Altitude Acclimatization

An introduction

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Altitude acclimatization Vs Altitude adaptation

- "**High altitude adaptation** refers to characteristics present in long-term high altitude residents that have arisen **as a result of natural selection** working on the gene pool."
- They have overcome the low ambient oxygen tension of high elevation via unique physiologic and genetic adaptations.

Normal physiological symptoms

- Increased heart rate at rest and with any level of exertion
- Increased respiratory rate and tidal volume
- Increased frequency of urination
- Dyspnea on exertion that resolves quickly with rest
- Poor sleep (frequent arousals, insomnia, vivid dreams)
- Transient light-headedness upon assuming upright position

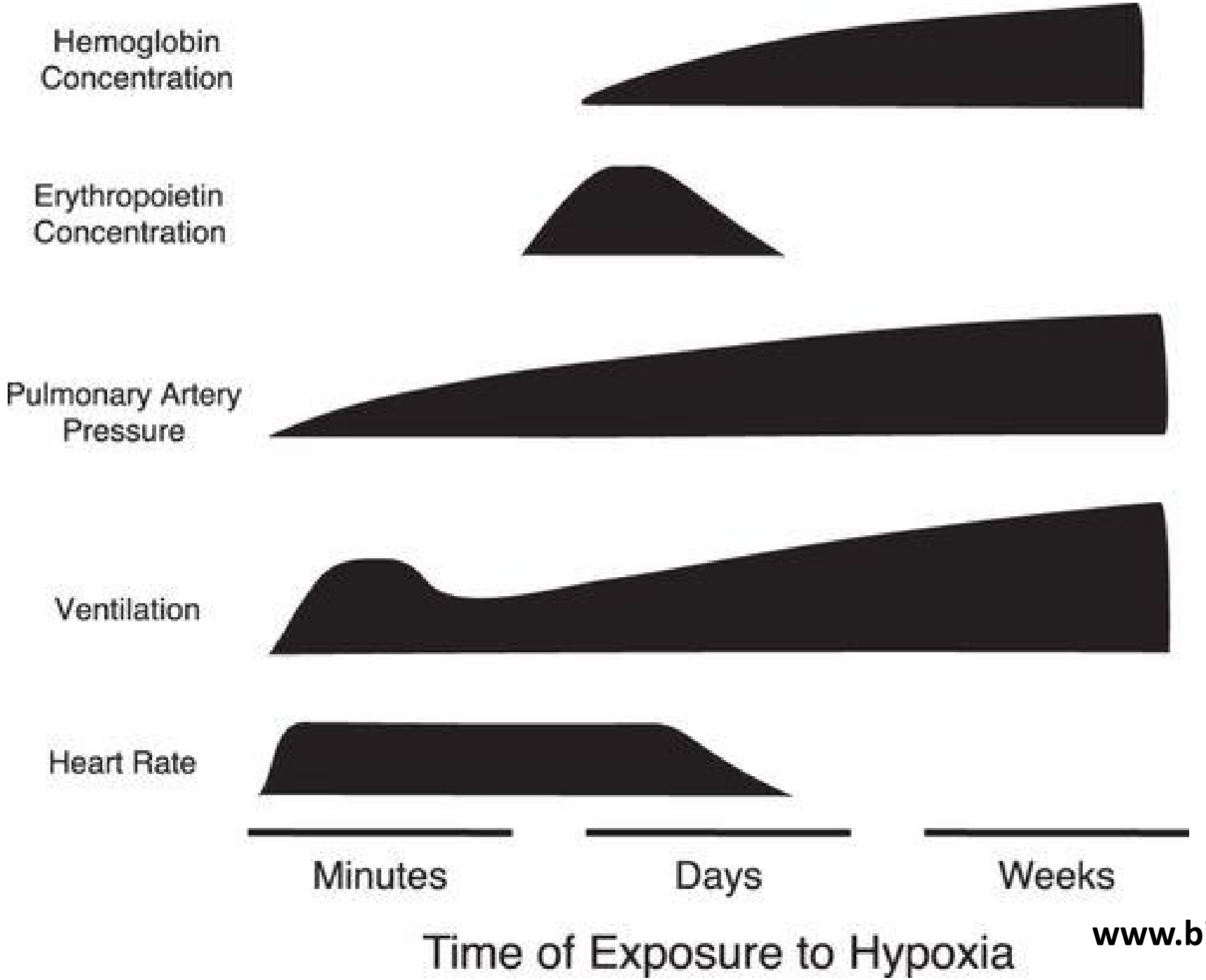
Defining Altitude Acclimatization

- "**become *more comfortable* at attitude** and find they can perform better than they first arrived (Houston 1955; Roach 2019)."

- "**sum of all the *beneficial* changes in response to altitude** hypoxia that occur with time spent at a given altitude, and that eventually disappear on descent to low altitude (Andrew M. Luks 2021)."

- "**Ability to cover more ground faster while *preserving a functional reserve* (**Houston 2005; Messner 1989)."

Effects of altitude acclimatization



Analyzing acclimatization process

Objective tests

Not available

Subjectively

Tasks of daily living become easier to accomplish.

Tolerance of low to moderate intensity exertion markedly improves.

The symptoms of AMS if present initially, fade.

Factors impacting successful acclimatization

Rate of ascent

- The rate of increase in sleeping elevation rather than the pace at which an individual walks or climb has a significant effect on an individual's ability to acclimatize.

Interindividual variability

- Significant interindividual variability.
- In general, prior experience at high altitude serves as a good, but not perfect, predictor for future performance at high altitude.

Factors impacting successful acclimatization

Prior experience at high altitude

- Never been validated in systematic studies.
- May simply reflect selection bias.
- Those who tend to do well at high altitude continue to climb on a frequent basis.

Age

- No clear evidence available.

Gender

- No clear evidence available.

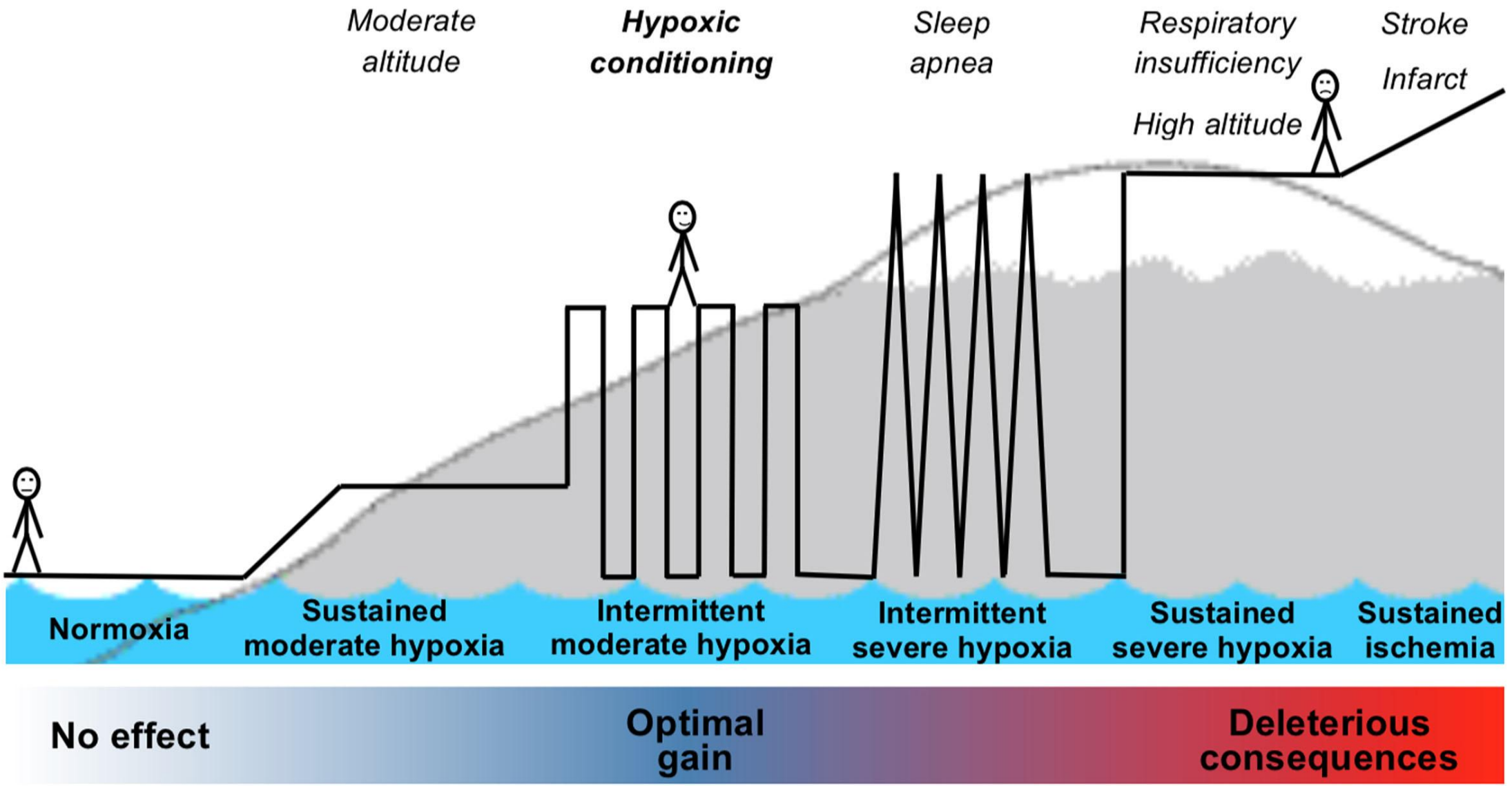
Principle of Hormesis

"Low dose stimulation, high dose inhibition"

"What kills you at a higher dosage will make you stronger at a lower dosage"

Hugo Paul Friedrich Schulz (1888)

Effects from normoxia to severe hypoxia



Beneficial physiological effects of hypoxia

- Erythropoietin
- Hypoxia inducible factor- 1 (HIF-1)
- Hemoglobin
- Red Blood Cell (RBC) mass
- Oxygen carrying capacity of blood
- Blood flow to lungs
- VO^2 Max

Beneficial physiological effects of hypoxia

- Mitochondrial number & functions
- Cardiac perfusion
- Vascular Endothelial Growth Factor (VEGF)
- Nitric oxide
- Capillary density
- Myoglobin concentration

Application of hypoxia in health, disease, sports

- Hypertension, lipid profile
- Anaemia
- Cardiac circulation/perfusion, risk of infarction
- Hypoxia Altitude Simulation Test (HAST)
- Fat loss
- COPD, Asthma
- Post-covid respiratory recovery & functional stamina
- Diabetes/ Insulin resistance

Sports & Performance

- Endurance sports- Cycling, Running, Swimming, Rowing
- Other sports- football, basketball, hockey
- Mountaineering, High altitude expeditions- training as well acclimatization
- Training soldiers

Efforts for successful acclimatization

During the trek

1. Ascend strategies

Preparing for trek

2. Hypoxic chambers (Intermittent Hypoxic Training)
3. Cold acclimatization

1. Ascend strategies for acclimatization

Wilderness Medical Society (Luks et al. 2019) guidelines:

After 3000 m, individual should not increase the sleeping elevation by more than 500 m/day and should include a rest day every three to four days (Bartsch and Swenson 2013; Hackett and Roach 2001).

Center of Disease Control (CDC) guidelines:

Avoid traveling from a low elevation to an elevation higher than 9,000 feet (2,750 m) above sea level in one day.

Once you are above an elevation of 9,000 feet (2,750 m), increase where you will sleep by no more than 1,600 feet (500 m) per day.

2. Newer strategies for acclimatization

Hypoxic chambers (Intermittent Hypoxic Training)

- One-and-a-half to four hours of daily exposure to >4000 m induces ventilatory acclimatization, decreases the incidence of AMS, and improves work performance after rapid ascent to 4300 m. (Beidleman et al.2003, 2004).
- For protocols of short duration there is no difference between rest and exercise in hypoxia.
- For longer protocols, exercise might enhance exercise performance at altitude.

Hypoxic training facility for acclimatization at DMH, Pune

- Altitude achieved up to- 6,000 m
- Well equipped
- ICU grade pulse oxygen monitoring
- Emergency code blue system (24 hours)
- Under doctor's advise.

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Intermittent Hypoxic exposure method for acclimatization

- Few minutes of hypoxic exposure
- Alternate exposure to normoxic exposure
- Oxygen saturation of blood is maintained at a specific range.
- Activity under hypoxia cycle: walking on a treadmill
- Altitude maintained : anywhere from 3,000 to 5,000 m.

3. Cold acclimatization

- Cold water bath

- Ice water immersion

Possible physiological effects of cold exposure

1. Increases energy expenditure
2. Non-shivering thermogenesis
3. Reduction in white fat tissue
4. Increased brown adipose tissue

To be a mountaineer

" A mountaineer is a being of non-conditioned mind within a conditioned body governed by a stable thought process surrounded by unstable weather directed towards the exploration of the self in the lap of mother nature away from rules of humanity for the dissolution of the ego where the mountain and the mountaineer becomes the one."

THANK YOU

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