Neuromuscular Adaptations to Training

Baechle Chapter 4, pp. 143-151,

Powers & Howley pp. 253-255

Lecture Overview

- Neural Adaptations
- Skeletal Muscle Adaptations
- Connective Tissue Anatomy
- Connective Tissue Adaptations

Key Concepts of Physiology Adaptations to Exercise Training

- Each person responds differently to each training program.
- The magnitude of the physiological or performance gain is related to the size of an athlete's adaptational window.
- The amount of physiological adaptation depends on the effectiveness of the exercise prescriptions used in the training program.
- Training for peak athletic performance is different from training for optimal health and fitness.
- There is a psychological component to training.

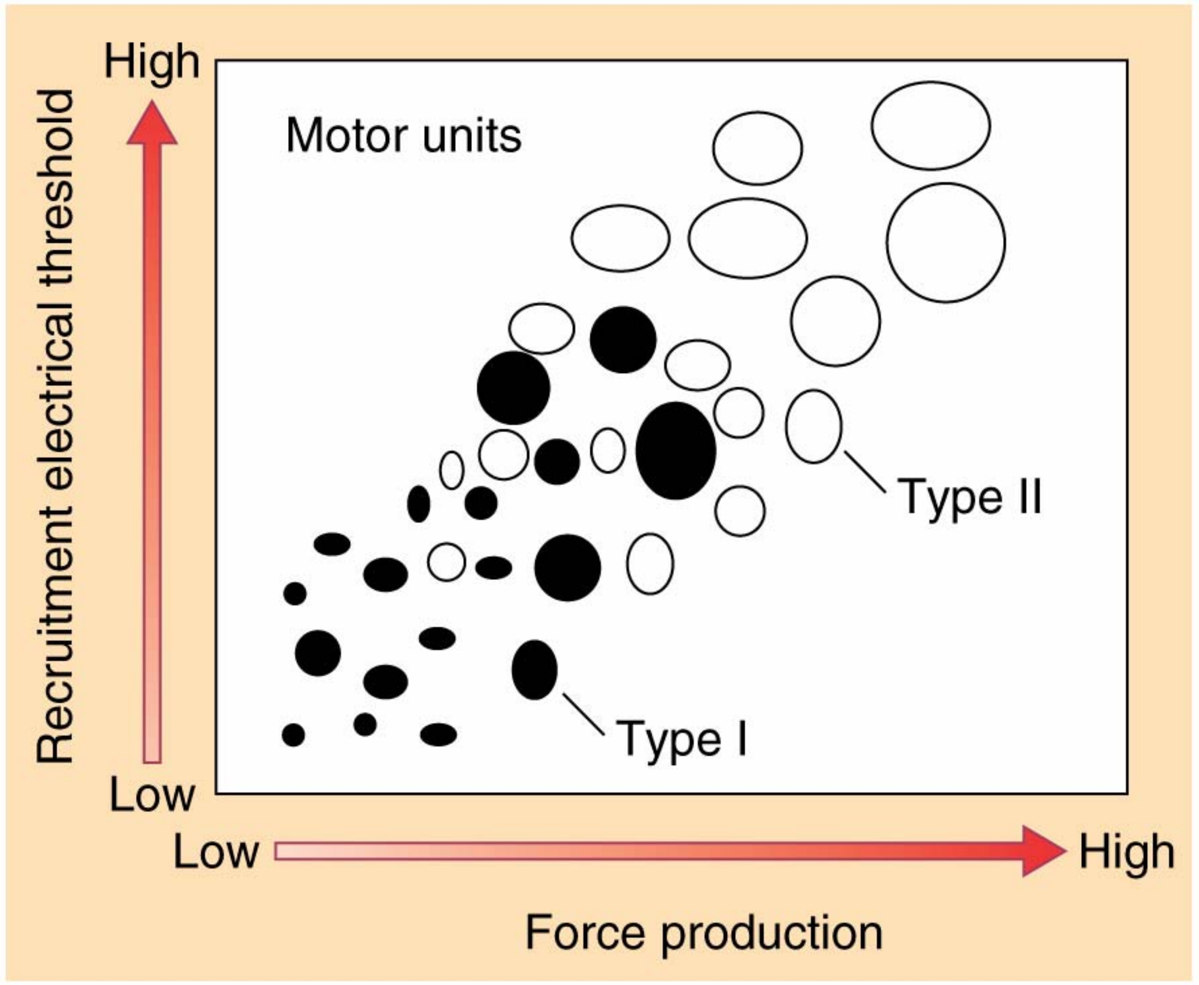
Neural Adaptations

- Increases in strength due to short term (eight to twenty weeks) training are the result of neural adaptations.
- Neural adaptations can include improved synchronization of motor unit firing and improved ability to recruit motor units to enable a person to match the strength elicited by electrical stimulation.

“Size Principle”

With heavy resistance training, all muscle fibers get bigger because they are all recruited in consecutive order by their size to produce high levels of force. In advanced lifters, the central nervous system might adapt by allowing these athletes to recruit some motor units not in consecutive order, but by recruiting larger ones first to help with greater production of power or speed in a movement.

Recruiting Order



Type of Training

- Adaptations to resistance training are specific to the type of exercise performed. Moreover, resistance training has no meaningful impact on aerobic power.
- Although aerobic endurance training increases aerobic power, it does not enhance muscle strength or size. In fact, intense aerobic endurance training can actually compromise the benefits of resistance training.

Stimulating Muscular Adaptations through Resistance Training

- For Strength
  - High loads, few repetitions, full recovery periods.
- For Muscle Size
  - Moderate loads, high volume, short to moderate rest periods.
- For Muscular Endurance
  - Low intensity, high volume, little recovery allowed.

Skeletal Muscle Adaptations

Variable	Resistance training	Aerobic endurance training
Size of muscle fibers	Increase	No change
Number of muscle fibers	No change	No change
Movement speed	Increase	No change
Strength	Increase	No change
Aerobic capacity	No change	Increase
Anaerobic capacity	Increase	No change

Skeletal Muscle Adaptations

Variable	Results following resistance training	Results following aerobic endurance training
Muscle fibers		
Fiber size	Increases	No change or increases slightly
Capillary density	No change or decreases	Increases
Mitochondrial density	Decreases	Increases
Fast heavy-chain myosin	Increases in amount	No change or decreases in amount
Type II muscle fiber subtype conversion	Almost all to Type IIa	With sprint interval, a majority to Type IIa

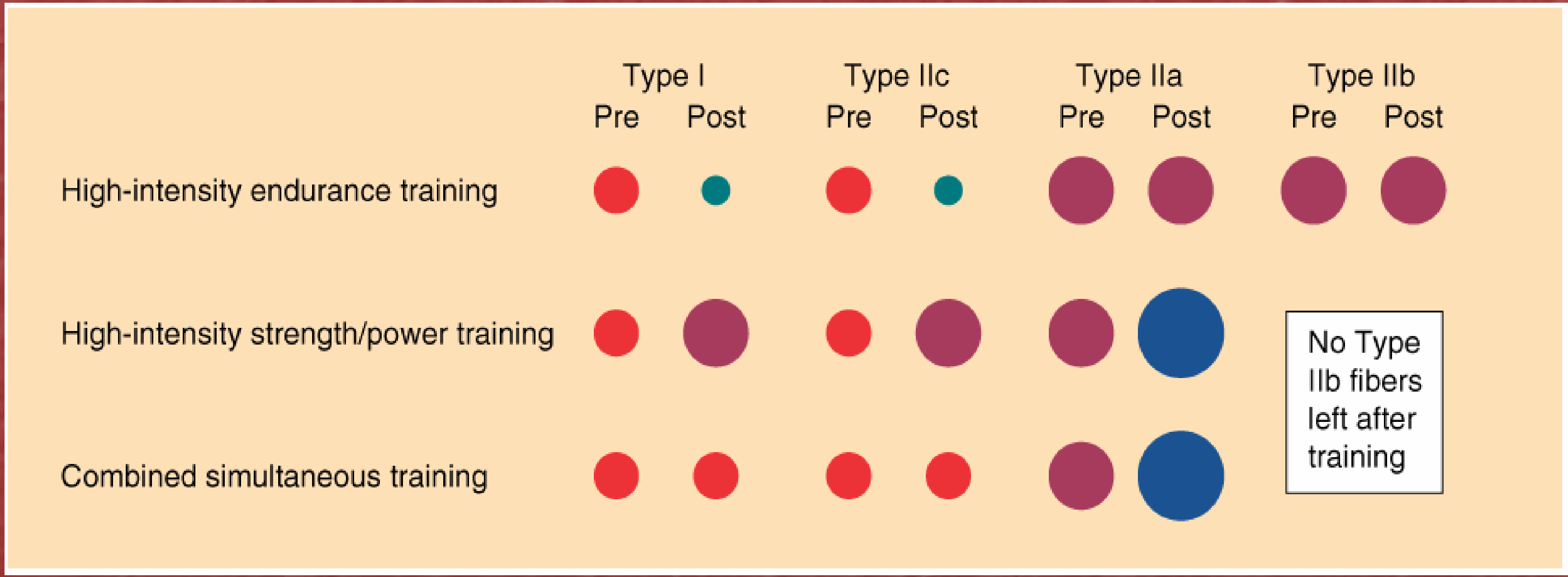
Muscle Fiber Size

- Hypertrophy: The process of hypertrophy involves both an increase in the synthesis of the contractile proteins actin and myosin within the myofibril and an increase in the number of myofibrils within a muscle fiber. The new myofilaments are added to the external layers of the myofibril, resulting in an increase in its diameter.
- Hyperplasia: Some studies report that elite body-builders have more fibers/motor unit than the average person.

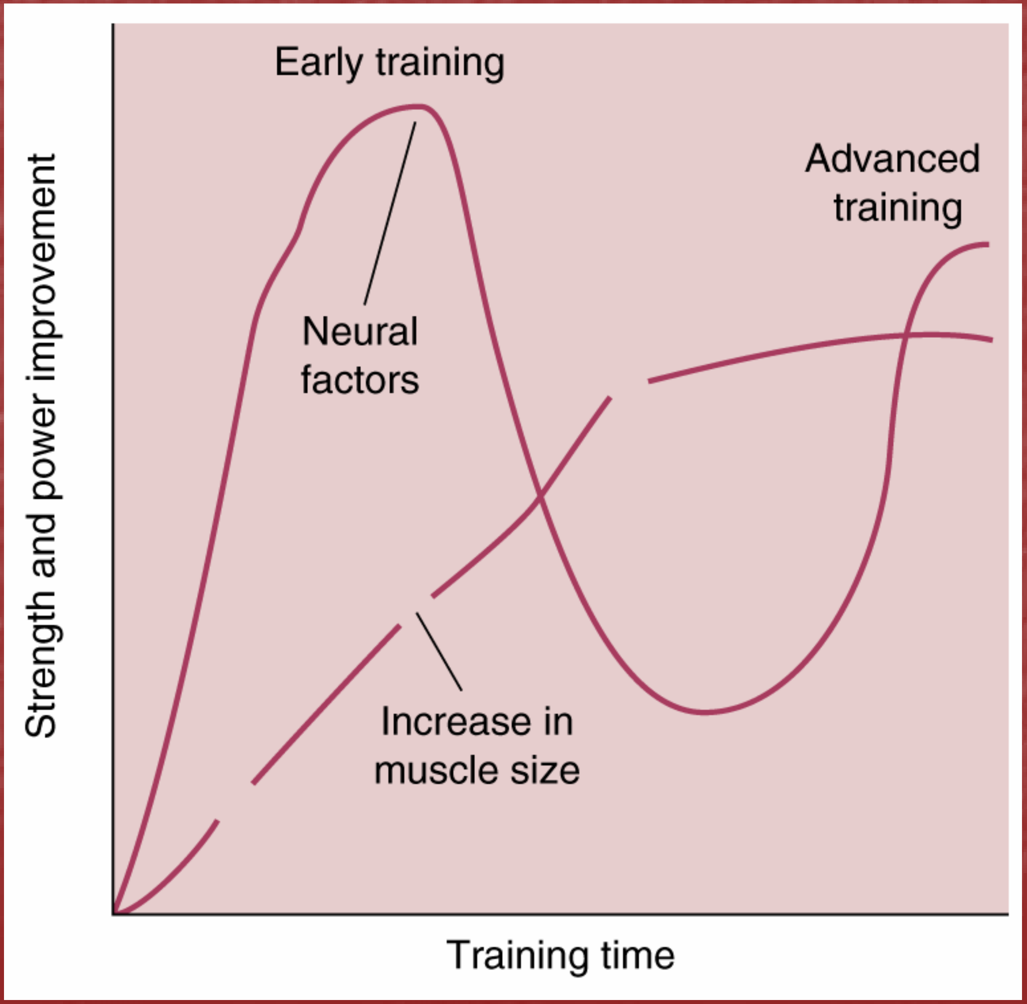
Alteration of Muscle Fiber Types

- Both endurance and resistance exercise training have been shown to promote a fast-to-slow shift in skeletal muscle fiber types.
- However, this shift is often small and generally results in a conversion of Type IIb fibers to Type IIa fibers.

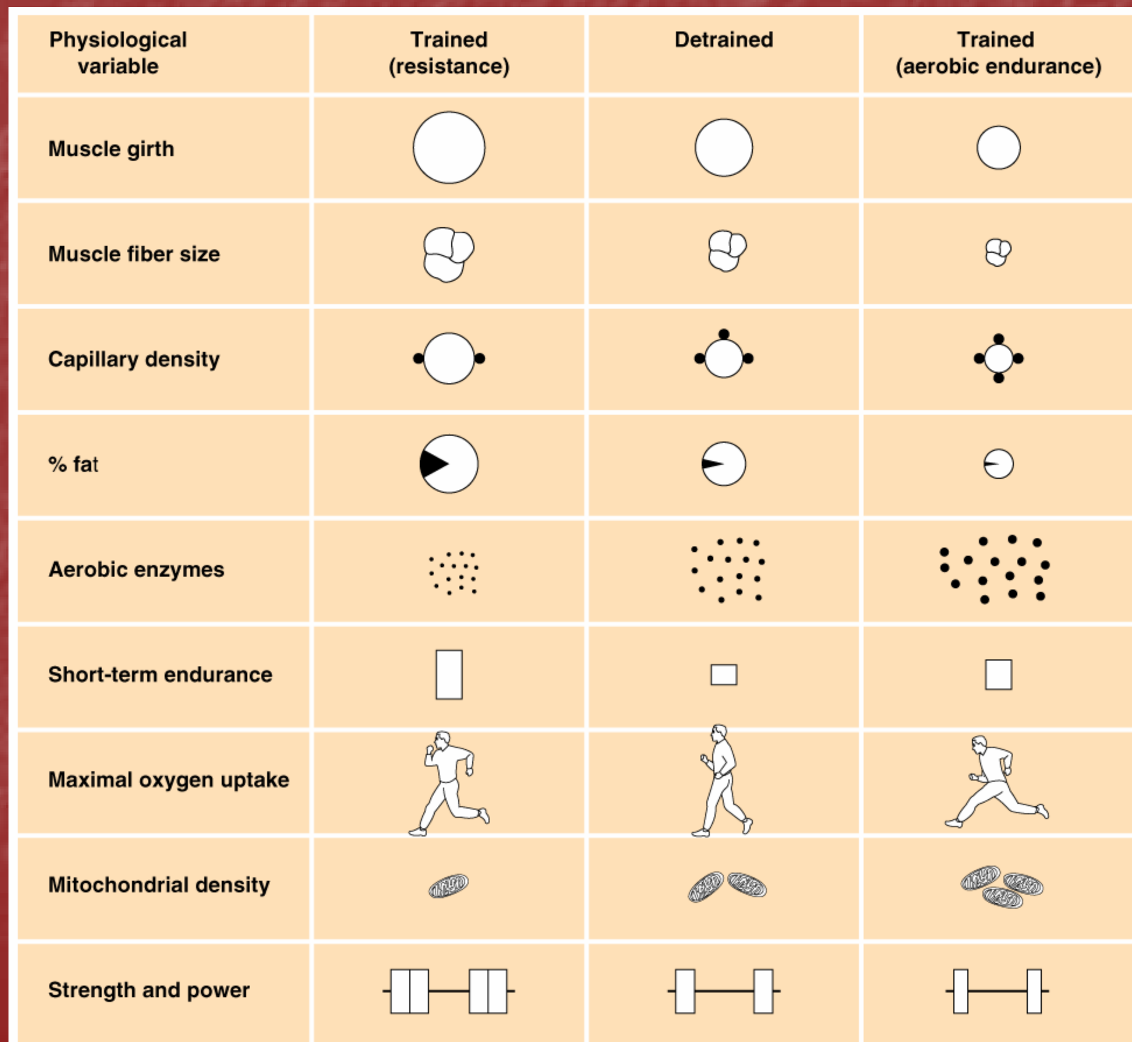
Muscle Fiber Reponses



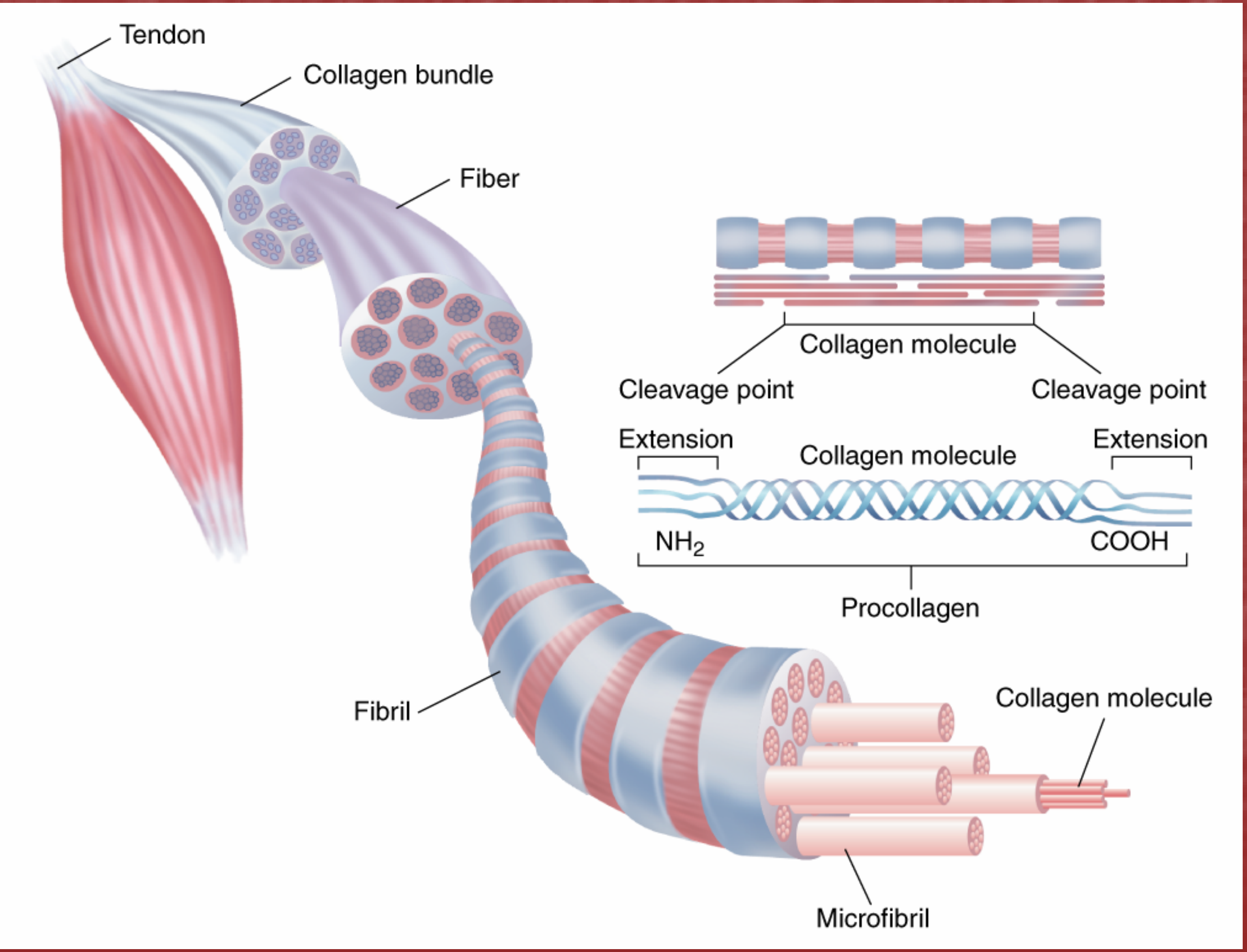
Neuromuscular Interplay



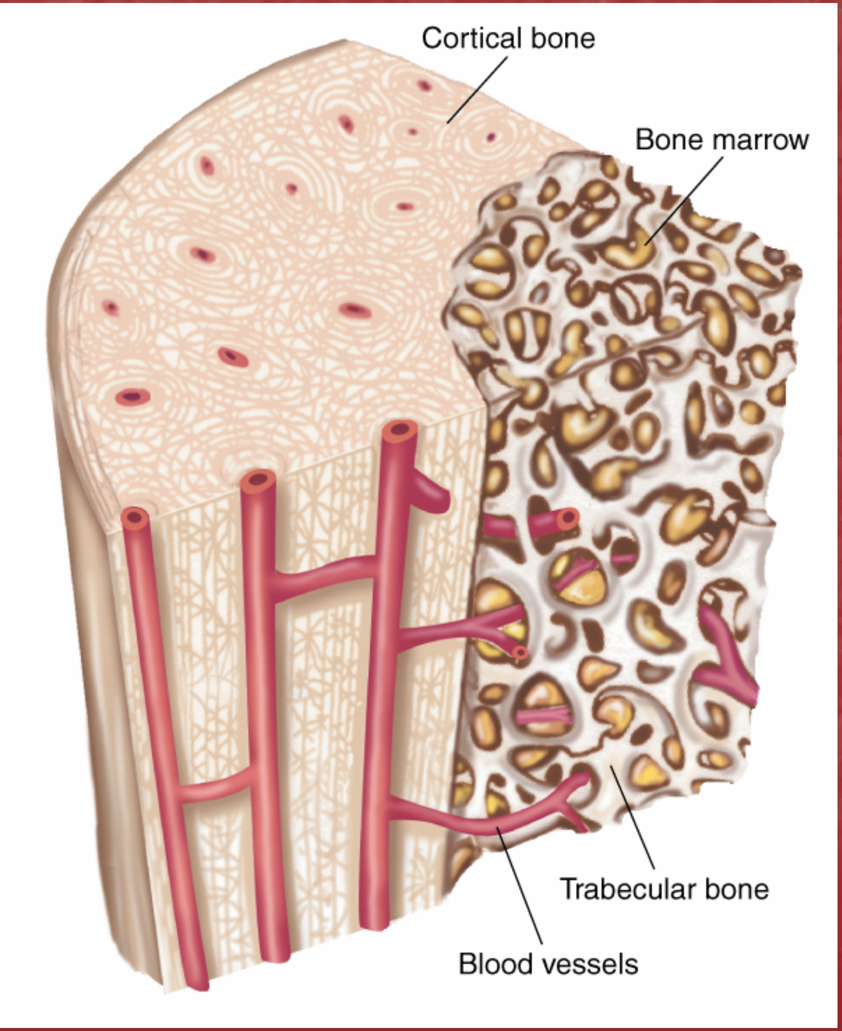
Responses of Physiological Variables



Collagen Fiber Anatomy



Bone Architecture



Connective Tissue Adaptations

Variable	Results following resistance training	Results following aerobic endurance training
Connective tissue		
Ligament strength	May increase	Increases
Tendon strength	May increase	Increases
Collagen content	May increase	Variable
Bone density	No change or increases	No change or increases

Adaptations to Tendon

- Specific changes within a tendon that contribute to the increase in its cross-sectional area and strength in response to a functional overload include
  - **an increase in collagen fibril diameter,**
  - **a greater number of covalent cross-links within a fiber of increased diameter,**
  - **an increase in the number of collagen fibrils, and**
  - **an increase in the packing density of collagen fibrils.**

Stimulating Connective Tissue Adaptations

- Tendons, Ligaments, Fascia
  - Exercise of low to moderate I does not markedly change the collagen content
  - High I loading results in a net growth of the involved tissues
- Cartilage
  - Weight-bearing forces and complete movement throughout the range of motion seem tot be essential to maintaining tissue viability.
  - Moderate aerobic exercise seems adequate for increasing cartilage thickness. Strenuous exercise does not appear to cause degenerative joint disease.

Bone Modeling

- Forces that reach or exceed a threshold stimulus initiate new bone formation in the area experiencing the mechanical strain.
- To stimulate bone formation:
  - Use exercises that directly load particular regions of the skeleton
  - Use structural exercises
  - Progressively overload the musculoskeletal system, & progressively increase the load as the tissues become accustomed to the stimulus
  - Vary exercise selection, changing the distribution of the force vectors to continually present a unique stimulus for new bone formation

Bone Modeling