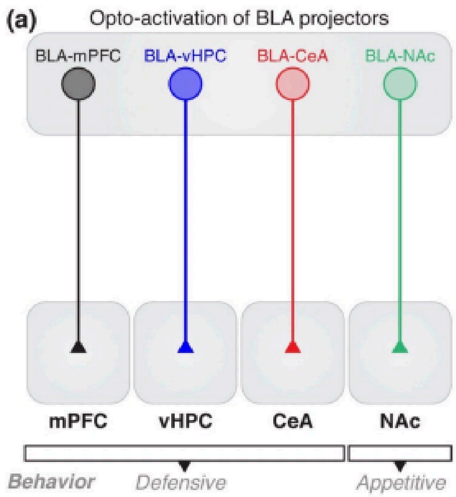
            - Anterior important for humans

Cortical structures:

- PFC
    - OFC/vmPFC
        - Damage to OFC/vmPFC can produce “acquired sociopathy” → disturbances of emotion/affect and decision making
        - Orbitofrontal cortex is important for generating somatic markets (gut feelings) which are critical to unconsciously guiding decision making
            - Somatic markers are feelings in the body that are associated with emotions (e.g. nausea with disgust)
        - It assigns values to choices in common currency
            - Some OFC neurons encode values of just 1 choice (e.g. 1 juice type) but there are neurons which encode the value of 2 different juices
                - Common currency, the values of the choice A and B are converted into a common currency. This is important as it may help compare between different stimuli
        - Flexible behaviour
            - Learning that contingencies have changes → stimulus which previously led to positive outcome is now negative
                - Learning that a stimulus associates with presence of water is no longer valuable if you are not thirsty anymore
        - Tracks value of rewards
            - OFC tracks external sensory stimuli
            - vmPFC tracks value in context of internally generated states
    - Insula
    - IPC

Subcortical sites:

- Amygdala
    - Amygdala important for emotional responses and recognition
        - Patient SM (amygdala became calcified in her early 20s) shows relatively selective deficits in recognition and reproduction of facial expression of fear
            - This may be due to SM’s deficit in monitoring eyes
        - Amygdala lesions in rodents prevent association of a neutral stimulus (e.g. bell ring) with an aversive stimulus (e.g. electric shock) → fear conditioning doesn’t work
    - Amygdala is important for processing social information, can code for values
        - Optogenetics reveals that amygdala codes both positive and negative values
        - BLA-NAc codes for appetitive feelings, BLA-CeA codes for defensive behaviours



Pignatelli and Beyeler, 2019, Curr. Opinion in Behav. Sci., 26: 97-106

- Ventral striatum
  - Nucleus accumbens important for affective reactions
    - Inhibition by injection of GABA agonists or glutamate antagonists generates strong affective reactions of different valence
- Ventral pallidum
- Peri-acqueductal gray

Amount of learning is proportional to the prediction error (rescorla-Wagner learning rule)
Phasic dopamine release encodes prediction error

- Dopamine neurons respond preferentially when rewards occur unpredictably as opposed to when predicted
  - Neuron fires less vigorously when reward fails to occur at habitual time
  - VTA (BOLD response encoded positive reward prediction errors

Dopamine is important for inducing curiosity but it is not the only neurotransmitter for generating pleasure reactions. Dopamine is important for learning as well.

Workshop 1

Skeletal muscle functions:

- Postural
- Movement (e.g. sports)
- Skilled movements

Musculoskeletal systems:

- Ease of walking

- Balance
- Visual ability
- Proprioception

Skeletal muscle:
- Strength and speed → explosive power (e.g. sprinting)
- Fatigue resistance → power maintenance (e.g. marathon)

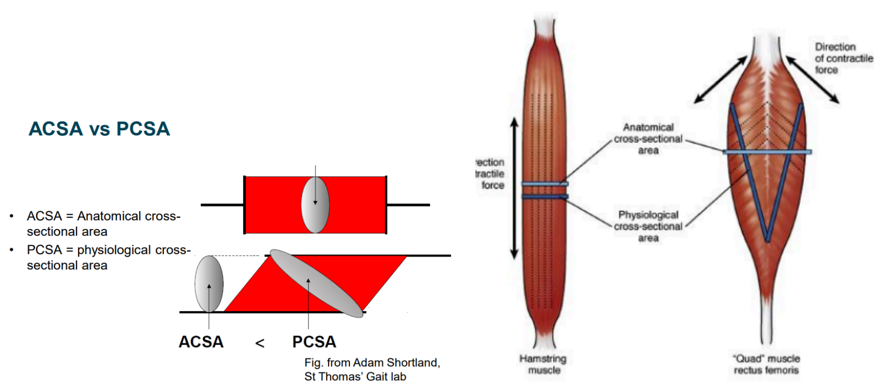
Cardiorespiratory system is important in muscle day to day activity because it is needed for supply of oxygen to the muscles hence essential for contraction

CNS affects cardiovascular system, cognitive/motivational system → influences motor control

Muscle strength is an important <u>muscle function</u> for movement

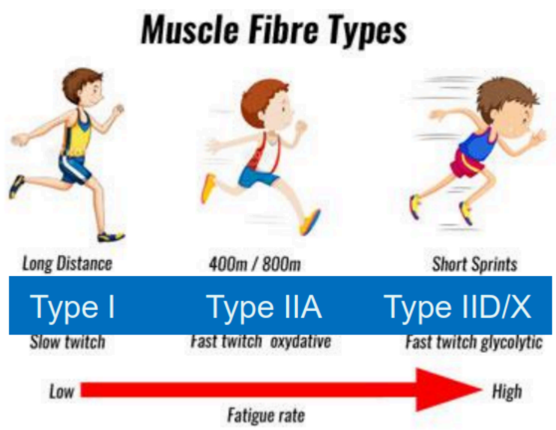
Functioning of skeletal muscle needs:

- Neural
    - Descending drive → important for efficient and successful movement (e.g. needed for muscle unit recruitment)
    - Motoneuronal recruitment/rate coding
        - Training can increase power of a muscle by increasing its force
        - Muscle can increase its force of contraction by recruiting more motor units
            - Recruiting more motor units
                - Spatial summation
                - Smallest motor units recruited first
            - Increase firing rate of motor neurons to generate greater force (rate coding)
                - Temporal summation
    - Afferent input from muscles
- Biomechanical
    - Cross sectional area
        - Cross-sectional area of muscle determine the amount of force that muscle can generate

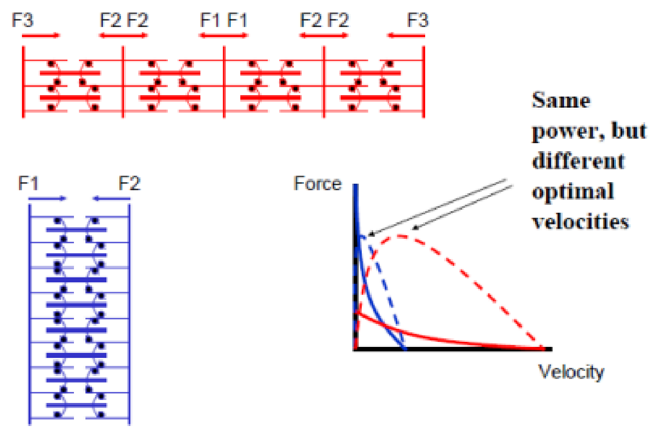


        -
            - Anatomical cross-sectional area → just the circumference from the top

- Physiological cross-sectonal area → circumference around the muscle fiber on an angle, can calculate the actual cross-sectional area for pennate muscle, can only be calculated from ultrasound, greater cross-sectional area

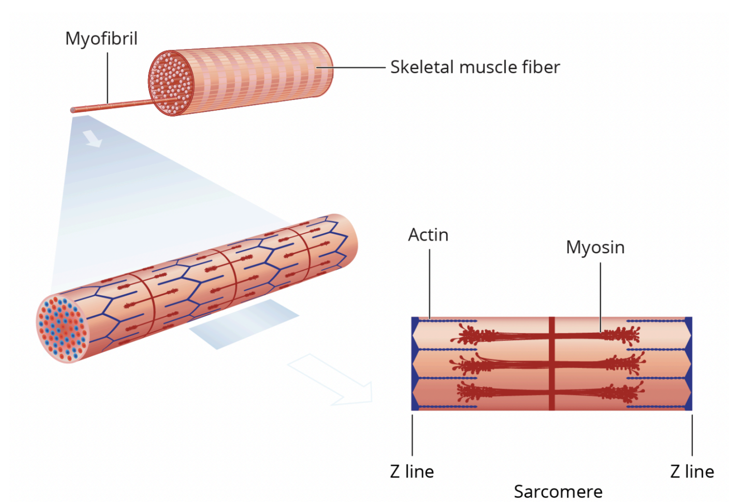
- Muscle fibre type
  - Type I
    - Slow twitch → innervated by small motor neurons
    - Oxidative
      - Produces water and CO_2
    - Less fatiguable
  - Type IIA
    - Fast twitch → innervated by larger motor neurons
    - Oxidative and glycolytic
      - Uses oxygen if there is oxygen present
  - Type IID/X
    - White muscle fibers
    - Glycolytic
      - Produces lactic acid
    - Fatiguable
  - Type II muscle fibers can generate the most force, short and fast bursts of energy
    - 

  - Mice muscle fibers contract faster than human muscle fibers → generate more force
  - Muscle fiber types can be determined using biopsy
    - However most muscles have mixed fiber types
    - Human muscle fiber is more mixed (mosaic), zebrafish muscle fiber types are arranged more orderly
- **Viscoelastic properties**
  - Velocity and elastic/stretch
- Muscle architecture
  - Arrangment of muscles
    - Longitudinal → fibers run parallel to one another
      - Contraction direction will be along the fibers
    - Pennate → fibers are attached on an angle (angle of pennation)
      - More muscle fibers can be packed in this arrangement

            - Greater force generated
        - Angle of pennation
    - Length-tension
    - Load velocity
    - Contraction time
    - Sarcomere arrangement
        - Arranged in parallel can produce more force with a slower velocity
        - Arranged in series can produce greater force only if velocity is greater
        - 

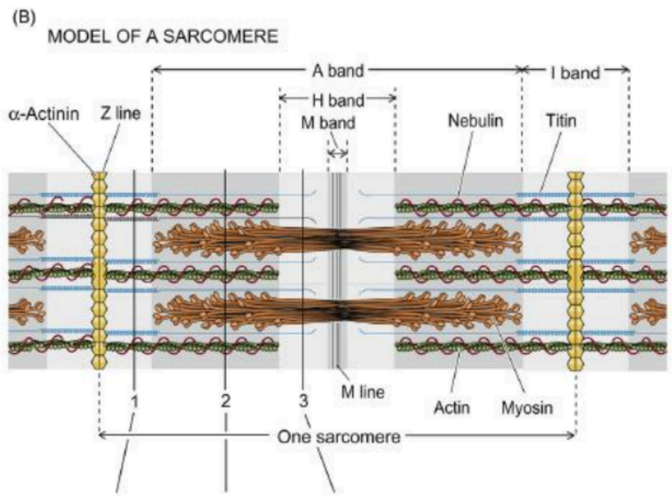
Muscle structures

- Muscles are multinucleate
    - Important for high energy demand
- Satellite cells are the stem cells of muscle
    - Important for growth
- Myofirbils group together to form muscle fibers
    - **Myofibrils are composed of overlapping thick and thin myofilaments organized into distinct, repeating units called sarcomeres.**



- Muscle fibers grouped together to form fasicles
- Fasicles groups together to form muscle

- Muscles are innervated by motor neurons.
- Each motor neuron will innervate more than 1 muscle fiber
    - Muscle fibers + motor neuron = motor unit
    - Motor units vary in size



Titin is a protein which attaches to the I band and actin
Very stretchy
When you lengthen muscle, titin could be stretched longer than other myofilaments

3 types of muscle contraction
- Concentric → shortening
    - Force > load
- Isometric → length stays the same
    - Force = load
- Eccentric → lengthening
    - Force < load
    - Generates the most force
    - Cross bridges join and rejoin quicker than concentric and isometric contract (?)
        - Main mechanism is unknown
    - Something to do with titin, kinda counterintuitive to overlap of actin and myosin

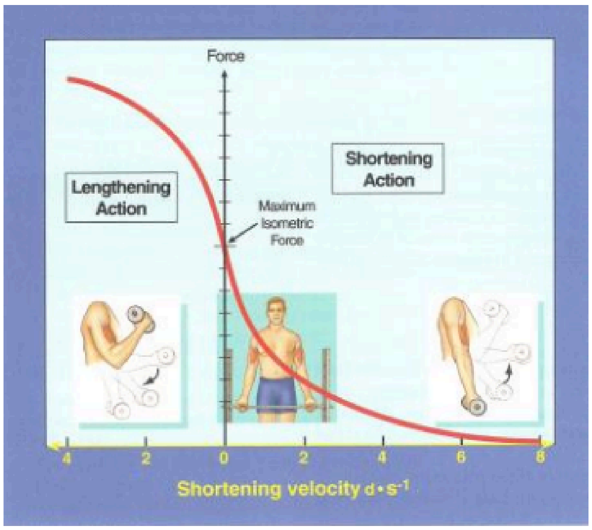
Muscle strength is defined as the maximum force or tension output generated by a snigle muscle or related muscle groups
Muscle torque is the angular motion
Absolute strength (measured) / Relative strength (normalise absolute strength to maximum)

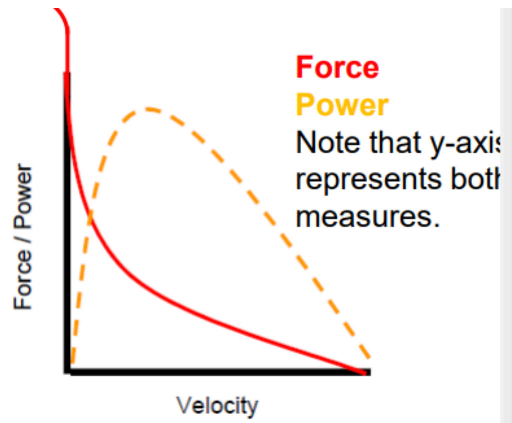
Length-tension relationship
- Length which has the maximum potential for overlap between actin and myosin = generate the most tension
    - Electrical drive can be the same, but muscle tension can vary due to different length (potential for overlap between actin and myosin)

$$muscle\ power = \frac{work}{time}$$

$$work = force \times distance$$

Faster velocity = less power and force because less tiem to reform crosbridges → cannot produce any more





Muscle is elastic but tendon is not

Stretch-shortening cycle is performed under different levels of intensity which is thought to utilise stored elastic energy

Training can increase force by:

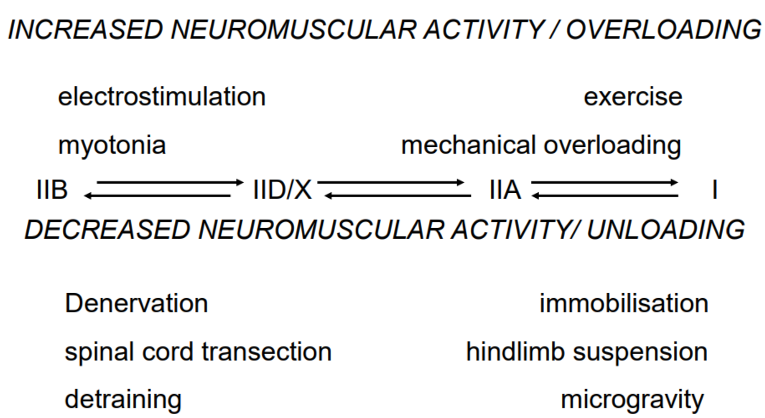
- Improved activation via neural system
  - Occurs in the first sessions of resisted muscle training
  - Increased activation of motor units (frequenc and number)
  - Involvement of afferent and efferent pathways
  - Synchronisation → motor units activate together more efficiently
- Decreased drive to antagonist muscles via neural system
- Changes in pennation angle
  - Increase in muscle cross sectional area
- Loss of intramuscular fat
- Hypertrophy (increase in muscle mass) of individual fibers

Principles of strength training

- Overload muscles → muscles must be worked against a load which is greater than normal
  - Progressive resistance weight raining
  - Isometric training (static)
  - Isokinetic training (dynamic)

- Specificity → Adaptations occur according to type of training (e.g. training at one angle will only improve strength at that one angle), also applies to length-tension relationships and velocities used
    - Need to identify the purpose to ge the best outcome for training
    - Types of training:
        - Resistance ⇒ increases in muscle mass and muscle fiber cross-sectonal area, resist stress of lifting heavy loads
        - Endurance ⇒ metabolic daptations design to enhance fuel selection and resist fatigue
        - Blood flow restricted training ⇒ occlude blood supply in the most proximal msucles to induce muscle hypertrophy under much lower loads than typically used
- Individuality → variable due to genetics, metabolism, endocrine regulation, relative fitness level
- Reversibility → effects can be reversed, use it or lose it

Elite athletes are mostly genetically determined
Muscle phenotypes can change with training

- Increased neuromuscular activity can change muscles
    - 

Aging effects on muscles

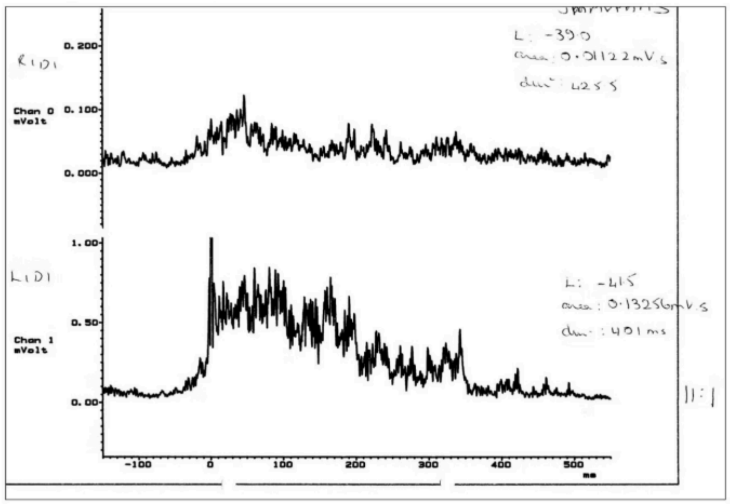
- Neural activation
    - Loss of spinal motor neurons causes reduction in muscle fiber number and size
        - Due to apoptosis, increase in circulating cytokines, reduced IGF1, increased cell oxidative stress
    - Changes in muscle unit recruitment and rate coding
- Muscle fibre cross sectional area
    - Fibre atrophy, smaller cross-sectional area
- Muscle architecture
    - Angle of pennation decreases
    - Stiffer and longer sarcomeres
- Muslce fibre type
    - Preferential loss of type II muscles
- Length tension relationship

- ○ Loss of elasticity

Aging effects can be delayed with training

Workshop 2

Neurophysiological techniques

- Non invasive
  - EMG (Electromyography)
    - Good starting point for experiments
    - 

      - Bottom is voluntary movement, begins ~2ms before involuntary movement
  - EEG
    MEG
  - Accelerometry
    - Detect very fine movements such as tremeor
  - Spike triggered averaging
  - Cross correlation analysis (timing)
  - Coherence analysis (frequency)
  - Stimulation: reflexes (tendon taps), TMS
  - Electrical: Cutaneomuscular eflex, H-reflex
  - Imaging: PET, fMRI, NIRS
- Invasive
  - Needle EMG
  - ICMS → enables accurate cortical mapping
  - Cortical implants

Mirror Movements

- Mirror movements are involuntary movements of one side of the body that accompany and mirror intentional movements of the other side
- Mostly occur in distal muscle of the upper limbs
- Involves homologous muscle pairs
- Typically seen in young children in early development
- Associated with various pathologies:
  - Klippel-Feil syndrome
  - **X-linked Kallmann syndrome**
    - Genetic condition passed through mother
    - Defects in axonal guidance, olfactory neurones, GnRH neurons
      - Lack of smell
      - Cannot have children
    - Midline anomalies (e.g. cleft palate, dental and renal abnormalities)
    - **Mirror movements**
  - Cerebral palsy
  - Idiopathic
  - Agenesis of the corpus callosum and sometimes after a stroke

X-linked Kallmann Syndrome

- May be due to an abnormality in the spinal cord, brain or both