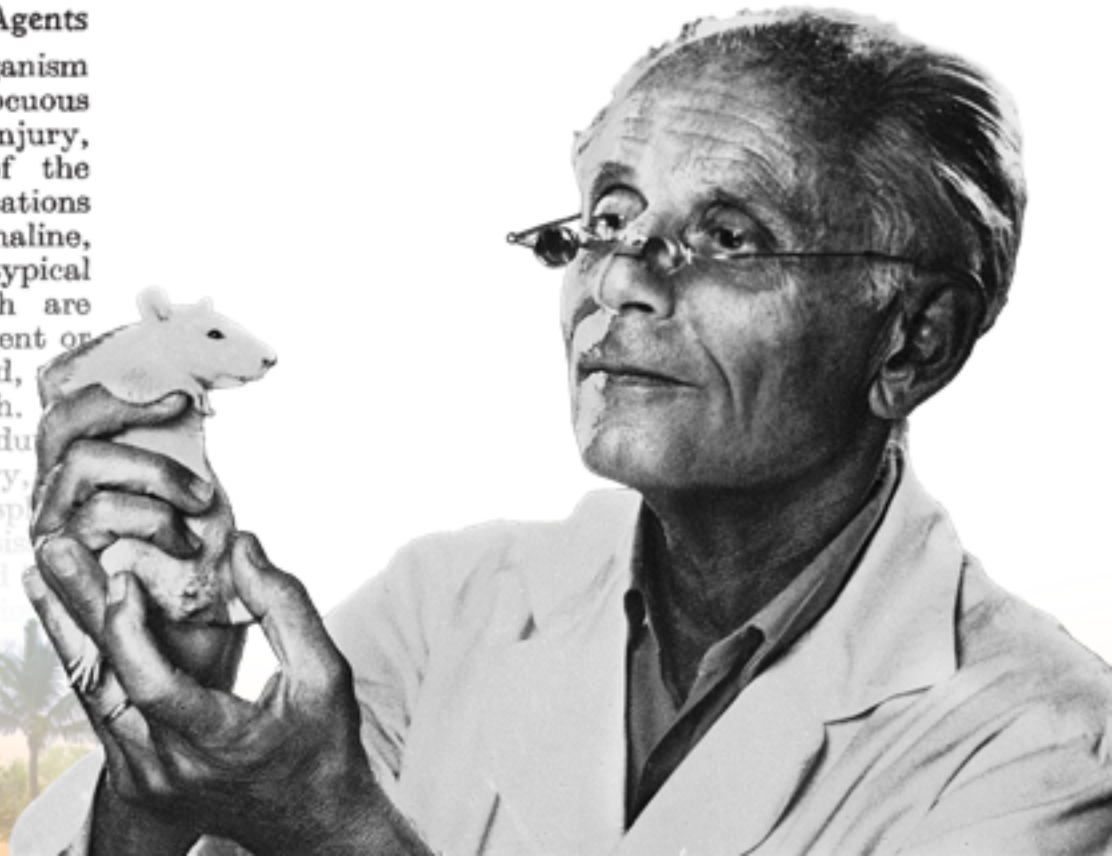
One of the most famous (and misleading) principles in human and exercise physiology was proposed by the Austrian-Canadian endocrinologist, Hans Selye.

NATURE JULY 4, 1936
32

A Syndrome produced by Diverse Nocuous Agents

EXPERIMENTS on rats show that if the organism is severely damaged by acute non-specific nocuous agents such as exposure to cold, surgical injury, production of spinal shock (transcision of the cord), excessive muscular exercise, or intoxications with sublethal doses of diverse drugs (adrenaline, atropine, morphine, formaldehyde, etc.), a typical syndrome appears, the symptoms of which are independent of the nature of the damaging agent or the pharmacological type of the drug employed, represent rather a response to damage as such.

This syndrome develops in three stages: du the first stage, 6–48 hours after the initial injury, observes rapid decrease in size of the thymus, sp lymph glands and liver; disappearance of fat ti oedema formation, especially in the thymus and retroperitoneal connective tissue; accumulati and peritoneal transudate; loss of



University of the Pacific

No matter what is causing you stress – physical or emotional – you will enter into an "alarm" phase, which jolts your physiology into panic mode. You experience different *amounts* of panic, stress, alarm, whatever, but *really* not different *types*.

Selye would say you're experiencing different *doses* of a general "stress."

1950s: Environmental physiologist Edward F. Adolph brought these redundancies to attention, pointing out that the adaptive responses of the body are more sophisticated than GAS, but redundant nonetheless. While our biology reacts to every threat and source of stress very specifically, there *is* plenty of overlap in those reactions.

General and Specific Characteristics of Physiological Adaptations

Received for publication November, 1954.

E. F. ADOLPH

From the Department of Physiology, University of Rochester School of Medicine and Dentistry, Rochester, New York

Specificity of adaptation (with redundancy in resources) shouldn't surprise anyone. Consider this example:

The United States goes to war wit
(because the drug situation really got

Or:

The United States goes to war
rea
(because they got electricity and then n

General military strategy?

How an organism responds to stress:

If it's not lethal (or otherwise threatening enough to notice), we ignore it, tolerate it, or merely accommodate.

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If a pronounced stress is experienced more frequently, we *adapt* to tolerate it. And that adaptation is very specific to the characteristics of the stresses that threaten us.

The breadth and depth of these changes are based on how many (and which) body systems are being challenged by the exercise, and how overwhelming the challenge.

An example:

"Angular specificity."

1: Belka D. (1968). Comparison of dynamic, static and combination training on dominant wrist flexor muscles. *Research Quarterly*, 39: 241-250. **2:** Fleck SJ & Kraemer WJ. (2004). *Designing Resistance Training Programs 3rd Edition*. Campaign, IL: Human Kinetics. **3:** Gardner GW. (1963). Specificity of strength changes of the exercised and nonexercised limb following isometric training. *Research Quarterly*, 34: 98-101. **4:** Lindh M. (1979). Increase of muscle strength from isometric quadriceps exercises at different knee angles. *Scandinavian Journal of Rehabilitation Medicine*, 11: 33-36.

Your physical form becomes the embodiment of what it endures.

Keep moving: body attempts to retain the ability of movement.

Stop moving: future moving privileges are (slowly) revoked.

How should you move *specifically* to achieve specific goals?

Step one: think about the stresses of your context.

Your physical form becomes the embodiment of what it endures.

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***Weird* moving:** the cause of most musculoskeletal pathology.

Proceedings of the Nutrition Society (2004), **63**, 331–335
DOI:10.1079/PNS2004357

Mechanotransduction and the regulation of protein synthesis in skeletal muscle

T. A. Hornberger and K. A. Esser*
Muscle Biology Laboratory, School of Kinesiology (m/c 194), University of Illinois, Chicago, 901 W Roosevelt Road, Chicago, IL 60608, USA

Specificity in mechanotransduction

In addition to being able to sense mechanical stimuli, it also appears that muscle cells can differentiate between different types of mechanical forces. For example, in skeletal muscle chronic longitudinal stretch produces growth in length but not cross-section (sarcomere deposition in series to the long axes), while chronic functional overload produces cross-sectional growth with no changes in length (sarcomere deposition is parallel to the long axes).

Bodily problems are seldom the result of "physiology gone wild"

Diseases, illnesses, conditions, disorders, syndromes, whatever.
Some of this results from poorly functioning physiology; much of it is a predictable consequence of inputs.

My computer is not doing what I'm telling it to do!

Computers can only obey commands; everything they do is merely a response (a perfect one) to the inputs received.

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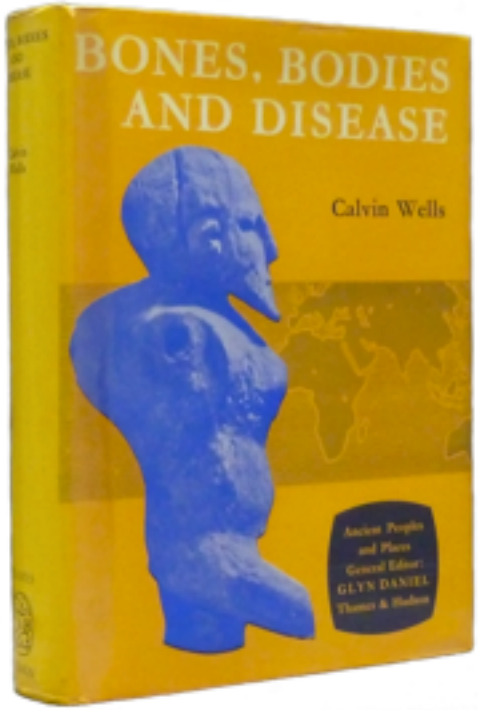
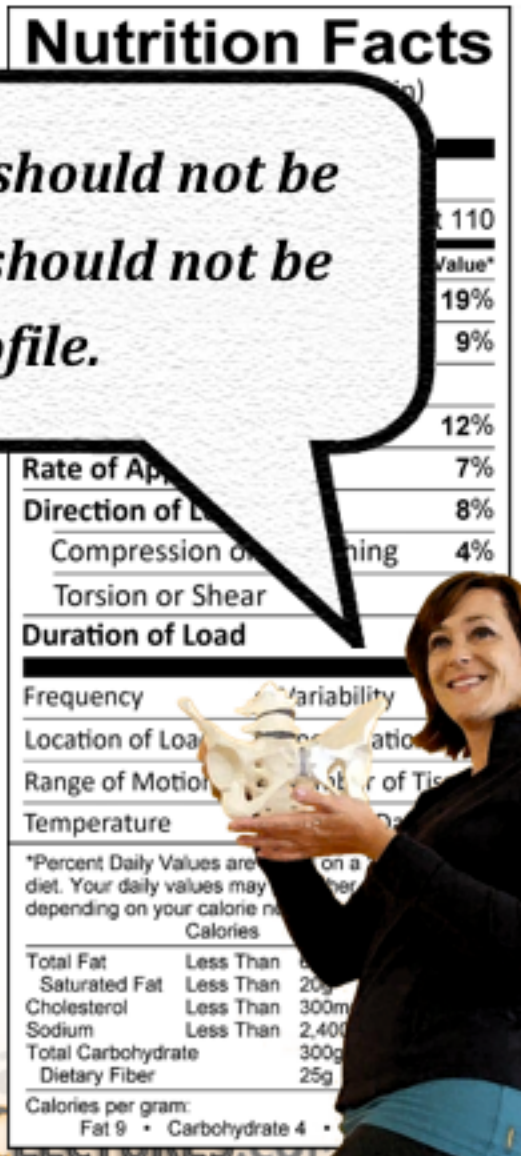


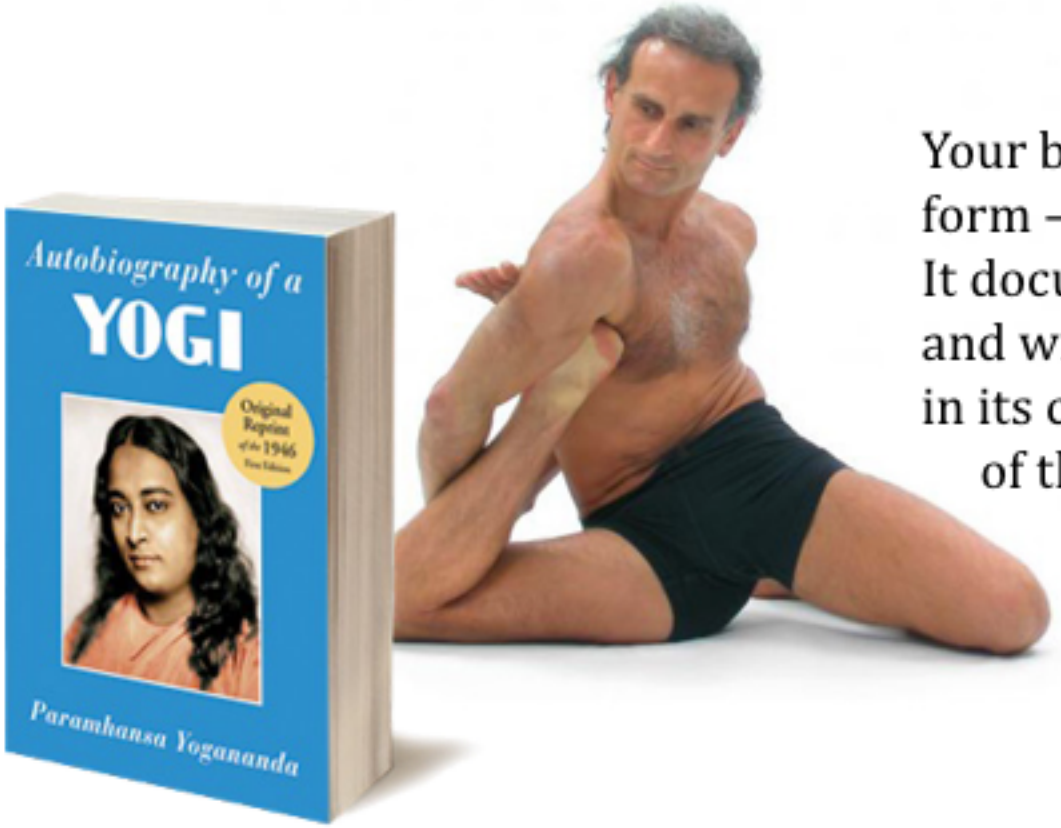
"The pattern of disease or injury that affects any group of people is never a matter of chance. It is invariably the expression of stresses and strains to which they were exposed, a response to everything in their environment and behavior."

In other words:
Your physiology isn't often naughty,
issuing illness through misbehavior.

Specificity of adaptation: “Activity” is not “activity”

In the same way supplements should not be the bulk of your diet, exercise should not be the bulk of your movement profile.





Your body – your physical form – is autobiographical. It documents every stress and writes their passages in its cells. The summation of those passages is what you see in the mirror.

Good vs. Bad Stress

SPORTSCIENCE · sportsci.org

Reviews / Pathology

SUDDEN DEATH AND EXERCISE

Timothy D Noakes MBChB MD

Physiology, University of Cape Town Medical School, Observatory 7925, South Africa. Email: noakes@iafrica.com

Sportscience 2(4), sportsci.org/jour/9804/tdn.html, 1998 (6281 words)

Reviewed by George D Swanson, Physical Education and Exercise Science, California State University, Chico, California

Sudden death in athletes will always be an emotive topic, for it suggests that athleticism may not prevent the development of heart disease and may actually increase the likelihood that the athlete will die suddenly during exercise. Persons who die suddenly during exercise have advanced heart disease of which they are frequently unaware. The commonest forms of heart disease associated with sudden death during exercise are coronary artery disease and hypertrophic cardiomyopathy. Less common cardiac conditions linked to sudden death in athletes include anomalous origin of the coronary arteries, aortic rupture associated with Marfan's syndrome, myocarditis, mitral valve prolapse and various arrhythmias. The incidence of these predisposing diseas… the athletic population is extremely low, possibly of the order of 1… 10,000 to 1 per 200,000 athletes. Detection of some of these … asymptomatic athletes may be difficult, if not impossible. Re… reduces the overall risk of sudden death in persons with l… artery disease, yet acutely increases the risk of sudden… exercise for those with heart disease that predispose… practical terms, only athletes with symptoms or clini… factors for coronary or other forms of heart disea… routine maximal exercise testing when they com… training program. However, once symptoms s… are present in athletes, detailed cardiologic…

KEYWORDS: cardiomyopathy, coronary …

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HEART DISEASE

Infrequent Sex or Exercise Can Trigger Heart Attacks

By Alice Park @aliceparkny | March 22, 2011 | Add a Comment

There's no denying that regular physical activity and a healthy sex life are good for your heart. But if you've ever huffed and puffed your way through a jog or a particularly strenuous bout of lovemaking, you might have wondered whether the exertion was actually stressing, rather than strengthening, your heart.

…estion is a valid one. Doctors have long …xtreme strain in the form of physical …) stress can trigger heart attacks. …on the matter — a review …ous studies — confirms …does indeed spike in the hour or so after an …tivity.

Email Print Share Comment Follow @TIMEHealth

…luded data on heart attack rates …ything from having sex to … found that during exercise, …an during periods of non-activity. During sex, the risk is 2.7 …of dying from a heart-related event during or immediately …hen you're not active.

Specificity of Adaptation
Take-Home Message

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It's not just your muscle adapting. No matter what exercise or activity you perform (ballet, physical therapy, hockey, etc.), every cell, organ, and body system that's involved is likely to adapt.

Those adaptations are aimed at self-preservation.

Specificity of Adaptation
Take-Home Message

All living cells, organisms, creatures (etc.) spend their lives making changes to better tolerate their environments.

Physical therapy **is** the manipulation of biological stresses and mechanical loads on tissues to restore proper cell signaling.

Specificity of Adaptation
Take-Home Message

If I had two semesters to fill with the specificity of Mechanotransduction (as it applies to therapeutic contexts), I would run out of time.
Today's lecture was meant to serve as a superficial introduction to the topic. One that I hope will inspire you to pursue it in more depth. Okay. That's all. Godspeed (or whatever)!