PHYSIOLOGY OF EXERCISE

EXERCISE:
1. **Dynamic** (positive/negative)
2. **Static**

MUSCLE TYPES
- Skeletal
- Heart
- Smooth

„Fight or flight“ – EVOLUTIONAL ASPECT

HOMEOSTASIS

THERMOREGULATION

ANTICIPATION OF WORK

CHANGES DURING EXERCISE:

1. Cardiovascular
2. Respiratory
3. Metabolic

CARDIOVASCULAR REACTIONS DURING WORK

1. Reactions of the heart
2. Reactions of the vessels

Ergotropic system – sympathetic NS

REDISTRIBUTION OF BLOOD

Demands on cardiovascular system:

1. Increase of cardiac output
2. Increase in coronary blood flow
3. Hyperaemia in lung circulation
4. Hyperaemia in muscles (difference between contraction and relaxation!!!)
5. Higher supply of O_2 and metabolites, higher removal of CO_2 and catabolites

METABOLIC REGULATION OF BLOOD FLOW

Decreased pH, decreased pO_2, increased pCO_2, increased K^+, increased body temperature

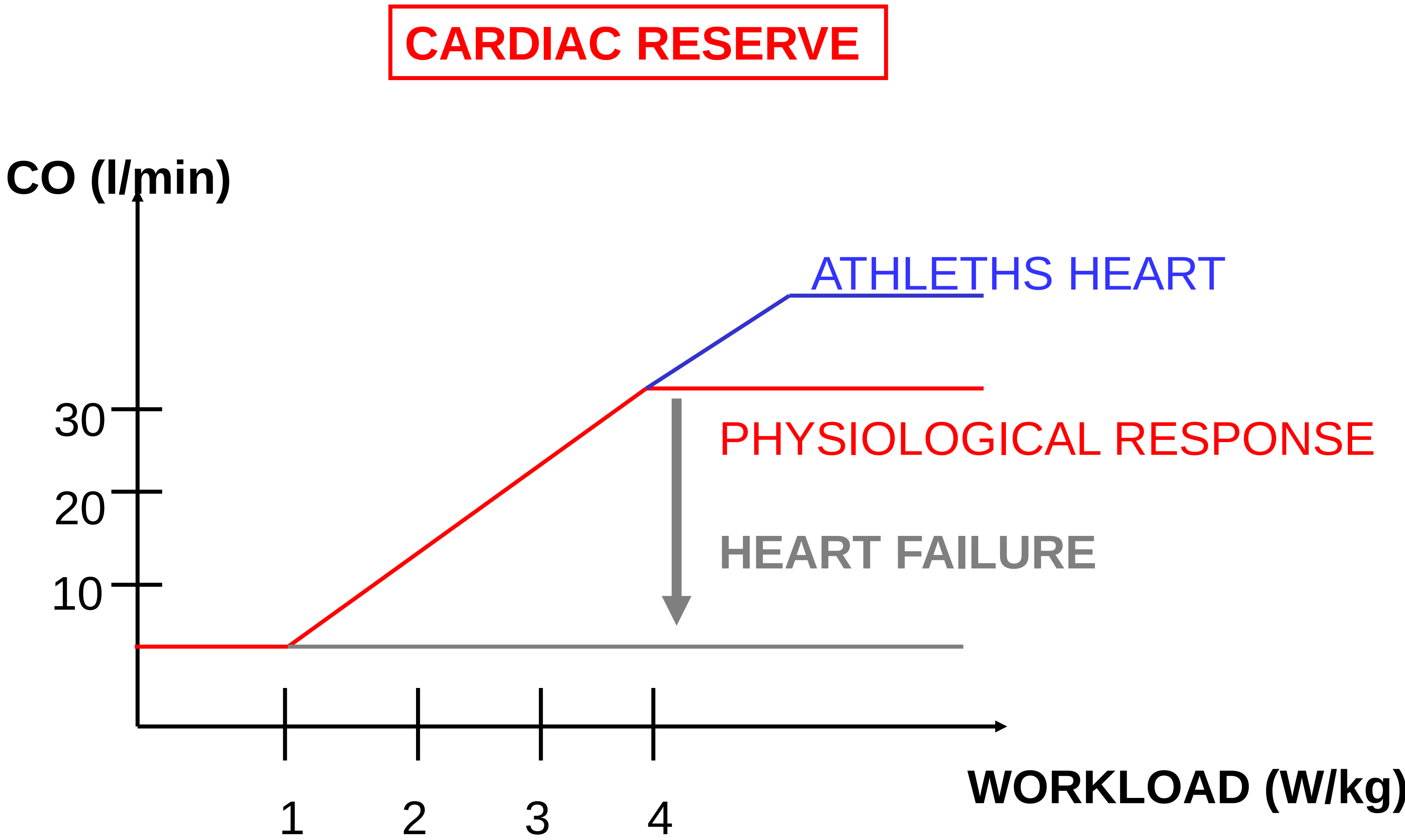
CARDIAC RESERVE = maximal CO / resting CO **4 - 7**

CORONARY RESERVE = maximal CF / resting CF **3.5**

CHRONOTROPIC RESERVE = maximal HR / resting HR **3 - 5**

VOLUME RESERVE = maximal SV / resting SV **1.5**

CO – cardiac output, CF – coronary flow, HR – heart rate, SV – stroke volume


CARDIAC RESERVE
CO (l/min)
30
20
10
ATHLETHS HEART
PHYSIOLOGICAL RESPONSE
HEART FAILURE
1
2
3
4
WORKLOAD (W/kg)

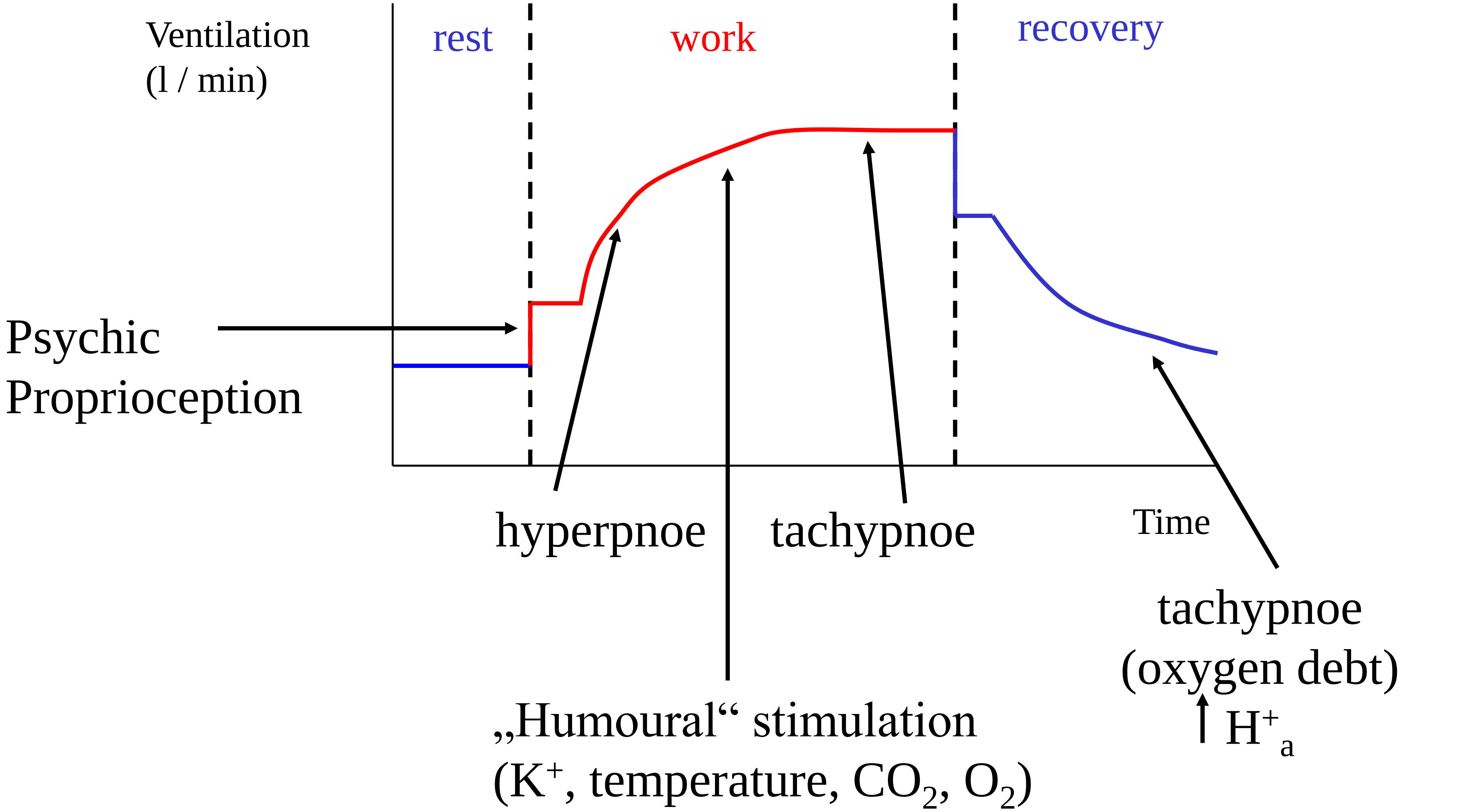
PARAMETER	REST	EXERCISE	INCREASE (x)
Cardiac output (l/min)	5-6	25 (35)	4-5 *Cardiac reserve*
Heart rate (t/min)	70	210 (250-190) ***depends on age***	3 *Chronotropic reserve*
Stroke volume (ml)	75	115	1.5 *Volume reserve*
Systolic BP (mmHg)	120	↑ ?	-
Diastolic BP (mmHg)	70	↓ ↑ — ?	-
Pulse BP (mmHg)	50	70-100	1.5-2
Mean BP (mmHg)	-	-	minor increase
Muscle perfusion (ml/min/100g)	2-4	60-120	30 (10% MV_{max})

RESPIRATORY REACTIONS DURING EXERCISE

Demands on respiratory system:

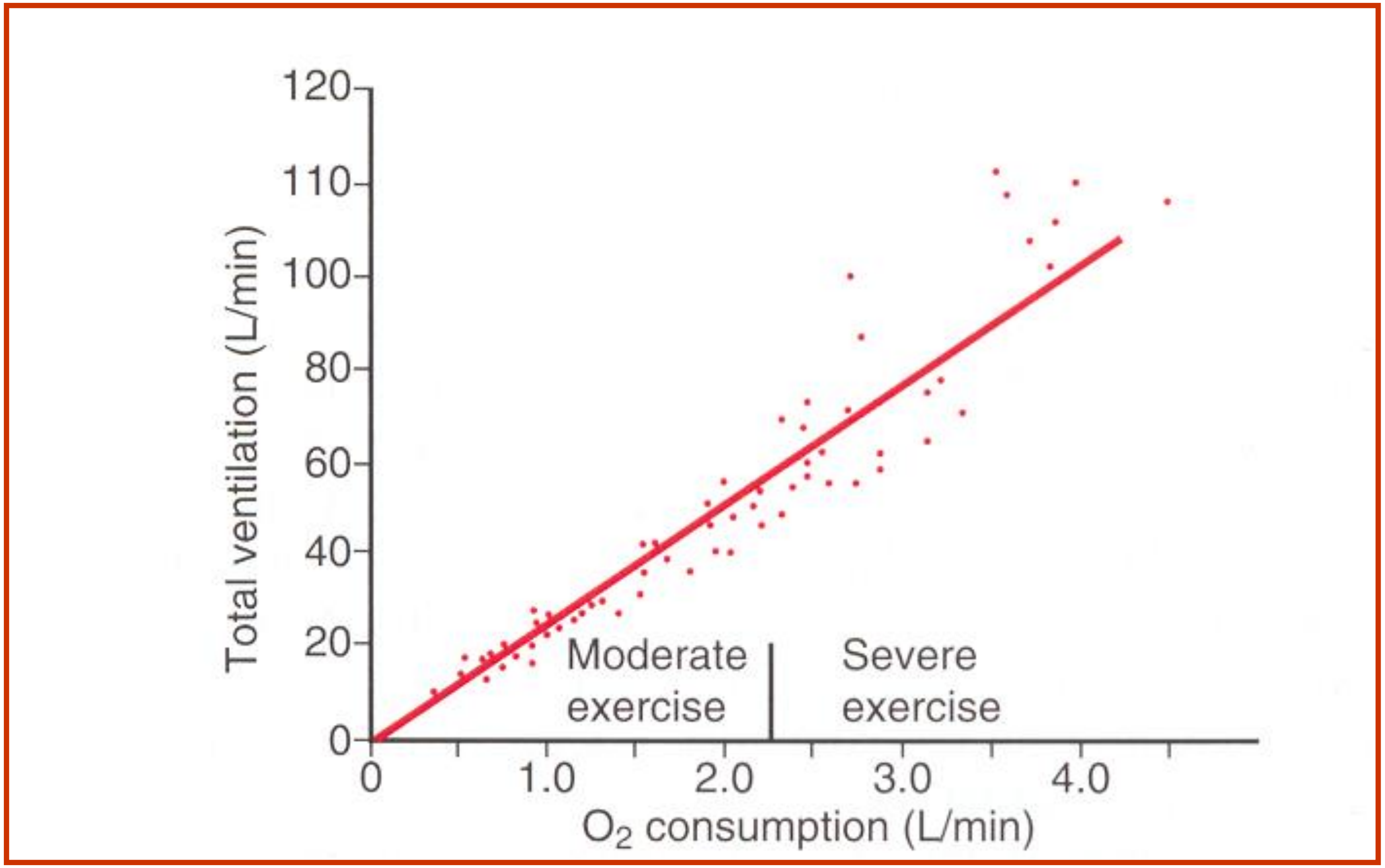
1. Higher gases exchange – higher diffusion
2. Higher ventilation
3. Higher perfusion (hyperaemia in lung circulation)

PARAMETER	REST	EXERCISE	INCREASE (x)
Minute ventilation (l/min)	6-12	90-120	15-20
Respiratory frequency (d/min)	12-16	40-60	4-5
Tidal volume (ml)	0,5-0,75	2	3-4
Blood flow (l/min)	5,5	20 – 35	4-6
O_2 intake (ml/min) -V_{O2}	250-300	3000	10-12
Total CO_2 (ml/min)	200	8000	40
pO_2 (Torr)	40	25	
O_2 extraction (%)	+	+	++


Ventilation
(l / min)
rest
work
recovery
Psychic
Proprioception
hyperpnoe
tachypnoe
Time
tachypnoe
(oxygen debt)
↑ H^+_a
„Humoural“ stimulation
(K^+, temperature, CO_2, O_2)

R = 1.5 – 2.0

R = 0.5



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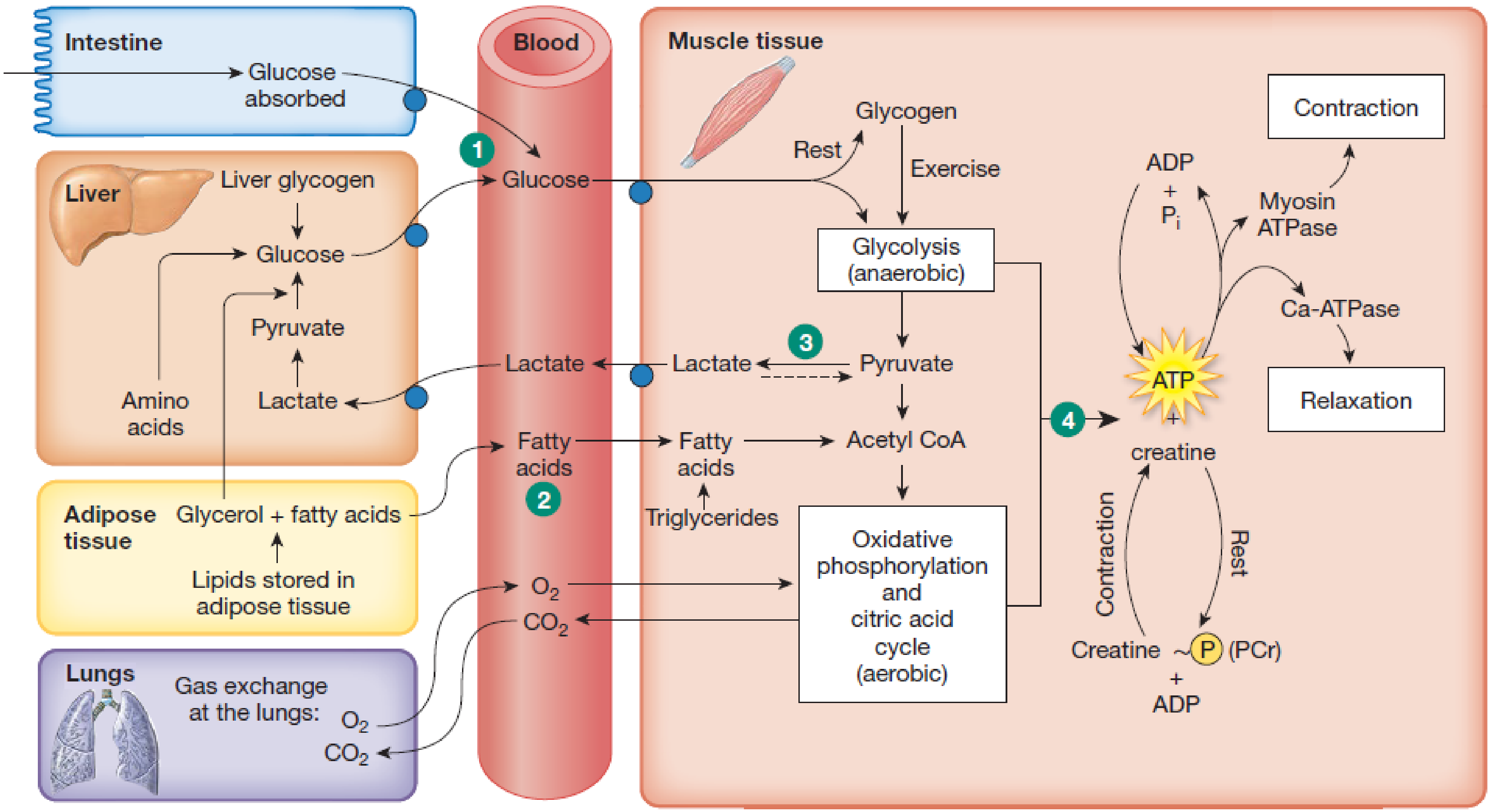
OVERVIEW OF MUSCLE METABOLISM

ATP for muscle contraction is continuously produced by aerobic metabolism of glucose and fatty acids. During short bursts of activity, when ATP demand exceeds the rate of aerobic ATP production, aerobic glycolysis produces ATP, lactate, and H^+.



1 Glucose comes from liver glycogen or dietary intake.

2 Fatty acids can be used only in aerobic metabolism.

3 Lactate from anaerobic metabolism can be converted to glucose by the liver.

4 Both aerobic and anaerobic metabolism provide ATP for muscle contraction.

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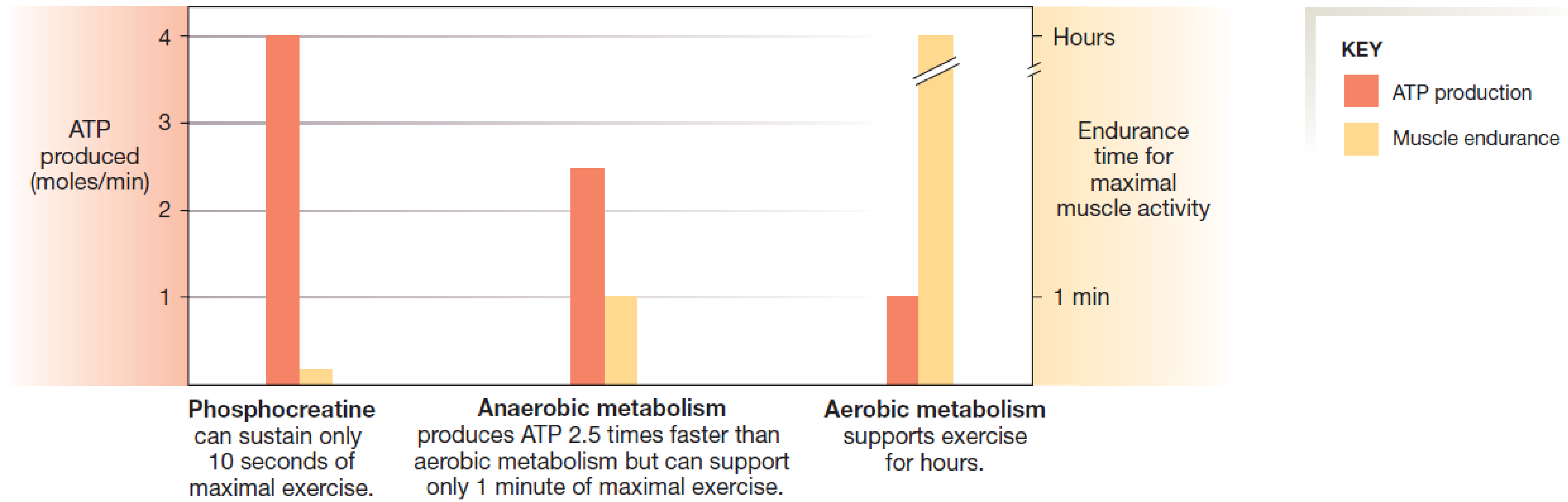
AEROBIC VERSUS ANAEROBIC METABOLISM

Anaerobic metabolism produces ATP 2.5 times faster than aerobic metabolism, but aerobic metabolism can support exercise for hours.



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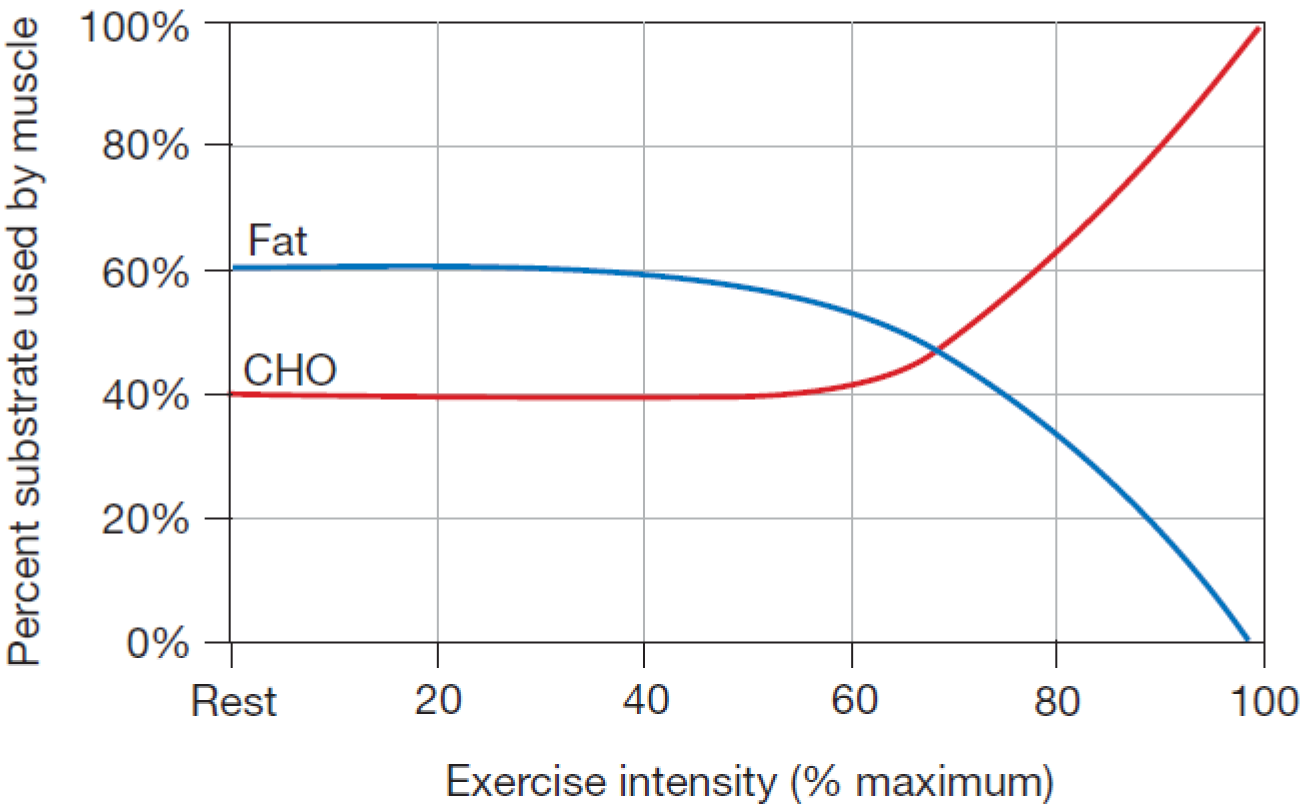
ENERGY SUBSTRATE USE DURING EXERCISE

At low-intensity exercise, muscles get more energy from fats than from glucose (CHO). During high-intensity exercise (levels greater than 70% of maximum), glucose becomes the main energy source.



Data from G. A. Brooks and J. Mercier, *J App Physiol* 76: 2253–2261, 1994

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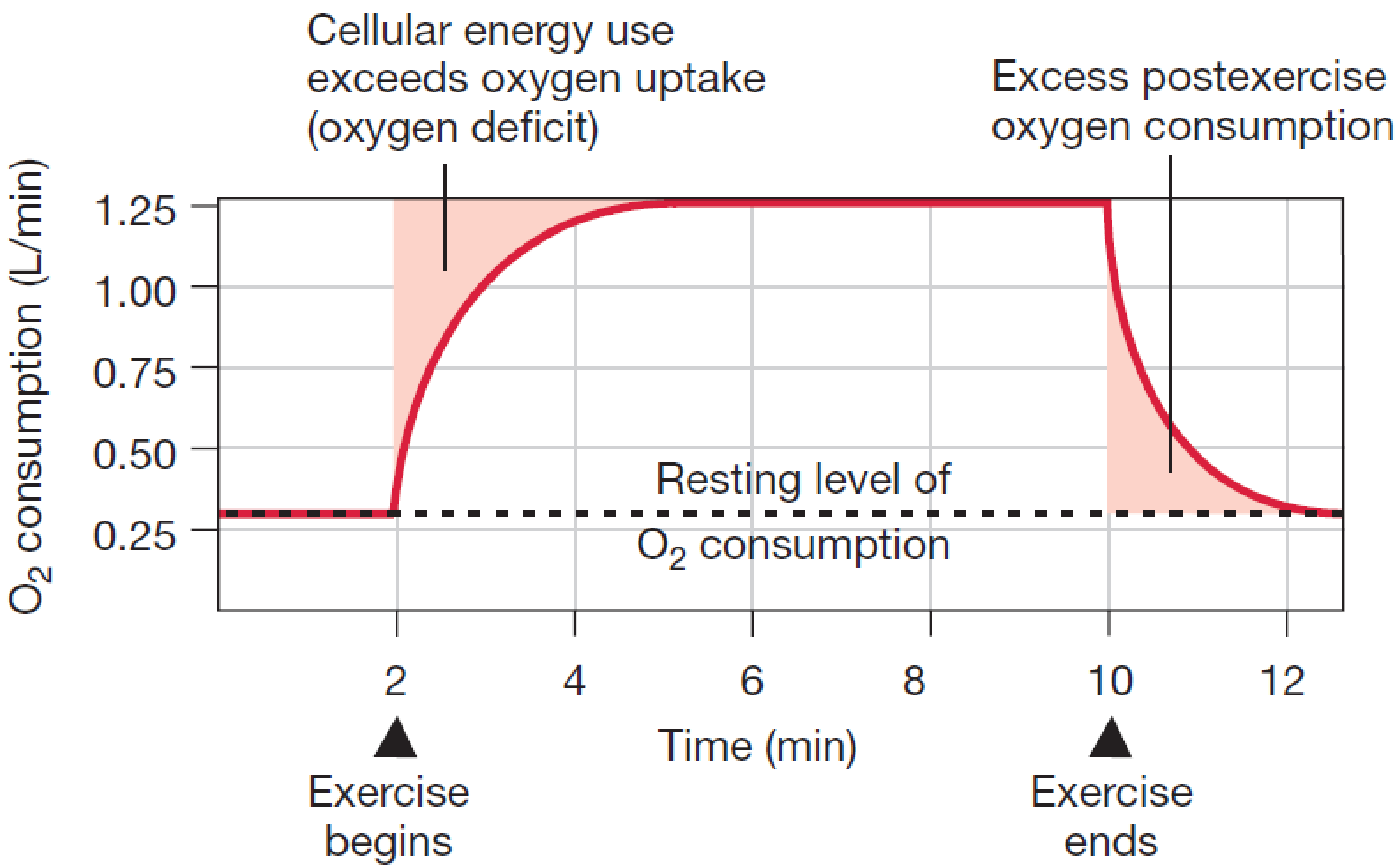
OXYGEN CONSUMPTION AND EXERCISE

Oxygen supply to exercising cells lags behind energy use, creating an oxygen deficit. Excess postexercise oxygen consumption compensates for the oxygen deficit.



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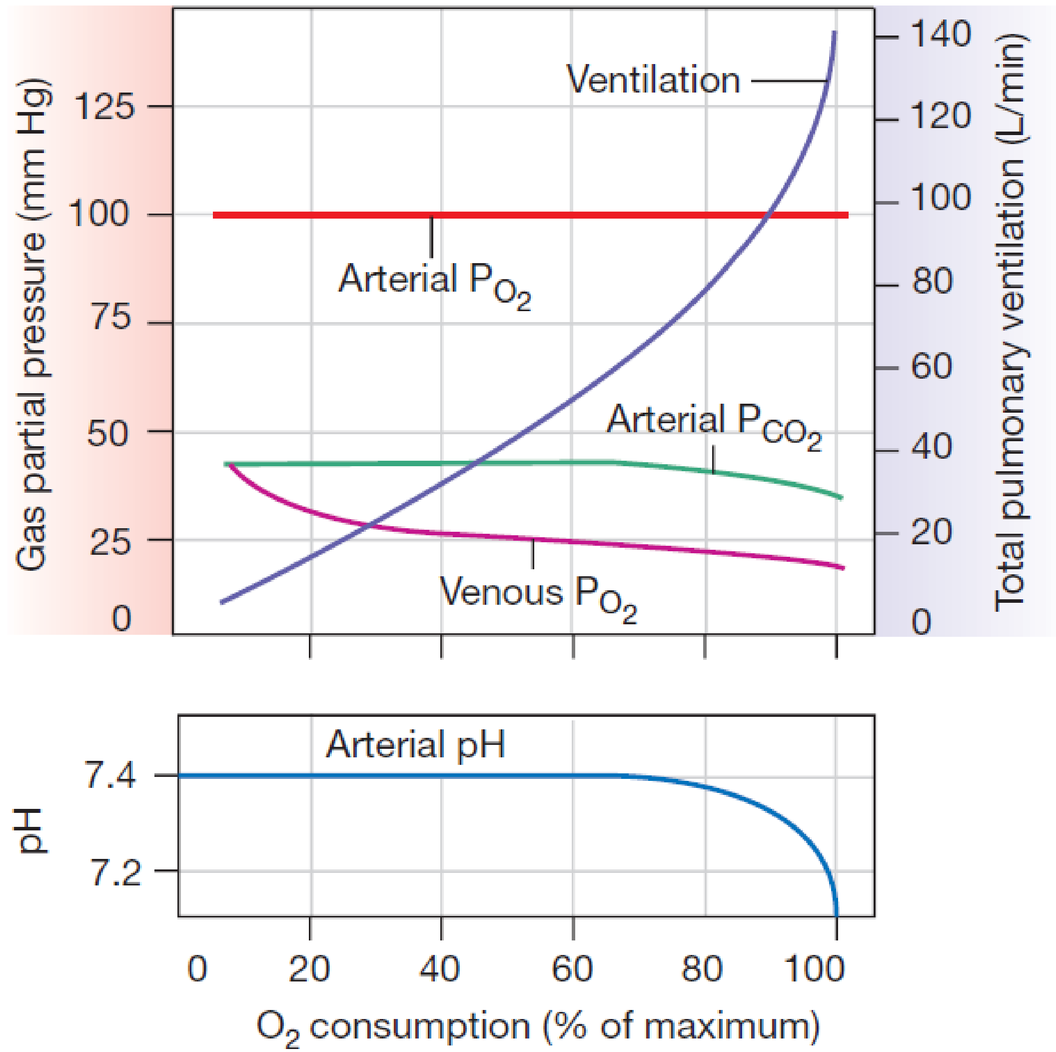
BLOOD GASES AND EXERCISE

Arterial blood gases and pH remain steady with submaximal exercise.



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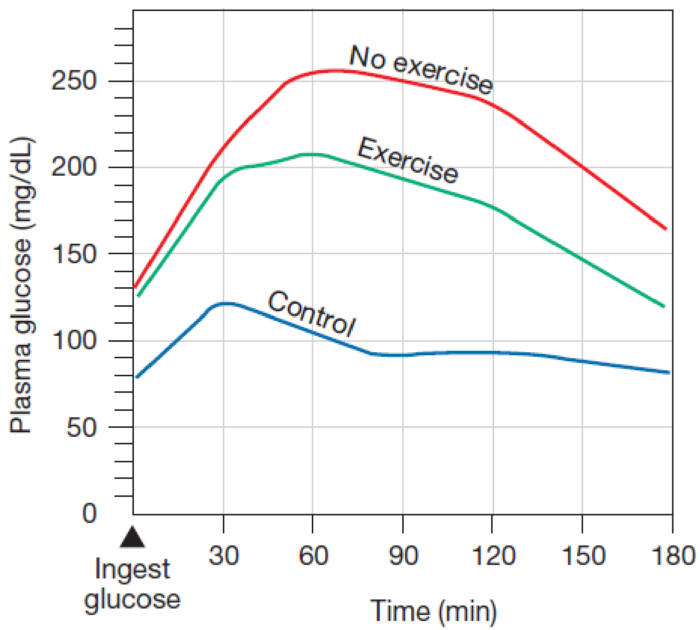
EXERCISE IMPROVES GLUCOSE TOLERANCE AND INSULIN SECRETION

The experiments tested normal men (blue line), men with type 2 diabetes who had not been exercising (red line), and those same diabetic men after seven days of exercise (green line).

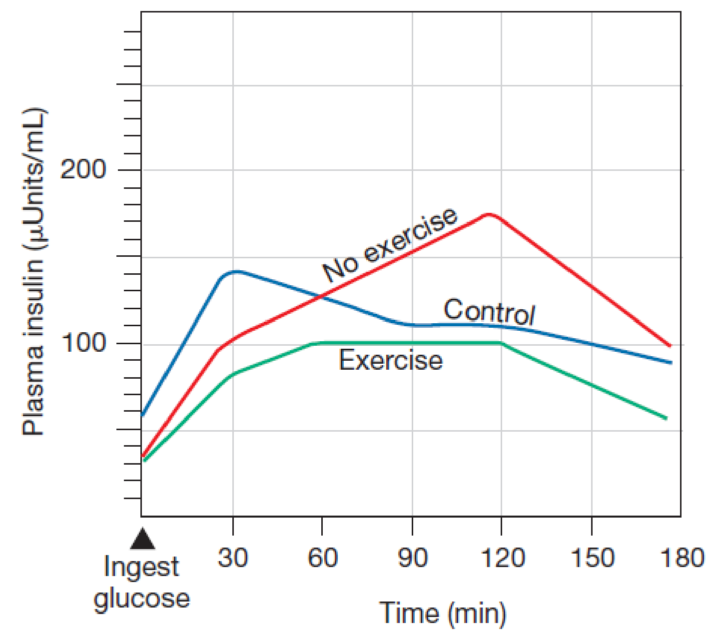
KEY

- Normal controls
- Type 2 diabetes, no exercise
- Type 2 diabetes, after 7 days of exercise

(a) Plasma glucose during glucose tolerance test



(b) Plasma insulin during glucose tolerance test



Data from B. R. Seals, *et al.*, *J App Physiol* 56(6): 1521–1525, 1984; and M. A. Rogers, *et al.*, *Diabetes Care* 11: 613–618, 1988.

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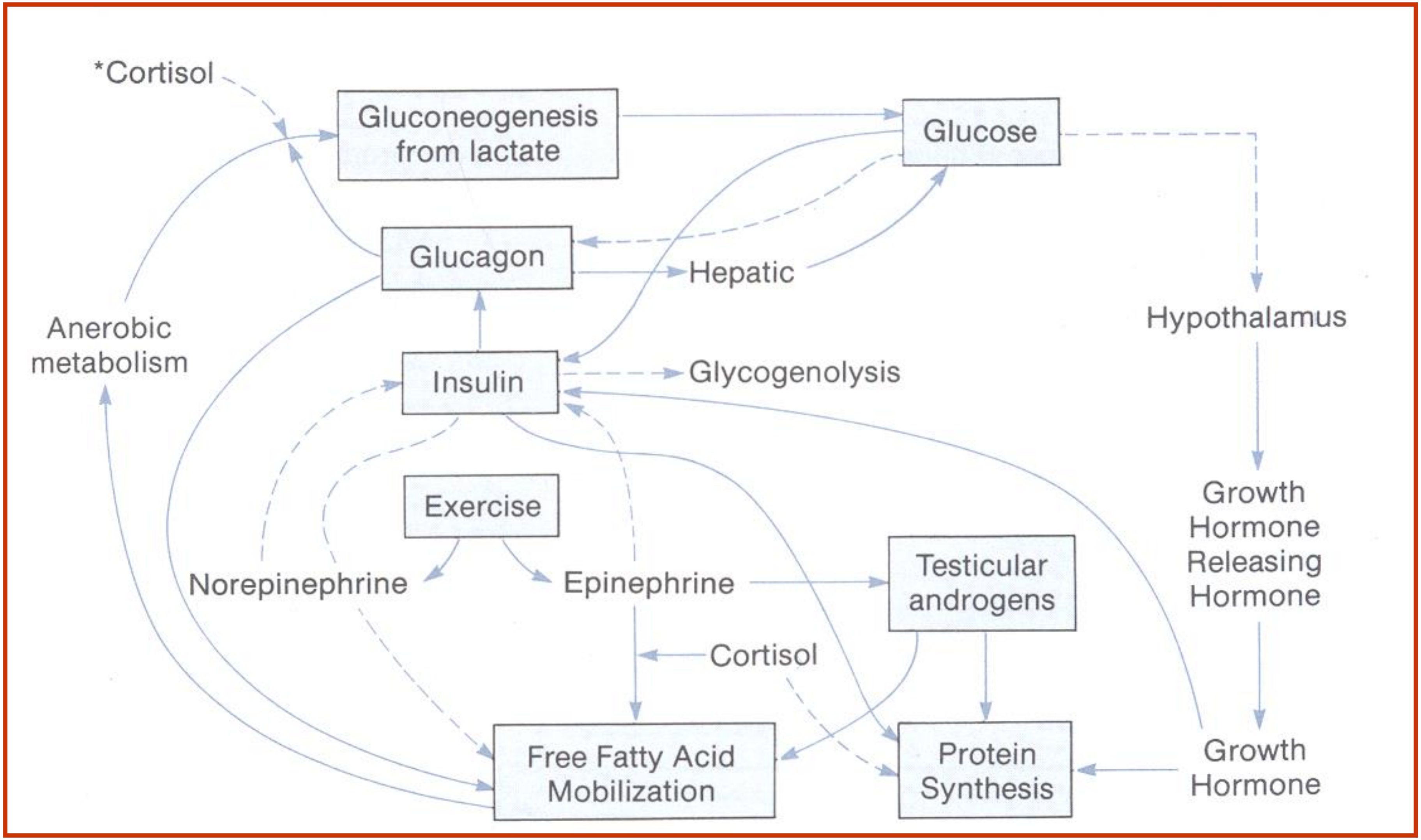

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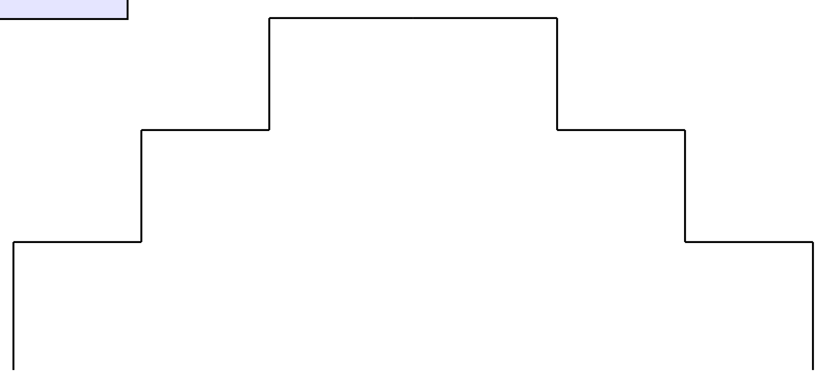
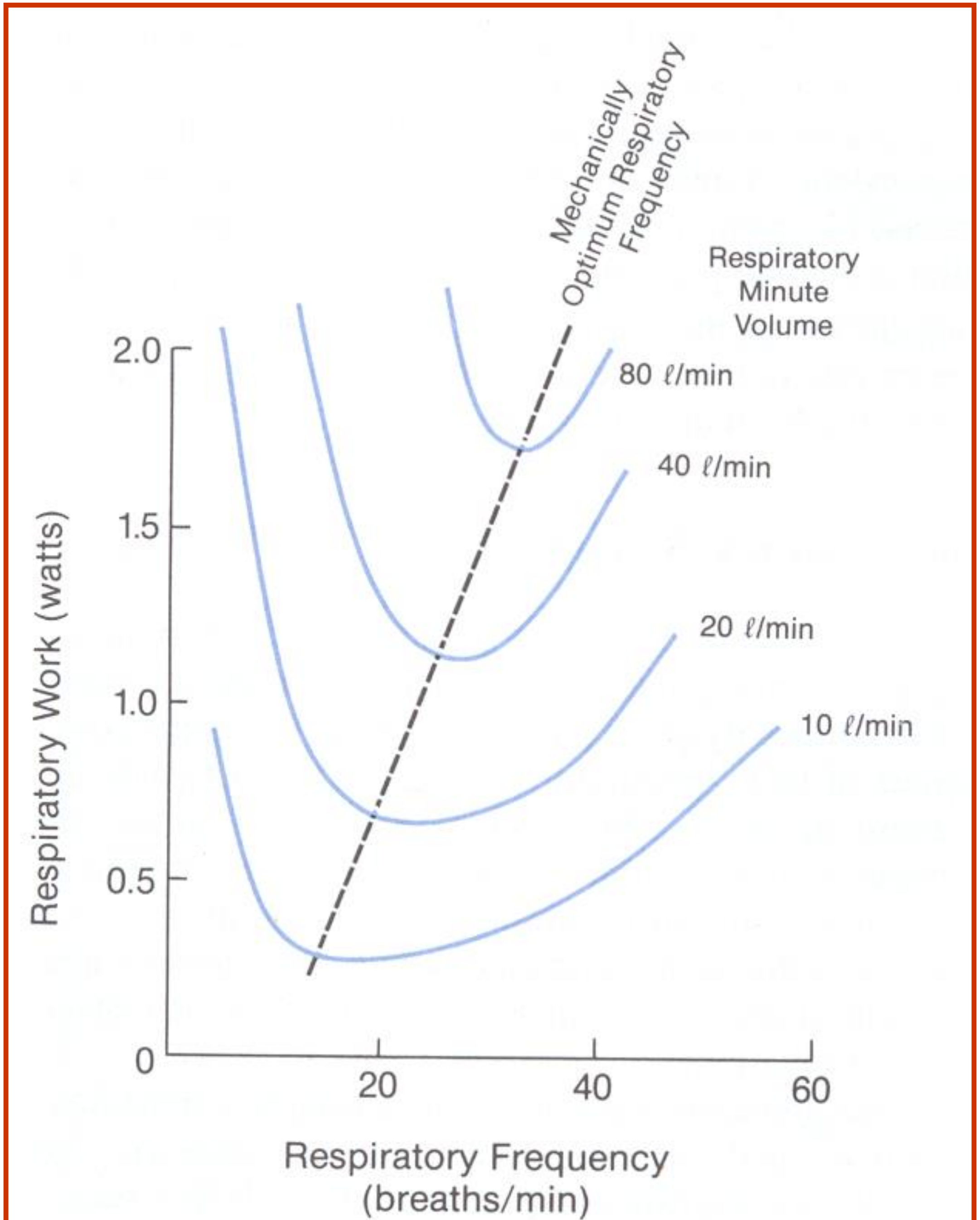
FITNESS

- Spiroergometry
- Types of ergometers
- Index W_{170}
- Training
- Fatigue (aerobic, anaerobic threshold)
- Adaptation to exercise





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