



SPORTS PHYSIOLOGY

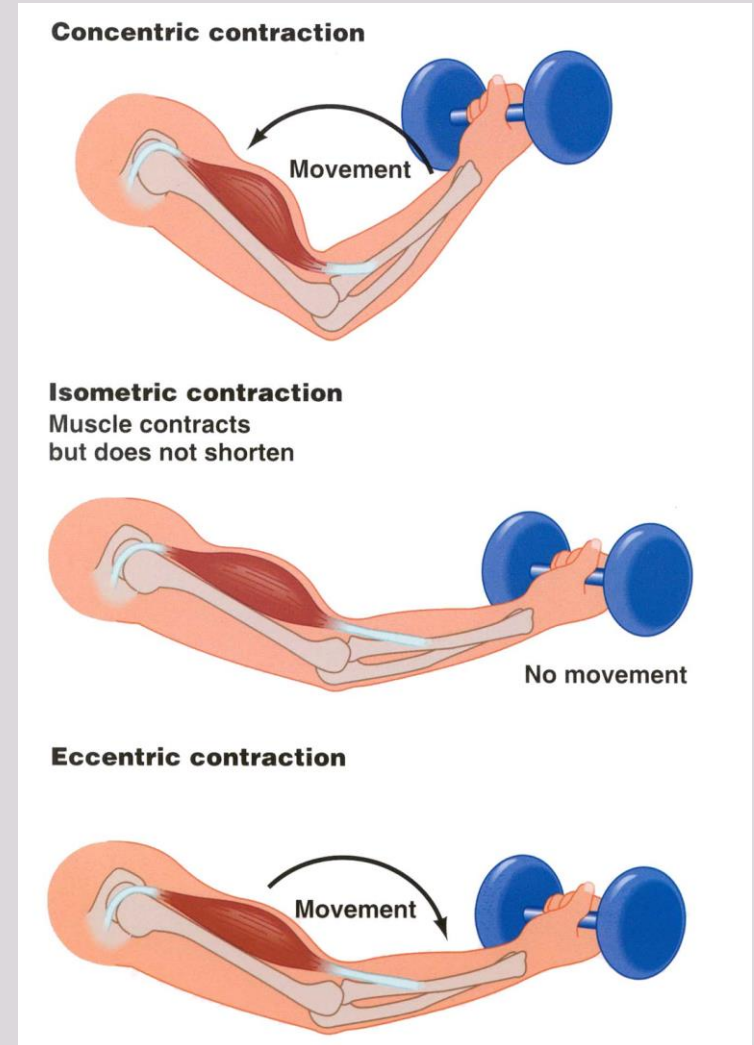
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Muscles in exercise

Aspect	Details
Muscle Contraction	Muscles contract when stimulated by the nervous system, shortening muscle fibers and generating force for movement and support.
Types of Muscle Contractions	a. Concentric: Muscle shortens (e.g., lifting in a bicep curl). b. Eccentric: Muscle lengthens under tension (e.g., lowering the weight). c. Isometric: Muscle length unchanged (e.g., holding a plank).



Muscle Fiber Types

- a. **Slow-Twitch (Type I):** High endurance, efficient oxygen use, fatigue-resistant (e.g., marathon running).
- b. **Fast-Twitch (Type II):** Powerful, quick fatigue.
 - a. **Type IIa:** Moderate endurance and strength (e.g., sprinting).
 - b. **Type IIb/IIx:** Maximum force, short duration (e.g., heavy lifting).

Types Of Muscle Fibres

Type 1



Slow twitch

Type 2A



Fast oxidative

Type 2B



Fast glycolytic

Fiber Type	Characteristics	Function & Adaptation
Fast-Twitch (Type II)	• Larger diameter • High power output • Enzymes for phosphagen & glycolytic energy systems are 2–3x more active	• Produce rapid, forceful contractions • Ideal for short-duration, high-intensity activities (e.g., sprinting, jumping) • Fatigue quickly
Slow-Twitch (Type I)	• Smaller diameter • Rich in mitochondria • High myoglobin content • More capillaries	• Designed for endurance and aerobic energy production • Efficient oxygen use • Resist fatigue over prolonged activity (e.g., long-distance running)

Hereditary Influence on Fiber Distribution

Aspect	Details & Explanation
Genetic Determinants	Ratio of fast-twitch to slow-twitch fibers is largely inherited and not significantly altered by training.
Athletic Implications	Fiber type ratio often dictates natural athletic strengths: • More fast-twitch fibers = better sprinters, jumpers • More slow-twitch fibers = better marathoners
Example Fiber Distributions	Quadriceps composition in various athletes: • Sprinters: ~60–80% fast-twitch • Marathon runners: ~60–80% slow-twitch • General population: ~50/50 mix

Muscle Adaptation	a. Hypertrophy: Muscle fiber damage, repair, and growth via resistance training. b. Increased Endurance: Better oxygen delivery, energy use.
Muscle Recovery	• Essential for adaptation. • Requires rest, nutrition, hydration, and sleep to support repair and growth.
Muscle Groups	• Chest, back, shoulders, arms, core, quadriceps, hamstrings, glutes. • Balanced routines should target all groups.
Importance of Variety	• Combining strength, endurance, and flexibility exercises ensures comprehensive muscular development and performance.

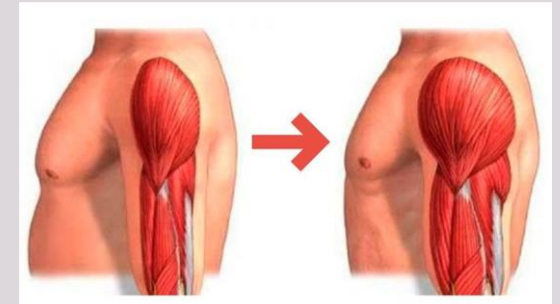
Muscle Hypertrophy and Cellular Adaptations

Category	Aspect	Details & Explanation
Hypertrophy	Mechanism	Caused mainly by increase in fiber diameter , not number. Rarely, large fibers may split to form new fibers.
	Genetic Influence	Muscle size influenced by heredity and testosterone . Men generally develop larger muscles than women due to higher testosterone levels.
	Potential Growth Range	With training, muscles can hypertrophy 30–60% beyond genetic baseline.

Intracellular Adaptations	Myofibrils	Increased number , proportional to hypertrophy.
	Mitochondrial Enzymes	Up to 120% increase , enhancing aerobic capacity .
	Phosphagen System	60–80% increase in ATP and phosphocreatine content for anaerobic energy.
	Glycogen Stores	50% increase , fueling anaerobic and aerobic activities.
	Triglyceride Stores	75–100% increase , providing long-term energy for endurance.
	Overall Metabolic Efficiency	Oxidative metabolism improves by up to 45% , enhancing aerobic endurance and recovery.

EFFECT OF ATHLETIC TRAINING ON MUSCLES AND MUSCLE PERFORMANCE

Muscle Hypertrophy	Increased muscle size due to micro-tears and repair from resistance training.
Increased Muscle Strength	Muscles adapt to training loads, generating more force and lifting heavier weights or performing powerful actions.
Enhanced Muscle Power	Ability to exert force quickly (e.g., jumping, sprinting). Improved by explosive exercises like plyometrics or Olympic lifts.



Improved Muscular Endurance	• Muscles sustain repeated contractions longer, delaying fatigue during activities like long-distance running or cycling.
Muscle Fiber Adaptation	• Endurance training promotes Type I fibers; strength/power training enhances Type II fibers. • Adaptations improve performance in targeted athletic areas.
Muscle Coordination & Efficiency	• Repeated movement practice improves neuromuscular control, leading to smoother, more efficient performance and reduced injury risk.
Increased Muscle Flexibility	• Stretching and mobility training improve flexibility and joint range, supporting better performance and injury prevention.

Training Variables	Influencing Factors	• Training intensity, duration, frequency, and genetics affect outcomes. • Proper recovery and nutrition are essential for effectiveness.
	Role of Professionals	Coaches and trainers help design personalized programs that maximize benefits while minimizing injury risk.

RESPIRATION IN EXERCISE

Category	Details
Importance of Respiration in Athletics	- Sprint events: Respiratory function plays a minimal role; energy comes mainly from anaerobic metabolism. - Endurance events: Respiratory function is critical for sustained aerobic metabolism; oxygen delivery becomes the performance-limiting factor.
Oxygen Consumption (VO₂)	- At rest (young adult male): ~250 ml/min - Maximal exercise: Can increase up to ~5000 ml/min (20× increase) - Reflects the muscle demand for oxygen during aerobic metabolism.

Pulmonary Ventilation (VE)	- At rest: ~6 L/min - Maximal exercise: Up to ~120–150 L/min - In well-trained individuals, both VO_2 and VE increase in proportion to exercise intensity.
Maximal Breathing Capacity vs. Ventilation Need	- Maximal voluntary ventilation (MVV): ~60% greater than what is used during maximal exercise - Safety margin allows for additional ventilation under stress (e.g., high altitude, heat, mild lung disease) - Respiratory system is not usually the limiting factor in oxygen supply.
Primary Limiting Factor in Maximal Exercise	- Cardiac output (CO) is the major limitation- VO_2 delivery depends more on how much blood the heart can pump than on lung ventilation capacity - Respiratory system has reserve capacity, whereas the cardiovascular system often operates near its limit.

Oxygen Diffusing Capacity (DL O₂)	- At rest: Limited by inactive pulmonary capillaries and lower alveolar surface area - During exercise: - Increases up to 3×–4× due to: - Full perfusion of capillaries - Recruitment of previously dormant vessels Expansion of surface area for gas exchange - Higher in endurance-trained athletes
Blood Gases During Exercise	- Arterial PO₂ and PCO₂: Remain nearly normal during even heavy exercise - Despite increased oxygen use and CO₂ production- Demonstrates efficiency of pulmonary system

Control of Respiration During Exercise	- Not triggered by changes in blood gases - Driven by neurogenic factors: - Signals from motor cortex to respiratory center - Sensory feedback from muscles and joints
Effect of Smoking on Pulmonary Function (Acute)	- Nicotine effects: Bronchoconstriction → ↑ airway resistance - Smoke irritation: Inflammation + fluid secretion - Cilia paralysis: Impairs mucus clearance → debris accumulation - Even light smoking reduces exercise capacity due to breathing inefficiency
Effect of Chronic Smoking	- Leads to chronic obstructive pulmonary disease (COPD) and emphysema- Features: 1. Chronic bronchitis (inflammation + mucus overproduction) 2. Obstruction of terminal bronchioles 3. Destruction of alveolar walls → ↓ surface area for gas exchange - Up to 80% loss of respiratory membrane in severe cases - Even mild activity causes dyspnea (breathlessness)

CVS IN EXERCISE

Category	Factor	Explanation
Factors That Maintain Circulation	1. Force of Heart Contraction	• Stronger heart contractions improve blood flow and help maintain circulation.
	2. Respiration	• Inhalation decreases intra-thoracic pressure and increases abdominal pressure, aiding venous return.
	3. Elastic Recoil of Arteries	• Arteries expand and contract, pushing blood forward, maintaining continuous circulation.
	4. Gravity	• Assists blood flow from upper body parts (above the heart) toward the heart.
	5. Pressure Gradient	• Blood flows from high-pressure arteries to low-pressure veins, ensuring forward circulation.

Factors Maintaining Cardiac Output	1. Venous Return	• The amount of blood returning to the heart (right atrium) from the body affects cardiac output.
	2. Force of Contraction	• Stronger contractions push more blood per beat (stroke volume).
	3. Starling's Law	• The more the heart muscle is stretched (by increased venous return), the stronger the contraction.

Factors Affecting Cardiac Output	1. Force of Contraction	• Influenced by respiration, gravity, elastic recoil, and pressure gradients.
	2. Venous Return	• More return = more preload = higher cardiac output.
	3. Frequency of Contraction	• Heart rate determines how often blood is pumped out.
	4. Peripheral Resistance	• Resistance in blood vessels affects how easily blood flows; increased resistance can reduce cardiac output.

Chronic Adaptations Due to Exercise	1. Cardiac Hypertrophy (Athlete's Heart)	• Enlarged heart, especially left ventricle, increases stroke volume. • Athletes: ~125 ml/beat vs. sedentary: ~70 ml/beat.
	2. Bradycardia	• Lower resting heart rate in trained individuals (e.g., 40 bpm) due to increased efficiency; • cardiac output remains sufficient.
	3. Increased Stroke Volume	• Exercise increases stroke volume. • Sedentary: ~110 ml/beat; • Athletes: ~170–200 ml/beat.
	4. Higher Capillary Density	• More capillaries form to supply active muscles more efficiently, enhancing oxygen and nutrient delivery.
	5. Increased Blood Volume	• Exercise mobilizes stored blood from tissues into circulation, increasing overall blood volume.
	6. Increased Total Hemoglobin	• Increased blood volume leads to more hemoglobin, enhancing oxygen-carrying capacity.

Aspect	Explanation
1. Heart Rate	- Increases during exercise; - Resting HR: 60–80 bpm (average), 100 bpm (sedentary), 28–40 bpm (elite athletes).
2. Anticipatory Response	HR increases before exercise due to release of epinephrine and norepinephrine.
3. Stroke Volume	Amount of blood ejected per beat. - Rest: 50–70 ml/beat (untrained) - Exercise: 110–130 ml/beat - Elite athletes: up to 150–220 ml/beat.

4. Cardiac Output	• Blood pumped per minute ($SV \times HR$). • Increases with exercise intensity. • Max output increases due to higher SV in trained individuals.
5. Blood Flow	• Redistribution to muscles: • At rest: 15–20% to skeletal muscle • During exercise: 80–85% of cardiac output directed to working muscles.
6. Blood Pressure	• Resting: 110–140 mmHg (systolic), 60–90 mmHg (diastolic) • During exercise: Systolic may exceed 200 mmHg in trained individuals.

BODY HEAT IN EXERCISE

Topic	Explanation
Energy Conversion in the Body	When the body uses nutrients (like carbohydrates and fats) for energy, almost all of it ends up as heat, even when it powers muscle movement.
Efficiency of Muscle Work	- Muscles only use 20–25% of nutrient energy to perform actual work. - The remaining 75–80% is lost as heat during chemical reactions inside cells.
Heat from Muscle Contraction	Even the energy that does go into movement still mostly becomes heat due to: 1. Viscous resistance in muscles/joints 2. Friction from blood flow 3. Other internal resistance forces.

Oxygen Use and Heat Production	• In trained athletes, oxygen consumption can increase up to 20 times during intense exercise. • Since heat production is linked to oxygen use, this creates massive internal heat.
Exercise and Heat Build-up	• During long periods of exercise (like marathons or cycling), the body generates tremendous amounts of heat. • This is usually controlled by sweating and blood flow.
Hot & Humid Conditions	• On hot, humid days, sweat does not evaporate well, making it hard for the body to cool down. • This increases the risk of overheating.
Heatstroke Risk	• When the body can't get rid of heat fast enough, heat builds up dangerously, potentially leading to a condition called heatstroke.

Normal Body Temperature	The average body temperature is 98.6°F (37°C).
Typical Rise During Exercise	During hard exercise, it's normal for body temperature to go up to 102–103°F (39–40°C).
Dangerous Temperature Levels	In extreme conditions (very hot, humid, or with excess clothing), temperature can rise to 106–108°F (41–42°C) this can damage organs and cells, especially the brain.
Heatstroke Symptoms	- Signs of heatstroke include: Extreme fatigue - Headache, dizziness, and nausea Profuse sweating (or sudden lack of sweat in late stages) Confusion or disorientation Staggering walk Collapse or fainting

Why It's Dangerous	• Even after stopping exercise, body temperature doesn't drop easily because: 1. The temperature control center in the brain can fail. 2. The body's chemical reactions speed up, producing even more heat.
Definition of Heatstroke	• A life-threatening condition where the body's internal temperature regulation fails and causes damage to the brain and organs.
Treatment – First Steps	• Immediate cooling is critical. • Steps include: • Remove all clothing • Spray or sponge the body with cool water • Use a fan to blow air over the skin.
Alternative Treatment	• If available, immerse the person in a bath of crushed ice and water • this is extremely effective but may not always be practical.

Body fluids and salts in exercise

Fluid Loss and Performance Impact

Topic	Detailed Explanation
Sweat-Induced Weight Loss	• In endurance events (e.g., marathons, military drills), especially in hot and humid weather, athletes can lose 5–10 pounds in just 1 hour. • This loss is primarily due to sweat, not fat or muscle loss.
Performance Effects of Fluid Loss	• A 3% loss in body weight from sweat can already reduce physical performance, causing fatigue and weakness. • A 5–10% fluid loss can be dangerous, leading to muscle cramps, nausea, dizziness, and heat illness.
Importance of Hydration	• Athletes must replace fluids continually during exercise. • Delaying rehydration can lead to serious health risks and drop in endurance, coordination, and even mental focus.

Sodium Chloride (Salt) and Acclimatization

Topic	Detailed Explanation
Salt in Sweat	Human sweat contains a significant amount of sodium chloride (NaCl), which is why athletes may appear to have white salt stains on clothing after exercise.
Traditional Use of Salt Tablets	For decades, athletes were advised to take salt tablets during hot-weather exercise to prevent salt depletion and associated cramps or fatigue.
Problems with Excess Salt Intake	Overconsumption of salt tablets can lead to electrolyte imbalance, bloating, or even high blood pressure, and may not be necessary in all cases.

Heat Acclimatization Process	• Gradual exposure to heat and physical exertion over 1–2 weeks helps the body adjust. • This reduces salt loss through sweat significantly.
Physiological Changes in Acclimatization	• The hormone aldosterone (from the adrenal cortex) increases during heat adaptation. • It enhances salt reabsorption in sweat glands, so less salt is lost in sweat.
Impact on Salt Supplementation	• Once acclimatized, athletes' bodies naturally conserve salt, and salt supplements are usually unnecessary, except in extreme or prolonged exertion.