FACTORS AFFECTING PERFORMANCE

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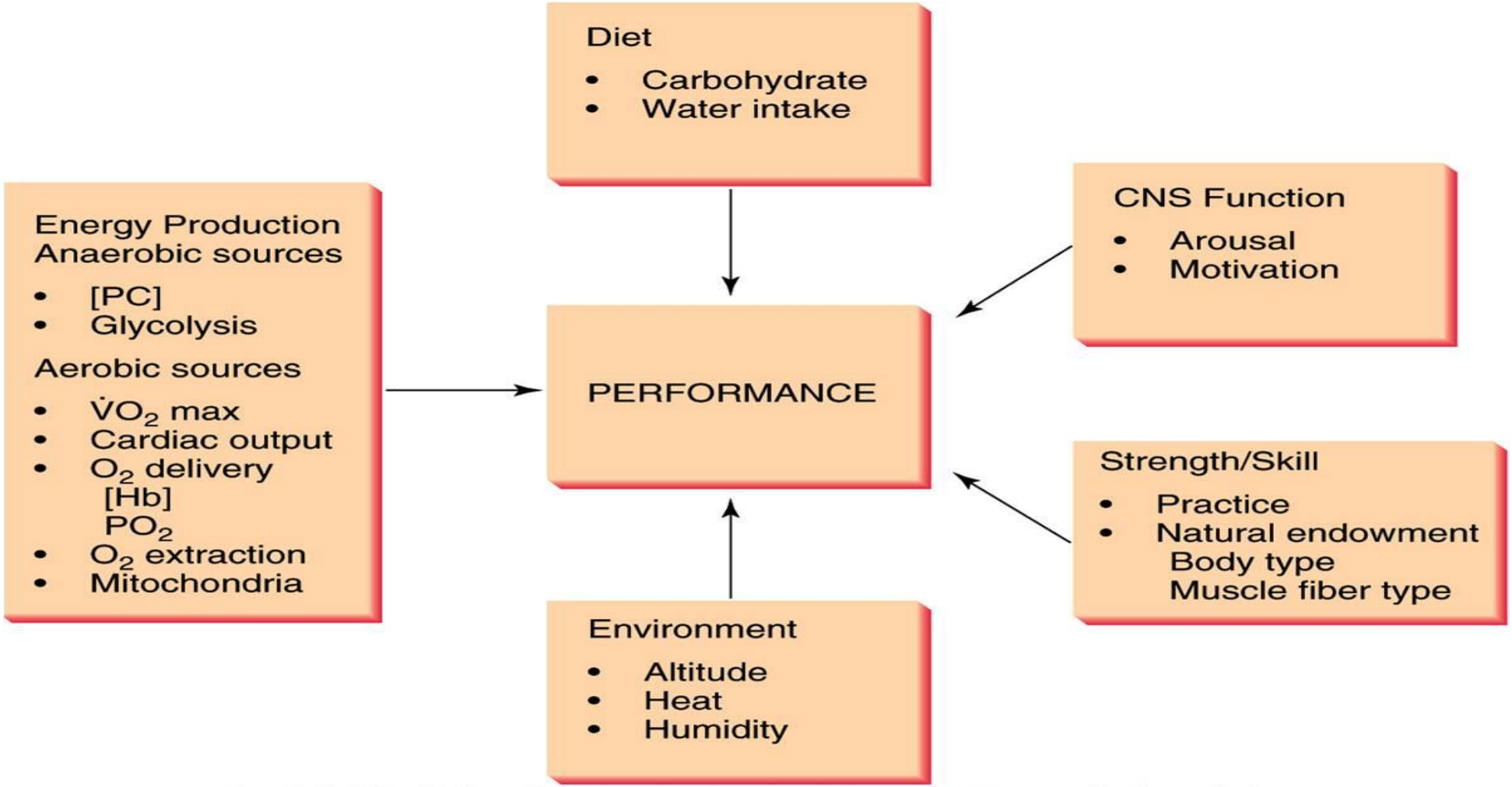
What are the requirement for optimal performance?

Do you think, there is a single criteria?

Each Performance requires a certain skill and Strength

FACTORS AFFECTING PERFORMANCE



SITES OF FATIGUE

Fatigue

- Inability to maintain power output or force during repeated muscle contractions

Central fatigue

- Central nervous system

Peripheral fatigue

- Neural factors
- Mechanical factors
- Energetics of contraction

CENTRAL FATIGUE

Reduction in motor units activated

Reduction in motor unit firing frequency

Central nervous system arousal can alter the state of fatigue

- By facilitating motor unit recruitment
  - Increasing motivation
  - Physical or mental diversion.

Merton's classic experiments showed no difference in tension development when a *voluntary* maximal contraction was compared to an *electrically induced* maximal contraction.

- When the muscle was fatigued by voluntary contractions, electrical stimulation could not restore tension .
- In contrast, the early work of Ikai showed that a simple shout during exertion could increase what was formerly believed to be "maximal“ strength.
- Asmussen and Mazin experiments.

Excessive endurance training (overtraining)

- Reduced performance, prolonged fatigue, etc.
- Related to brain serotonin activity

PERIPHERAL FATIGUE: NEURAL FACTORS

Fatigue due to neural factors could be associated with failure at the

I. Neuromuscular junction,
II. The sarcolemma, the transverse tubules
III. The sarcoplasmic reticulum that is involved in calcium (Ca++) storage, release, and reuptake

PERIPHERAL FATIGUE: NEURAL FACTORS

Neuromuscular junction

The action potential appears to reach the neuromuscular junction even when fatigue occurs.

In addition, evidence based on simultaneous measurements of electrical activity at the neuromuscular junction and in the individua muscle fibers suggests that the **neuromuscular junction is not the site of fatigue.**

PERIPHERAL FATIGUE: NEURAL FACTORS

Sarcolemma and transverse tubules

sarcolemma might be the site of fatigue due to

Inability of Na^+/K^+ pump to maintain action potential amplitude and frequency

When the Na+/K+ pump cannot keep up, K+ accumulates outside the membrane and decreases inside the cell. This results in a depolarization of the cell and a reduction in action potential amplitude

- Can be improved by training

- An action potential block in the T-tubules
  - Reduction in Ca^{+2} release from sarcoplasmic reticulum

IN SUMMARY

- Increases in CNS arousal facilitate motor unit recruitment to increase strength and alter the state of fatigue.
- The ability of the muscle membrane to conduct an action potential may be related to fatigue in activities demanding a high frequency of stimulation.
- Repeated stimulation of the sarcolemma can result in a reduction in the size and frequency of action potentials; however, shifts in the optimal frequency needed for muscle activation preserve force output.
- Under certain conditions an action potential block can occur in the t-tubule to result in a reduction in Ca^{+2} release from the SR.

PERIPHERAL FATIGUE: MECHANICAL FACTORS

Cross-bridge cycling and tension development depends on:

- Functional Arrangement of actin and myosin

Ca^{+2} binding to troponin to allow the cross-bridge to bind with the active site on actin,

- ATP availability

High H^{+} concentration may contribute to fatigue

- Reduce the force per cross-bridge
- Reduce the force generated at a given Ca^{+2} concentration
- Inhibit Ca^{+2} release from SR

Longer “relaxation time” is a sign of fatigue

- Due to slower cross-bridge cycling

PERIPHERAL FATIGUE: ENERGETICS OF CONTRACTION

Imbalance ATP requirements and ATP generating capacity.

When ATP-generating mechanisms cannot keep up with ATP use, inorganic phosphate begins to accumulate in the cell

- Accumulation of P_i
  - Inhibits maximal force
  - Reduces cross-bridge binding to actin
  - Inhibits Ca^{+2} release from SR

Rate of ATP utilization is slowed than rate of ATP production to maintain cellular homeostasis

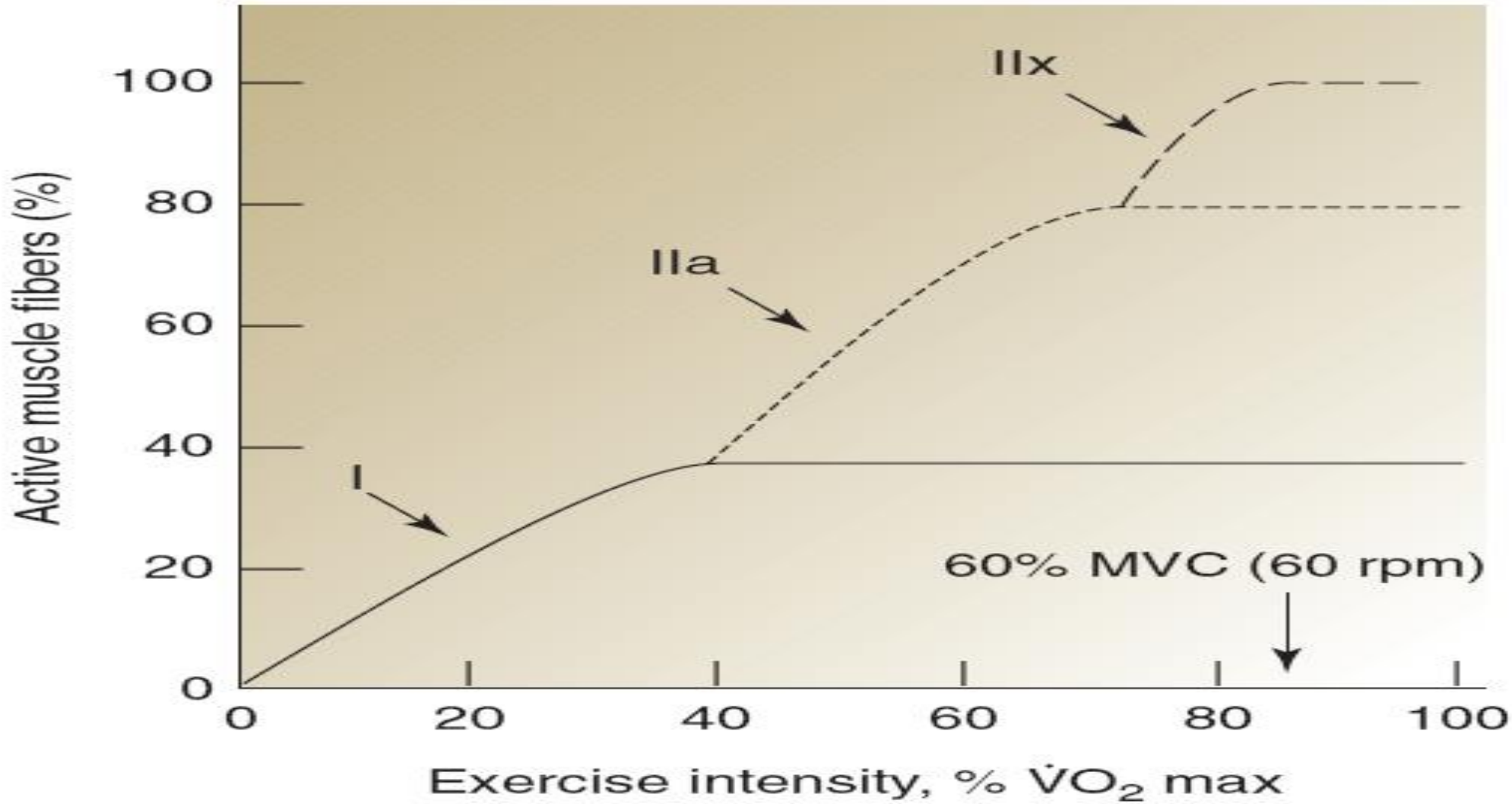
IN SUMMARY

- Fatigue is directly associated with a mismatch between the rate at which the muscle uses ATP and the rate at which ATP can be supplied.
- Cellular fatigue mechanisms slow down the rate of ATP utilization faster than the rate of ATP generation to preserve the ATP concentration and cellular homeostasis.

PERIPHERAL FATIGUE: ENERGETICS OF CONTRACTION

Muscle fiber recruitment in increasing intensities of exercise

- Type I → Type IIa → Type IIx
- Up to 40% VO_2 max type I fibers recruited
- Type IIa fibers recruited at 40–75% VO_2 max
- Exercise >75% VO_2 max requires IIx fibers
- Results in increased lactate production


Active muscle fibers (%)
100
80
60
40
20
0
0
20
40
60
80
100
Exercise intensity, % $\dot{V}O_2$ max
IIx
IIa
I
60% MVC (60 rpm)

IN SUMMARY

- Muscle fibers are recruited in the following order with increasing intensities of exercise: Type I → Type IIa → Type IIx
- The progression moves from the most to the least oxidative muscle fiber type. Intense exercise (>75% VO_2 max) demands that type IIx fibers be recruited, resulting in an increase in lactate production

ULTRA SHORT-TERM PERFORMANCES

Events lasting <10 seconds

Dependent on recruitment of Type II muscle fibers

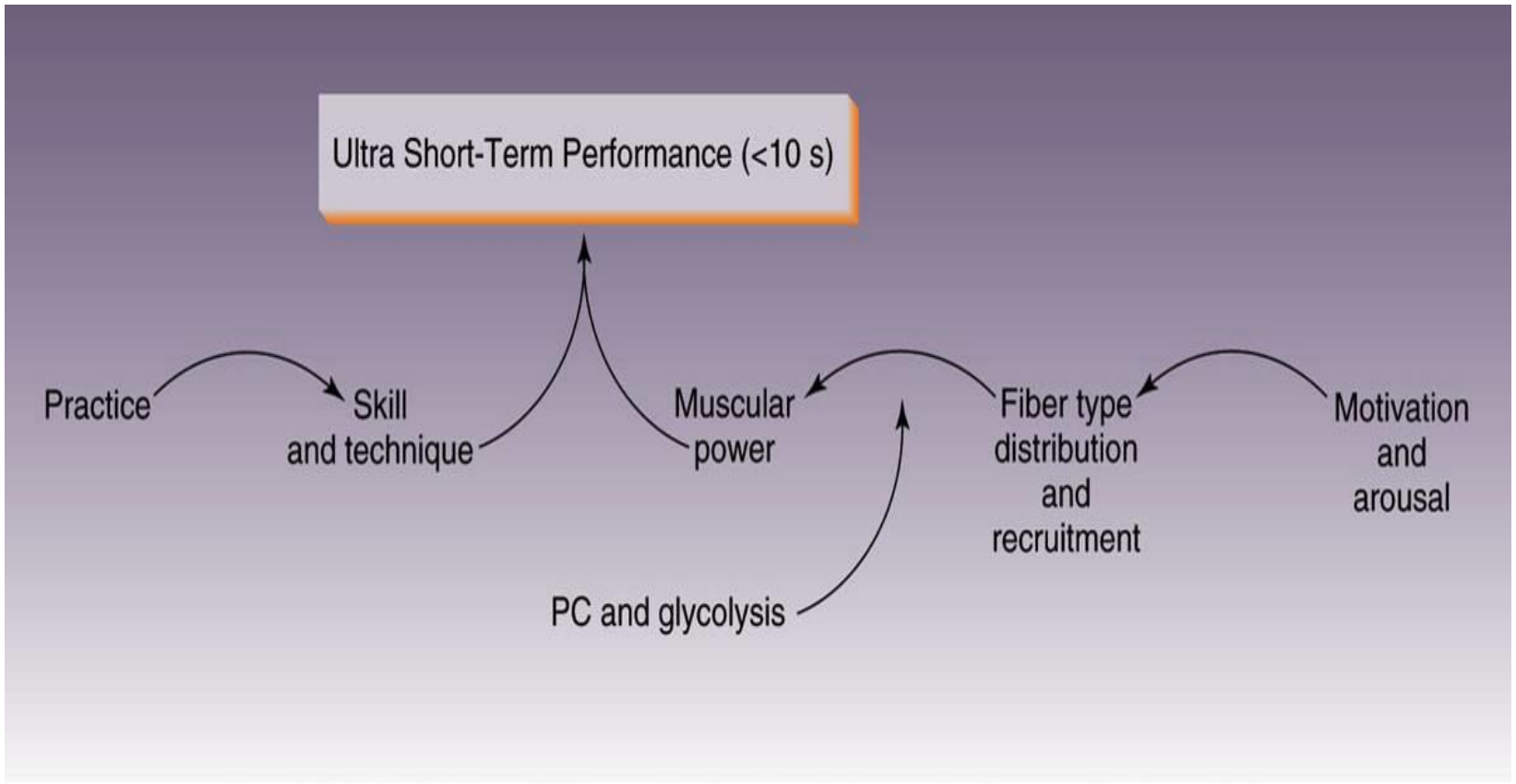
- Generate great forces that are needed

Motivation, skill, and arousal are important

Primary energy source is anaerobic

- ATP-PC system and glycolysis
  - Creatine supplementation may improve performance

FACTORS AFFECTING FATIGUE IN ULTRA SHORT-TERM EVENTS



IN SUMMARY

- In events lasting less than ten seconds, optimal performance is dependent on the recruitment of appropriate type II fibers to generate the great forces needed.
- Motivation or arousal is required, as well as the skill needed to direct the force.
- The primary energy sources are anaerobic, with the focus on phosphocreatine.

Creatine phosphate can be obtained from two **sources**: ingestion of meat and internal production by the liver and kidneys.

SHORT-TERM PERFORMANCES

Events lasting 10–180 seconds

Shift from anaerobic to aerobic metabolism
- 70% energy supplied anaerobically at 10s
- 60% supplied aerobically at 180s

Anaerobic glycolysis is primary energy source
- Results in elevated lactate and H^+ levels
  - Interferes with Ca^{+2} binding with troponin

Ingestion of buffers may improve performance

IN SUMMARY

- In short-term performances lasting 10 to 180 seconds, there is a shift from 70% of the energy supplied anaerobically at 10 seconds to 60% being supplied aerobically at 180 seconds.
- Anaerobic glycolysis provides a substantial portion of the energy, resulting in elevated lactate levels.

MODERATE-LENGTH PERFORMANCES

Events lasting 3–20 minutes

- 60% ATP generated aerobically at 3 min
- 90% ATP supplied aerobically at 20 min

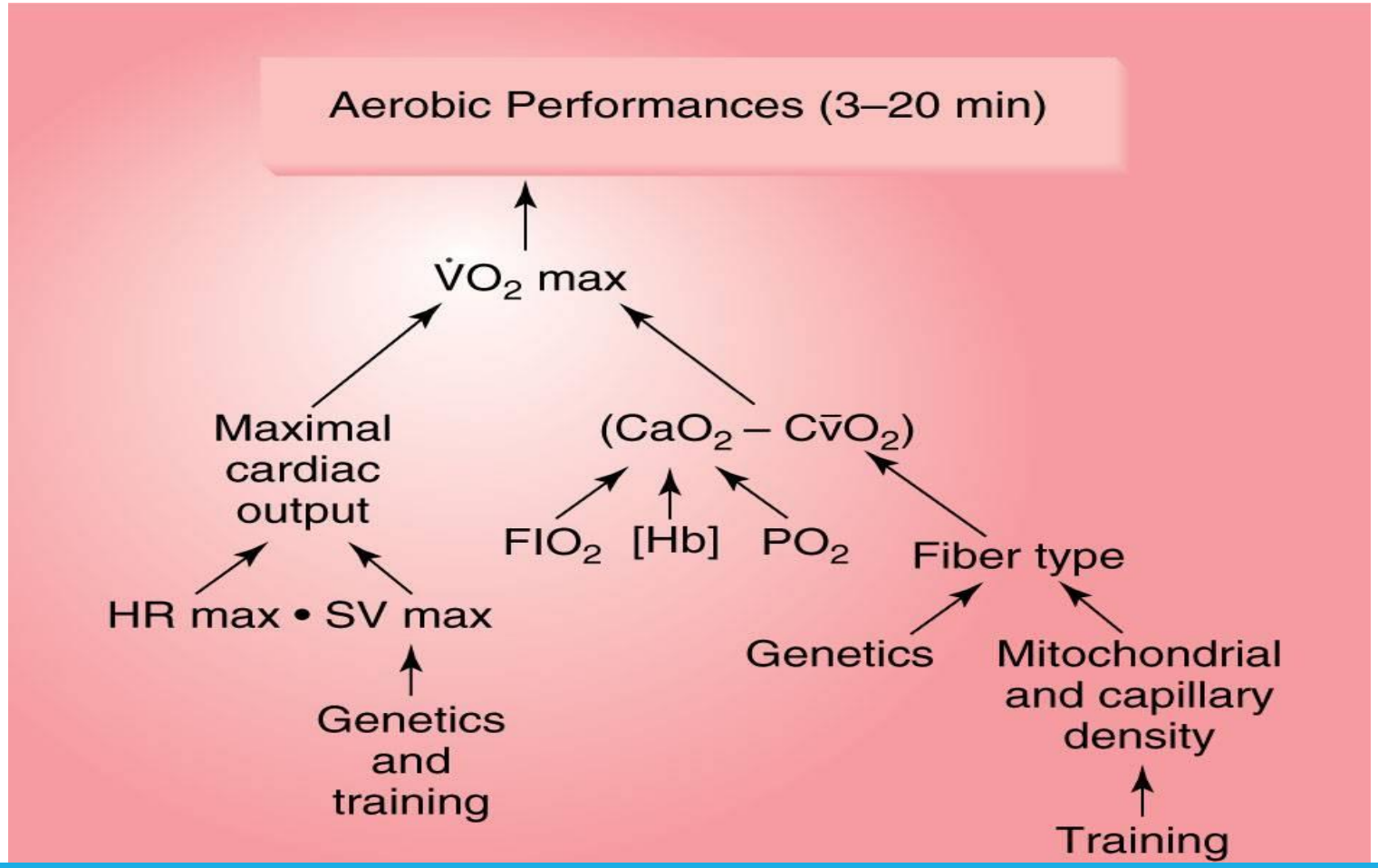
High VO_2 max is important

- High maximal stroke volume
- High arterial oxygen content
  - Hemoglobin content
  - Inspired oxygen

Requires energy expenditure near VO_2 max

- Type IIx fibers recruited
  - High levels of lactate and H^+ accumulation

FACTORS AFFECTING FATIGUE IN AEROBIC PERFORMANCES LASTING 3–20 MINUTES



IN SUMMARY

- In moderate-length performances lasting three to twenty minutes, aerobic metabolism provides 60% to 90% of the ATP, respectively.
- These activities require an energy expenditure near VO_2 max, with type II fibers being recruited.
- Any factor interfering with oxygen delivery (e.g., altitude or anemia) would decrease performance, since it is so dependent on aerobic energy production. High levels of lactate accompany these types of activities.

INTERMEDIATE-LENGTH PERFORMANCES

Events lasting 21–60 minutes

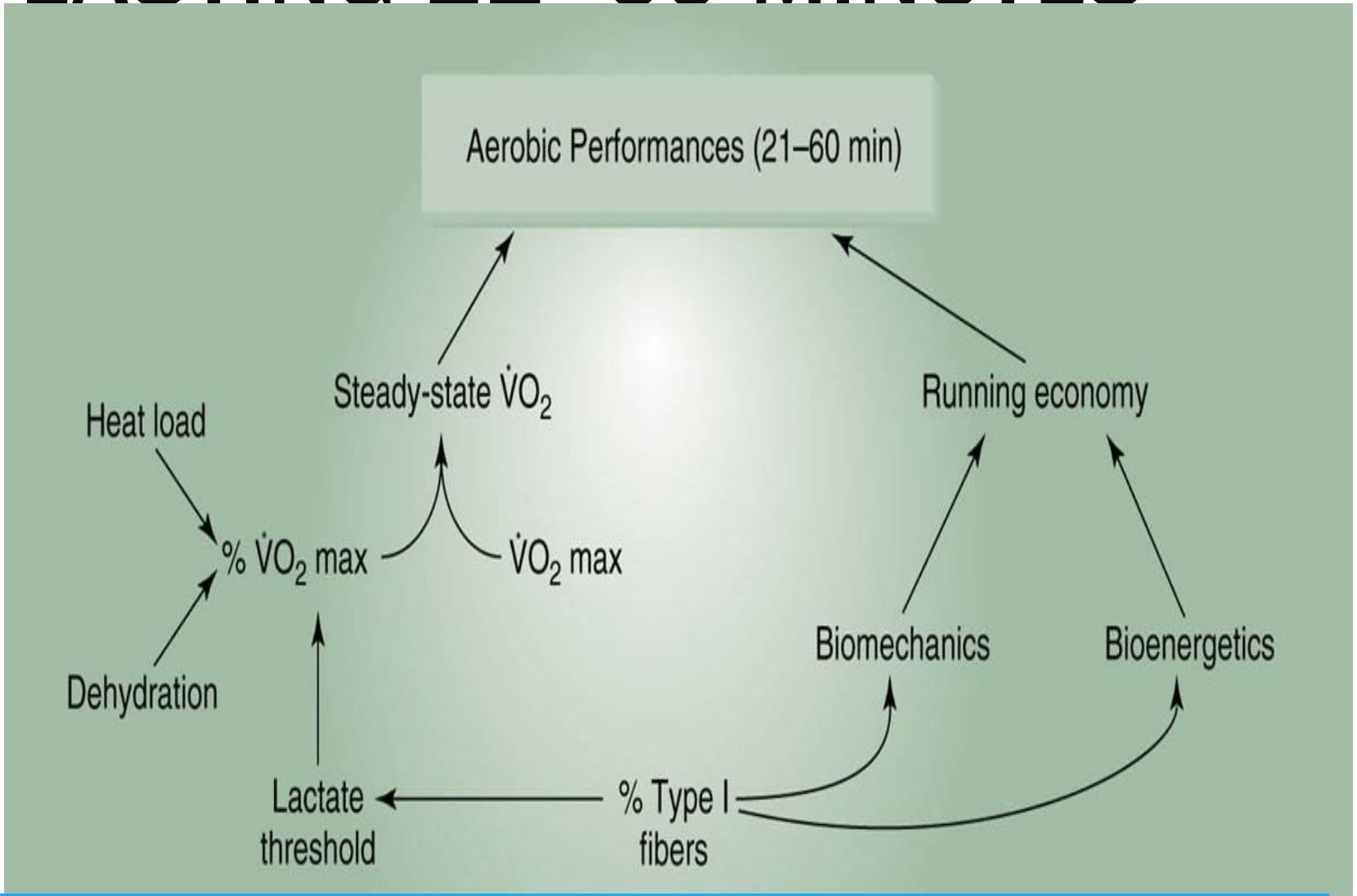
Predominantly aerobic

- Usually conducted at <90% VO_2 max
- High VO_2 max is important

Other important factors

- Running economy
  - High percentage of type I muscle fibers
- Environmental factors
  - Heat
  - Humidity
- State of hydration

FACTORS AFFECTING FATIGUE IN AEROBIC PERFORMANCES LASTING 21–60 MINUTES



IN SUMMARY

- Intermediate-length activities lasting twenty-one to sixty minutes are usually conducted at less than 90% VO_2 max, and are predominantly aerobic.
- Given the length of the activity, environmental factors such as heat, humidity, and the state of hydration play a role in the outcome

LONG-TERM PERFORMANCES

Events lasting 1–4 hours

- Clearly aerobic

Environmental factors more important

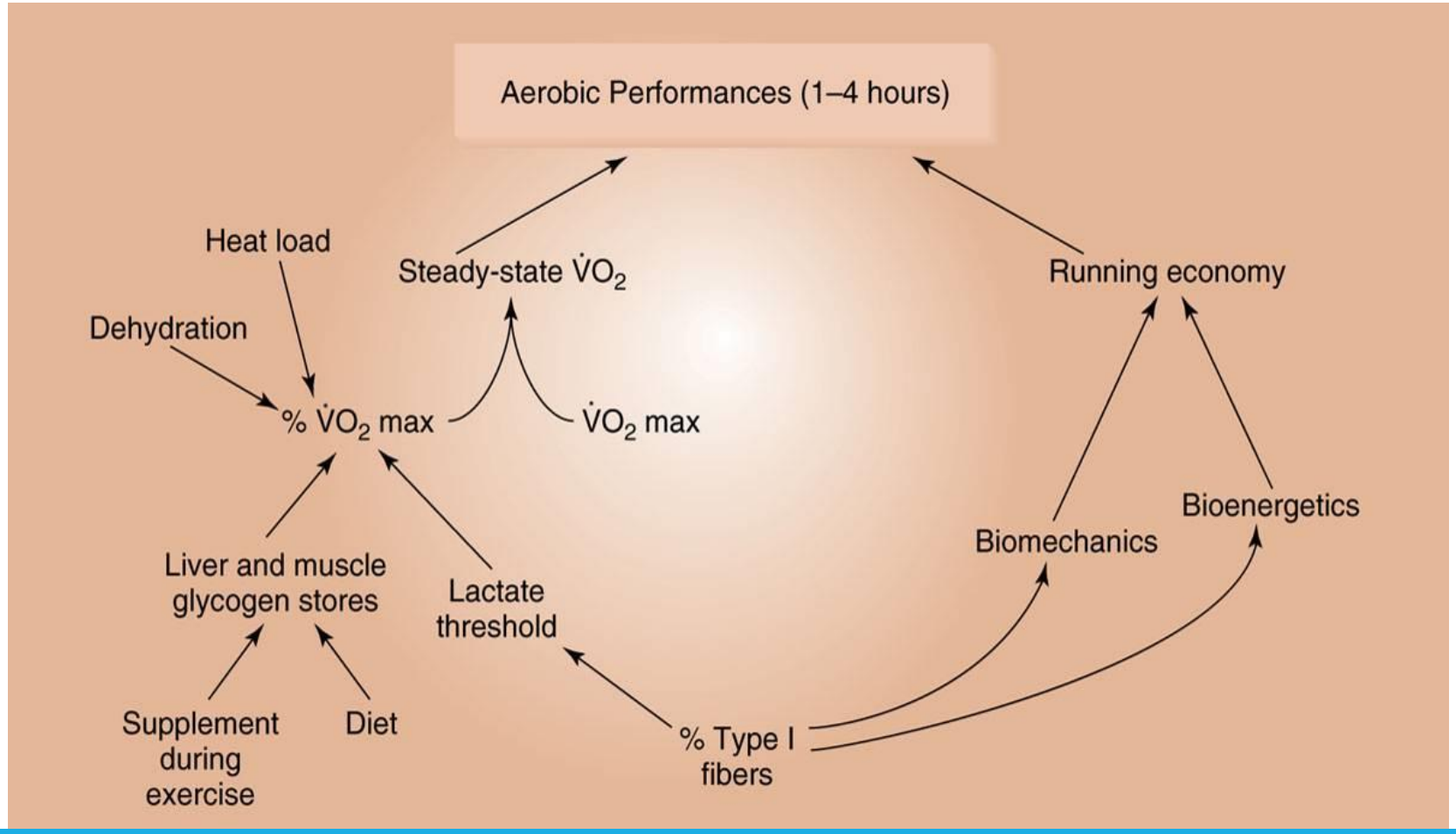
Maintaining rate of carbohydrate utilization

- Muscle and liver glycogen stores decline
- Ingestion of carbohydrate
  - Maintain carbohydrate oxidation by the muscle

Consumption of fluids and electrolytes

Diet also influences performance

FACTORS AFFECTING FATIGUE IN AEROBIC PERFORMANCES LASTING 1–4 HOURS



IN SUMMARY

- In long-term performances of one to four hours duration, environmental factors play a more important role as the muscle and liver glycogen stores try to keep up with the rate at which carbohydrate is used.
- Diet, fluid ingestion, and the ability of the athlete to deal with heat and humidity all influence the final outcome.

ATHLETE AS MACHINE

Continuing goal to improve performance

Potential to treat elite athletes like machines

- Collection of parts evaluated by specialists
- Implementation of research to improve performance
- May be exposing athletes to risk
  - In research or in implementation of techniques

Institutional Review Boards

- Minimize risk to subjects being studied