

Chapter

# 11

## Acid-Base Balance during Exercise

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### Objectives

1. Define the terms *acid*, *base*, and *pH*.
2. Discuss the importance of acid-base regulation to exercise performance.
3. List principal intracellular and extracellular buffers.
4. Explain the role of respiration in the regulation of acid-base status during exercise.
5. Outline acid-base regulation during exercise.
6. Discuss the principal ways that hydrogen ions are produced during exercise.

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### Acids & Bases

- Acid
  
  
  
  
  
  
  
  
  
  
- Base

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## pH of Blood

- Normal
- Acidosis
- Alkalosis
- Abnormal pH can disrupt normal body function & affect performance

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## The pH Scale

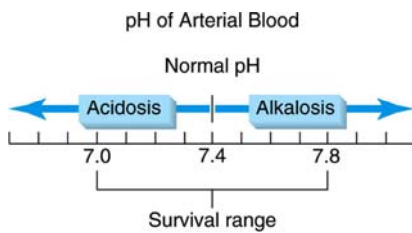


Figure 11.1

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## Acidosis & Alkalosis

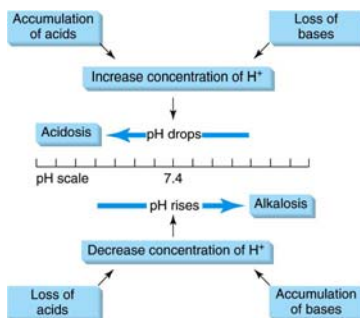


Figure 11.2

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**Clinical Applications 11.1**  
**Conditions & Diseases that Promote Metabolic Acidosis or Alkalosis**

- **Metabolic acidosis**
  - Gain in the amnt of acid in the body
  - Long-term starvation
    - Through production of ketoacids
    - From fat metabolism
  - Uncontrolled diabetes
    - Diabetic ketoacidosis
- **Metabolic alkalosis**
  - Loss of acids from the body
  - Severe vomiting
  - Kidney disease

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**Sources of H<sup>+</sup> Ions during Exercise**

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**Sources of H<sup>+</sup> Ions Due to Metabolic Processes**

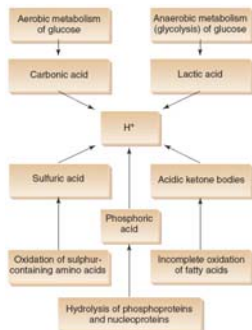


Figure 11.3

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## Popular Sports & Acid-Base Balance

**TABLE 11.1** Risk of Developing an Acid-Base Disturbance in Popular Sports

Sport	Risk of Acid-Base Disturbance
Baseball	Low
Basketball	Low-to-moderate
Boxing	Low-to-moderate
Cross-country skiing	Low
Football (American)	Low
100-meter sprint	Low
100-meter swim	High
400-meter run	High
800-meter run	High
1,500-meter run	Moderate-to-high
5,000-meter run	Moderate
10,000-meter run	Low-to-moderate
Marathon run	Low
Soccer	Low-to-moderate
Weight lifting (low repetitions)	Low
Volleyball	Low

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## *A Closer Look 11.1* Sport & Exercise-Induced Disturbances in Muscle Acid-Base Balance

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## Importance of Acid-Base Regulation During Exercise

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## Acid-Base Buffer Systems

- Acid-base balance maintained by buffers
- Intracellular buffers
- Extracellular buffers

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## Bicarbonate Buffering System

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## Acid-Base Buffer Systems

Buffer System	Constituents	Actions
Bicarbonate system	Sodium bicarbonate ( $\text{NaHCO}_3$ )	Converts strong acid into weak acid
	Carbonic acid ( $\text{H}_2\text{CO}_3$ )	Converts strong base into weak base
Phosphate system	Sodium phosphate ( $\text{Na}_2\text{HPO}_4$ )	Converts strong acid into weak acid
Protein system	$\text{COO}^-$ group of a molecule	Accepts hydrogens in the presence of excess acid
	$\text{NH}_3$ group of a molecule	Accepts hydrogens in the presence of excess acid

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### Respiratory Influence on Acid-Base Balance

- Carbonic acid dissociation equation

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### Regulation of Acid-Base Balance via the Kidneys

- Important in long-term acid-base balance
- Regulate bld bicarbonate concentration

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### Regulation of Acid-Base Balance during Exercise

- Lactic acid production depends on:

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### Δs in Arterial Bld & Muscle pH during Exercise

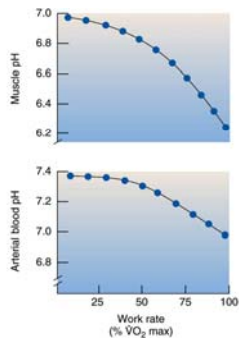


Figure 11.4

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### Regulation of Acid-Base Balance during Exercise

- Buffering of lactic acid in the muscle
  
- Buffering of lactic acid in the bld

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### Δs in Bld Lactic Acid, HCO<sub>3</sub><sup>-</sup> & pH during Exercise

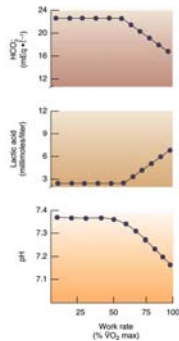


Figure 11.5

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## Regulation of Acid-Base Balance during Exercise

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## Lines of Defense Against pH $\Delta$ during Intense Exercise

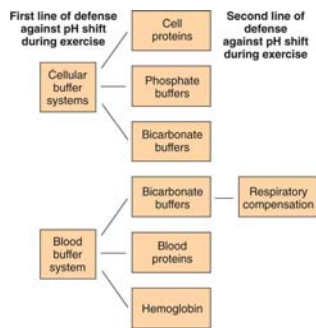


Figure 11.6

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## Study Questions

1. Define the terms *acid*, *base*, *buffer*, *acidosis*, *alkalosis*, and *pH*.
2. Graph the pH scale. Label the pH values that represent normal arterial and intracellular pH.
3. List and briefly describe the major groups of acids formed by the body.
4. Why is the maintenance of acid-base homeostasis important to physical performance?
5. What are the principal intracellular and extracellular buffers?
6. Discuss respiratory compensation for metabolic acidosis. What would happen to blood pH if an individual began to hyperventilate at rest? Why?
7. Briefly, outline how the body resists pH change during exercise.

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