

Cardiovascular dynamics

(Text Pg 117)

Cardiovascular dynamics deals with the functioning of the cardiovascular system and how it adapts to meet the demands that are placed on it.

What Happens Inside the Body During an Acute Bout of Exercise?

- O₂ consumption & CO₂ production increases by working muscle

How does the cardiovascular system respond to this stress?

- HR ↑'s
- Heart contractility ↑'s
 - Heart pumps harder = ↑'ed blood pumped *per beat*
- Blood vessel diameter changes
 - *Vasoconstriction* in non-working muscle
 - *Vasodilation* in working muscle
- Blood pressure ↑'s
 - *getting blood where it needs to go quickly*
- Distribution of blood changes

How do we measure how hard the cardiovascular system is working?

Cardiac Output (Q)

- The rate of blood pumped out of the left ventricle per minute (L/min)
- Resting **Q** values range between 5 – 6 L/min
- During vigorous exercise **Q** may go above 45 L/min
- Q is directly related to the intensity of exercise.

Two factors contribute to cardiac output

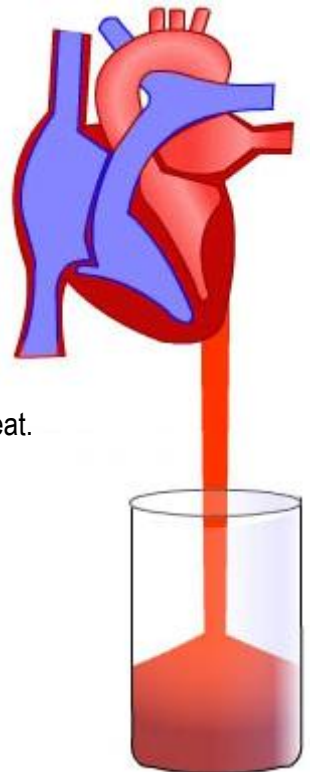
- Heart Rate:** The number of times the heart contracts in a minutes (BPM)
- Stroke Volume:** the volume of blood ejected from the left ventricle in a single beat.

Stroke Volume:

- Typical SV rest values: ~ 70 ml/beat
- During exercise SV ↑'s: ~ 150 – 300 ml/beat (depends on intensity)

$$SV (ml) = LVEDV(ml) - LVESV(ml)$$

- **LVEDV:** Left ventricular end-diastolic volume
 - The amount of blood remaining in the left ventricle when it is relaxed i.e. the volume when the ventricle is “full”
- **LVESV:** Left ventricular end-systolic volume
 - The amount of blood remaining in the left ventricle after it contracts i.e. the volume when the ventricle is “empty”



SV is Regulated by 3 factors

1. Strength of ventricular contractions (larger contraction = \uparrow **SV** by \downarrow **LVESV**)
 - (heart pumps harder = less blood in ventricle)
2. Aortic blood pressure (larger BP = \uparrow **SV**)
3. LVEDV (Larger LVEDV = \uparrow **SV**)

How do we increase our Q?

Frank Starling's Law:

- When more blood comes back to the heart (venous return) it causes the ventricles to be stretched causing them to contract harder.
 - When **LVEDV** \uparrow 's, **LVESV** \downarrow 's which means a greater **SV**.
- Therefore, any factor that causes an increase in the blood coming back to the heart (\uparrow LVEDV) or factors that increase the amount leaving (\downarrow LVESV) will cause an increase in **Q**.

Four Factors that cause an increase in venous return (LVEDV).

*** Probably the most important factor in regulating SV***

1. Vasoconstriction:

- Pushes blood back to heart
- Directs blood away from areas not in use

2. Skeletal muscle pump:

- Muscles contract and squeeze blood up towards heart

3. Thoracic pump

- Pressure increases in thoracic cavity pushing blood back to heart

4. Sympathetic Drive

- Nervous stimulation of the heart causes an $_$ in HR and force of contraction

Ejection Fraction

How efficient is our heart? (i.e. how well does it eject blood?)

Ejection Fraction (EF):

- Determines how much blood actually leaves the left ventricle.
- **Rest EF values** ~ 50 – 60% (of the blood in the ventricle is pumped out)
 - meaning that lots of blood remains in the ventricle
- **Exercise EF values** ~ 85%:
 - meaning that more of the blood in the left ventricle actually gets pumped out of the ventricle. (only 15% of what was there remains)
- Heart failure: < 35% some patients <11% end stage heart failure
 - Meaning that 65 - 89% of the blood remains – the heart is not working well at all!