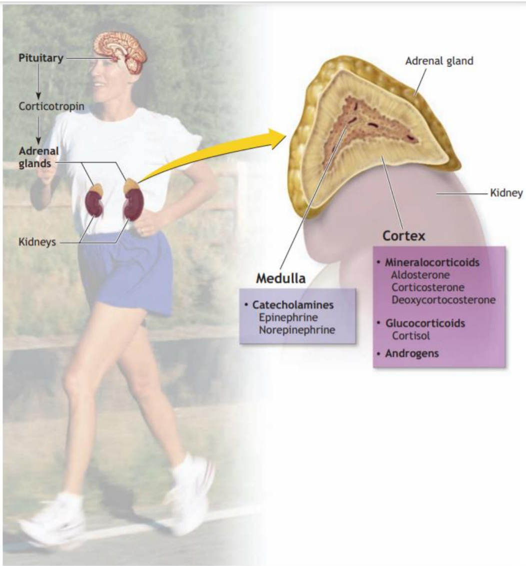
HORMONAL RESPONSES OF EXERCISE IN RESPECT TO CATECHOLAMINES: EPINEPHRINE AND NOREPINEPHRINE

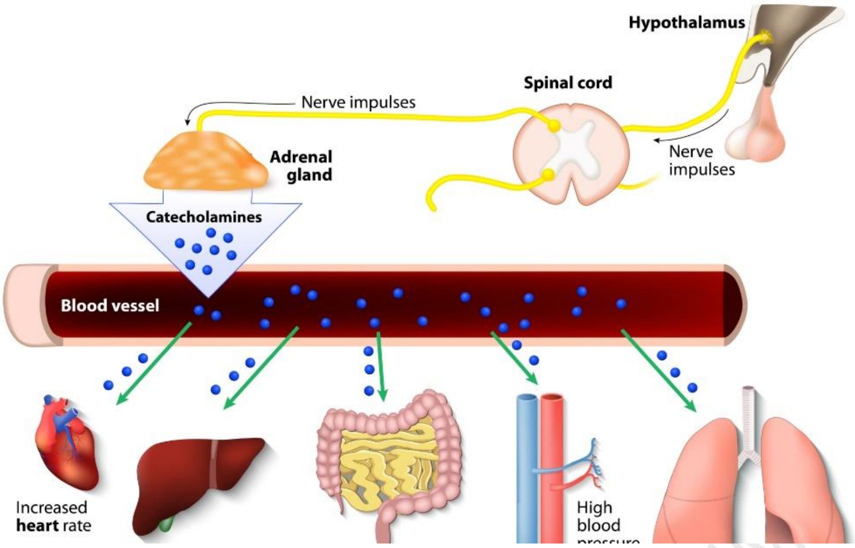
INTRODUCTION

- Both endocrine and nervous system are considered as important mediators for physiological functioning of the body adjustments to different behavioural, physical and environmental stressors.
- Catecholamines plays considerable role in adaptation processes during any acute stress or even at rest.
- Several components taken under the term “Catecholamines” are all derived from an acid e.g., tyrosine. Principle components including adrenaline (epinephrine) and nor-adrenaline (nor-epinephrine).
- Both are synthesized at two levels: (i) sympathetic nervous fibre extremities for noradrenaline; and (ii) chromaffin cells of the adrenal medulla for both adrenaline and noradrenaline.
- Representation of epinephrine is 80% of adrenal medulla secretions, whereas nor-epinephrine is the principle neurotransmitter released from the sympathetic nerve endings.
- Catecholamines act by using membrane receptors. There are two adrenergic receptor sites (α and β). These receptors are also divided into subtypes α1, α2, β1 and β2 and β3. Norepinephrine primarily activates α -receptors and epinephrine activates primarily β-receptors.
- These hormones affect the heart, blood vessels, and glands in the same, slower acting way as direct sympathetic nervous system stimulation.



FUNCTIONS OF EPINEPHRINE AND NOR-EPINEPHRINE

- Catecholamines serves as both neurotransmitters and hormones vital to the maintain homeostasis via the autonomic nervous system.
- The “fight or flight” response of the sympathetic nervous system is a result of the action of catecholamines.
- Musculoskeletal actions of catecholamines include:
  1. enhanced contractility of cardiac muscle
  2. contraction of the pupillary dilator
  3. piloerection
  4. relaxation of smooth muscle in the gastrointestinal tract, urinary tract, and bronchioles
- Both epinephrine and norepinephrine modulate metabolism to increase blood glucose levels by stimulating glycogenolysis in the liver, increased glucagon secretion and decreased insulin secretion from the pancreas.
- Epinephrine also inhibits release of mediators from mast cells and basophils in type I hypersensitivity reactions.



- MECHANISM OF SECREATION

external stimulus triggers the body's stress response

autonomic nervous system is activated

Glucocorticoids production increases in the adrenal gland, and acetylcholine (Ach) is released from sympathetic splanchnic nerves

Ach binds to nicotinic receptors located on the membrane of chromaffin cells in the adrenal medulla

In the blood, catecholamines target alpha and beta-adrenergic receptors

adrenergic receptors utilize either cyclic adenosine monophosphate (cAMP) messenger systems to activate ion channels that mediate the body's sympathetic response

Main Cardio-Respiratory and Metabolic Effects of Catecholamines

	Adrenoreceptors	Physiological effects	Responses
Cardiovascular and respiratory effects			
Heart			
atria and ventricles	β_1	↑ Contractility	↑ Cardiac output
sinotrial node	β_1	↑ Conduction velocity	↑ Heart rate
Arteries			
renal	α	Vasoconstriction	↓ Local blood flow
splanchnic	α	Vasoconstriction	↑ Systemic arterial pressure
skeletal muscles	β_2	Vasodilation	↑ Local blood flow ↓ Arterial pressure
Veins	α_2	Vasoconstriction	↑ Blood return to the heart ↑ Cardiac output
Lungs			
airway smooth muscles	β_2	Relaxation	Bronchodilation
Metabolic effects			
Liver	α_1 or β_2	↑ Glycogenolysis ↑ Glyconeogenesis	↑ Blood glucose
Muscle	β_2	↑ Glycogenolysis	↑ Blood lactate
	β_2	↓ Glucose utilization	↑ Blood glucose
Pancreas	α_2	↓ Insulin secretion	↑ Blood glucose
	β_2	↑ Insulin secretion	↓ Blood glucose
Adipose tissue	β_1 β_2 β_3?	↑ Lipolysis	↑ Free fatty acids
	α_2	↓ Lipolysis	↓ Free fatty acids

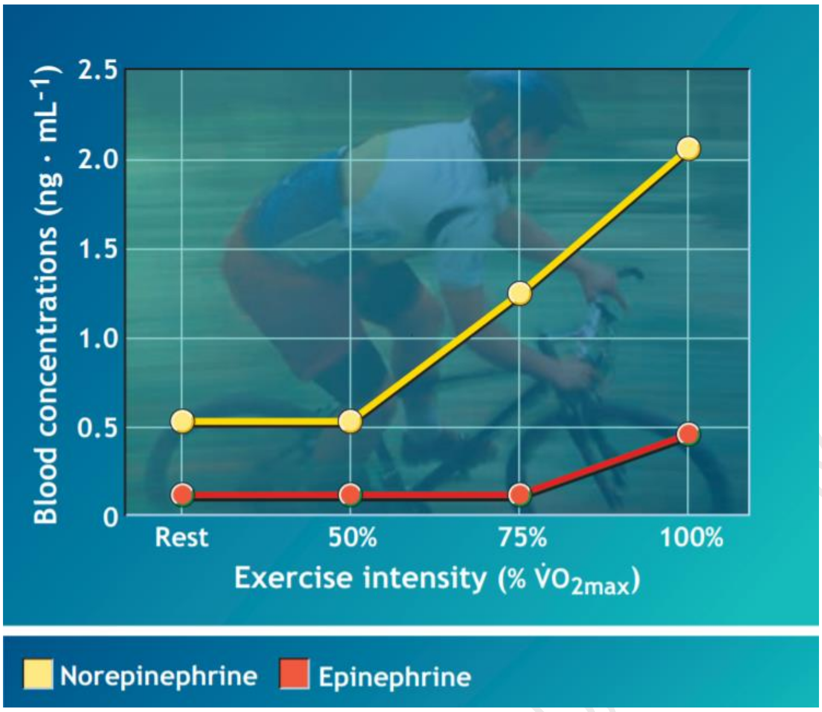
↓ indicates decrease; ↑ indicates increase; ? indicates not sure.

EFFECT OF ACTIVITY ON CATECHOLAMINES

- Effect of Posture:
    a) In sitting and lying position plasma level concentration of catecholamines is lower than in upright position; (>40%).
    b) Epinephrine increases from 43ng/mL to 62ng/mL and norepinephrine increases from 348ng/mL to 696ng/mL between lying and upright position.
    c) Some intensity activities/exercises whether in lying or an upright position increases level of catecholamines in plasma.
- Exercise with upper or lower body:
    a) Plasma level concentration of catecholamines is higher when exercise is carried out with arms rather than legs.
    b) The main explanation being the muscular mass bought into play during arms exercise.
    c) Through measuring heart rate and vascular resistance, it is reported that sympathetic nervous system stimulation as well as ventilation were higher when exercises were carried out using small muscle group rather than big muscle group.
    d) At same VO2 max catecholamines shows a significantly higher plasma concentration when exercises concerned a smaller group.
- Effect of static and dynamic exercises
    a) Plasma concentration of catecholamines increase markedly in men during dynamic exercises and various sport activities such as swimming, cycling, running but also increment is seen during static exercises.
    b) An increase in heart rate during exercises leads to a relatively higher catecholamines level.
    c) Previous literature reported high plasma catecholamines rate during contraction of quadriceps muscle (one leg) lasting two minutes at% of maximum force.
    d) Norepinephrine level increases from 0.21ng/mL to 0.32ng/mL; epinephrine level increases from 0.10ng/mL to 0.24ng/mL.
- Effect of exercise duration:
    a) Exercise duration plays an important role in sympathoadrenal activity.

b) For constant VO_2 max plasma noradrenaline concentration continuously increases until exhaustion.
c) Noradrenaline level increases more quickly than adrenaline.
d) Minimal duration of exercise is necessary to result in increase of catecholamines level.
e) Previous literature reports increase in level at end of 6-8 seconds of ergocycle sprint.

- Effect of exercise intensity:
    a) Catecholamines concentration is directly related to intensity of exercise when expressed in a relative value %age of VO_2 max or body weight.
    b) For a given duration noradrenaline level increases **exponentially** with intensity of exercises.; noradrenaline increases from 0.2ng/mL to 2-3 ng/mL.
    c) Increment rate becomes faster beyond 75% of maximal aerobic power.
    d) In adults, plasma adrenaline concentration at rest is approx. 0.10ng/mL at 50% of maximal aerobic power it reaches 0.40ng/mL when duration is less than 20 minutes.
    e) 20minutes of exercise at 40-50% of VO_2 max is necessary to increase adrenaline concentration.
    f) Indeed, after a short intense exercise session, the concentration of catecholamines turn over quickly to their basal values. In one minute after the end of exercise concentration decreases by 35%.


Blood concentrations (ng · mL-1)
2.5
2.0
1.5
1.0
0.5
0
Rest
50%
75%
100%
Exercise intensity (% VO2max)
Norepinephrine
Epinephrine

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