Chapter 7
Cardiovascular Function and Adaptation to Exercise

Components of the Cardiovascular System

The cardiovascular system is composed of blood, the heart, and the vasculature within which blood is pumped throughout the body.

Pulmonary circulation - concerning blood flow to, within and from the lungs

Systemic circulation - concerning blood flow to, within and from the remainder of the body, and consists of tissue/organ specific circulation beds, e.g., renal, hepatic, cranial, gastric, intestinal, skeletal muscle, cutaneous, etc.

Blood

Cell component - red and white blood cells, and platelets constitutes ~45% of blood volume = hematocrit

Polycythemia - excess production of red blood cells causing an abnormal increase in red blood cells

Anemia - abnormally low red blood cell counts

Liquid component - water, clotting proteins, transport proteins, lipoproteins, glucose, fatty acids, antibodies, transferrin, waste products (e.g., urea, ammonia, etc.), etc.

Plasma - the liquid component of blood and all of its non-cellular content

Serum - what remains of plasma after blood has clotted.

Blood volume approximates 5 L, but varies in proportion to body size, endurance training status, and exposure to extreme environments (hypobaria, hyperbaria, heat, etc.)

\[ 5 \text{ L} = \text{plasma volume (PV)} + \text{cell volume (hematocrit)} \]
\[ = (0.55 \times 5) + (0.45 \times 5) \]
\[ = 2.75 + 2.25 \]

For young men aged 18-35, PV can be estimated from,

\[ PV (L) = 0.042 \times \text{LBM (kg)} + 0.567 \] (7.1)

Cardiac output (Q) - the volume of blood pumped by the heart each minute

\[ Q (L/min) = SV (L) \times HR (b/min) \]

for example, \[ 5 \text{ L/min} = 0.01 \times 50 \text{ b/min} \] (rest conditions)

Fick equation - equation based on \( VO_2 \), Q and the arterial-venous \( O_2 \) difference

for example, \[ \text{VO}_2 = Q \times a-vO_2\Delta \]
\[ 0.25 \text{ L/min} = 5 \text{ L/min} \times 0.05 \text{ L} \] (rest conditions)
QUESTIONS

1. Why is blood an important component of the cardiovascular system?
2. In what ways does myocardium differ from skeletal muscle?
3. Why does the muscle mass of the left and right ventricle differ?
4. Why is an increase in contractility so important to heart function during exercise?

Acute Adaptations to Exercise

With the start of exercise, cardiovascular function changes by:
- ↑ heart rate
- ↑ ejection fraction
- ↑ stroke volume
- ↑ cardiac output
- redistribution of Q in favor of contracting skeletal muscle
- ↓ vascular resistance
- ↑ muscle blood flow

Blood Flow Redistribution

Due to limitations in maximal cardiac output and blood volume, vascular regulation enables a preferential increase in the proportion of the cardiac output that perfuses working skeletal muscle.

For example, muscle receives 5% of Q at rest, but can receive 85% of Q during intense exercise.

Hyperemia - ↑ blood flow
Vasodilation - ↑ diameter of a blood vessel.
Vasoconstriction - ↓ diameter of a blood vessel.
Chronic Adaptations to Exercise

Cardiovascular adaptations to training are extremely important for improving endurance exercise performance, and preventing cardiovascular diseases.

The more important of these adaptations are,
- $\uparrow$ plasma volume
- $\uparrow$ red cell mass
- $\uparrow$ total blood volume
- $\downarrow$ systolic and diastolic blood pressures
- $\uparrow$ end diastolic dimensions and ventricular volumes
- $\uparrow$ maximal stroke volume
- $\uparrow$ maximal cardiac output