



## DANIL HAMMOUDI.MD MUSCLE LECTURE PART III

### Developmental Aspects: Regeneration

 Cardiac and skeletal muscle become amitotic, but can lengthen and thicken
 Myoblastlike satellite cells show very limited regenerative ability
 Cardiac cells lack satellite cells

 Smooth muscle has good regenerative ability

#### Satellite cells

- Satellite cells are mononuclear progenitor cells found in mature muscle between the basal lamina and sarcolemma.
- Satellite cells are able to differentiate and fuse to augment existing muscle fibres and to form new fibres.
- These cells are involved in the normal growth of muscle, as well as regeneration following injury or disease.
- In undamaged muscle, the majority of satellite cells are quiescent; they neither differentiate nor undergo cell division.
- In response to mechanical strain, satellite cells become activated.
- Activated satellite cells initially proliferate as skeletal myoblasts before undergoing myogenic differentiation.

## Slide 4 Dorsal root ganglion

#### Satellite cells





## Developmental Aspects: After Birth

 Muscular development reflects neuromuscular coordination
 Development occurs head-to-toe, and proximal-to-distal
 Peak natural neural control of muscles is achieved by midadolescence

 Athletics and training can improve neuromuscular control

## Developmental Aspects: Male and Female

There is a biological basis for greater strength in men than in women

• Women's skeletal muscle makes up 36% of their body mass

Men's skeletal muscle makes up 42% of their body mass



# Developmental Aspects: Male and Female

These differences are due primarily to the male sex hormone testosterone

 With more muscle mass, men are generally stronger than women

Sody strength per unit muscle mass, however, is the same in both sexes

#### Developmental Aspects: Age Related

 With age, connective tissue increases and muscle fibers decrease

Muscles become stringier and more sinewy

 By age 80, 50% of muscle mass is lost (sarcopenia)

## SARCOPENIA





Artwork for animated & print advertising campaign showing aging with and without good skin co These are disital paintings that are shown here at 1 /20th the original resolution

#### **Consequences of Sarcopenia**

Decreased resting energy expenditure
Decreased insulin sensitivity
Diminished muscle strength
Increased risk of physical disability
Increased risk of falls
Increased risk of mortality

#### Developmental Aspects: Age Related

Regular exercise reverses sarcopenia

Aging of the cardiovascular system affects every organ in the body

 Atherosclerosis may block distal arteries, leading to intermittent claudication and causing severe pain in leg muscles

## MORE PHYS

### Muscle Response to Varying Stimuli

- A single stimulus results in a single contractile response a muscle twitch
- Frequently delivered stimuli (muscle does not have time to completely relax) increases contractile force – wave summation



## Muscle Response to Varying Stimuli

- More rapidly delivered stimuli result in incomplete tetanus
- If stimuli are given quickly enough, complete tetanus results



## Muscle Response: Stimulation Strength

Threshold stimulus – the stimulus strength at which the first observable muscle contraction occurs

 Beyond threshold, muscle contracts more vigorously as stimulus strength is increased

 Force of contraction is precisely controlled by multiple motor unit summation

 This phenomenon, called recruitment, brings more and more muscle fibers into play

### Stimulus Intensity and Muscle Tension



#### Size Principle



#### Treppe: The Staircase Effect

- Staircase increased contraction in response to multiple stimuli of the same strength
- Contractions increase because:
  - There is increasing availability of Ca<sup>2+</sup> in the sarcoplasm
  - Muscle enzyme systems become more efficient because heat is increased as muscle contracts

#### Treppe: The Staircase Effect



#### • How is the contraction regulated?

- ATP is present, so contractions would be continuous
- BUT
  - <u>Tropomyosin</u> lies along actin filament
  - <u>Troponin</u> is attached to tropomyosin.
- Tropomyosin is in the way, myosin can't bind to actin.

• <u>Ca<sup>2+</sup> influx</u> releases troponin/tropomyosin block -> muscle contracts!

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#### **Muscle Fiber Action Potential**

i). <u>ACh binds</u> with receptors and <u>opens Na+</u> channels

Na+ Channels open and Na+ in

There is a decrease in the resting potential

Na + rushes in and the sarcolemma depolarizes.

The regional <u>depolarization spreads</u> rapidly.

The positive patch in the membrane changes the adjacent patch of the membrane. Thus depolarization spreads.

The K+ channels open and the region repolarizes

Ca++ is released from the sarcoplasmic reticulum.

Step 5). Sliding Filament Theory of Contraction



### **Rigor Mortis**

- Upon death, muscle cells are unable to prevent calcium entry.
- This allows myosin to bind to actin.
- Since there is no ATP made postmortem, the myosin cannot unbind and the body remains in a state of muscular rigidity for almost the next couple days.



Thought questions: why do chickens have white breast meat and dark leg meat? What does this say about the activities of the associated muscles? Why do ducks have dark breast meat?

