EID424 Final Review

Jonathan Lam

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Contents

1 Introduction to sports medicine **1**

2 Reading and interpreting medical research **2**

3 Terminology **3**

4 Leg and ankle anatomy **4**

5 Knee **4**

6 Nerve and muscle physiology overview **5**

7 Electromyography (EMG) **7**

8 Electrocardiogram (EKG) and other matters of the heart **8**

9 Introduction to exercise physiology and metabolism **9**

10 Introduction to the shoulder **10**

11 Biomechanics **11**

12 Controversial topics **12**

1 Introduction to sports medicine

- "Sports medicine practitioners": Orthopaedic surgeon, internist/general practitioner, cardiologist, nephrologist, neurologist, endocrinologist,

psychiatrist (MD), psychologist, physical therapist, athletic trainer, coach, etc.

- Anyone doing exercise can use sports medicine knowledge
- **Linkage**: all body's systems are connected
- **7 P's**: performer, performance, pathology, prescription, practitioner, practice, prevention

2 Reading and interpreting medical research

- Types of papers: invited (state-of-the-art in a field), review (overview of whole field), original research (data collected on their own)
- Types of original research: retrospective (easy, but no control over confounding variables), prospective (designed to answer a specific questino, eliminates confounding factors), randomized vs. paired (matched), blinded vs. non-blinded
  - Best is prospective, double-blind randomized
- Ethical research: research should not compromise treatment; HIPAA (privacy and anonymization of patient data), informed consent, institutional review boards (IRB)
- Introduction to biostatistics, terms:
  - **Sensitivity**: true positive rate; probability of positive test given true
  - **Specificity**: true negative rate
  - **Positive/negative predictive value**: probability of true/false given positive/negative test
  - **False positive/negative**: in the case of a rapid test for a highly-contagious disease (e.g., COVID), more worried about false negatives; prioritize high specificity
  - **Type I error**: detecting a difference between two groups when none really exists (false positive)
  - **p-value**: expresses probability of a Type I error; 0.05 is general threshold for significance
  - **Type II error**: opposite of Type I error, false negative, typically with small sample sizes

3 Terminology

- **Ligament**: tough fibrous tissue from bone to bone
- **Cartilage**: smoot tissue (two types), distributes load and keeps things running smothly; hard to repair or replace
- **Sesamoid bone**: bone not connected to other bones via ligaments (e.g., kneecap)
- **Planes of the body**: (viewed relative to the body, not the viewer): sagittal (side), coronal (front), transverse (top)
- **Anatomical position**: (think Leonardo da Vinci)
- **Relative locations**: proximal (closer to center of mass), distal (further from com), superior (closer to head), inferior (closer to foot), superficial (closer to surface), deep (further from surface), anterior/ventral (more towards front), posterior/dorsal (more towards back), medial (closer to center line of body), lateral (further from central line of body), ipsilateral (same side), contralateral (other side)
- **Joint rotations**: flexion/extension (bend/straighten joint), abduction/adduction (movement away/towards midline of body), external/internal rotation (rotation toward or away from midline of body)
  - **Dorsiflexion/plantarflexion**: flexion and extension at ankle and wrist
- **Tendonitis**: irritation and inflammation of tendon
- **Tendonosis**: degenerative process of tendon, no inflammation
- **Sprain/strain**: sprain is injury to ligament, strain is injury to muscle or tendon (acute/chronic)
- **Dislocation**: joint is no longer a joint
  - **Flexbility/laxity**: increased range of motion, by stretching and muscle weakness, respectively
- **Osteoarthritis**: degeneration of articular cartilage
- **Sex/gender**: sex is biological, differences in hormonal milieu

4 Leg and ankle anatomy

- **Leg**: knee to foot, tibia (large, medial) and fibula
- **Foot**: three major things to note: calcaneus (heel), talus (above heel), plantar fascia (connective tissue along bottom of foot)
  - Note: "plantar" means relating to the sole of the foot, e.g., plantar flexors (calf muscles), plantar fascia, plantar flexion (flexing of plantar)
- Ankle ligaments: many (too complicated to remember on test)
- Muscles: ankle plantar flexors (soleus and gastrocnemius; i.e., calf), toe flexors, foot inverters, ankle dorsiflexors, toe extensors, peroneal muscles (ankle evertors; for rolling ankle outwars)
- **Achilles tendon**: largest tendon, between plantar flexors and calcaneus, vital for walking
- Common injuries: turf toe (hyperextension of toe), plantar faciitis (flat/high arches, sudden changes in exercise, or tight Achilles tendon); ankle sprain (most common sports injury; usualy lateral from bad landing), high ankle sprain (ligament between tibia and fibula, painful, twisting injury), achilles tendonitis (overuse injury); achilles tendonosis (degenerative issue), compartment syndrome (fluid/swelling in compartments, can be acute)
- Common treatment: **RICE** (rest, ice, compression, elevation), rehabilitation, surgery for extreme cases
  - Example surgery: achilles tendon repair; think about practical considerations

5 Knee

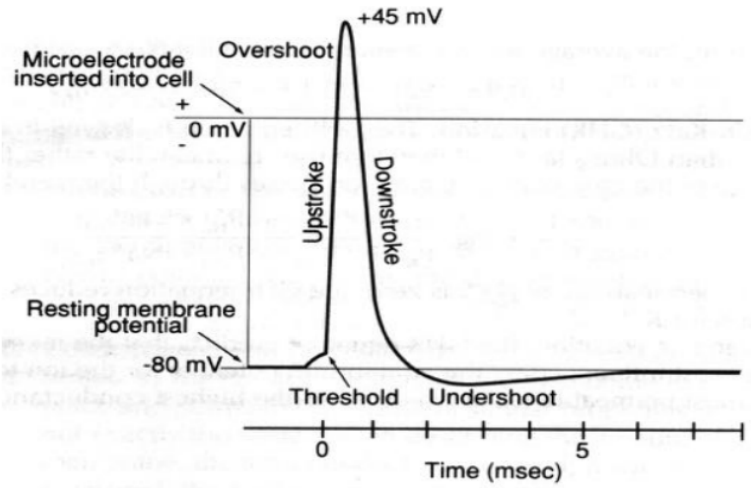
- Knee is junction of femur and tibia
- **Patella** (kneecap): sesamoid bone, increases moment arm for quads; connected via two tendons, slides along a groove (femoral trochlea); problematic if the groove's cartilage degrades
- Ligaments: MCL (medial collateral ligament), LCL (lateral " "), PCL (posterior cruciate "), **ACL** (anterior " ")

- **Joint capsule**: membrane surrounding joint, holds nutritious fluids and supports meniscus
- **Meniscus**: medial and lateral, helps with knee stability and distributing pressure; requires blood supply for healing and nutrition
- Muscles: quads (extend knee, flex hip), hamstrings (flex knee, extend hip)
- Common pathologies: ACL tears (very common; most often is non-contact; painful, swelling, instability; test by checking for translation; women at greater risk than men due to training, laxity, estrogen; rehabilitation or surgery), PCL tears (knee hyperflexion, in conjunction with other ligamentous injury, not common); MCL and LCL less common tears; meniscal tears (twisting injury, easier to repair when vertical longitudinal, good to save the meniscus when possible but this takes longer than removing via meniscectomy); knee dislocation (emergency!)
- Some research now in treating articular cartilage defects, difficult and still experimental

6 Nerve and muscle physiology overview

- Basic cell structure review: nucleus, mitochondria (ATP!), microtubules, endo(sarco-)plasmic reticulum (protein synthesis, store Ca2+ ions in muscle cells), cytoplasm/cytosol (fluid, voltage potential created across cell wall), cell membrane (selective permeable to ions; good insulator)
- -90mV **resting potential** (a.k.a. "membrane potential"): aids in transport, provides proper environmint for cellular processes, necessary for nerve/muscle function, Na+ is constantly leaking in from intercellular fluid, K+ constantly leaking out; sodium-potassium pump actively reverses this, requires ATP
- **Neurons**: dendrites (coming off of cell body, like tree branches, accepts inputs from outside the cell), cell body, axon hillock (connection between cell body and axon), axon (long fiber, the "nerve," carries electrical impulses), synapses (tips of axon, like mini tree branches); types: motor neuron, sensory neuron, interneuron (sits between other neurons)

- **Action potential**: sudden change in voltage, and then a quick return to resting potential; all the same size (almost like binary 0/1); overshoots a little bit in both directions; caused by brief positive feedback loop causing explosive voltage growth, then potential difference restricting growth



  - When returning to original position, some overshoot and time before it reaches resting membrane potential: **refractory period**; this prevents an action potential from traveling backwards
  - Summary of action potentials: all-or-nothing electrical impulse; fast positive change from influx of Na+, slower negative change from outgoing K+, chemical transmission to next neuron/muscle through synapse via neurotransmitters
  - Intensity of a stimulus is related to frequency of action potentials
  - Action potential propagates faster through larger (diameter) axons and **myelinated nerves**, which have highly-concentrated Na+ gates spaced out; much faster and more efficent

- **Reflexes**: impulse goes to interneuron in spinal cord and returns; no brain interaction

- **Motor unit** is a group of muscles innervated by a single neuron; all contract at the same time; muscle fiber propagates electrical signal like nerve, but slower impulse and physical motion; single muscle cell

is called a sarcomere; muscle fiber contracts via sliding thin and thick filaments using ATP "ratchet"

- Muscles types: smooth, cardiac, skeletal
- Muscles are recruited from smaller to larger, Type I to Type II
- Muscle contraction types: concentric, isometric, eccentric (does most muscle damage/reformation; most hypertrophy); muscle damage is different than a muscle tear, normal in exercise
- **Agonist/antagonist** muscles: working in/against direction of net movement
- Muscle length-tension relationship: can exert less force at longer muscle lengths

7 Electromyography (EMG)

- Measurement of electrical signals produced by muscle tissue; performed by electrodes and a differential amplifier; need to be sure to position in direction of muscle fiber and do proper skin prep
- **Surface/thin wire**: non-invasive vs. invasive
- Hard to compare EMG because of many factors: skin prep, different muscles, placement of electrodes, etc.; thus typically normalize to something (standard activity, maximum voluntary contraction, etc.)
  - EMG is not stationary: over time, the source of the signal changes
- Can stimulate nerve electrically to see the output: M-wave is normal stimulus, F-wave is from the nerve cell re-firing due to stimulus
  - Also H-reflex, which causes reflex up to brain, which stimulates the muscle
- EMG and **fatigue**: EMG amplitude increases with fatigue, but frequency decreases; women more fatigue-resistant than men, elderly more fatigue-resistant than children
  - **Central activation ratio**: ratio between maxiumum voluntary contraction and maximum stimulated contraction; **central vs. peripheral fatigue**

- Magnetic stimulation replacing electric stimulation; also magnetic stimulation of motor cortex

8 Electrocardiogram (EKG) and other matters of the heart

- Cardiovascular system review: heart, lungs, arteries, capillaries, veins
  - Pulmonary arteries/veins are the exception to arteries/veins
  - Heart: atria (upper chambers, receive blood), ventricles (pump blood away); right -> lung -> left -> body; valves keep blood from backing up; atria contract simultaneously, ventricles contract simultaneously; systole/diastole are contraction/relaxation of ventricles; valves cause heartbeat sounds
  - Heart electrical properties: cardiac potential much longer than skeletal muscle contractions; long refractory period, always twitching, heart muscle is self-exciting (pacemakers); atria and ventricles are insulated from each other except at AV node; action potential begins at sinus node (SA node), propagates along atrium, arrives at AV node, some delay so that ventricle contracts after atria
  - **Pacemaker**: any signal that begins the heart contractions; can be any of the folowing: SA node, several locations in the atria, AV junction, Purkinje fibers; **overdrive suppression** means that faster pacemaker suppresses slower pacemakers
- EKG wave parts:
  - **P wave**: atrial depolarization
  - **QRS complex**: ventricular depolarization; largest
  - **ST plateau**: very important
  - **T wave**: "rapid phase"; is important for unknown reasons, disrupting it may cause bad problems (e.g., fibrillation)
- **12-lead EKG**: (some signal redundancy): I, II, III (limb leads), aVL, aVR, aVF (augmented limb leads), V1-V6 (chest leads; progressive changes in QRS potential)
- EKG can be used to examine the following: heart rate (too high/low, abnormal variability), bad rhythms (irregular rhythms caused by multiple active pacemakers; escape rhythms due to pacemaker escaping

overdrive suppression or escape beats for a single beat), **fibrillation** (multiple pacemakers firing, irregular rhythm; atrial is okay, ventricular is fatal; requires defibrillation), heart blocks (signal not propagating correctly), hypertrophy (thickening of heart chambers, can be indicative of pathology, can discover due to QRS vector angle, can be an inherited trait that causes death even amongst young athletes), **myocardial infarction** (heart attack, blockage of flow in coronary artery, causing heart muscle to die; can be discovered by angle of QRS vector or ST plateau abnormalities)

- Defibrillation doesn't start a stopped heart! Only helps with fibrillation (erratic heartbeat firing)

9 Introduction to exercise physiology and metabolism

- Fuel sources during metabolism: **creatine phosphate** (anaerobic, fast, only for a short time, restores itself in about an hour), **anaerobic glycolysis** (anaerobic, fast, generates lactic acid, Type II motor units), **oxidative metabolism** (aerobic, slow, efficent, Type I motor units)
- "Hitting the wall" when glygocen depleted; good to intake carbs (and protein) right after exercise (not mediated by insulin); central fatigue due to brain reserving some glucose for itself
- **VO2 max**: measures maximum rate of oxygen consumed; higher means more fit; depends on method (exercise) used to test; measured by metabolic cart
- Maximum heart rate is approximately 220 - age; when more fit resting heart rate goes down but maximum stays about the same, corresponding with increased stroke volume
- **Anaerobic threshold** (first threshold): point at which Type II muscles begin getting recruited, exercise starts feeling hard
- **Respiratory compensation threshold** (second threshold): point at which ability to buffer is outpaced by lactate production, exercise starts feeling unbearable
- **Respiratory exchange ratio** (RER): ratio of CO2 expired to O2 consumed; higher means harder work, RER > 1.2 for maximum exertion test

- Calorie sources: carbs (4kcal/g), proteins (4kcal/g), fats (9kcal/g); 3500kcal in 1lb of fat
- **Weight loss** is only determined by net caloric intake; hard because limiting fats and proteins are essential; exercise does not burn that many calories but has many other benefits ("exercise is medicine"), and in women it tends not to aid weight loss
- **Benefits of exercise**: weight maintenance, therapy for chronic diseases, stay healthier until death
- **Living long**: low caloric intake and moderate exercise
- Consequences of the obesity epidemic: **metabolic syndrome** (cluster of health issues, such as overweight, high body fat, high cholesterol, hypertension, diabetes (which can cause many more issues on its own))
- **Ergogenic aids** (performance aids): sports drinks (must have sugar! and electrolytes); dietary supplements are unregulated; many types of ergogenic aids (mechanical, psychological, physiologic, nutritional, pharmacologic); carb loading takes longer than is currently advertised (few days at least), caffeine is a miracle drug, anabolic steroids increase protein synthesis but have many adverse effects, "epo" for blood doping, "live high, train low"
- Careful about dehydration, heatstroke (more dangerous than dehydration) or over-hydrating (**hyponatremia** – very dangerous and underrecognized); also cramping (may be cause by electrolytes)

10 Introduction to the shoulder

- Three bones: **humerus** (arm bone), **clavicle** (collarbone), **scapula** (shoulder blade)
- Two joints: **glenohumeral joint** (humerus to scapula; **glenoid** is socket in scapula; ball-and-socket joint; much ROM but low stability and strength), **acromioclavicular joint** (AC joint; many ligaments)
  - GH static joint stabilizers: joint capsule, **glenoid labrum** (equivalent to meniscus in knee), ligaments (three of them)
- Many muscles: latissimus dorsi, trapezius, rhmboids, teres major, pectoralis, deltoids, **rotator cuff** (set of four muscles that dynamically

stabilize the GH joint; supraspinatus, infraspinatus, teres minor, subscapularis)

- Common shoulder pathologies: shoulder instability (acute, chronic due to laxity); **dislocation** (can be due to laxity, also repetitive microtrauma, can usually pop back into place); **Bankart lesion** (tear in the lower rim of the glenoid labrum (like meniscal tear)); SLAP lesion; **shoulder separation** (AC joint injury, usually from direct trauma)
  - Instability usually due to TUBS ("torn loose," traumatic event) or AMBRI ("born loose," laxity)
  - Common treatments include immobilization and rehabilitation; sometimes surgical treatment
  - In general: dislocation is GH injury, separation is AC injury

11 Biomechanics

- **Kinematics**: motions of the body
  - Mechanics vs. kinematics: mechanics deals with actions of forces on material objects with mass, but kinematics is not concerned with forces, only movement
- **Goniometer**: device to measure angle; needs careful placement
- Current technologies use motion capture via high-speed cameras with high-visibility markers; can also be EM-based (magnetic field); can get 3D by using multiple cameras and parallax
  - Not great because on skin, not skeleton; markers may be placed inconsistently; have to determine centers of joints
- Also have to measure forces, use **force plate** (measures forces in three directions, very accurate if installed correctly): **kinetics** is the forces on and of the body
- **Inverse dynamics**: kinematics + kinetics: combine motion and force plate measurements to estimate forces acting at joints of the body, using Newton's laws of motion; assume body is a connected set of rigid links

  - Big assumptions: body segments are completely rigid links; know mass and moment of inertia of body segments (this is much more inaccurate than other measurements)
  - Issues: not accurate due to last assumption above; errors propagate the farther you get from force plate; only gets net forces about joints, not the effect of single muscles; best to combine this with EMG
  - Don't have to use measurements from force plate; can start from wrist, e.g., in pitching

- **Gait analysis**: gait is the set of limb actions to move the body forward; single sequence by one limb is called **gait cycle** (heel strike to heel strike, a.k.a., **stride**); gait cycle has stance phase (60%) followed by swing phase (40%), leading to 20% time with both feet on the ground; **step** is timing between two limbs, half of stride; efficient gait will reduce vertical motion of COM
  - Ground reaction forces have two peaks separated by a valley: initial contact (F1), foot rolling forward (F2), and then push off (F3); also small sideways forces
  - Running has different gait pattern; no double support, phase when both feet are off the ground, only single vertical ground reaction force peak (with an initial "impact" peak)
  - Barefoot running, forefoot strike, shorter strides, smaller impact peak

12 Controversial topics

- Stretching controversies:
  - **Stretching does/does not prevent injuries**: seems like stretching prevents the type of injuries you would expect, in the places you would expect
  - **Stretching causes/does not cause transient strength loss**: stretching seems to reduce strnegth at regular muscle lengths but increase strength at longer muscle lengths, indicating a shift in the length-tension curve

- **Concussions**: mild traumatic brain injury; lots of misinformation; caused by rapid acceleration or impact of the head

- Signs and symptoms: amnesia, loss of consciousness, headache, dizziness, blurred vision, attention deficit, nausea
- Harder for people to learn new things and switch mental set; increased glycolysis and decreased cerebral blood flow which makes the brain susceptible to further injury
- **Post-concussion syndrome**: many side effects after the expected recovery time
- Controversy over diagnosis and measurement of severity, determining when it is okay to return to play, whether second-impact syndrome exists (probably doesn't?)
- Research: instrumented helmets
- Misinformation spread by NFL Concusion Committee