Course 11

Environment and Sport

Learning objectives of the course

Upon completion of this course, the student will be able to:

- Identify the physiological constraints related to extreme environments (altitude, heat, cold, pollution).
- Apply prevention and adaptation measures for each situation.
- Recognise the signs of environmental pathologies (acute mountain sickness, heat stroke, hypothermia, etc.).
- Plan for jet lag and propose mitigation strategies.
- Integrate environmental issues into competition preparation.

Introduction:

An athlete who trains at sea level and goes to compete at altitude, in the desert or in the middle of winter may see their performance drop by 10 to 30% without adaptation. More seriously, the environment can cause life-threatening emergencies: high-altitude pulmonary or cerebral oedema, heat stroke, severe hypothermia.

The coach must know the rules of acclimatisation, the warning signs and the procedures to protect the athlete's health and optimise performance.

1. Altitude

1.1 Physiological effects of hypoxia

Parameter	Change at altitude (>1500-2000 m)
Partial pressure of O_2 (PO_2)	↓ (hypobaric hypoxia)
Ventilation	↑ (hyperventilation)
Heart rate	↑ at same power (to maintain O_2 delivery)
Diuresis	↑ (altitude-induced diuresis)
Haematocrit	↑ after a few days (erythropoiesis)
VO_2max	↓ (about −1% per 100 m above 1500 m)

Critical threshold: from 1500 m, a performance decrease is detectable; at 3000 m, VO_2max drops by 15-20%; above 5000 m, humans can only live temporarily.

1.2 Altitude illnesses

Pathology	Symptoms	Prevention	Treatment
Acute mountain sickness (AMS)	Headache, nausea, fatigue, sleep disturbances	Progressive acclimatisation, hydration, avoid alcohol/sleeping pills	Descent if severe, acetazolamide (on prescription)
High-altitude pulmonary oedema (HAPE)	Dyspnoea at rest, dry then pink sputum, cyanosis	Slow ascent (<300-400 m/day above 2500 m)	Immediate descent, oxygen, nifedipine
High-altitude cerebral oedema (HACE)	Ataxia (drunken gait), confusion, coma	Same as above	Emergency descent, dexamethasone

Any recent headache at altitude (>2500 m) should be considered AMS until proven otherwise.

1.3 Acclimatisation and training strategies

- Progressive acclimatisation: ascend in stages (e.g., 1-2 nights at 2000 m, then 3000 m). Avoid flying directly to high altitude.
- Partial acclimatisation duration: 5-7 days for significant improvement in tolerance.
- "Live high – train low": optimises erythropoiesis without losing intensity. Used by endurance athletes.
- Increased hydration: up to 3-4 L/day due to altitude diuresis.
- **Iron supplementation**: if deficient, because erythropoiesis requires iron.

1.4 Return to sea level (rebound effect)

After a prolonged stay at altitude, performance may be improved for 2-3 weeks (increased haematocrit). Optimal stage duration: 3-4 weeks at 2000-2500 m.

2. Heat

2.1 Physiological effects

Thermoregulation: evaporation of sweat (more efficient at low humidity). High humidity limits evaporation → risk of hyperthermia.

Cardiac output: partially diverted to the skin (cutaneous vasodilation) → less flow to muscles → higher heart rate at same power.

Fluid losses: up to 2 L/h (in high heat + humidity).

2.2 Heat-related pathologies

Pathology	Core temperature	Signs	Management
Heat cramps	Normal	Painful cramps (sodium deficit)	Rest, water + salt, stretching
Heat exhaustion	37-40°C	Intense fatigue, dizziness, tachycardia, nausea, thirst	Stop, shade, hydration, passive cooling. Avoid progression.
Heat stroke (emergency)	>40°C	Altered consciousness (confusion, coma), hot dry or moist skin, hyperventilation	Immediate active cooling (cold water, ice). Call EMS. Do not wait.

2.3 Prevention in hot environments

Action	Details
Heat acclimatisation	10-14 days of progressive exposure (less intense sessions initially)
Adapted hydration	Drink before thirst, add salt (500-700 mg/L) if exercise >1 h
Session timing	Early morning or evening, avoid 12-16 h
Clothing	Light-coloured, loose, technical sweat-wicking fabrics
Pre-exercise cooling	Cool shower, ice vest (lowers core temperature)
Monitoring	Weigh before/after (loss >2% body weight = risk)

Practical rule: as soon as temperature exceeds 28-30°C with high humidity (WBGT >28), reduce intensity, increase breaks.

3. Cold

3.1 Physiological effects

- Cutaneous vasoconstriction → heat conservation.
- Shivering (muscle thermogenesis) → increased O_2 consumption.
- Risks of hypothermia, frostbite, exercise-induced asthma (cold, dry air).

3.2 Cold-related pathologies

Pathology	Signs	Prevention	Treatment
Mild hypothermia (35-32°C)	Violent shivering, coordination problems, confusion	Warm multi-layer clothing, hat, warm drinks	Shelter, dry clothes, warm sweet drink, passive rewarming
Moderate to severe hypothermia (<32°C)	Shivering ceases, unconsciousness, bradycardia	Same + vigilance	EMS, active rewarming (heated blankets), avoid sudden movements
Frostbite	White, hard, numb extremities	Gloves, warm socks, no direct contact with cold metal	Slow rewarming (warm water 40°C), do not rub

3.3 Cold weather prevention

- **Multi-layer clothing**: inner layer (breathable), insulating layer (fleece), outer layer (windproof and waterproof).
- **Protect extremities**: hat, neck warmer, gloves/mittens, warm socks.
- Prolonged warm-up before exercise (indoors if possible).
- **Recovery**: warm drink, change clothes immediately after exercise.
- **Contraindications**: uncontrolled severe asthma, some Raynaud's diseases.

4. Air pollution

4.1 Main pollutants affecting athletes

Pollutant	Source	Effect
Fine particles (PM2.5, PM10)	Traffic, industry	Bronchial inflammation, decreased lung function, oxidative stress
Ozone (O_3)	Photochemical reactions	Respiratory tract irritation, reduced vital capacity
Nitrogen dioxide (NO_2)	Diesel exhaust	Bronchial hyperreactivity, ENT infections
Carbon monoxide (CO)	Engine exhaust	↓ O_2 transport (binds to haemoglobin)

4.2 Effects on performance

- Increased ventilation during exercise → inhalation of more pollutants.
- Bronchoconstriction, reduced VO_2max, impaired recovery.
- Long-term risk: increased asthma, cardiovascular diseases.

4.3 What the coach should do

- Check air quality indices (if available). If poor/extreme:
- Postpone intense sessions (interval training, tests) indoors or to another day.
- Reduce duration, lower intensity (aerobic threshold).
- Favour morning sessions (often less pollution).
- **For sensitive athletes (asthmatics):** bronchodilator before exercise, FFP2 mask when travelling.
- **Site selection**: avoid busy roads, bowl-shaped stadiums.

5. Jet lag

5.1 Effects of jet lag on athletes

System	Consequences
Sleep	Insomnia, early awakenings, daytime drowsiness
Performance	Decreased strength, power, reaction time
Hormonal	Shifted cortisol, performance peak out of phase
Digestive	Transit disorders, nausea

Approximate rule: the body adapts at about 1 time zone per day (slower for eastward travel).

5.2 Adaptation strategies

Strategy	Details
Gradual anticipation	Advance or delay bedtime by 30-60 min/day several days before departure.
Light exposure	For eastward travel: bright light in the morning after arrival; westward: light in the late afternoon.
Melatonin (3-5 mg at local bedtime)	Effective, use after medical advice (some athletes under supervision).
Hydration	Drink plenty of water during the flight, avoid alcohol and caffeine.
Short nap	If possible, 20-30 min max, not late in the day.
Training plan	First days: light training at key local times. Schedule competition 1-2 days per time zone shift if possible (e.g., 5 zones → 5-10 days adaptation).

Special case: explosive power sports (sprint, weightlifting) adapt better than endurance; technical sports (shooting, gymnastics) are sensitive to phase shift.

6. Overall prevention of environmental risks – checklist

Parameter	Pre-competition actions	Day of event actions
Altitude	Acclimatisation stage (≥7 days if >2000 m). Hydration + iron.	Monitor for AMS signs. Descent if suspected HAPE/HACE.
Heat	Acclimatisation 10-14 d. Light clothing.	Ice slushies, ice, shaded breaks, weigh-ins.
Cold	Multi-layer clothing. Prolonged warm-up.	Dry spare clothes. Warm drinks.
Pollution	Monitor indices. Plan morning sessions.	Mask if sensitive. Reduce intensity if peak.
Jet lag	Gradually adjust sleep schedule. Melatonin?	Appropriate light exposure. No long nap.

Key points to remember

- ✓ **Altitude**: hypoxia → decreased performance. Progressive acclimatisation, monitor AMS/HAPE/HACE. Descent if severe neurological or respiratory signs.
- ✓ **Heat**: major risk = heat stroke (>40°C + altered consciousness). Acclimatisation + hydration + active cooling.
- ✓ **Cold**: hypothermia (shivering, then absence of shivering = severity). Multi-layer clothing, warm drinks.
- ✓ **Pollution**: check air quality index, postpone intense sessions if poor. Sensitive athletes: bronchodilator.
- ✓ **Jet lag**: adaptation −1 hour/day. Light, melatonin (medical advice), hydration.
- ✓ **Prevention**: anticipating and planning acclimatisation is as important as physical training.

Appendix: Field card – Environmental warning signs (to keep on the field)

Environment	Absolute warning sign	Action
Altitude	Headache + ataxia, dyspnoea at rest	Immediate descent, O_2, EMS
Heat	Confusion, hot dry skin, cessation of sweating	Active cooling, EMS
Cold	Absence of shivering, unconsciousness, low heart rate	Passive rewarming, EMS
Pollution	Cough, chest tightness, wheezing	Stop, bronchodilator