MATHS GROUP PRESENTATION

NUMERICAL ANALYSIS FOR IDENTIFYING THE EFFECT OF EXERCISE ON HUMAN ORGANS

PRESENTED BY - MEMBERS OF GROUP 6

CONTENT

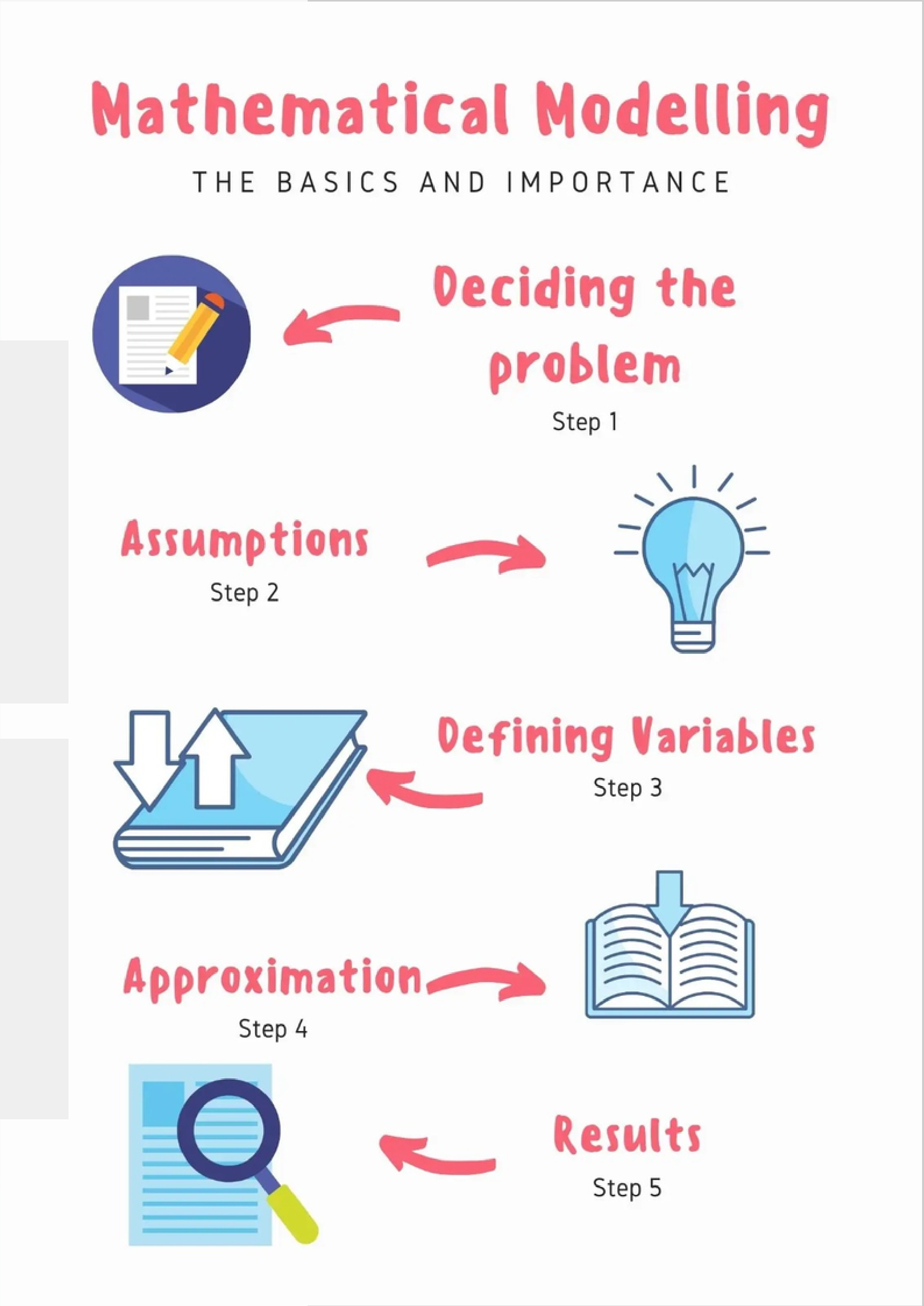
MATHEMATICAL MODELING

Mathematical modeling: Representation of real-world systems using mathematical equations.

Simplification: Translating complex behavior into a simplified mathematical framework.

Application: Used in various fields for analysis, prediction, and optimization

Steps: Problem formulation, model construction, parameter estimation, analysis, and validation.

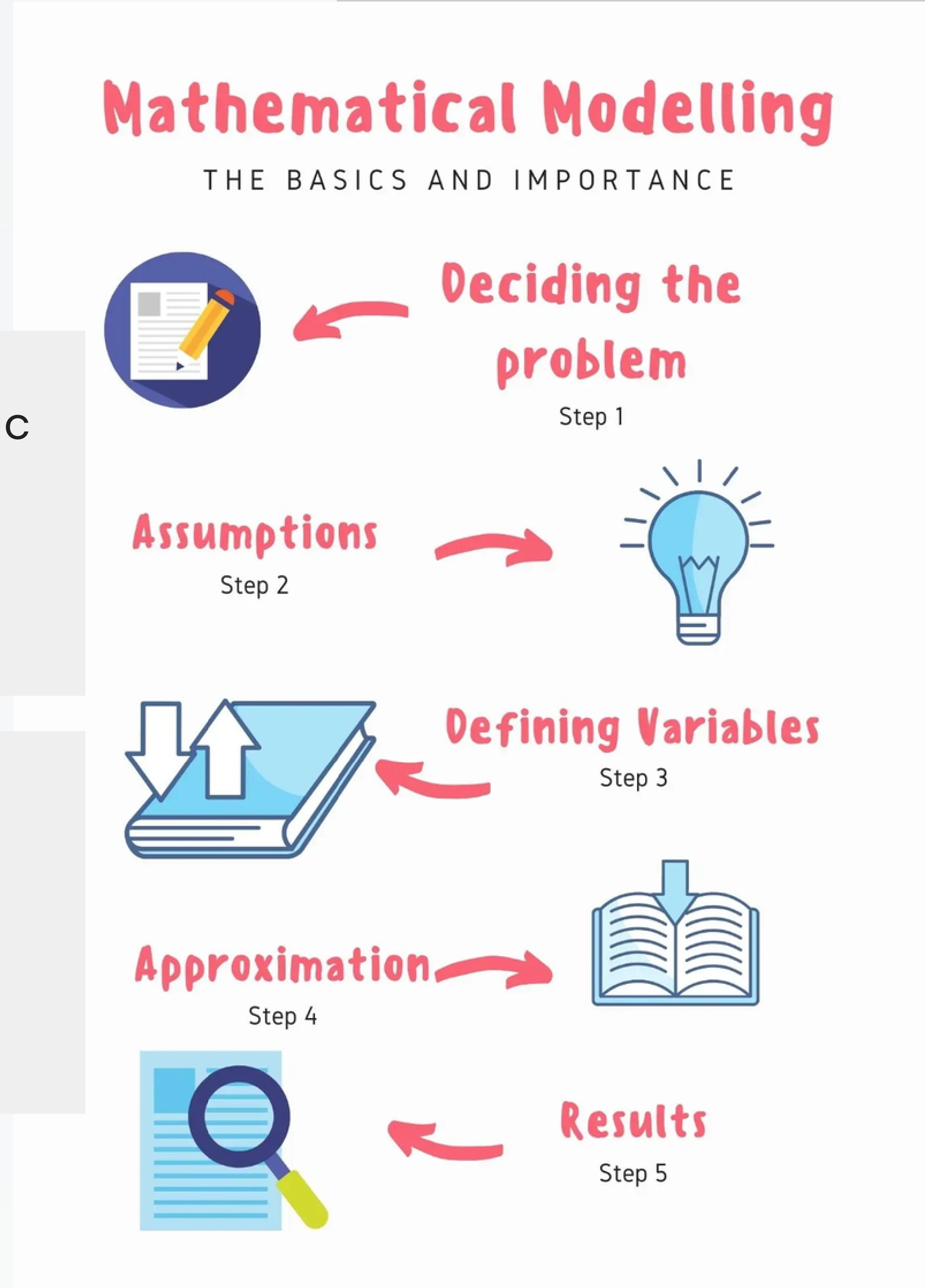


MATHEMATICAL MODELING

Types: Deterministic (precise equations) and stochastic (incorporating randomness).
Simulation: Computational exploration of system behavior and hypothesis testing

.**Assumptions**: Simplifications made for tractability, introducing limitations and uncertainties.

Validation: Comparison of model predictions with real-world data.



IMPORTANCE OF EXCERCISE

Strength and flexibility:

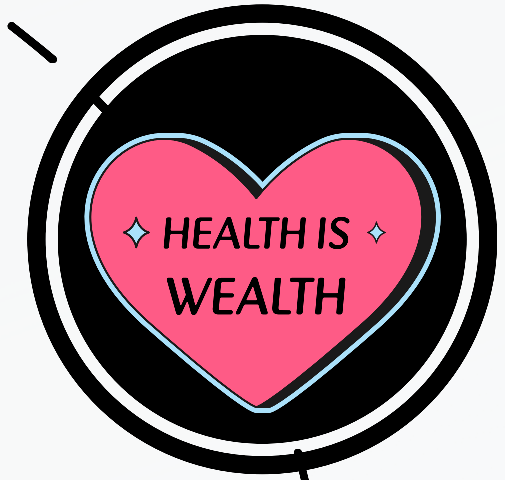
Enhances strength, endurance, and flexibility.

Social interaction

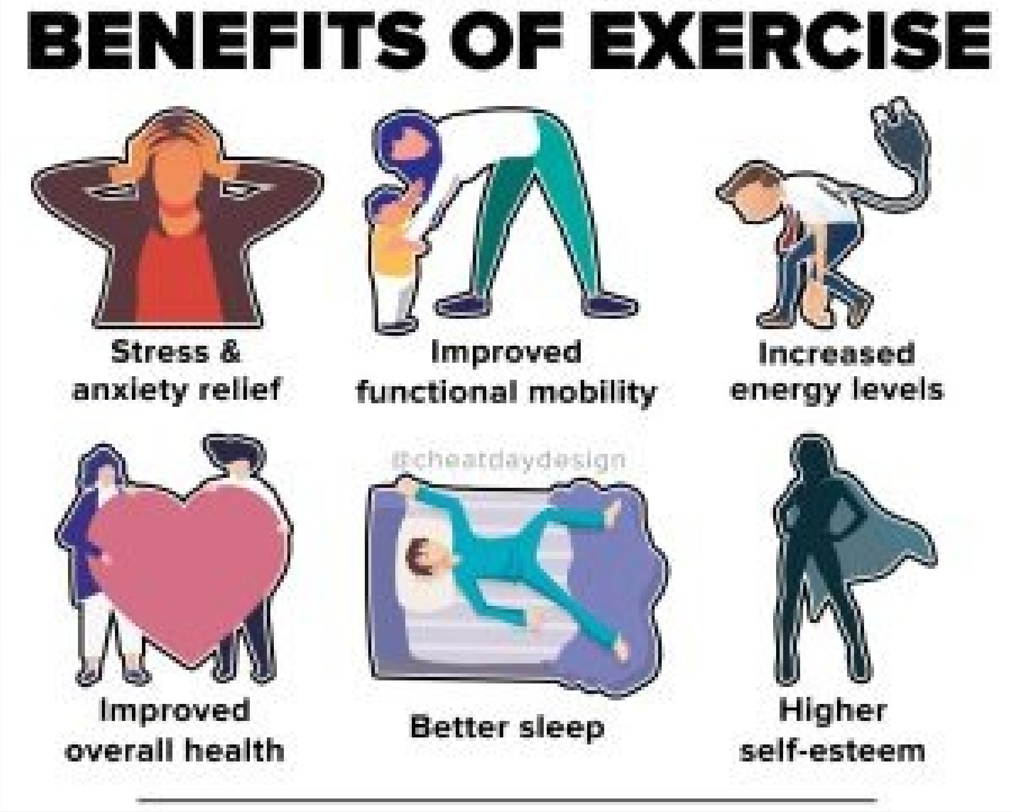
Provides opportunities for social engagement..

Longevity

Associated with longer lifespan and improved quality of life



IMPORTANCE OF EXERCISE



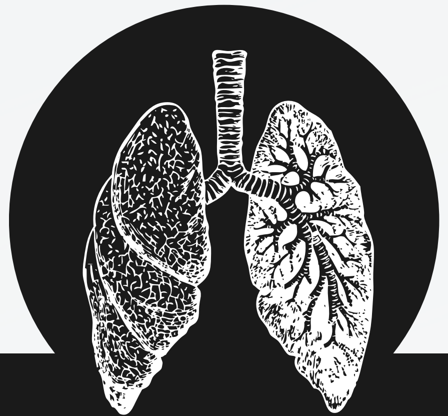
- **Physical health**: Enhances cardiovascular health, strengthens muscles and bones.
- **Mental health**: Reduces stress, anxiety, and depression; improves sleep and mood.
- **Weight management**: Burns calories, boosts metabolism for maintaining a healthy weight.

- **Disease prevention**: Lowers risk of chronic conditions like heart disease and diabetes.
- **Energy and productivity**: Increases energy, focus, and productivity.
- **Cognitive function**: Improves brain function, memory, and learning abilities

EFFECT OF EXERCISE ON ORGANS

HEART

Strengthens the heart, improves circulation, reduces cardiovascular risks.



LUNGS

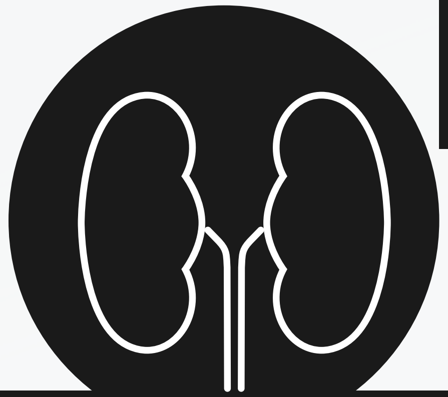
Increases lung capacity, enhances respiratory efficiency

MUSCLES AND BONES

Promotes muscle growth, strength, and bone density..

BRAIN

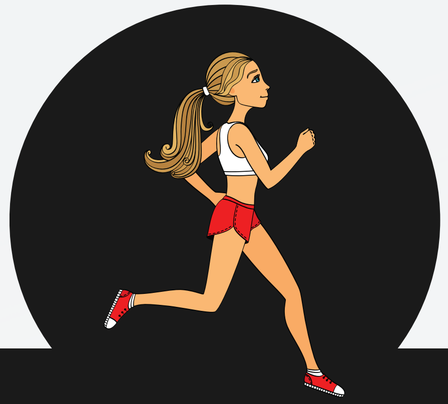
Boosts mood, reduces stress, improves cognitive function.



KIDNEYS

Improves blood flow, aids in waste removal.

EFFECT OF EXERCISE ON ORGANS



METABOLISM

Increases calorie burn, aids weight management

IMMUNE SYSTEM

Strengthens immune function, reduces illness risks.

DIGESTIVE SYSTEM

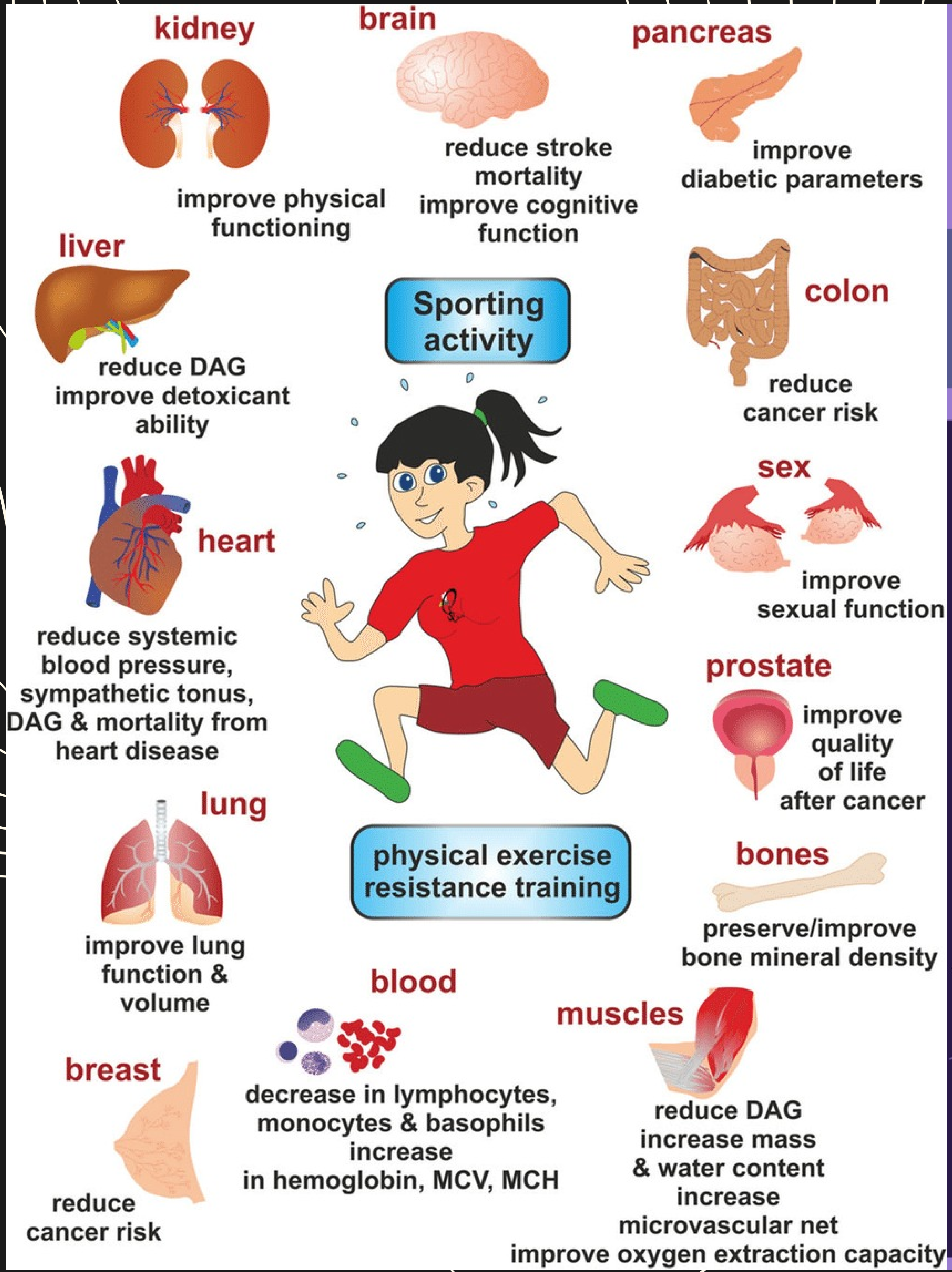
Enhances digestion, promotes regular bowel movements.

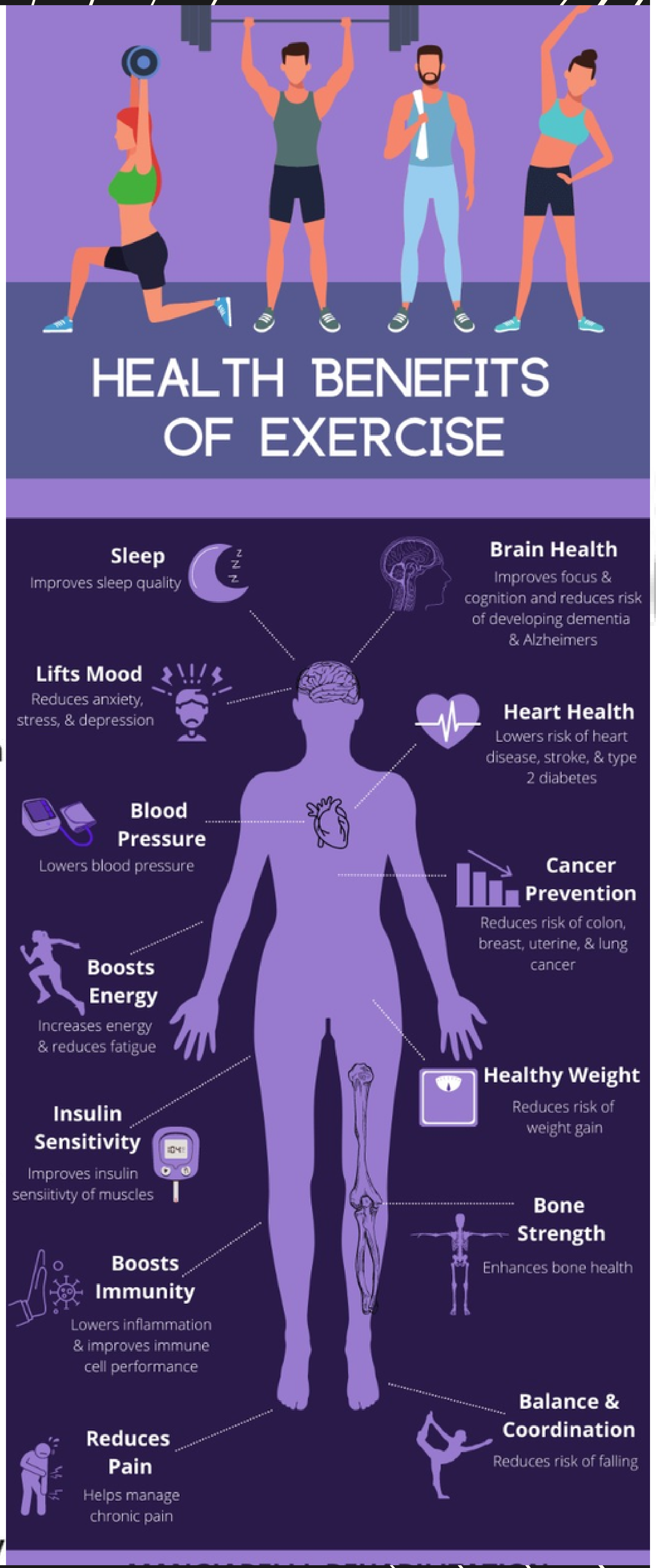
ENDOCRINE SYSTEM

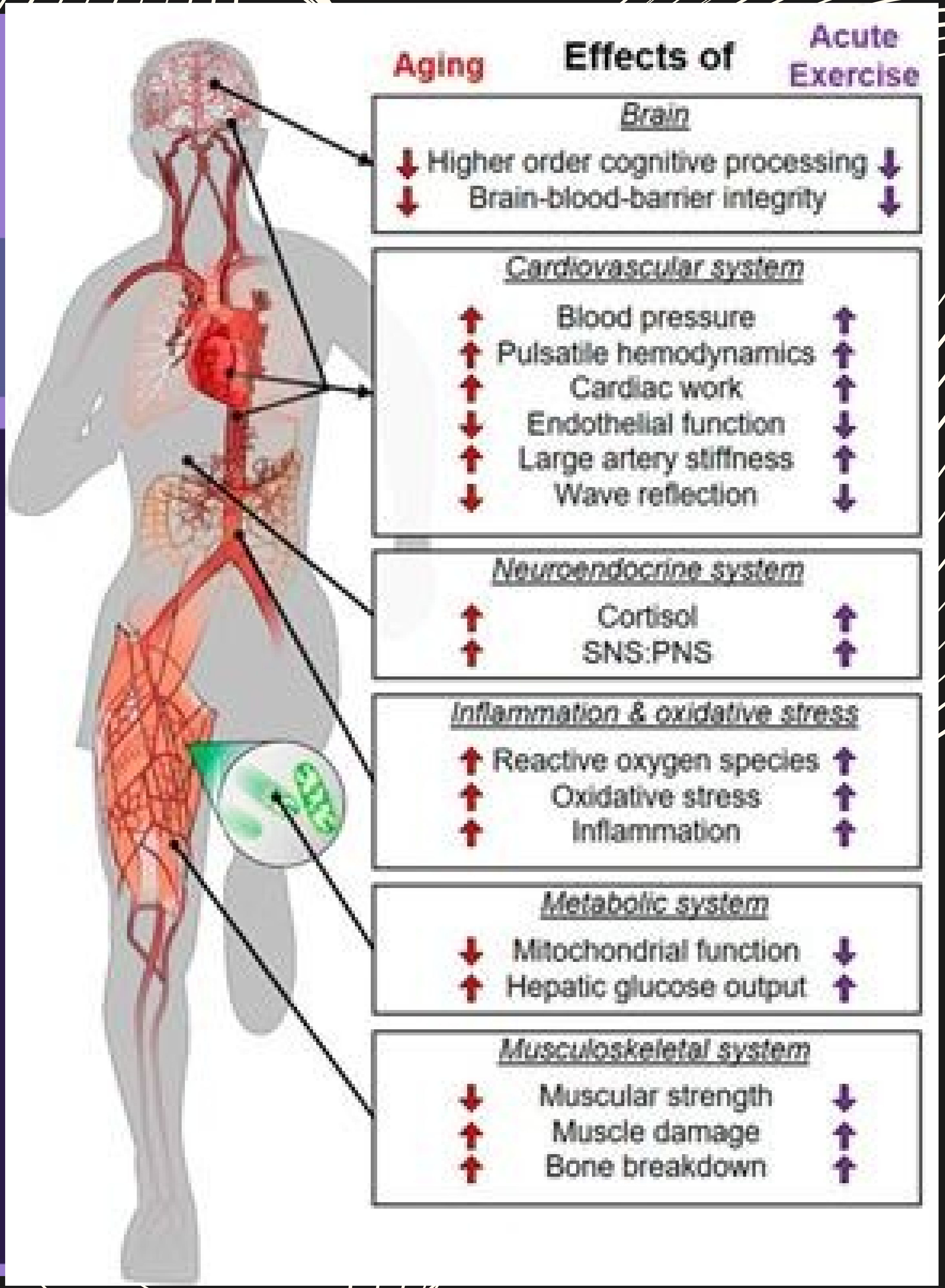
Enhances insulin sensitivity, regulates blood sugar.

WELL BEING

Boosts mental health, happiness, and overall well-being.

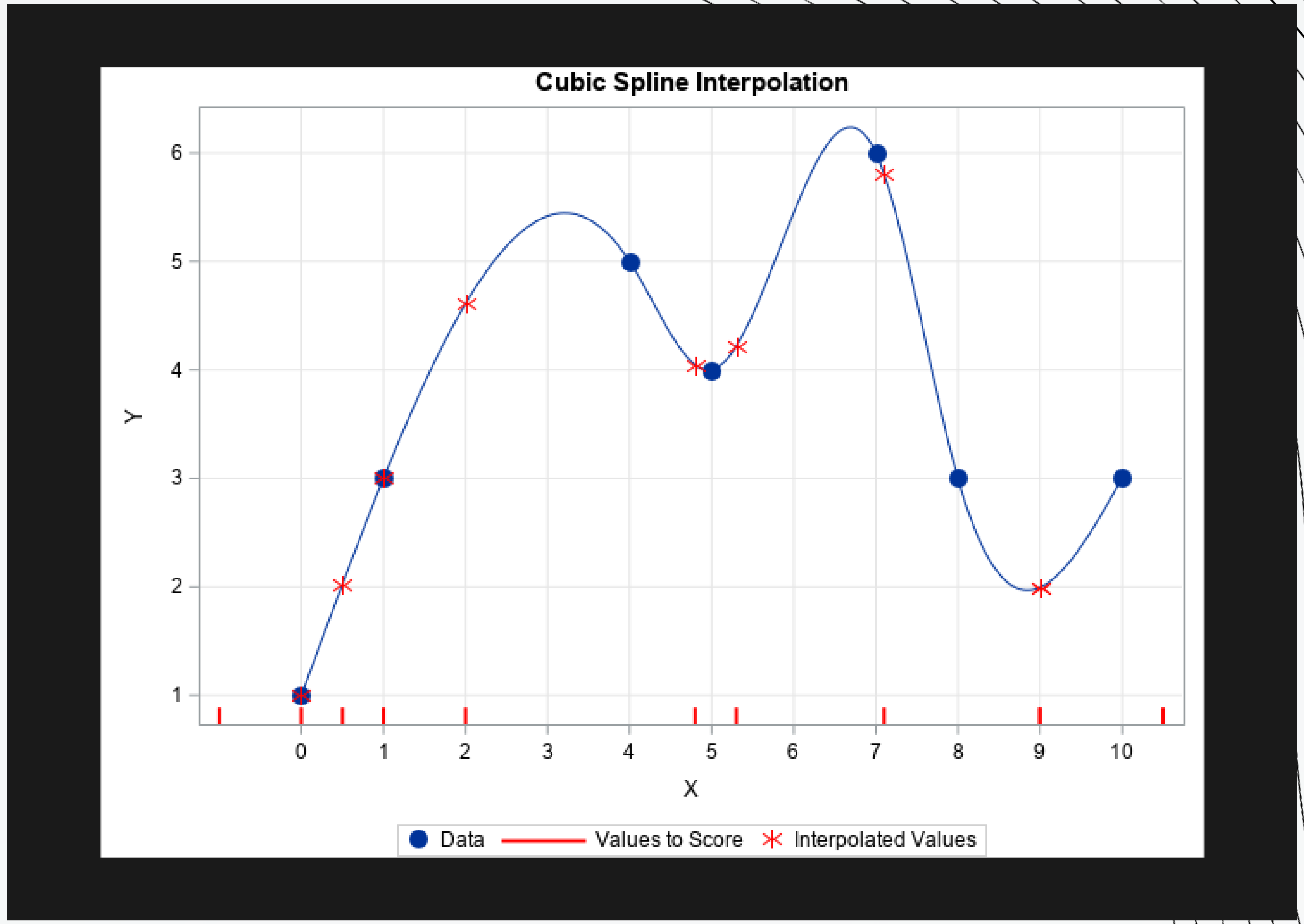

kidney
improve physical functioning
brain
reduce stroke mortality
improve cognitive function
pancreas
improve diabetic parameters
liver
reduce DAG
improve detoxicant ability
Sporting activity
colon
reduce cancer risk
heart
reduce systemic blood pressure, sympathetic tonus, DAG & mortality from heart disease
sex
improve sexual function
prostate
improve quality of life after cancer
lung
improve lung function & volume
physical exercise
resistance training
bones
preserve/improve bone mineral density
blood
decrease in lymphocytes, monocytes & basophils
increase in hemoglobin, MCV, MCH
muscles
reduce DAG
increase mass & water content
increase microvascular net
improve oxygen extraction capacity
breast
reduce cancer risk

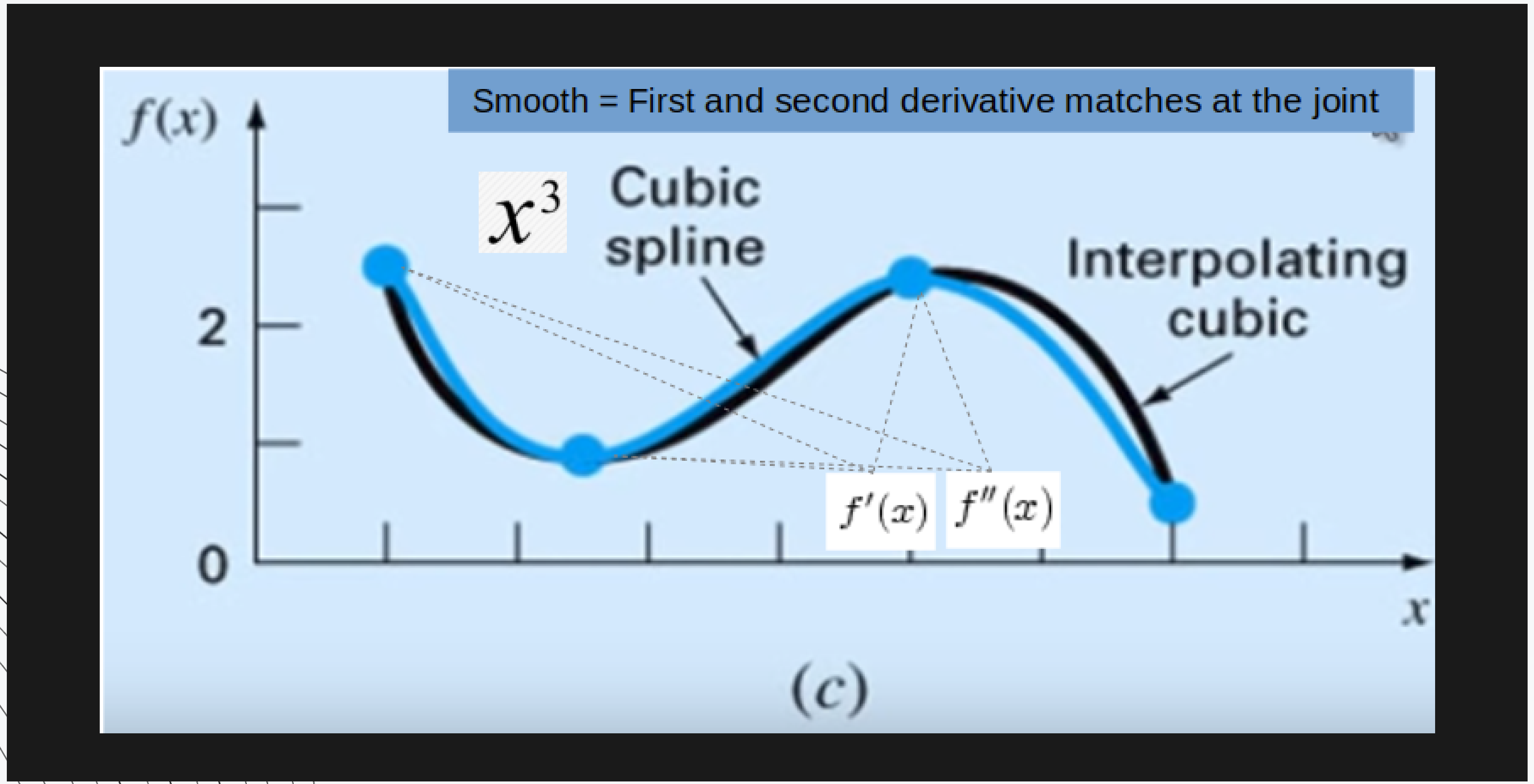

HEALTH BENEFITS OF EXERCISE
Sleep
Improves sleep quality
Brain Health
Improves focus & cognition and reduces risk of developing dementia & Alzheimers
Lifts Mood
Reduces anxiety, stress, & depression
Heart Health
Lowers risk of heart disease, stroke, & type 2 diabetes
Blood Pressure
Lowers blood pressure
Cancer Prevention
Reduces risk of colon, breast, uterine, & lung cancer
Boosts Energy
Increases energy & reduces fatigue
Healthy Weight
Reduces risk of weight gain
Insulin Sensitivity
Improves insulin sensitivity of muscles
Bone Strength
Enhances bone health
Boosts Immunity
Lowers inflammation & improves immune cell performance
Balance & Coordination
Reduces risk of falling
Reduces Pain
Helps manage chronic pain


Aging
Effects of
Acute Exercise
Brain
↓ Higher order cognitive processing ↓
↓ Brain-blood-barrier integrity ↓
Cardiovascular system
↑ Blood pressure ↑
↑ Pulsatile hemodynamics ↑
↑ Cardiac work ↑
↓ Endothelial function ↓
↑ Large artery stiffness ↑
↓ Wave reflection ↓
Neuroendocrine system
↑ Cortisol ↑
↑ SNS:PNS ↑
Inflammation & oxidative stress
↑ Reactive oxygen species ↑
↑ Oxidative stress ↑
↑ Inflammation ↑
Metabolic system
↓ Mitochondrial function ↓
↑ Hepatic glucose output ↑
Musculoskeletal system
↓ Muscular strength ↓
↑ Muscle damage ↑
↑ Bone breakdown ↑

CUBIC SPLINE

- Cubic spline interpolation is a method that uses cubic polynomials to create a smooth curve passing through known data points. It ensures continuity and smoothness by satisfying certain conditions at each data point. The resulting curve can be used to estimate values between the given data points.





- cubic spline interpolation finds application in a wide range of fields where smooth and accurate estimation of data between known points is required such as:
  1. Computer graphics
  2. Engineering and design
  3. Mathematical modelling
  4. Image and signal processing

FORMULA

$$M_0 = 0$$

$$M_n = 0$$

$$M_{i-1} + 4M_i + M_{i+1} = \frac{6}{h^2}(y_{i-1} - 2y_i + y_{i+1})$$

$$y(x) = \frac{(x_{i+1} - x)^3}{6h} M_i + \frac{(x - x_i)^3}{6h} M_{i+1} + \frac{(x_{i+1} - x)(y_i - \frac{h^2}{6} M_i)}{h} + \frac{(x - x_i)(y_{i+1} - \frac{h^2}{6} M_{i+1})}{h}$$

CODE

```
% Ask the user for input on SpO2 and body temperature
spo2_before = input('Enter SpO2 level before exercise (%): ');
temp_before_f = input('Enter body temperature before exercise (F): ');
temp_before = (temp_before_f - 32) * 5/9; % Convert Fahrenheit to Celsius
spo2_after = input('Enter SpO2 level after exercise (%): ');
temp_after_f = input('Enter body temperature after exercise (F): ');
temp_after = (temp_after_f - 32) * 5/9; % Convert Fahrenheit to Celsius


% Define exercise intensity levels
x = 1:0.1:10;


% Define the effect of exercise on different organs as a function of exercise intensity
y_heart_before = 30*(1 - exp(-0.2*x));      % Heart rate increases by 30% of baseline
y_lungs_before = 40*(1 - exp(-0.3*x));      % Oxygen consumption increases by 40% of
baseline
y_muscles_before = 50*(1 - exp(-0.4*x));    % Oxygen uptake increases by 50% of baseline


y_heart_after = 30*(1 - exp(-0.2*x))
((spo2_after/100)/(spo2_before/100))^0.25((temp_after+273.15)/(temp_before+273.15))^0.15
;
y_lungs_after = 40*(1 - exp(-0.3*x))
((spo2_after/100)/(spo2_before/100))^0.25((temp_after+273.15)/(temp_before+273.15))^0.15
;
y_muscles_after = 50*(1 - exp(-0.4*x))
((spo2_after/100)/(spo2_before/100))^0.25((temp_after+273.15)/(temp_before+273.15))
^0.15;
```

CODE

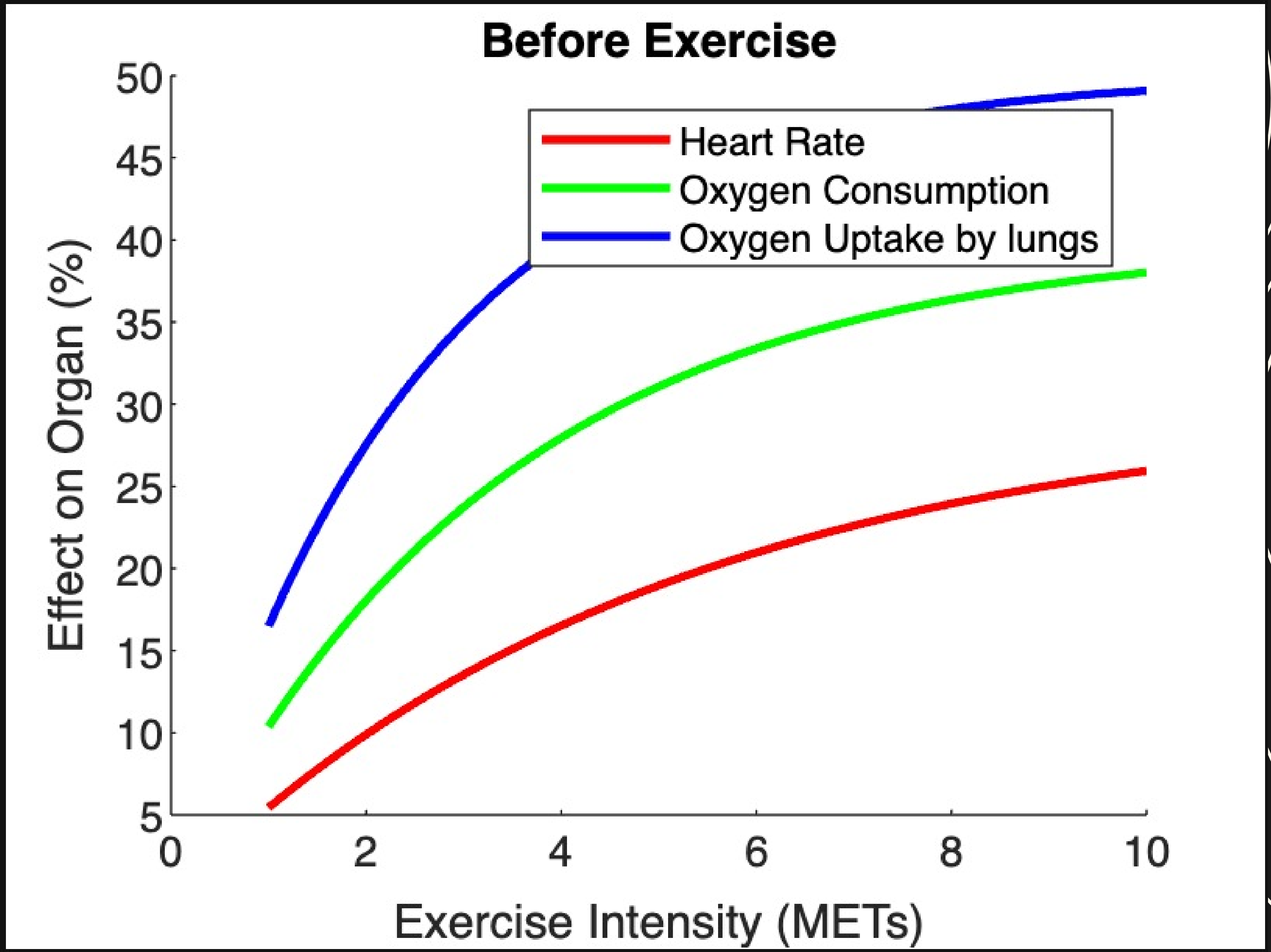
% Perform cubic spline interpolation

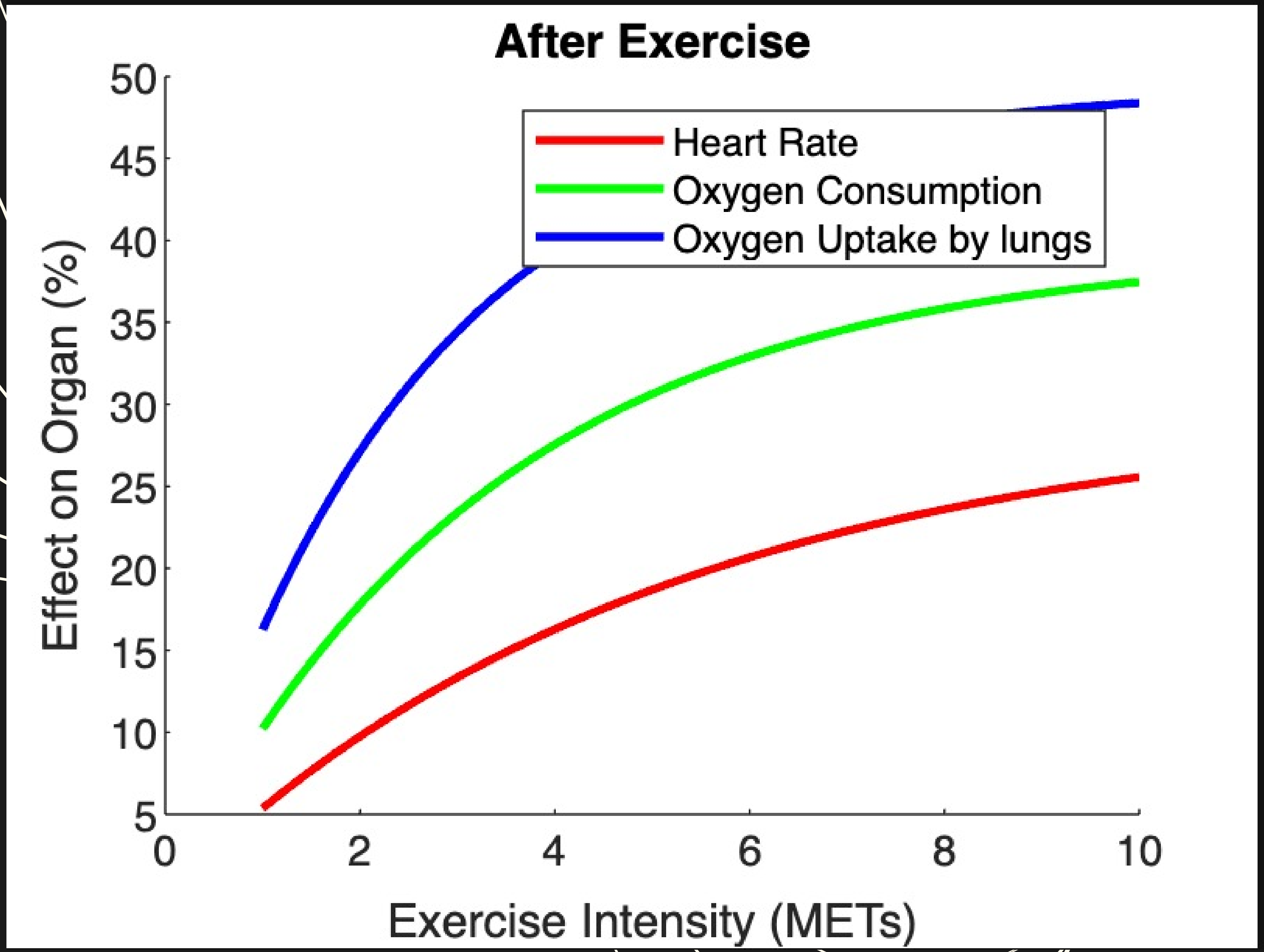
```
xq = linspace(min(x), max(x), 1000);
yq_heart_before = interp1(x, y_heart_before, xq, 'spline');
yq_lungs_before = interp1(x, y_lungs_before, xq, 'spline');
yq_muscles_before = interp1(x, y_muscles_before, xq, 'spline');

yq_heart_after = interp1(x, y_heart_after, xq, 'spline');
yq_lungs_after = interp1(x, y_lungs_after, xq, 'spline');
yq_muscles_after = interp1(x, y_muscles_after, xq, 'spline');

% Plot the effect of exercise on different organs before exercise
figure;
hold on;
plot(xq, yq_heart_before, 'r', 'LineWidth', 2);      % Heart rate before exercise
plot(xq, yq_lungs_before, 'g', 'LineWidth', 2);      % Oxygen consumption before exercise
plot(xq, yq_muscles_before, 'b', 'LineWidth', 2);    % Oxygen uptake before exercise
xlabel('Exercise Intensity (METs)');
ylabel('Effect on Organ (%)');
title('Before Exercise');
legend('Heart Rate', 'Oxygen Consumption', 'Oxygen Uptake by lungs');


% Plot the effect of exercise on different organs after exercise
figure;
hold on;
plot(xq, yq_heart_after, 'r', 'LineWidth', 2);     % Heart rate after exercise
```


Before Exercise
Heart Rate
Oxygen Consumption
Oxygen Uptake by lungs
Effect on Organ (%)
50
45
40
35
30
25
20
15
10
5
0
2
4
6
8
10
Exercise Intensity (METs)


After Exercise
Heart Rate
Oxygen Consumption
Oxygen Uptake by lungs
Effect on Organ (%)
50
45
40
35
30
25
20
15
10
5
0
2
4
6
8
10
Exercise Intensity (METs)

IMPACT OF EXCERCISE ON BLOOD GLUCOSE

IMPROVED INSULIN SENSITIVITY:

Exercise enhances the body's response to insulin, promoting efficient glucose uptake.

INCREASED GLUCOSE UPTAKE

Physical activity stimulates the uptake of glucose by muscles, lowering blood glucose levels.

REDUCED DIABETES RISK

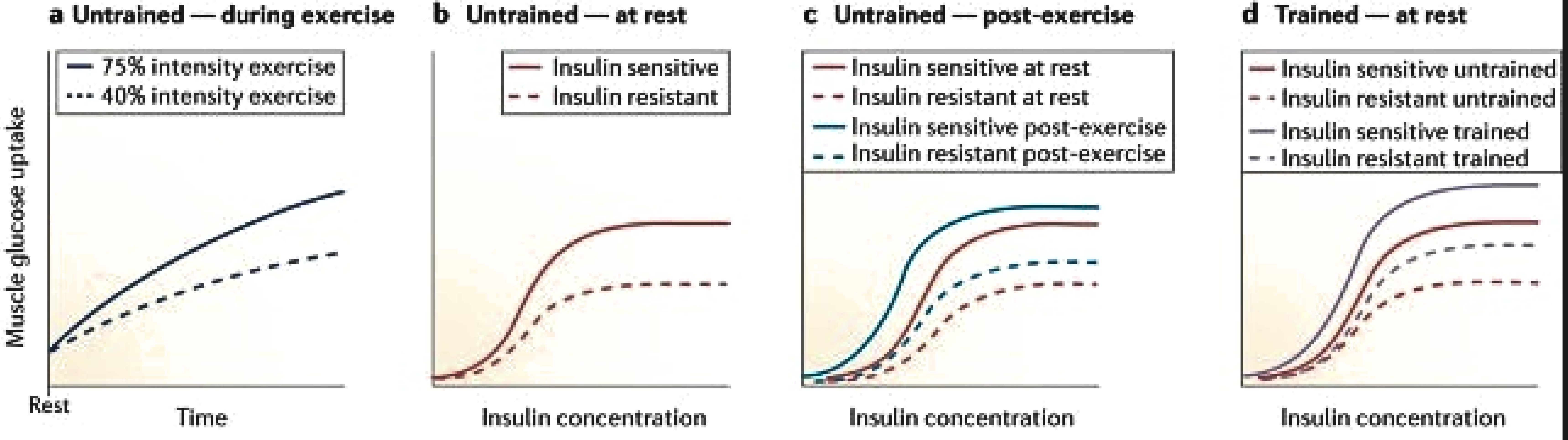
Regular exercise lowers the risk of type 2 diabetes by improving blood glucose regulation.

WEIGHT MANAGEMENT

Exercise aids in weight control, crucial for maintaining healthy blood glucose levels.

CARDIOVASCULAR BENIFITS

Exercise reduces the risk of cardiovascular diseases associated with diabetes, promoting overall heart health..



Delivery	↑ Microvascular recruitment and blood flow	↓ Microvascular recruitment in insulin resistance	↑ Microvascular recruitment	↑ Capillarization
Transport	↑ GLUT4 translocation	↓ GLUT4 translocation by insulin in insulin resistance	↑ GLUT4 translocation by insulin	↑ GLUT4 expression and translocation
Metabolism	↑ Glycolysis ↑ Oxidative phosphorylation	↓ HK expression in insulin resistance	↑ Glycogen synthesis	↑ HK and mitochondrial expression

ENDOCRINE RESPONSE TO EXERCISE

HORMONAL RESPONSE
Exercise triggers the release of hormones in the endocrine system.

ENDORPHINS
Exercise releases mood-boosting endorphins.

BALANCE
Exercise promotes a healthy hormonal balance for overall well-being..

GROWTH HORMONE
: Exercise stimulates growth hormone release for muscle growth and repair..

THYROID HORMONES
Exercise helps regulate thyroid hormones for a healthy metabolism.

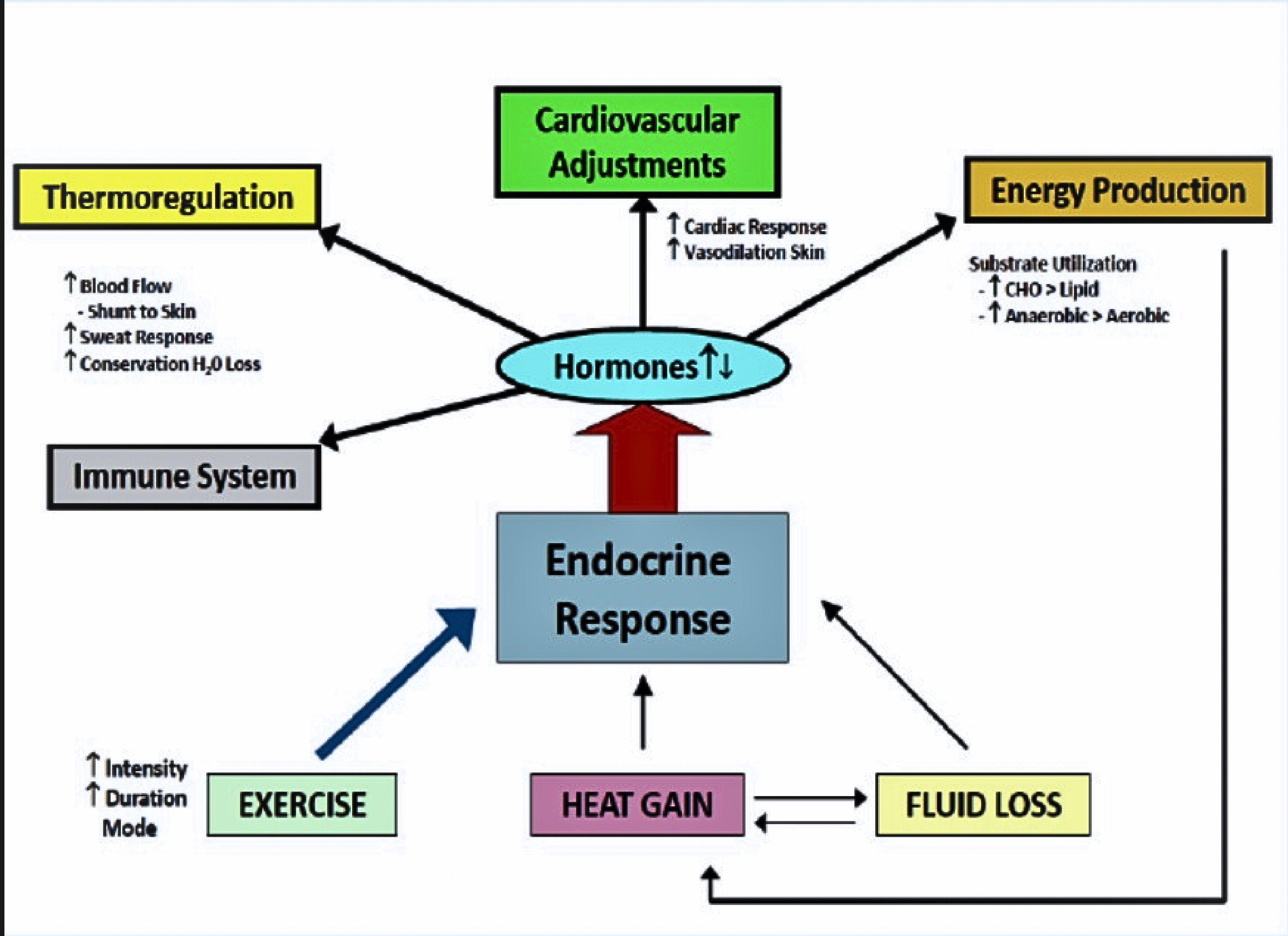
INSULIN
Exercise improves insulin sensitivity for blood glucose regulation.

CORTISOL:
Intense exercise increases cortisol levels for energy and inflammation regulation.

TESTOSTERONE
: Exercise raises testosterone levels, promoting muscle development and strength..

ADRENALINE AND NORADRENALINE:
Exercise boosts adrenaline and noradrenaline, increasing heart rate and blood flow

APPETITE HORMONES
Exercise affects appetite-regulating hormones like leptin and ghrelin



. A schematic illustration of the biological systems invoked to allow for adjustments in the homeostasis of the body during the adjustment to physical exercise.

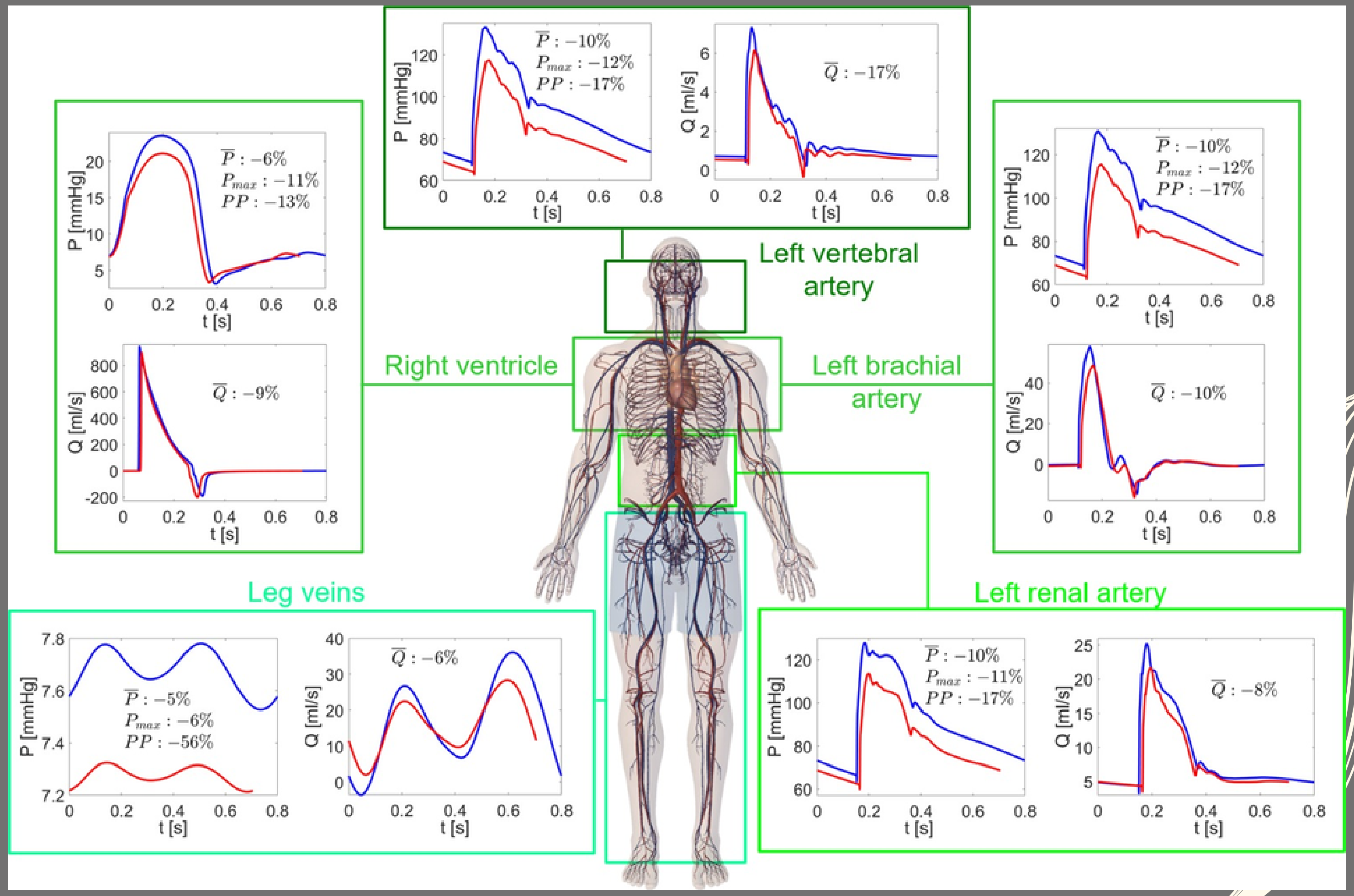
MATHEMATICAL MODEL FOR EXERCISE

A basic mathematical model for exercise can be described as follows:

Energy Expenditure = (Metabolic Equivalent of Task) x (Body Weight) x (Time Spent Exercising)

where:

- Energy Expenditure: The amount of energy (measured in calories or joules) expended during exercise.
- Metabolic Equivalent of Task (MET): A measure of the energy cost of a specific physical activity, compared to the energy cost of rest. One MET is equal to the energy expended while sitting quietly, which is approximately 3.5 milliliters of oxygen uptake per kilogram of body weight per minute (ml/kg/min).
- Body Weight: The weight of the individual performing the exercise, measured in kilograms or pounds.
- Time Spent Exercising: The duration of the exercise, measured in minutes.



MATHEMATICAL MODEL FOR EXERCISE

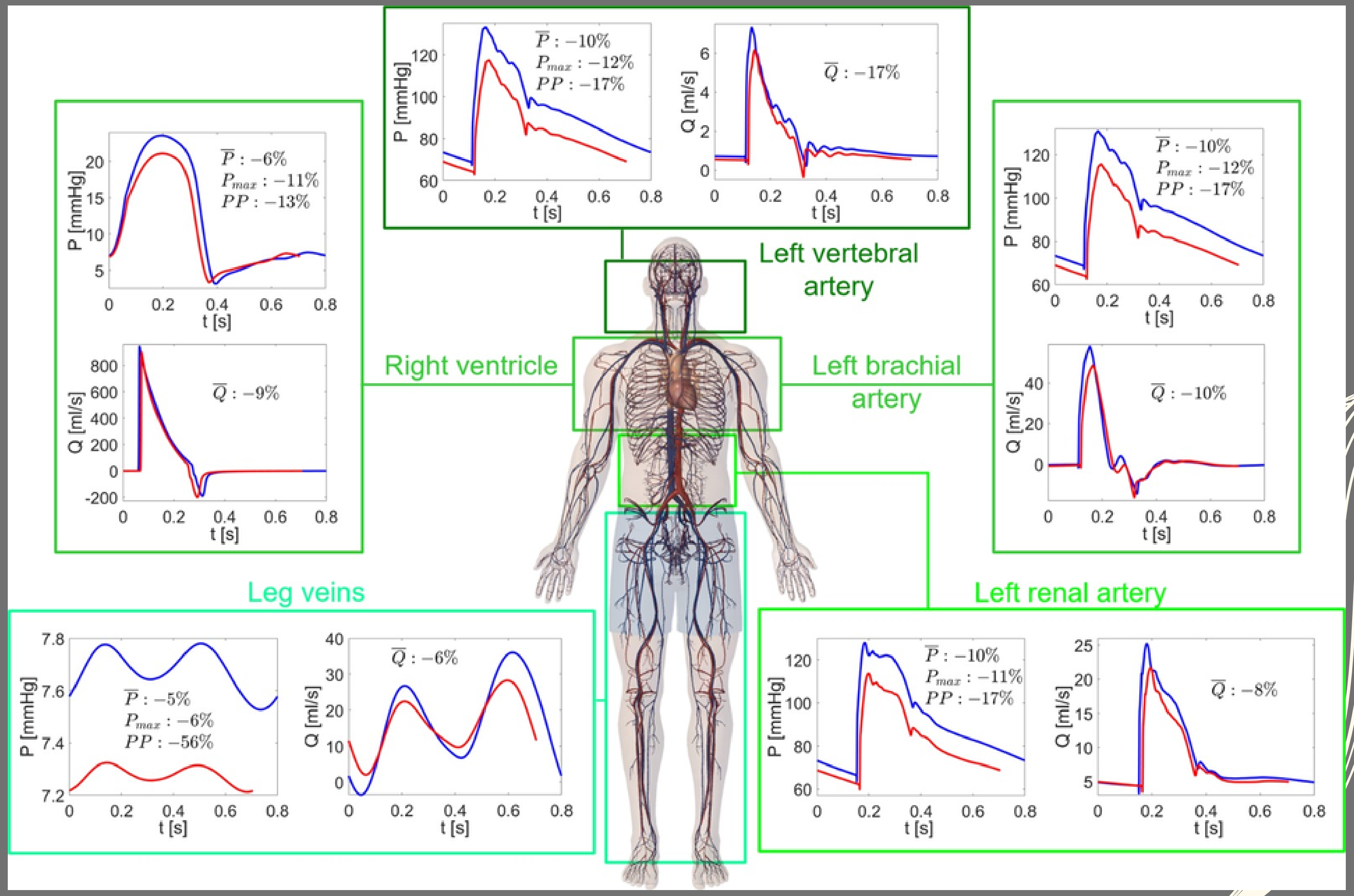
Cardiovascular system: Describes changes in heart rate, blood pressure, and stroke volume during exercise.

Respiratory system: Analyzes increased oxygen uptake and ventilation rate during exercise.

Musculoskeletal system: Models muscle activation, contraction, and energy utilization during exercise.

Metabolic system: Examines energy substrate utilization and metabolite production during exercise.

Endocrine system: Considers hormonal responses, such as cortisol and growth hormone release, and their impact on metabolism.



CONCLUSION

In conclusion, mathematical modeling and numerical analysis offers valuable insights into the effect of exercise on human organs. By incorporating various physiological systems such as the cardiovascular, respiratory, musculoskeletal, metabolic, endocrine, thermoregulatory, and neural systems, these models provide a comprehensive understanding of the complex interactions that occur during exercise. Such models enable us to optimize training protocols, enhance performance, and promote overall health.

REFRENCES

McArdle, W. D., Katch, F. I., & Katch, V. L. (2014). Exercise Physiology: Nutrition, Energy, and Human Performance. Lippincott Williams & Wilkins.

2)Bassett Jr, D. R., & Howley, E. T. (2000). Limiting factors for maximum oxygen uptake and determinants of endurance performance. Medicine and Science in Sports and Exercise, 32(1), 70-84.
[3)Plowman, S. A., & Smith, D. L. (2017). Exercise Physiology for Health, Fitness, and Performance. Lippincott Williams

4)Wikipedia
5)Lichtenbelt, W. D., & Sartor, F. (2019). A MATLAB-based toolbox for controlling thermoregulatory models. Journal of Thermal Biology, 84, 431-439.
6)MATLAB Documentation: MathWorks provides extensive documentation, tutorials, and examples for MATLAB coding related to mathematical modeling and simulation. You can find specific topics related to exercise physiology by searching in the MATLAB documentation.

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