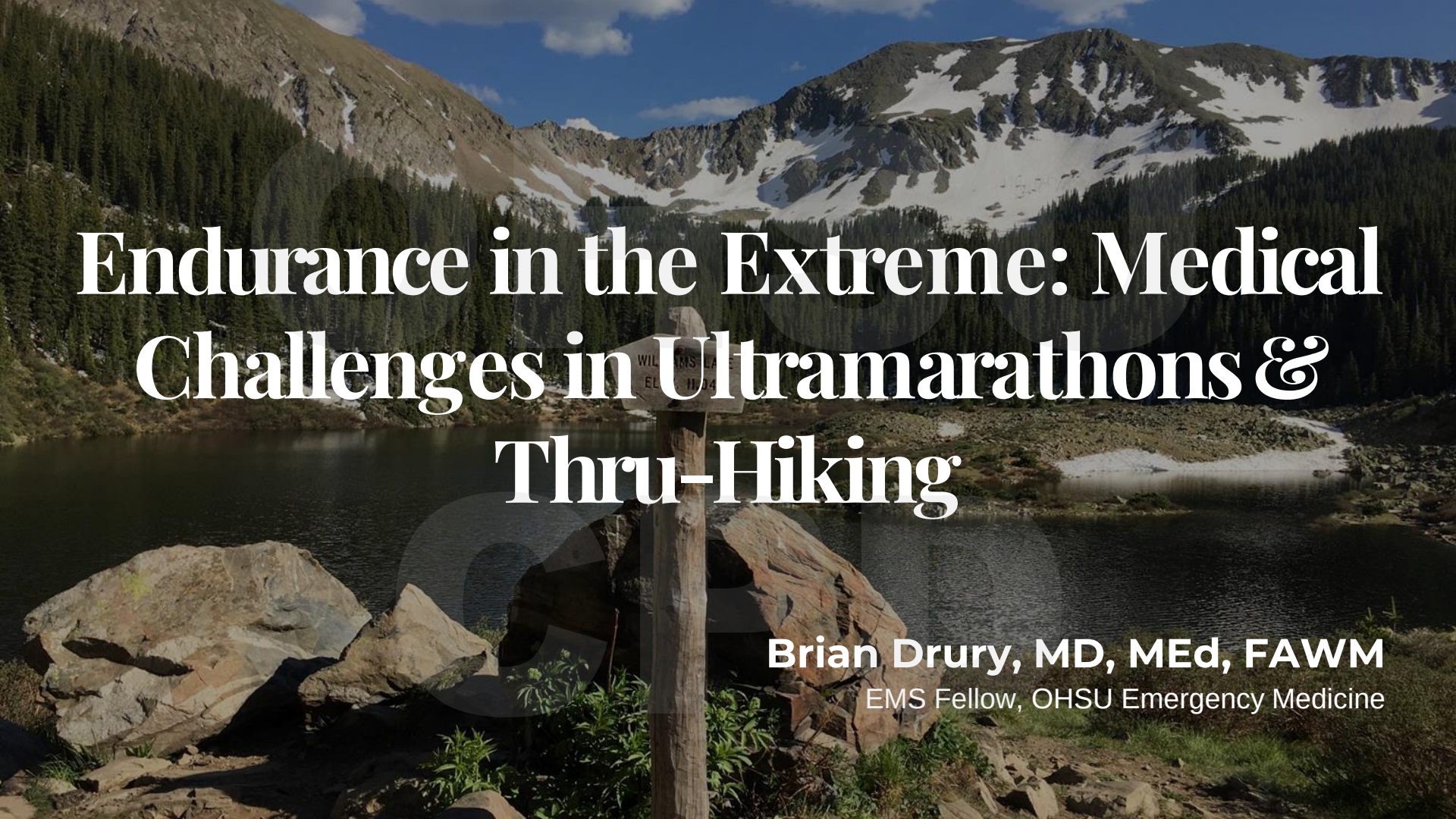

Endurance in the Extreme: Medical Challenges in Ultramarathons & Thru-Hiking

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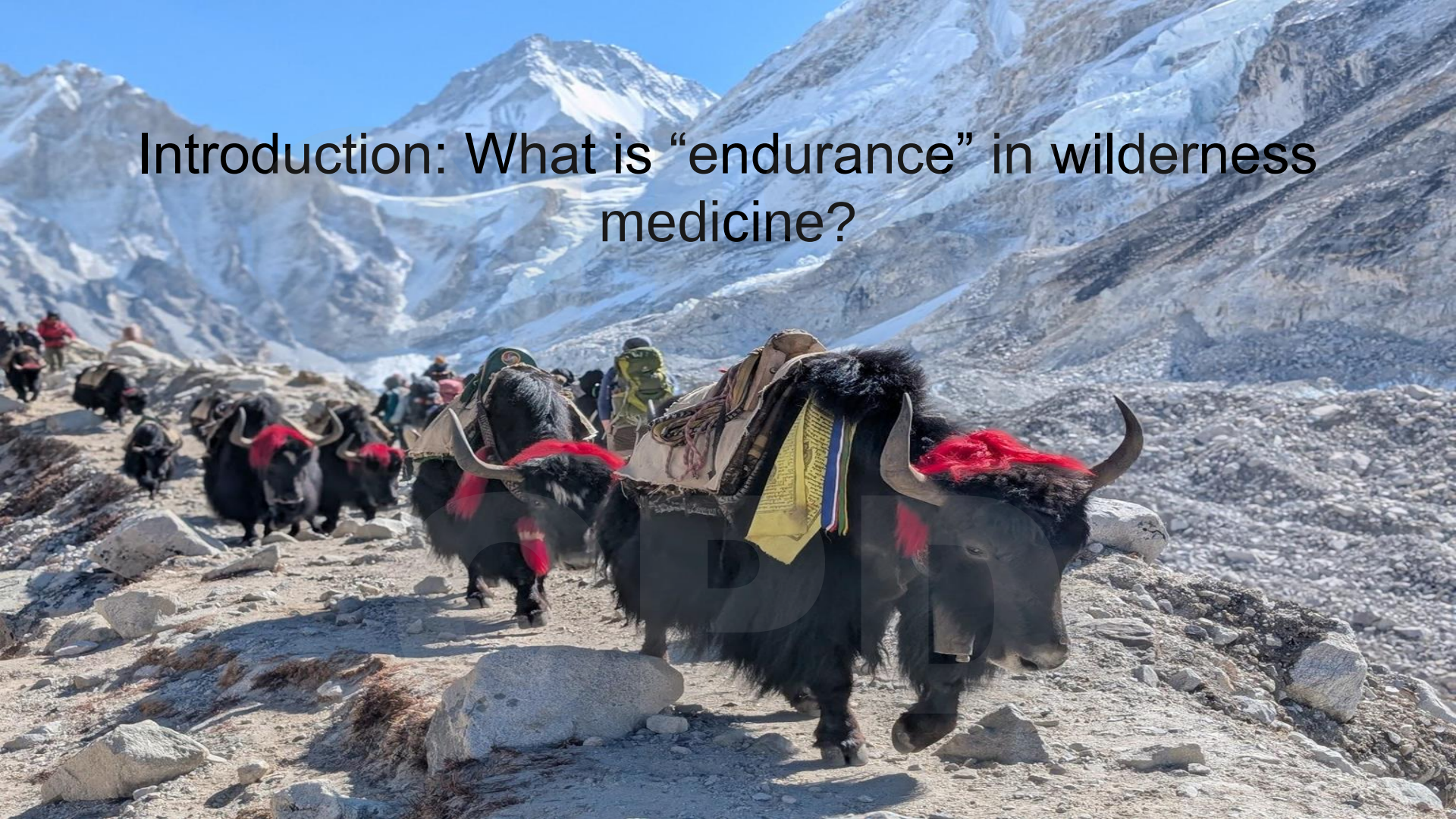
Learning Objectives

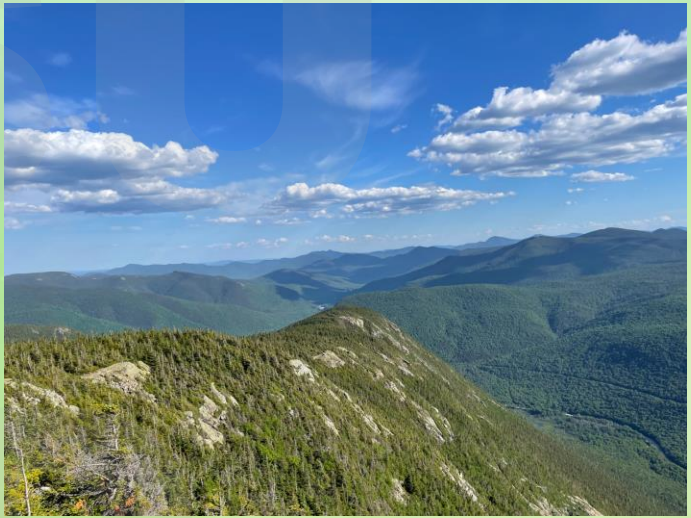
- What is “endurance” in wilderness medicine?
- Why these environments matter for physicians?
- Review epidemiology of endurance event injuries in remote settings
- Discuss diagnosis & management of hyperthermia, hyponatremia, and MSK injuries
- Highlight prevention & systems considerations

Introduction: What is “endurance” in wilderness medicine?



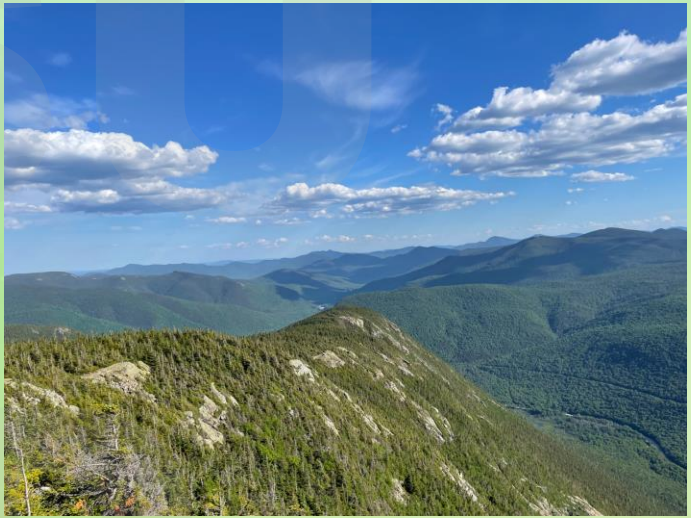
Running-based

- Marathon running
- Ultramarathon (50k, 100k, 100-mile races)
- Trail running
- Stage races (e.g., Marathon des Sables)



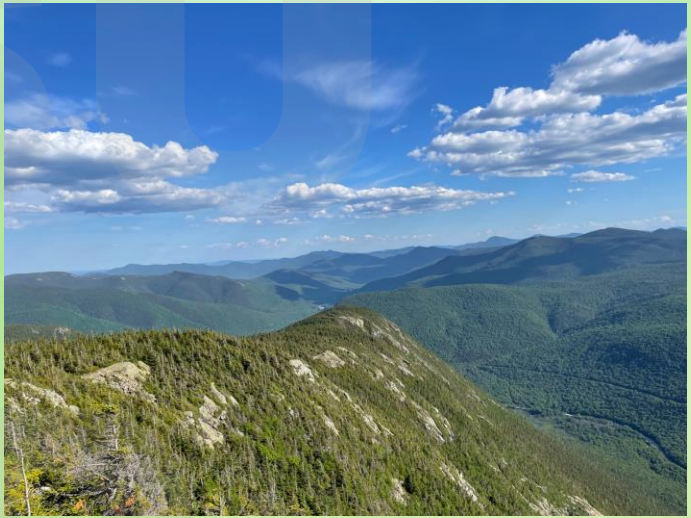
Cycling-based

- Road cycling (centuries, stage races)
- Mountain biking endurance events
- Gravel racing (e.g., Unbound Gravel)
- Bikepacking / ultra-distance cycling



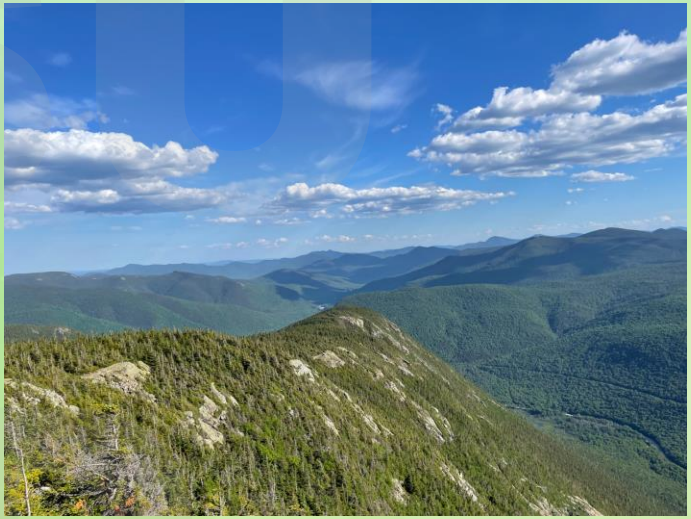
Swimming-based

- Open-water swimming (marathon swims, channel crossings)
- Long-distance pool swimming (e.g., 10k)Triathlon (sprint, Olympic, half-Ironman, Ironman)
- Aquathlon (swim + run)
- Duathlon (run + bike)
- Swimrun (Ötillö-style events)
- Adventure racing (multi-day, multiple disciplines)



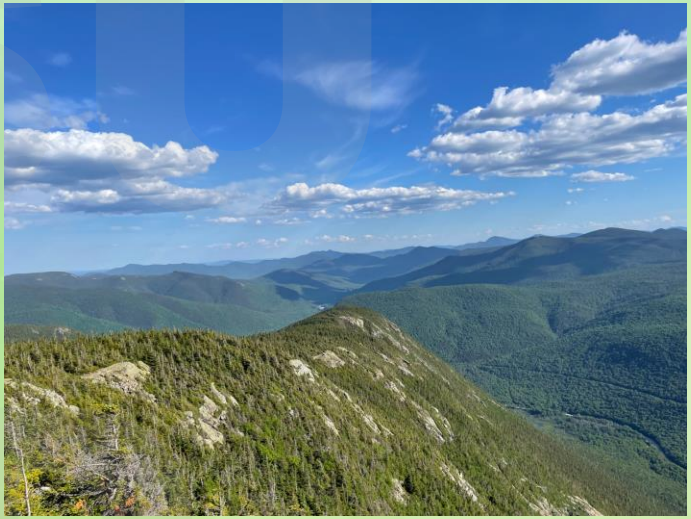
Mountain / Outdoor

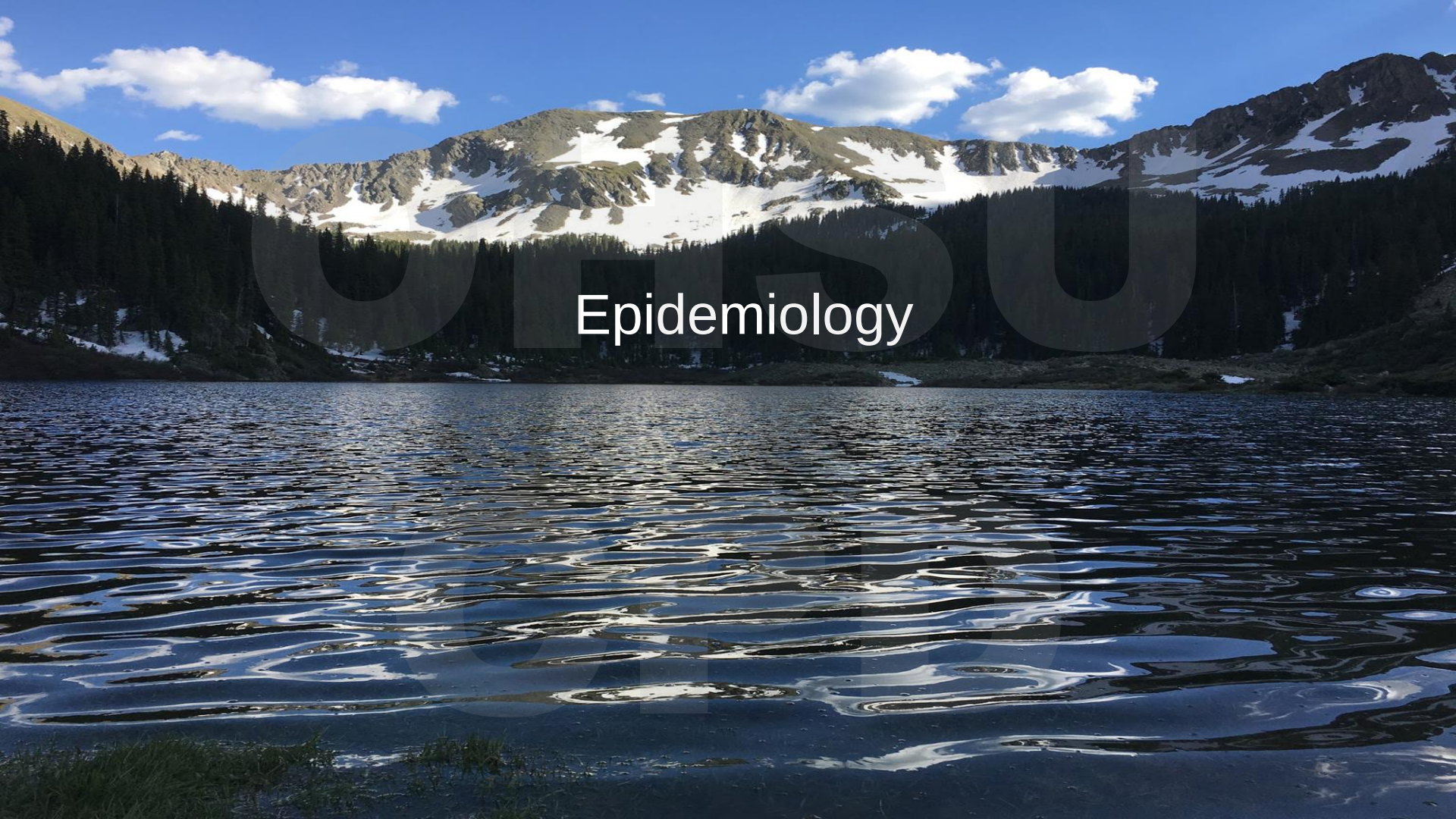
- Thru-hiking (e.g., Appalachian Trail, PCT, CDT)
- Fastpacking
- Mountaineering / high-altitude expeditions
- Ski mountaineering (Skimo)
- Cross-country skiing marathons (e.g., Vasaloppet)
- Snowshoe racing



Why these Scenarios matter?

- Remote environments
- Delayed care
- Unique injury patterns
- Limited diagnostics—critical in wilderness medicine.




Epidemiology

- **Musculoskeletal injuries** are the most commonly reported injury
- Overuse injuries such as medial tibial stress syndrome and patellofemoral pain syndrome (7.2 injuries per 1000 hours)
- Annual incidence:
  - 14.9% in novice runners
  - 60% in competitive runners

Individuals most at risk for injuries in endurance sports

- Lower training volume or inadequate preparation
- Less experience in the sport
- Previous injury
- Younger Age
- Female sex (for certain types of injuries)
- Higher BMI
- Insufficient caloric intake

- The American College of Sports Medicine
  - Endurance events are associated with a high prevalence of musculoskeletal overuse injuries, and that injury rates increase with event duration and participant heterogeneity
- 85% of participants required medical care
- 3.86 medical encounters per runner,
- 65 per 1,000 running hours
- Most common issues: **skin disorders (74.3%)**, **MSK injuries (18.2%)**, and **medical illness (7.5%)**

Musculoskeletal (MSK) Injuries

MSK Injuries

- **Lower limb MSK injuries** are very common (~50–60%) in long ultramarathons
- In multi day desert ultramarathons, MSK injuries accounted for **18.2%** of the total medical encounters
- Field focus: identify red flags (open fracture, compartment syndrome), use functional testing, manage with RICE-adapted tactics, bracing, cautious analgesia (notably cautious NSAID use due to risks in dehydration and renal strain).

Hyperthermia in Endurance Events

Epidemiology

- Hard to quantify
  - Prevalence of hyperthermia in endurance sports is high
  - How do we define “hyperthermia”?
- Above 40C
  - 15km road race: 15%
  - Marathon and Triathlon: 5-56%
  - Ironman: nearly all
- American College of Sports Medicine
  - Incidence of exertional heat illness much lower at 1-20 cases per 10,000 entrants

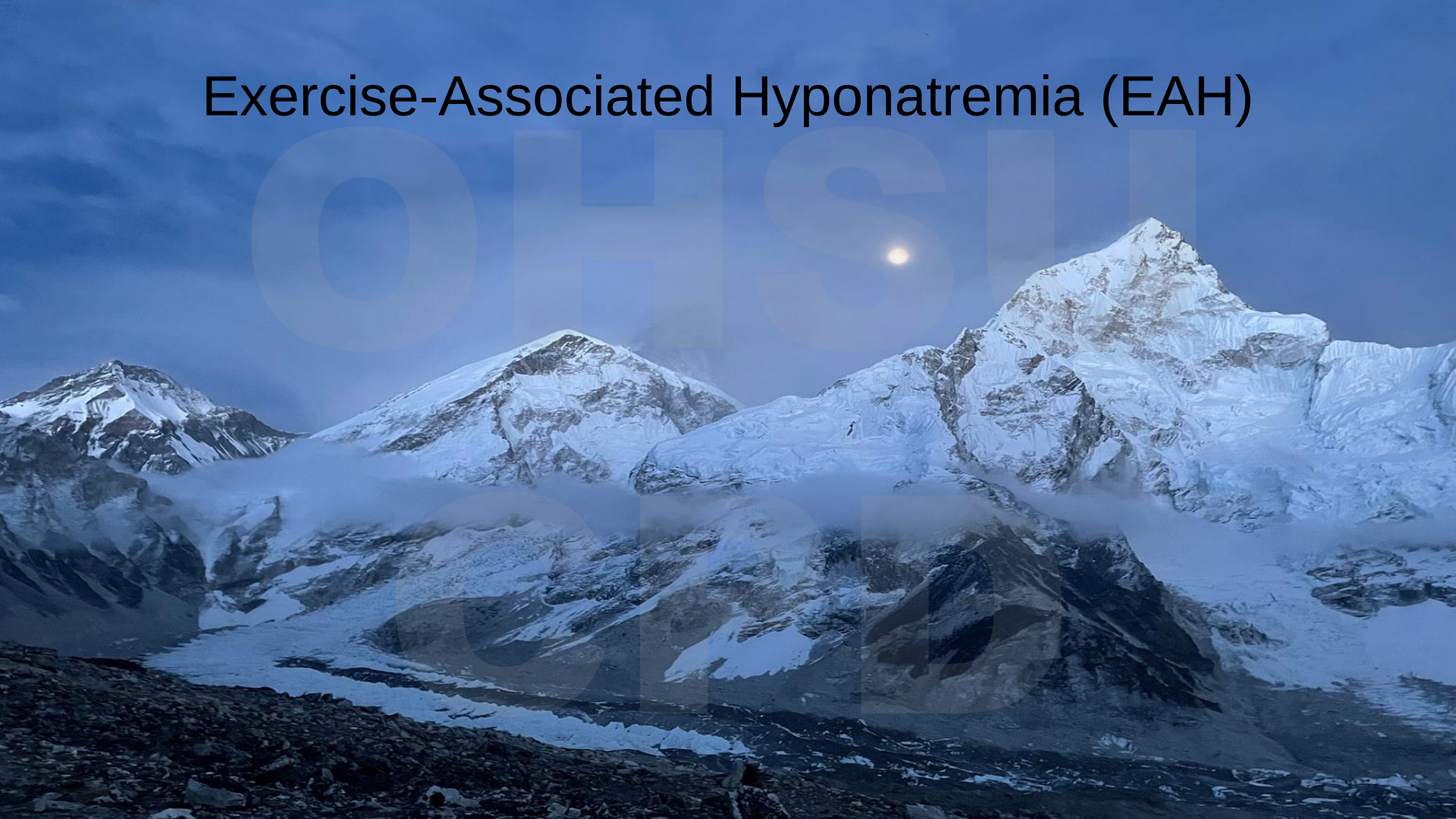
Prevention

- **Heat acclimatization**: single most powerful intervention, typically achieved gradually over a 7-14 days duration
- **Hydration:** begin exercise euhydrated and have unrestricted access to fluids
- **Activity modification:** scheduling events during cooler parts of day, reducing exercise intensity and duration
- **Pre-cooling strategies**: light, breathable clothing, cold water immersion, etc

Treatment

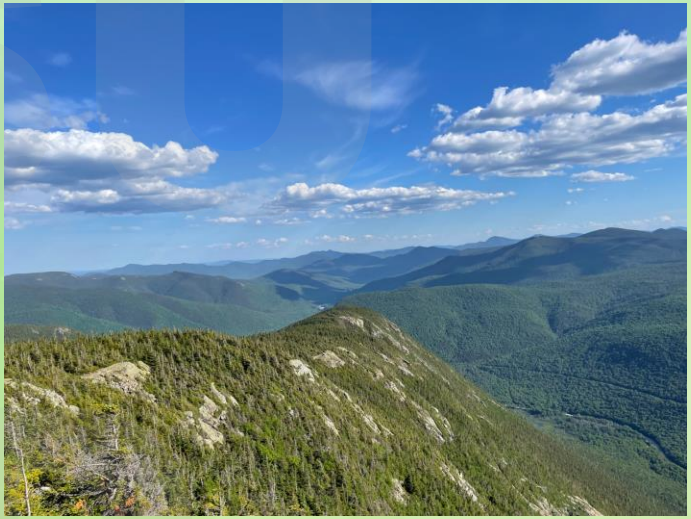
- **Cold Water Immersion**
  - Whole body up to the neck
  - Temps: 1-15C
  - Fastest reduction in core temps
  - Near-zero fatality rates when initiated within 30 mins of collapse
- **Adjunctive Strategies**
  - Rotating Ice water-soaked towels
  - Repeated dousing with ice water
  - Water spray/misters combine with high power fans

Exercise-Associated Hyponatremia (EAH)



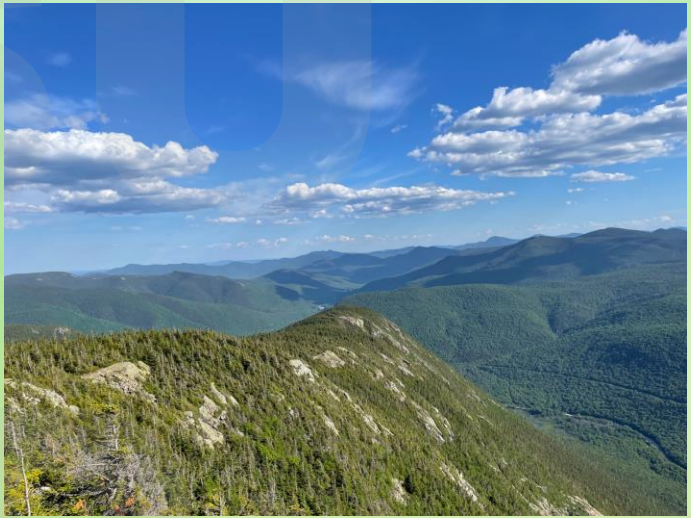
Epidemiology

- Ranges from **15% to 50%** among asymptomatic ultramarathon participants
- Most common in events lasting **>4-6 hours**
- Higher prevalence in hot climates
- Reported in **half marathons, sprint triathlons**
- Comprise **23-38%** of athletes presenting for medical care in high risk events



Individuals Most at Risk

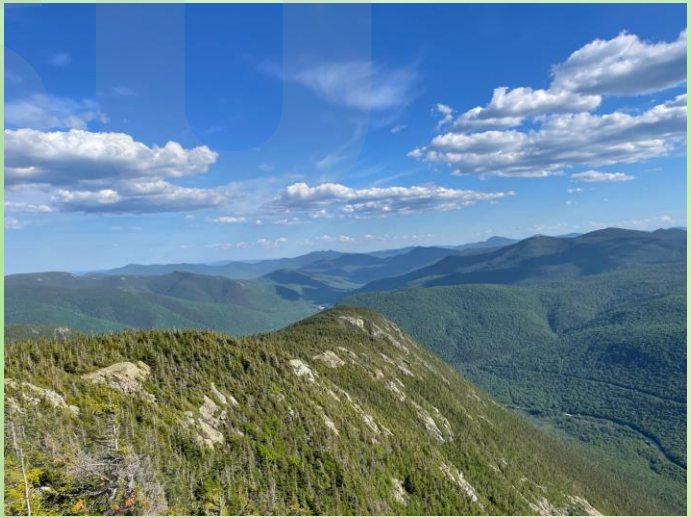
- Recreational Athletes
- Slower Finishers
- Smaller Body Mass
- Over consuming fluids
- Women (in some contexts)
- Older athletes
- NSAIDs use



Diagnosis

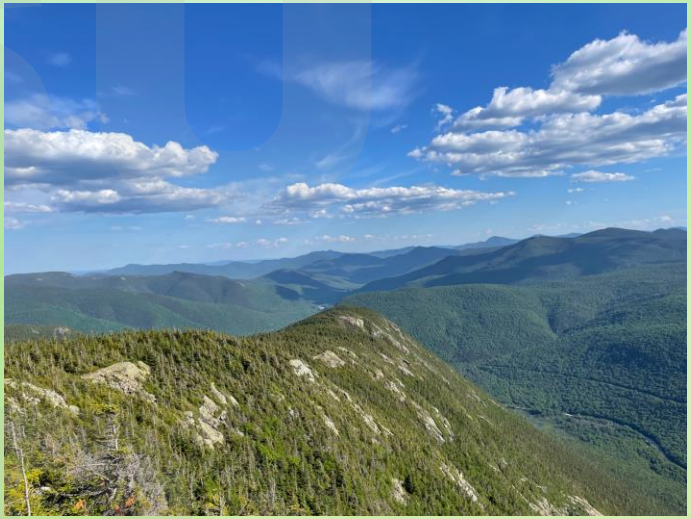
- Defined as **serum sodium <135 mmol/L**, with severe neuro symptoms generally at < 125 mmol/L

- General Symptoms
  - Weakness
  - Fatigue/Malaise
  - Irritability
  - Headache
  - Bloating
  - Dizziness, nausea, vomiting



Diagnosis

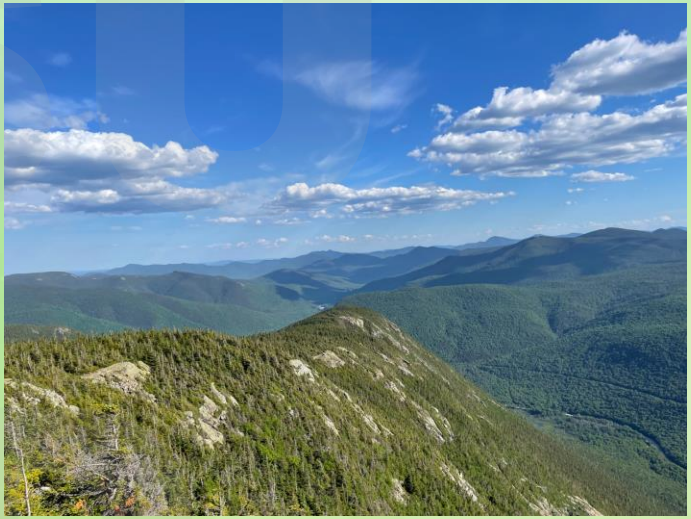
- **Recreational Athletes:** bloating, puffiness, weight gain, nausea, vomiting, headaches
- **Ultra-endurance Athletes:** confusion, delirium, seizures, respiratory distress with risks of cerebral and pulmonary edema, coma, and death
- **Females:** more frequently vomiting and hypokalemia
- **Males:** AMS, abdominal pain, muscle cramps, hypertension, and tachycardia



Symptom-driven Approach

- **Mild-to-moderate**
  - Fluid restriction, oral hypertonic solutions or salty foods
  - Avoid IV fluids

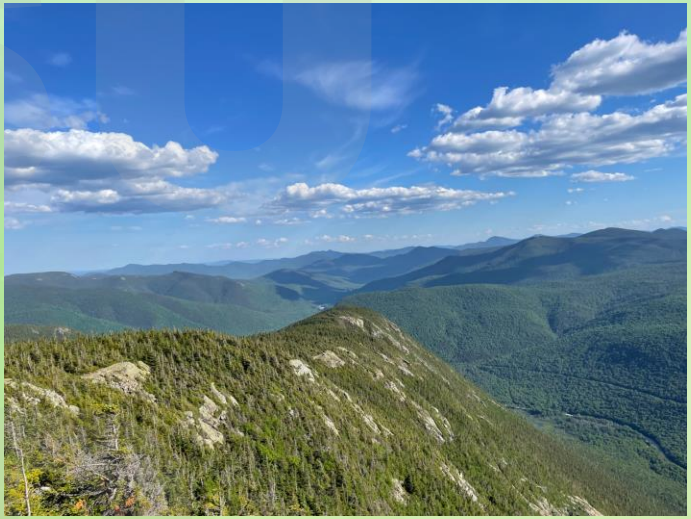
- **Severe (neuro symptoms)**
  - IV hypertonic saline—e.g., **100 mL of 3% NaCl bolus**—can rapidly improve sodium.
  - Reverse cerebral edema and prevent fatal complications



Exercise-associated Collapse

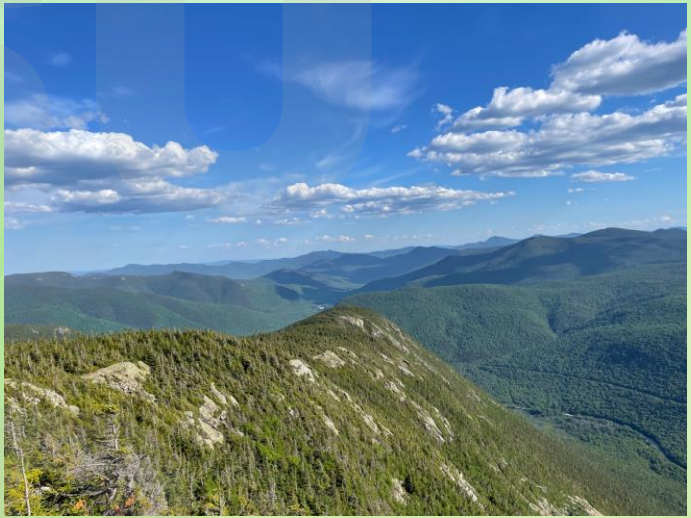
Epidemiology

- Prevalence of EAC in endurance sports is 1.5 per 1,000 race starters
- Most common medical complication encountered at the finish line
- Typically presenting with inability to stand, walk, or postural hypotension
- Similar rates between men and women
- Majority of cases are not life-threatening



Management

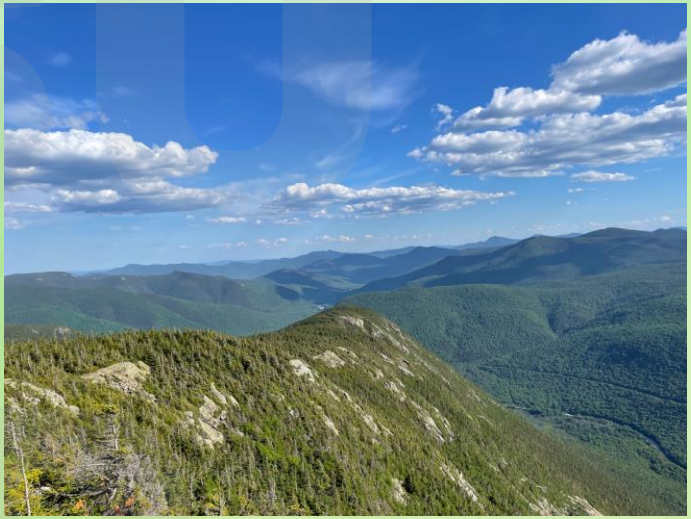
- Ruling out Life-threatening causes
- Rapid assessment of vital signs, rectal temperature, and mental status
- Lay the athlete supine with leg elevation
- Oral hydration and rest
- Red Flags
  - Occurs during exercise
  - AMS or abnormal cardiac findings



Exertional Rhabdomyolysis & Acute Kidney Injury

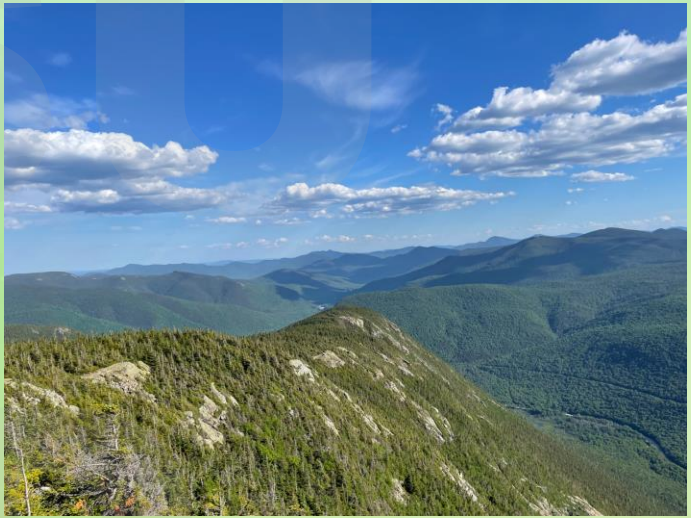
Epidemiology

- Prevalence of ER varies widely
  - 43.5% of athletes screened had a creatine kinase >5000
  - Often underdiagnosed and most cases resolve without sequelae
- Prevalence of AKI a complication of ER
  - 4-85% depending on diagnostic criteria



Individuals Most at Risk

- **Ultra-endurance runners** (nearly all cases of combined ER+AKI in systematic reviews)
- Young male athletes
- Hot and humid environments
- Dehydration
- Genetic predispositions (sickle cell trait)
- Use of NSAIDs



Management

- **On Site monitoring**
  - Early signs of muscle pain, weakness, cramps, and dark urine
- **Prepare for rapid response**
  - Immediate IV or oral hydration
  - Active cooling for heat stress
- **Cornerstone of treatment**
  - Aggressive IV fluids
  - Ideally >6 hours of symptom onset
  - Target urine output >300 mL/h for the first 24 hours

Integrated Prevention & Systems Approach

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- **Pre-event Planning**
  - 6-12 months prior to event
- **Plan**
  - Medical Staffing
  - Equipment
  - Emergency Action Protocols
  - Participant risk stratification
  - Coordination with Local EMS/Hospitals

American College of Sports Medicine

- **Participant Education**
  - Event risks
  - Hydration
  - Acclimatization
  - Recognition of early warning signs of heat illness, hyponatremia, cardiac events
- **Environmental Monitoring**
- **Screening** for medical conditions
- Ensure logistical access to rapid on-site cooling and defibrillation resources

Summary & Key Take-Home Points

- **High rates** of medical encounters and MSK injuries in ultradistance/remote endurance athletes.
- **EAH is very prevalent**, especially in ultramarathon conditions—up to **65%** in some races
- **Hyperthermia and EAH** often present with overlapping signs—field differentiation is critical
- **.EAC** is common presentation at the finish line; most are benign when in doubt transpor
- **MSK injuries** frequent; prevention and adaptive management are ke
- Preparation, education, and coordinated care systems enhance outcomes in austere endurance contexts


Questions?

References