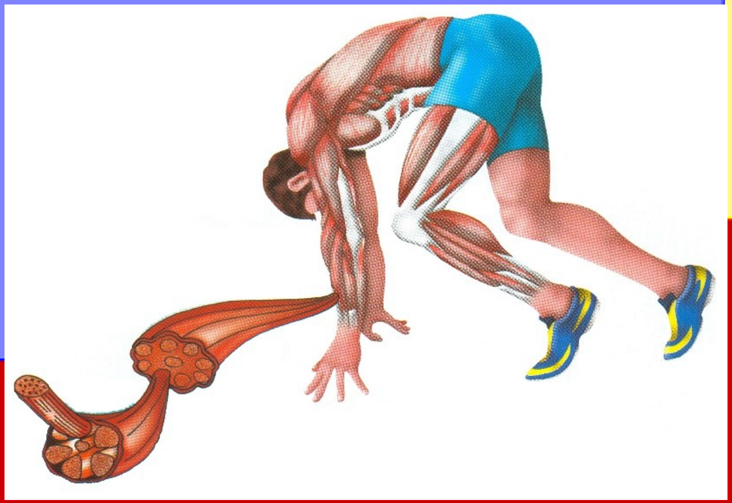
ADAPTATIONS TO AEROBIC AND ANAEROBIC TRAINING



Key Points

ADAPTATION OF MUSCLE METABOLISM

- AERE AEROBIC TRAINING:
  - increases muscle myoglobin
  - increases oxidative enzymes
  - lactate threshold, RER, VO_2
- ANAEROBIC TRAINING:
  - adaptations in the ATP-PCr system
  - adaptations in the glycolytic system
  - increase the ATP-PCr and glycolytic enzymes

TABLE 11.5 Selected Muscle Enzyme Activities ($mmol \cdot g^{-1} \cdot min^{-1}$) for Untrained, Anaerobically Trained, and Aerobically Trained Men

	Untrained	Anaerobically trained	Aerobically trained
AEROBIC ENZYMES			
Oxidative system			
Succinate dehydrogenase	8.1	8.0	20.8[a]
Malate dehydrogenase	45.5	46.0	65.5[a]
Carnitine palmityl transferase	1.5	1.5	2.3[a]
ANAEROBIC ENZYMES			
ATP-PCr system			
Creatine kinase	609.0	702.0[a]	589.0
Myokinase	309.0	350.0[a]	297.0
Glycolytic system			
Phosphorylase	5.3	5.8	3.7[a]
Phosphofructokinase	19.9	29.2[a]	18.9
Lactate dehydrogenase	766.0	811.0	621.0

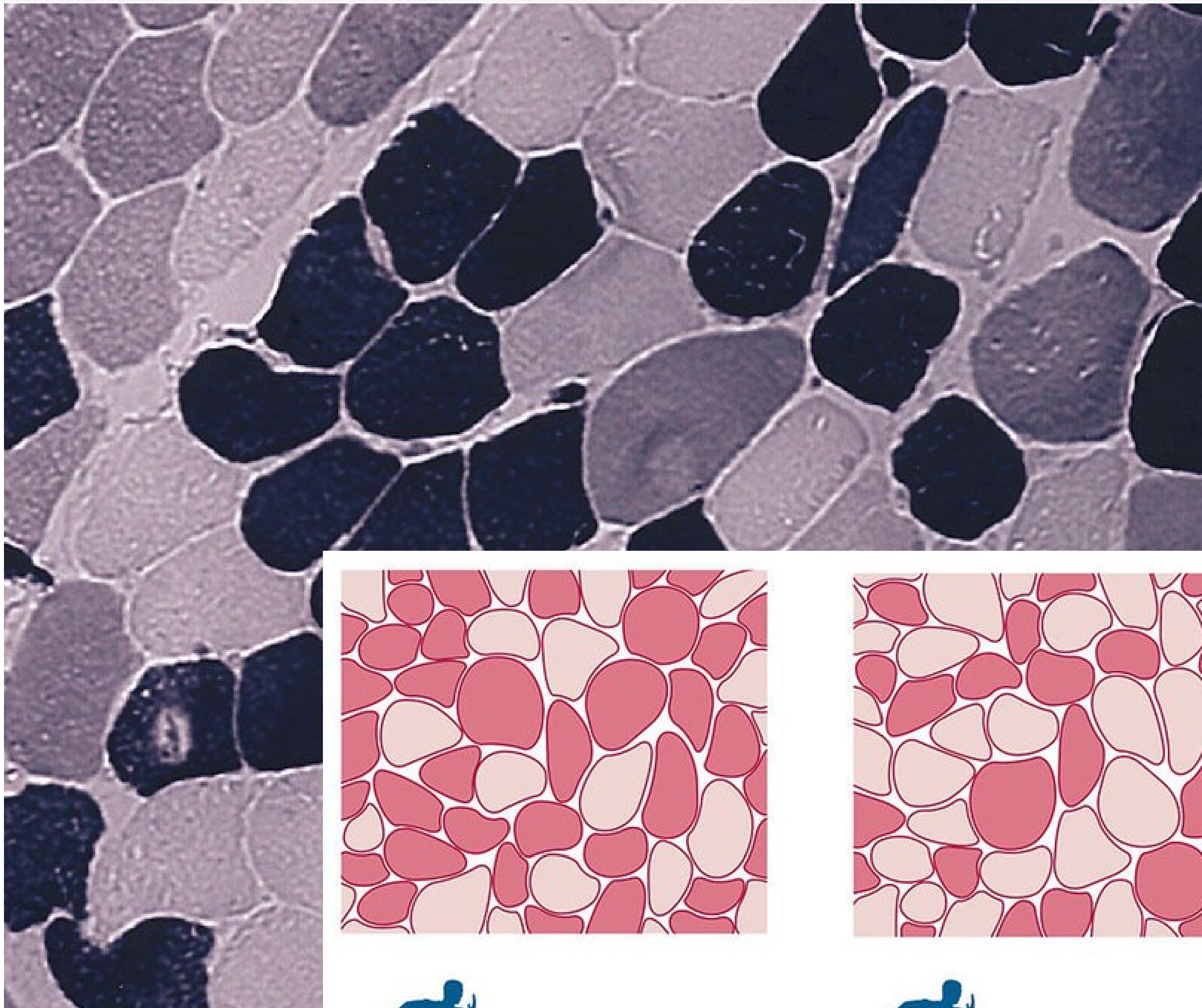
[a]Significant difference from the untrained value.

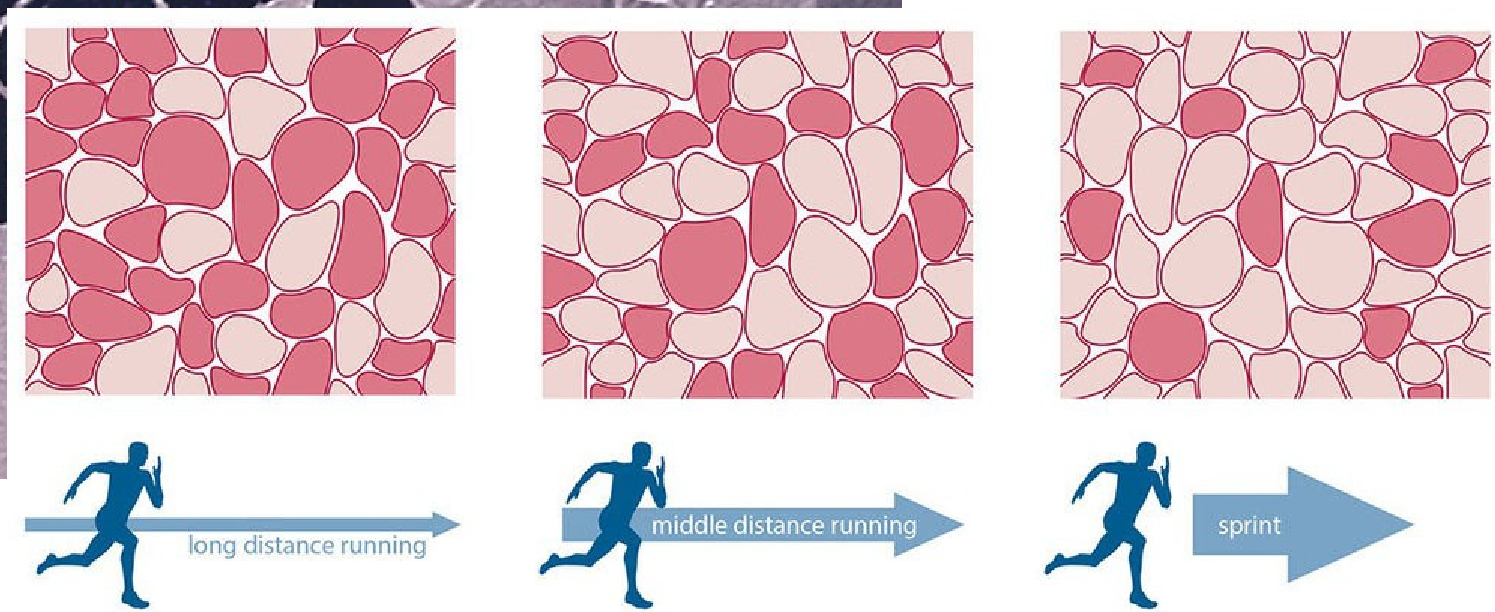
Key Points

ADAPTATION OF MUSCLE

- Muscle fiber type
- Capillary supply
- Myoglobin content
- Mitochondrial function

SLOW- AND FAST-TWITCH FIBERS





Změny podílu různých typů svalových vláken po vytrvalostním tréninku

(Powers, 2007)

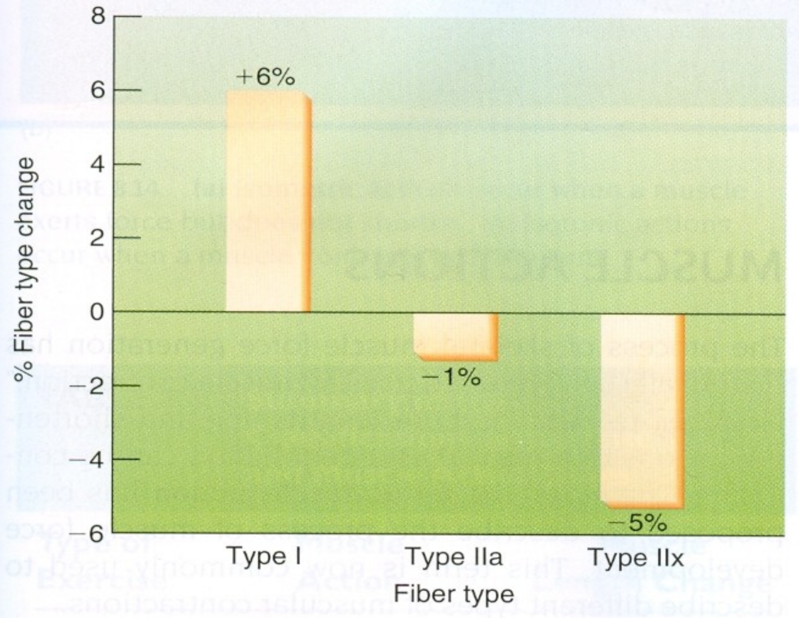
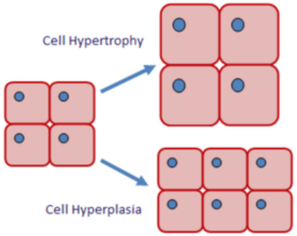
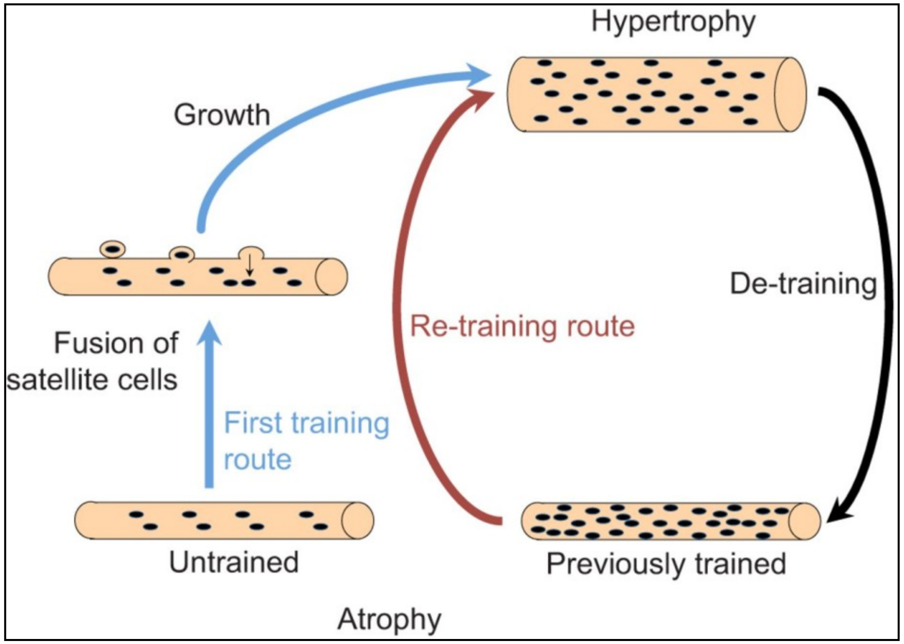


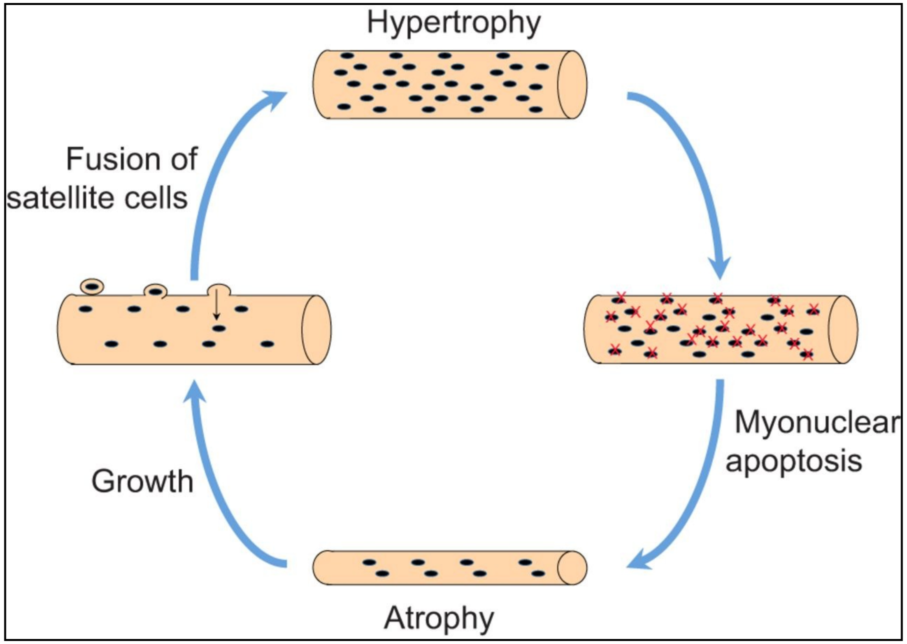
FIGURE 8.13 Effects of 16 weeks of endurance exercise training (i.e., 3–4 days/week at 50–60% $\dot{V}O_2$ max) on human skeletal muscle fiber types. Note that exercise training promoted a significant fast-to-slow shift in muscle fiber type resulting in a net reduction in the percent of fast type IIx fibers and an increase in the percent of slow, type I fibers. Data are from Short et al. (90).

MECHANIZMY → HYPERTROFIE / HYPOTROFIE SVALOVÝCH VLÁKEN

http://jeb.biologists.org/content/219/2/235



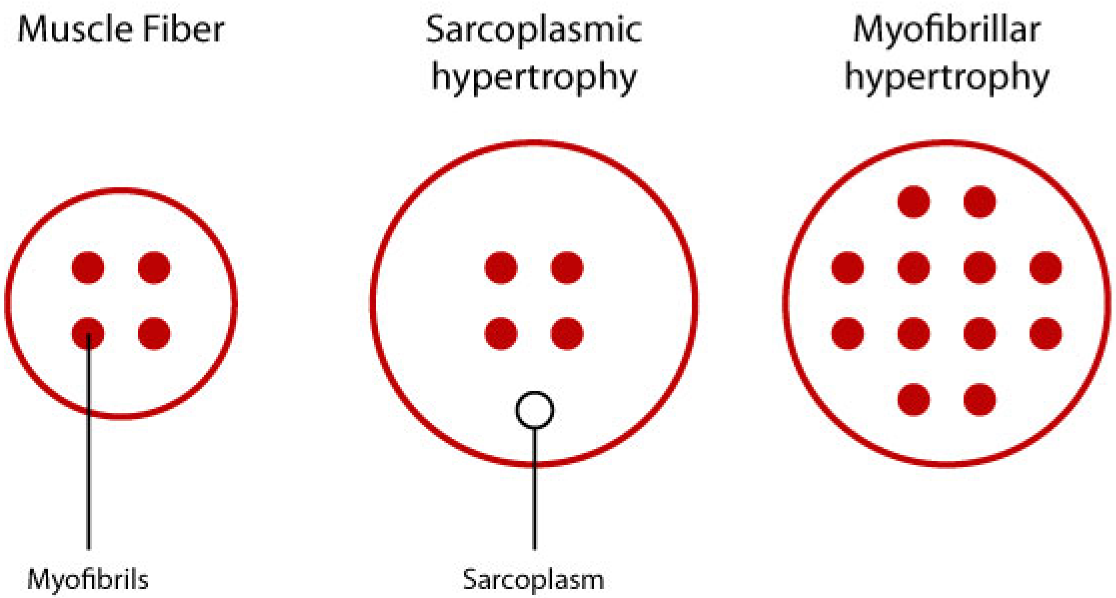




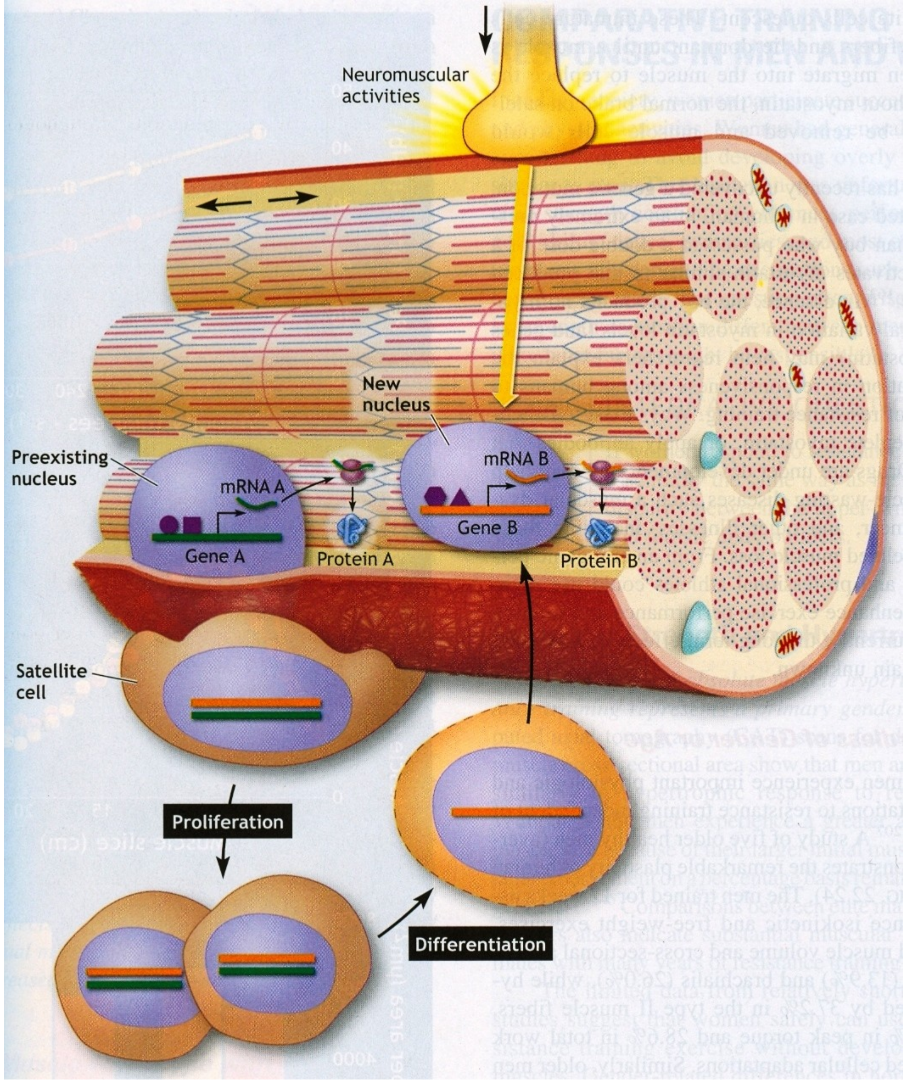
CELL HYPERTROPHY OF MUSCLE

- **myofibrillar**: growth of muscle contraction parts
- **sarcoplasmic:** increased muscle glycogen storage

Muscular hypertrophy types	Increases	Activates
myofibrillar	strength and speed	contractor muscles
sarcoplasmic	energy storage and endurance	glycogen storage in muscles



Muscle adapattion



HYPERTROFIE RŮZNÝCH TYPŮ SVALOVÝCH VLÁKEN

http://danogborn.com/underestimating-type-i-fibres/

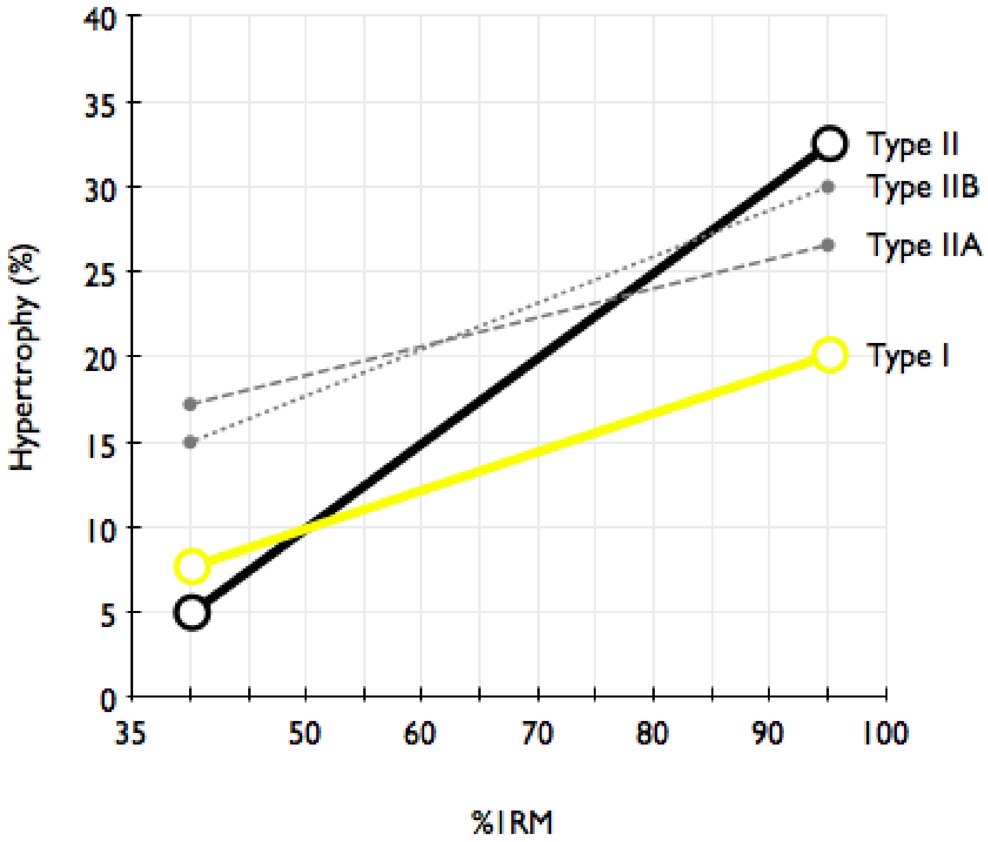


TABLE 11.2 Muscle Fiber Capillarization in Well-Trained and Untrained Men

Stage	Capillaries per mm^2	Muscles fibers per mm^2	Capillary-to-fiber ratio	Diffusion distance[a]
Well-trained				
Preexercise	640	440	1.5	20.1
Postexercise	611	414	1.6	20.3
Untrained				
Preexercise	600	567	1.1	20.3
Postexercise	599	576	1.1	20.5

Note. This table illustrates the larger size of the muscle fibers in the well-trained men in that they had fewer fibers for a given area (fibers per mm^2). They also had an approximately 50% higher capillary-to-fiber ratio than the untrained men.

[a]Diffusion distance is expressed as the average half-distance between capillaries on the cross-sectional view expressed in micrometers.

Adapted from L. Hermansen and M. Wachtlova, 1971, "Capillary density of skeletal muscle in well trained and untrained men," *Journal of Applied Physiology* 30: 860-863. Used with permission.

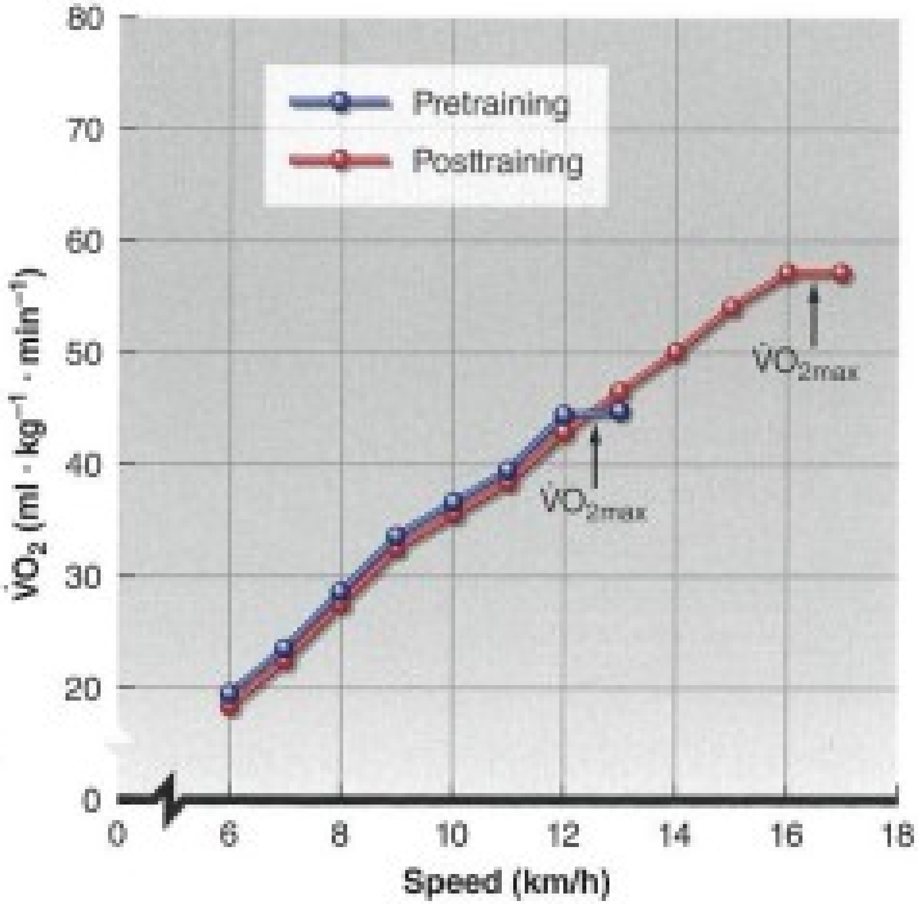
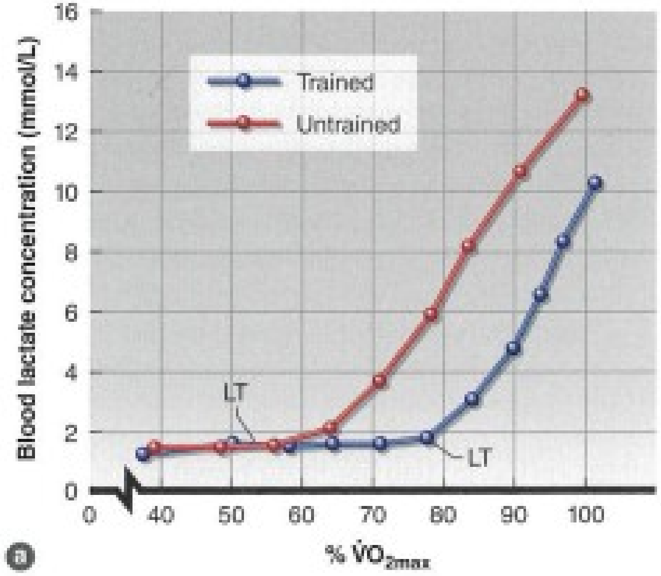


FIGURE 11.1 Changes in $\dot{V}O_{2max}$ with 12 months of endurance training. $\dot{V}O_{2max}$ increased from 44 to 57 ml · kg^{-1} · min^{-1}, a 30% increase. Peak speed during the treadmill test increased from 13 km/h (8 mph) to 16 km/h (~10 mph).



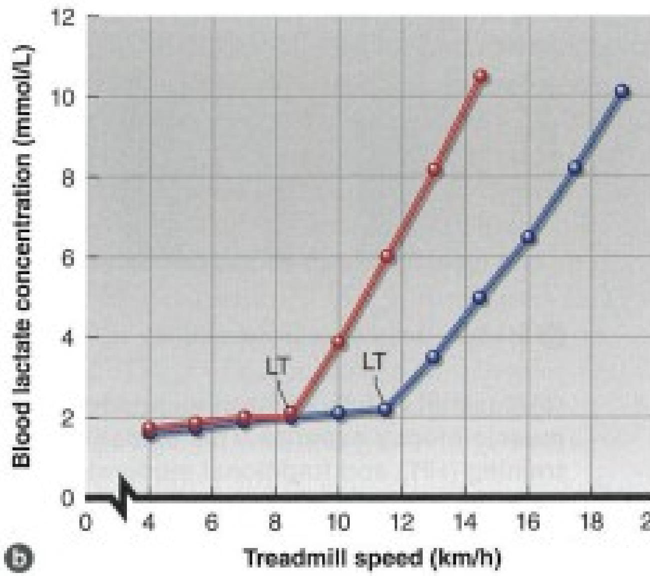


FIGURE 11.10 Changes in lactate threshold (LT) with training expressed as (*a*) a percentage of maximal oxygen uptake (%$\dot{V}O_{2max}$) and (*b*) an increase in speed on the treadmill. Lactate threshold occurs at a speed of 8.4 km/h (5.2 mph) in the untrained state and at 11.6 km/h (7.2 mph) in the trained state.

Key Points

CARDIOVASCULAR ADAPTATIONS

- Heart size
- Stroke volume
- Cardiac output
- Blood flow
- Blood volume
- HR (HRrest, HRrecovery, HR during training)

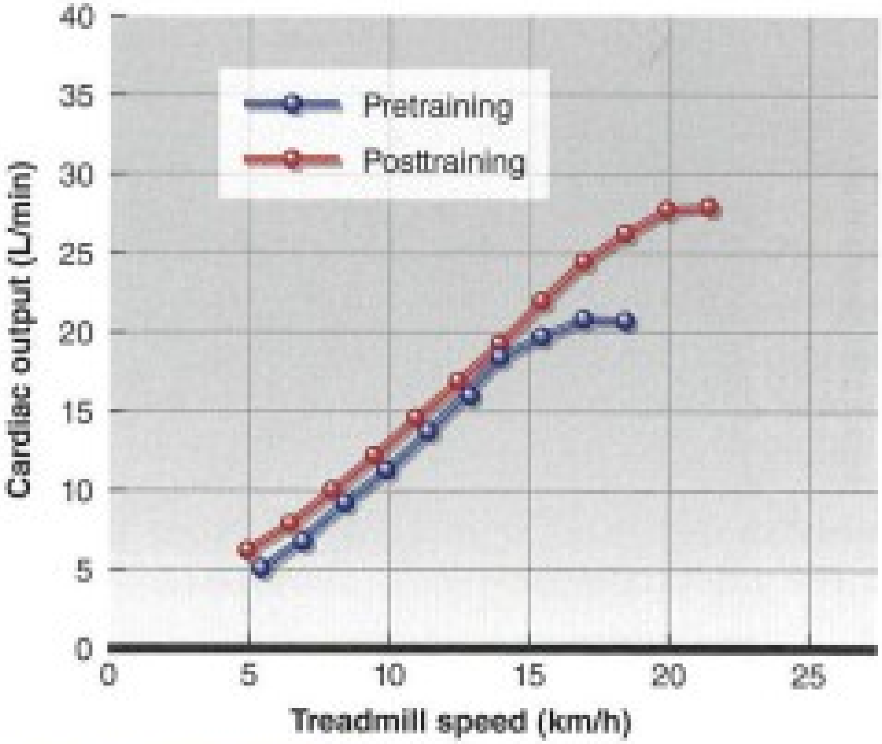


FIGURE 11.6 Changes in cardiac output with endurance training during walking, then jogging, and finally running on a treadmill as velocity increases.

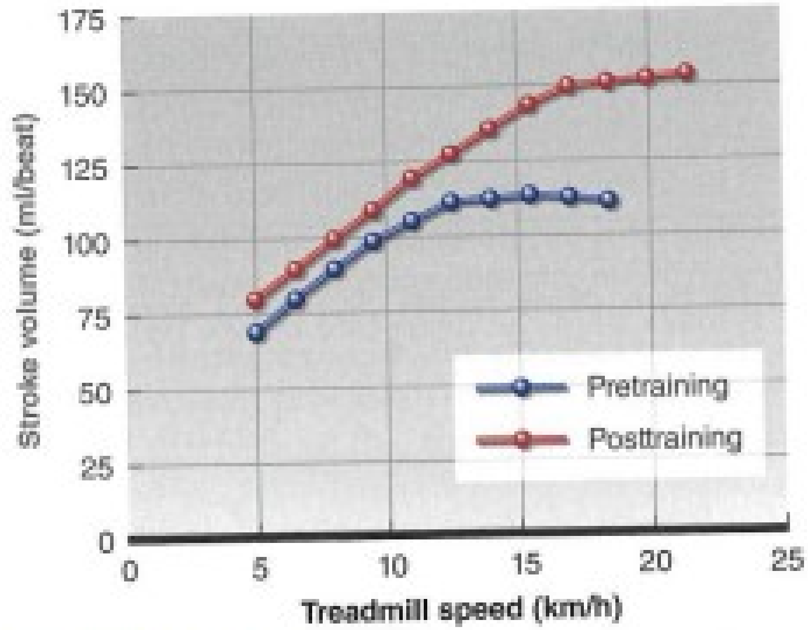


FIGURE 11.3 Changes in stroke volume with endurance training during walking, jogging, and running on a treadmill at increasing velocities.

TABLE 11.1 Stroke Volumes at Rest (SV_{rest}) and During Maximal Exercise (SV_{max}) for Different States of Training

Subjects	SV_{rest} (ml/beat)	SV_{max} (ml/beat)
Untrained	50-70	80-110
Trained	70-90	110-150
Highly trained	90-110	150-220+

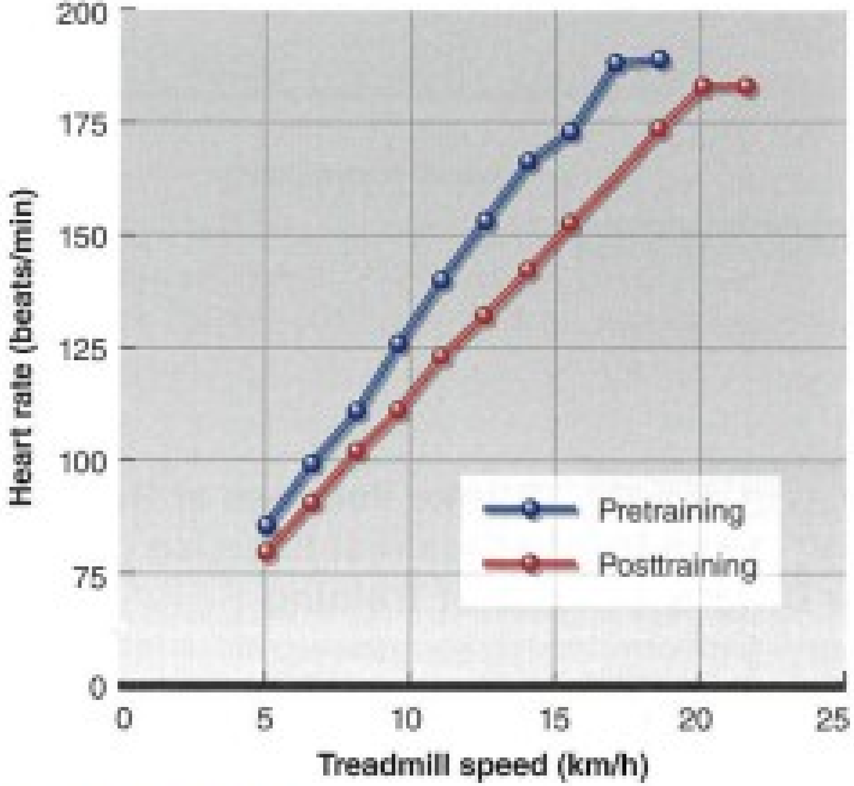


FIGURE 11.4 Endurance training–induced changes in heart rate during progressive walking, jogging, and running on a treadmill at increasing speeds.

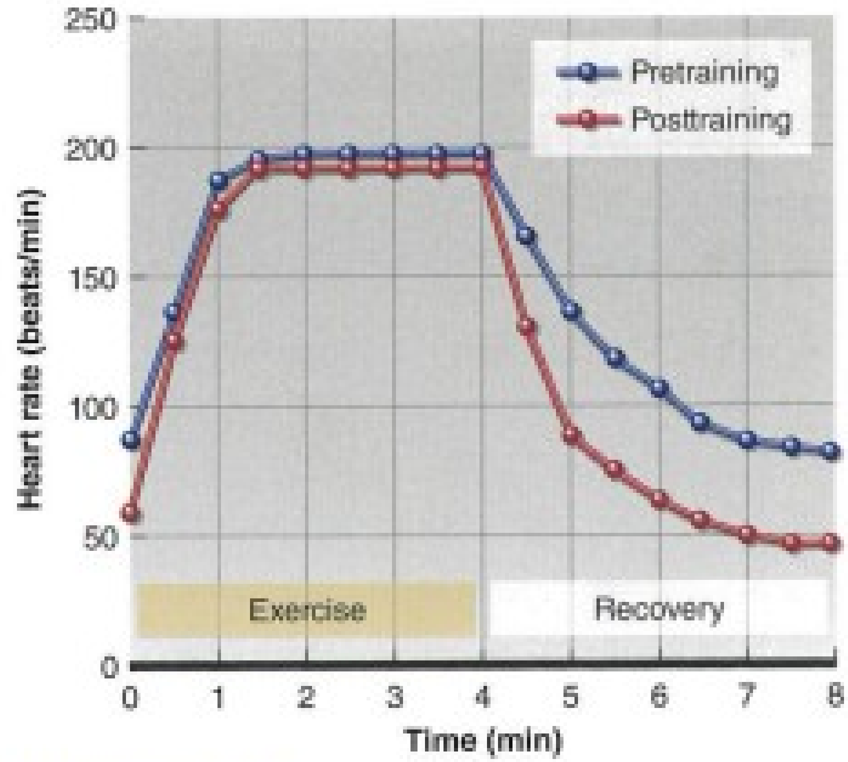


FIGURE 11.5 Changes in heart rate during recovery after a 4 min, all-out bout of exercise before and after endurance training.

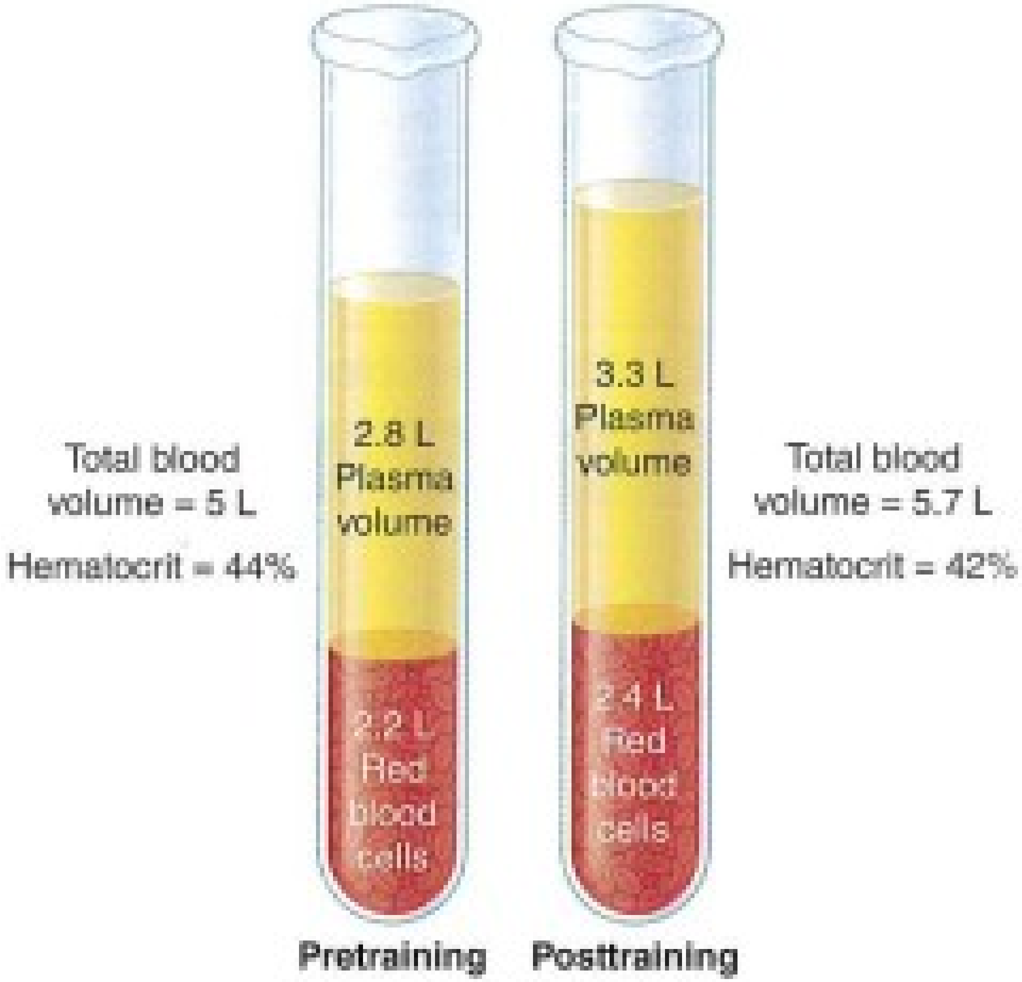
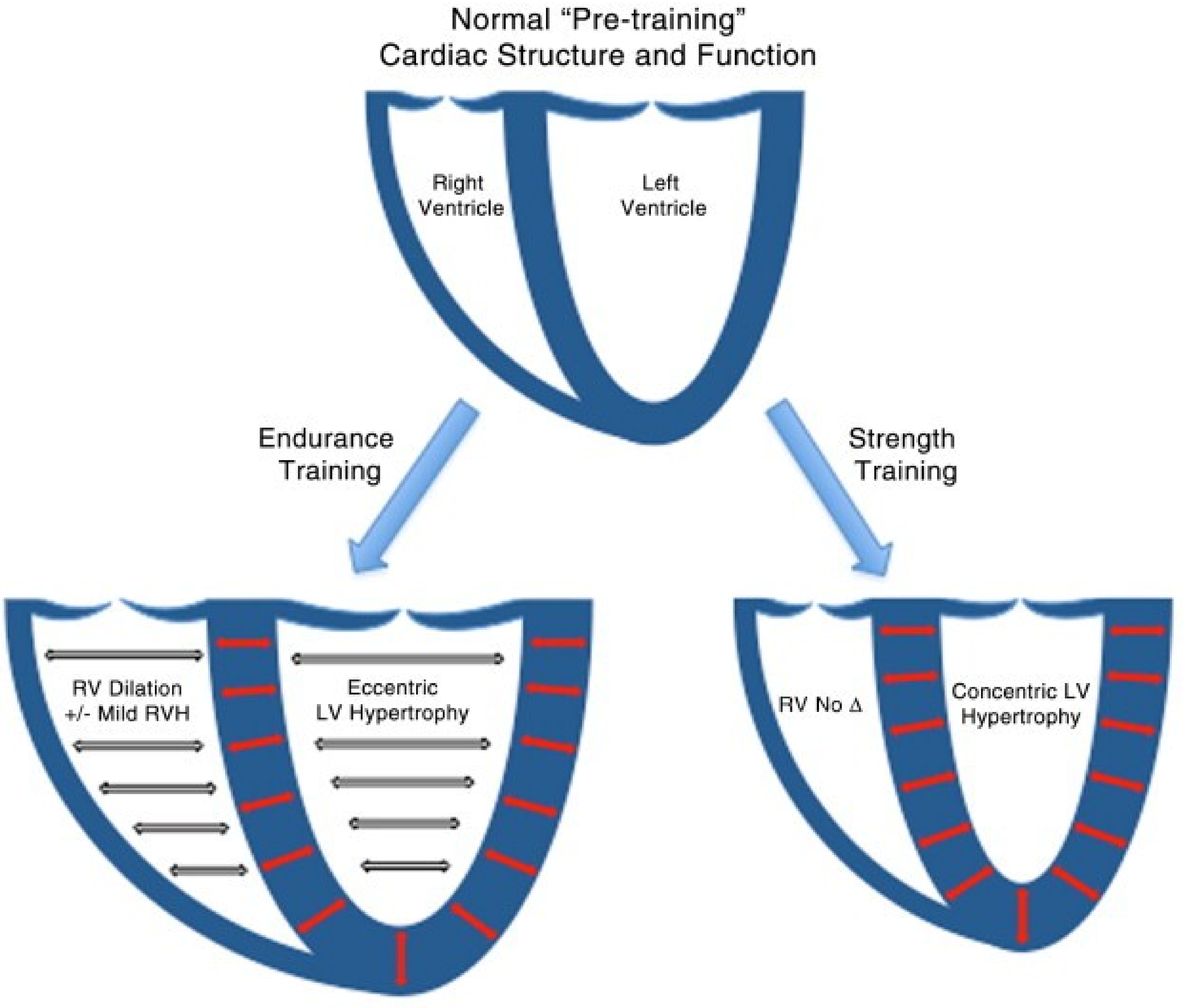


FIGURE 11.7 Increases in total blood volume and plasma volume occur with endurance training. Note that although the hematocrit (percentage of red blood cells) decreased from 44% to 42%, the total volume of red blood cells increased by 10%.

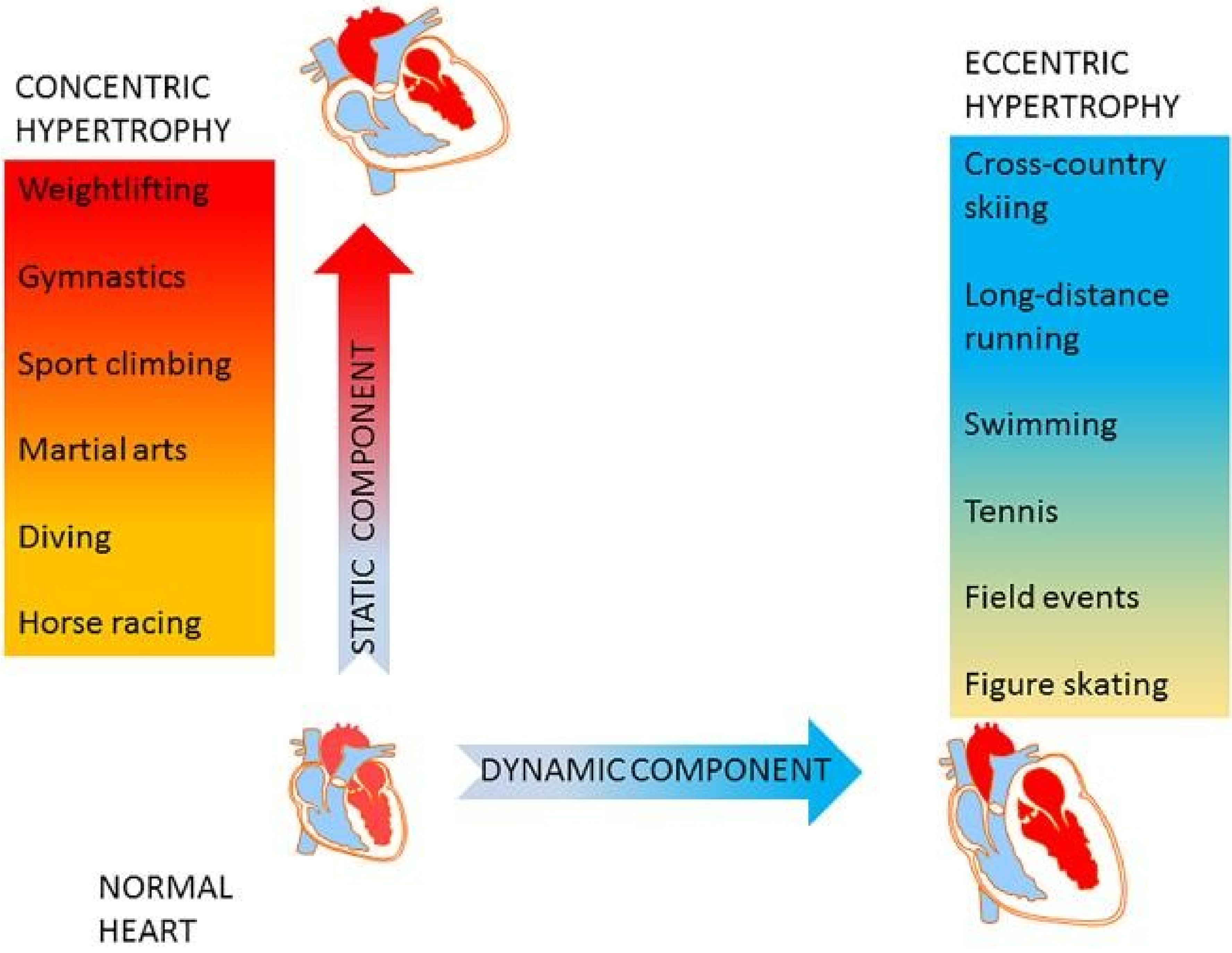
Key Points

HYPERTROPHY OF HEART

- Eccentric hypertrophy
- Concentric hepertrophy



Normal “Pre-training”
Cardiac Structure and Function
Right
Ventricle
Left
Ventricle
Endurance
Training
Strength
Training
RV Dilation
+/- Mild RVH
Eccentric
LV Hypertrophy
RV No Δ
Concentric LV
Hypertrophy


CONCENTRIC
HYPERTROPHY
Weightlifting
Gymnastics
Sport climbing
Martial arts
Diving
Horse racing
STATIC COMPONENT
ECCENTRIC
HYPERTROPHY
Cross-country
skiing
Long-distance
running
Swimming
Tennis
Field events
Figure skating
DYNAMIC COMPONENT
NORMAL
HEART